FACULTAD DE INGENIERÍAS Y CIENCIAS AGROPECUARIAS

Implementación de un arreglo de antenas Yagi para mejorar la eficiencia en un enlace punto a punto con radios RF digitales entre Mariscal Sucre y Lasso en el rango de 915 a 928 MHz.

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Trabajo de titulación presentado en conformidad con los requisitos establecidos para optar por el título de Ingeniero en Redes y Telecomunicaciones

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"Declaro haber dirigido el trabajo, Implementación de un arreglo de antenas Yagi para mejorar la eficiencia en un enlace punto a punto con radios RF digitales entre Mariscal Sucre y Lasso en el rango de 915 a 928 MHz, a través de reuniones periódicas con el estudiante Carlos Iván Tapa Caiza, en el semestre 201920, orientando sus conocimientos y competencias para un eficiente desarrollo del tema escogido y dando cumplimiento a todas las disposiciones vigentes que regulan los Trabajos de Titulación”.

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DEDICATORIA

A la memoria de mi madre, que fue mi primera maestra y un gran ejemplo de lucha hasta su último día de vida. A mi padre, que, con su constancia y trabajo duro, me enseño que se debe luchar por cumplir las metas. A mis hermanas, quienes con su consejo me hacen cada día un mejor ser humano y a mi sobrino Damián que con su sonrisa me impulsa a ser mejor de lo que fui ayer.

RESUMEN

En el presente proyecto se revisará la teoría general acerca de antenas y arreglos, se presentará las diferentes fórmulas que se debe tomar en cuenta para la formación de un arreglo de dos antenas. Con los conceptos definidos se procederá por facilidad a realizar los cálculos para un arreglo de dos antenas yagi, con el arreglo diseñado se usa el software libre de nombre Mmana-gal para realizar el diseño, concluido la etapa teórica se procederá a realizar la construcción y finalmente la implementación del arreglo de dos antenas Yagi entre los puntos Lasso y Mariscal Sucre

En el Capítulo 1 se revisará conceptos generales como son los parámetros a tomar en cuenta al momento de estudiar antenas y los arreglos de antenas.

En el Capítulo 2 se realizará los cálculos para el arreglo de dos antenas Yagi y la simulación en el software libre Mmana-gal.

En el Capítulo 3 se realizará la construcción, pruebas e implementación del arreglo de dos antenas Yagi.

En el Capítulo 4 se darán a conocer las conclusiones y recomendaciones del desarrollo del proyecto de titulación.

ABSTRACT

In this project we will review the general theory about antennas and array and we will present the different formulas that should be taken into account for the formation of an array of two antennas. With the defined concepts, it will be easy to carry out the calculations for an array of two yagi antennas, using the free software Mmana-gal to make the design. Once the theoretical stage is finished, the construction and finally the implementation of the arrangement of two Yagi antennas between Lasso and Mariscal Sucre will be carried out.

Chapter 1 will review general concepts such as the parameters to be taken into account when studying antennas and antenna arrays.

In Chapter 2 the calculations will be made for the arrangement of two Yagi antennas and the simulation done in the free software Mmana-gal.

In Chapter 3 the construction, testing and implementation of the arrangement of two Yagi antennas will be presented.

In Chapter 4 the conclusions and recommendations of for development of this project will be provided.

ÍNDICE

1. CAPÍTULO I. INTRODUCCIÓN

En la actualidad, el avance que ha traído consigo las comunicaciones inalámbricas, crea la necesidad de utilizar de una manera más eficiente el espectro radioeléctrico para transmitir y recibir los diferentes tipos de datos, uno de los componentes que permiten llevar a cabo este proceso es la antena.

Entre los Puntos Lasso y Mariscal Sucre se encuentra instalado un enlace punto a punto, el cual es débil por no contar con una línea de vista totalmente limpia, los radios que se utilizarán en el presente proyecto son digitales, de marca *Freewave* y de frecuencia libre, que trabajan en los rangos de 902 a 928 MHz, las antenas utilizadas para la transmisión y recepción de los datos actualmente son Yagi, diseñadas para este rango. Con la resolución de la Arcotel de abril de 2017, limita el rango de 915 a 928 MHz, por lo que es necesario el diseño de un nuevo transductor.

Por tal motivo, con la implementación del arreglo de antenas Yagi para el rango de frecuencias de 915 a 928 MHz en los puntos antes mencionados se presentará una mejora a la calidad del enlace y se podrá visualizar mediante el software de monitorización de los radios digitales, además de que este diseño quedará documentado en el presente escrito para poder construir más arreglos de antenas si se requiere.

1.1 Alcance

Para el presente proyecto, se integra los principales conceptos, características y diferentes parámetros a considerar en un arreglo de antenas de radio de ultra alta frecuencia, se realizará los cálculos matemáticos para cada elemento que conforma la misma.

En la actualidad existen una gran variedad de herramientas para el diseño de antenas, para el presente proyecto se utilizará un software específico para la simulación de antenas denominado Mmana-gal, se trabajará para obtener diferentes datos con los que se pueda comparar la información teórica con los resultados prácticos.

Una vez construido el arreglo se obtendrá medidas de VSWR en los rangos diseñados, además se podrá verificar el acople con carta de Smith mediante un equipo especializado.

Se realizará pruebas en campo entre el enlace Mariscal Sucre-Lasso para verificar su funcionamiento y mediante el radio visualizar la señal a ruido, y constatar que no existan pérdidas de paquetes y el comportamiento general del arreglo de antenas.

1.2 Justificación

En la actualidad las antenas yagi tienen gran acogida en lo que respecta a proyectos de radiocomunicaciones debido a su rápida construcción y su gran rendimiento. En el Ecuador se ha ejecutado estudios, diseños, guías e implementación utilizando antenas Yagi, pero no se encuentra documentación acerca de arreglos para mejorar las características de la antena, además debido a los cambios realizados en la ARCOTEL que redujo el número de frecuencias que eran destinadas para el libre desarrollo de aplicaciones, se necesita de una antena que sea diseñada en este rango del espectro.

Este proyecto pretende presentar un documento de manera técnica y detallada de cómo se podría mejorar la ganancia de la antena, relación *front to back* y señal a ruido además de evitar el multi-camino de las ondas electromagnéticas cuando se diseña e implementa un arreglo de antenas.

Una vez concluido el proyecto se donará a la Universidad de las Américas más específicamente al laboratorio de Telecomunicaciones para que se puedan producir pruebas, estudiando y analizando los diferentes parámetros que pueden presentar este tipo de antenas, de esta forma ayudar a los estudiantes en la formación académica y técnica.

1.3 Objetivos

1.3.1 Objetivo General

Diseñar e implementar el arreglo de antenas yagi en el rango de frecuencias de 915 a 928 MHz para el enlace de datos entre los puntos Mariscal Sucre y Lasso.

1.3.2 Objetivos Específicos

- Documentar la información necesaria acerca del arreglo de antena yagi como; definición, características, funcionamiento, etc.

- Realizar los cálculos matemáticos teniendo en cuenta todos los parámetros que intervienen en el diseño.

- Construir cada elemento que compone el diseño de la antena teniendo en cuenta el resultado teórico.

- Validar y evaluar el funcionamiento del arreglo de antenas mediante mediciones con equipos especializados en la instalación en el campo, para garantizar el óptimo funcionamiento de la misma.

A continuación, se describen los conceptos que deben ser considerados al momento de diseñar una antena, con la finalidad de conceptualizar las bases de este trabajo de titulación.

1.4 Antena

Una antena es un dispositivo metálico capaz de transmitir y recibir ondas electromagnéticas que son producidas en el espacio, capaz de convertir corriente eléctrica en ondas electromagnéticas cuando se trata de un transmisor y lo contrario cuando se trata de un receptor. Para viajar por el espacio esas señales eléctricas deben acoplarse primero al mismo, es decir, esta transferencia de energía debe realizarse con la mayor eficiencia posible, el acoplamiento entre ambas debe ser óptimo, de no ser así, se pueden generar otro tipo de ondas electromagnéticas que pueden causar distorsiones en la señal que se transporta, además de daños en los diversos componentes que conforman el sistema línea-antena. (Monachesi, Frenzel, & Chaile, 2011)

Con el desarrollo de las comunicaciones inalámbricas se generan distintos circuitos prácticos sin la necesidad de cables, como se representa en la Figura 1.

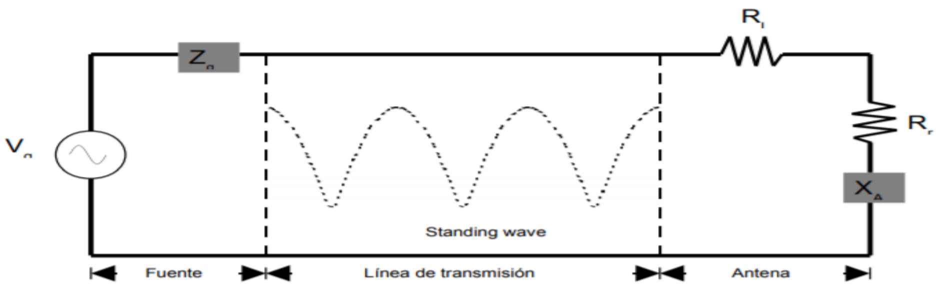


Figura 1. Circuito equivalente de una antena.
Tomado de (Ferrando & Valero, 2019)

1.4.1 Parámetros de una antena

A partir de las Ecuaciones de Maxwell, se puede calcular los campos eléctricos y magnéticos radiados por una antena, pero las expresiones resultantes son demasiado complejas, por lo que se busca describir de una manera fácil a través de parámetros que son susceptibles a medidas y se puede tener una idea de cómo trabajaría la antena cuando sea instalada.

1.4.1.1 Impedancia

Para entender este parámetro nos guiamos de la Figura 2:

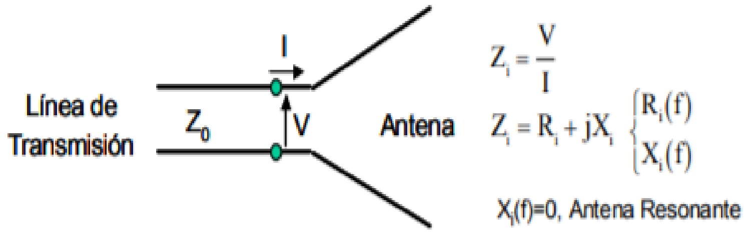


Figura 2. Esquema de una antena en transmisión.
Tomado de *(Ocwupmes, 2004)*

Se define como la tensión que se tiene en los bordes y la intensidad que atraviesa por la antena, como resultado, es una impedancia la cual consta de una parte real llamada resistencia y la imaginaria conocida como la reactancia de la antena. Para poder trabajar como circuito es necesario tomar en cuenta que la impedancia de carga de la antena debe ser igual a la impedancia de entrada como se muestra en la
Figura 3.

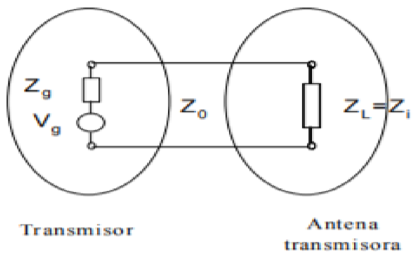


Figura 3. Esquema de antena en transmisora.
Tomado de (Ocwupmes, 2004)

La resistencia (parte real) proviene de la suma de la resistencia de radiación y la resistencia óhmica; la resistencia de radiación se obtiene de relación entre la potencia total radiada y el valor eficaz de la corriente en sus terminales de entrada elevada al cuadrado, mientras que la resistencia óhmica se obtiene de la relación entre la potencia disipada por efecto de las perdidas resistivas y la corriente terminal al cuadrado. (Miguel, 2017)

1.4.1.2 Diagrama de radiación de una antena

Se define como la representación gráfica de cómo se encuentra distribuida la radiación dentro del espacio, cabe mencionar que todas las antenas no radian en la misma dirección, sino que dependerá de su geometría, forma de excitación y dimensiones para que esta energía sea emanada en las distintas direcciones del espacio.

Cada antena puede generar un diferente diagrama de radiación, pero casi siempre comparten las mismas características que se visualiza en el grafico en la Figura 4:

Figura 4. Diagramas generales de radiación.
Tomado de *(Miguel, 2017)*

La clasificación de las antenas se da según su diagrama de radiación y las tres principales es como se muestra en la Figura 4:

- Isótropa: cuando la radiación es idéntica en todas las direcciones.
- Omnidireccionales: cuando en uno de sus planos radia de manera isotrópica, es decir radia a los 360 grados de un solo plano.

- Directivo: cuando existe una dirección predominante de radiación, para este tipo de antenas existirá varios subtipos debido a que se puede mover a conveniencia los lóbulos de radiación.

En el presente proyecto se diseñará un arreglo de antenas Yagi por ende tendrá gran directividad, por lo que es suficiente conocer los cortes de los diagramas de los planos principales, es decir en el plano E (vector campo eléctrico) y plano H (vector campo magnético) que son perpendiculares entre sí, y estos cortes pueden ser representados mediante los formatos polares y cartesianos.

Asociados a los diagramas de radiación, aparecen parámetros de radiación que se toman en consideración al momento del diseño de la antena, estos son:

- Lóbulo principal: donde se encuentra la máxima radiación.
- Lóbulos secundarios: aquellos que son diferentes del principal
- Lóbulos laterales: Son los adyacentes al principal.
- Lóbulo posterior: siempre se encuentra opuesto al principal

En la Figura 5 se puede visualizar los parámetros antes descritos en el diagrama de radiación en coordenadas cartesianas.

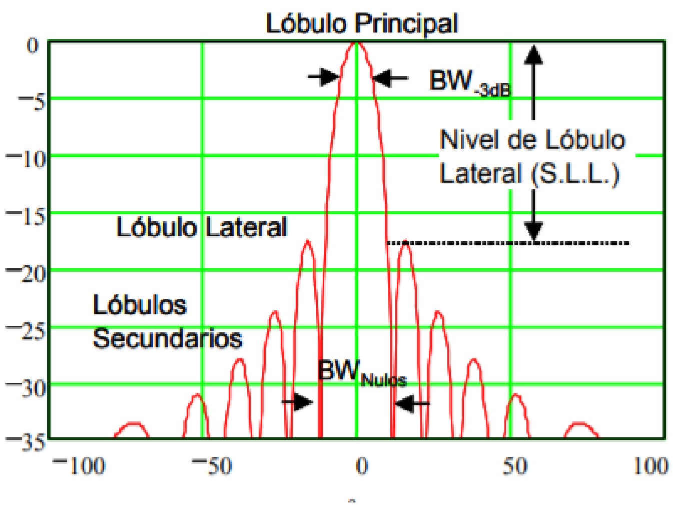


Figura 5. Parámetros del diagrama de radiación.
Tomado de *(Ocwupmes, 2004)*

Como se puede visualizar en el grafico se busca que los niveles de los lóbulos secundarios sean mínimos, además que si existen señales de telemetría en rangos de frecuencia similares esto podría causar interferencias.

1.4.1.3 Intensidad de radiación (directividad y ganancia de una antena).

La intensidad de radiación es la capacidad que tiene una antena de radiar energía en una dirección y es utilizada para definir la ganancia directiva de una antena. Esta se define como la relación entre la intensidad de radiación en una dirección y la intensidad de radiación de una antena isótropa que radiara la misma potencia total, (Ocwupmes, 2004) expresada la ganancia en términos generales, quedaría de la siguiente forma:

$$G = 4\pi \frac{intensidad\ de\ radiacion}{potencia\ total\ de\ entrada}$$ *(Ecuación 1)*

La ganancia práctica de una antenas se obtiene del gráfico del lóbulo de radiación de la antena en posición horizontal y vertical, de manera visual se identifica los puntos de media potencia de las dos polaridades, estos valores se transforman a radianes, se multiplican entre si y por último 4π se divide por el resultado antes obtenido, La expresión queda de la siguiente manera.

$$G = \frac{4\pi}{\Delta\theta_{H_{-3db}} * \Delta\theta_{V_{-3db}}}$$ *(Ecuación 2)*

Mientras que la directividad representa la capacidad que tiene una antena en concentrar la intensidad de radiación en una determinada dirección del espacio (Ocwupmes, 2004), y su representación en fórmula sería de la siguiente forma.

$$D(\theta,\emptyset) = \frac{i\ (\theta,\emptyset)}{I}$$ *(Ecuación 3)*

Siendo:
i= intensidad de radiación de la antena en direcciones $(\theta, \emptyset)$.
I= intensidad media de radiación en todas las direcciones.

1.4.1.4 Polarización de la antena

La polarización de una antena es la figura que traza en función del tiempo, para una dirección determinada, el extremo del vector de campo radiado y su sentido de giro, visto por un observador situado sobre la antena, existen tres tipos de polarizaciones las cuales son; lineales, circulares y elípticas, para identificar el tipo de polarización dependerá de cómo varíe el campo eléctrico y de su máxima radiación. El concepto de polarización es importante debido a que las antenas receptoras deben encontrarse en la misma posición del campo de la antena transmisora, además se debe entender que las polarizaciones que se obtienen son solo teóricas ya que las antenas radian con una polarización nominal. (Madrid, 2004)

1.4.1.5 Ancho de banda

Es el intervalo de frecuencias en la cual debe funcionar satisfactoriamente la antena, dentro de las normas técnicas vigentes a su aplicación. Puede ser descripto en términos de porcentaje respecto a la frecuencia central de la banda:

$$BW[\%] = 100\frac{f_H - f_L}{f_c}$$ *(Ecuación 4)*

Donde; f_H es la frecuencia más alta de la banda, f_L es la frecuencia más baja, y f_c es la frecuencia central. De esta forma, el ancho de banda porcentual es constante respecto a la frecuencia central. Los diferentes tipos de antenas tienen variadas limitaciones de ancho de banda. (Monachesi, Frenzel, & Chaile, 2011)

1.4.1.6 Antena receptora

El arreglo de antenas será considerado como antenas pasivas y debido al principio de reciprocidad del electromagnetismo podemos deducir que los parámetros calculados para la antena transmisora serán iguales para la antena receptora, además consta del siguiente circuito representado en la Figura 6:

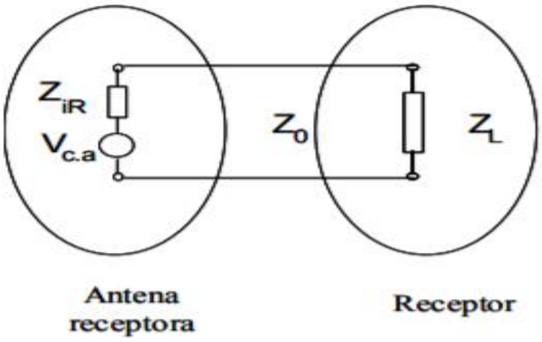


Figura 6. Diagrama circuito de la antena de recepción.
Tomado de *(Ocwupmes, 2004)*

Con todo lo revisado, se puede tener una idea general de los parámetros que se van a tomar en cuenta al momento de la construcción del arreglo de antenas, y como son de tipo Yagi se revisara su concepto.

1.5 Tipos de antena

1.5.1 Antena isotrópica

Es una antena hipotética sin pérdida que tiene intensidad de radiación igual en todas direcciones. (IEEE Standard Dictionary of Electrical and Electronic Terms, 1979).

Sirve de base de referencia para evaluar la directividad. La antena isotrópica no es una antena, sino un concepto de referencia para evaluar a las antenas en su función de concentración de energía y a las pérdidas por propagación en el espacio libre en los enlaces de radiofrecuencia. Su patrón de radiación es una esfera. Cada aplicación y cada banda de frecuencia presentan características peculiares que dan origen a unos tipos de antenas especiales muy diversas. Los tipos más comunes de antenas son los que se explican en los siguientes apartados. (Huidobro, 2013).

1.5.2 Antena dipolo

Las antenas dipolo son las más sencillas de todas. Consiste en un hilo conductor de media longitud de onda a la frecuencia de trabajo, cortado por la mitad, en cuyo centro se coloca un generador o una línea de transmisión.
Para determinar la longitud de un dipolo en ejemplos prácticos se considera la siguiente formula:

$$L = \frac{142{,}5}{f}$$ *(Ecuación 5)*

La impedancia nominal de un dipolo es de 73 ohmios. Sin embargo, en un dipolo real situado a una cierta distancia del suelo la impedancia varía considerablemente. Este efecto no tiene demasiada importancia si se puede aceptar una ROE máxima en la línea de transmisión de 2:1. (Ruesca P. , 2016)

1.5.3 Antena Yagi

Es una de las antenas más comunes debido a su fácil construcción. Esta antena no sólo tiene una ganancia de potencia elevada en una dirección determinada cuando se trasmite, sino que también eleva el nivel de la señal recibida en esa dirección. (Harry, Hooton, & W6TYH, 1969)

Las partes de la antena son; excitador o activo, es el único elemento que se alimenta de forma directa, los elementos que se encuentran a la parte trasera del elemento activo se denomina reflector y en la parte de adelante son nombrados parásitos o directores, este tipo de antenas son muy utilizadas debido a que con muy sencilla excitación se gana una considerable ganancia.

En la Figura 7 se muestra cada parte de la que se encuentra conformado la antena.

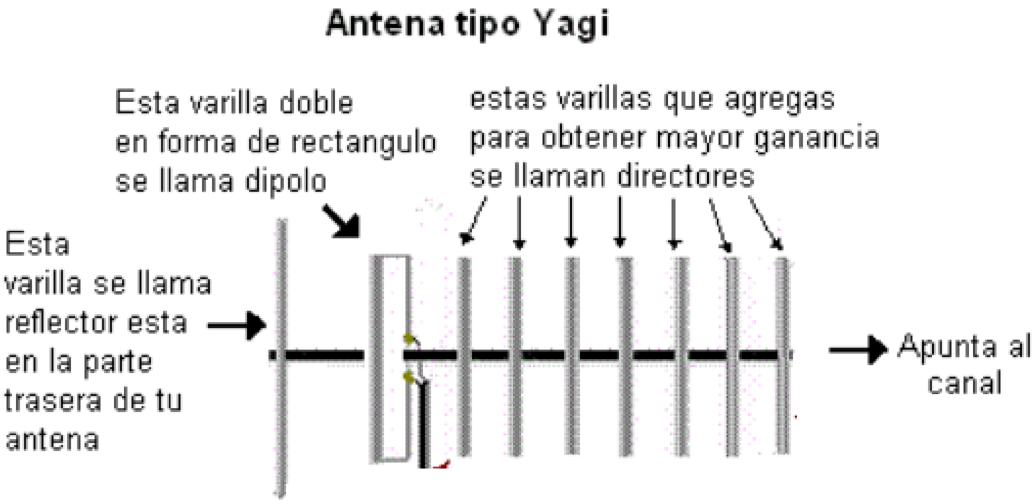


Figura 7. Partes de una antena Yagi.

La antena Yagi consta de un dipolo doblado o plegado, donde ingresa la alimentación de la señal para ser enviada, además debe constar de las dimensiones que se muestran en la figura 8. Este dipolo, está hecho por una varilla de cobre o aluminio en forma de bucle cerrado en cuyos extremos se conecta la línea de transmisión. La ganancia de esta antena es la misma que la del dipolo simple, pero su principal ventaja sobre el dipolo simple es su mayor resistencia mecánica, ya que es 4 veces superior, cuando se habla de un dipolo doblado simétrico y viene dada por la siguiente expresión:

$$Z = 2^N Z_0 \qquad \textit{(Ecuación 6)}$$

Donde Zo es la impedancia del Dipolo simple (75 Ω) y N el número de hilos que contribuyen al dipolo plegado, para el caso del presente proyecto son dos hilos, calculado este valor es; 300Ω, pero los cálculos se realizan con una impedancia de 292Ω debido a que en diferentes textos toman este valor como práctico. El dipolo doblado a utilizarse se muestra en la Figura 8. (Udbedusv, 2011)

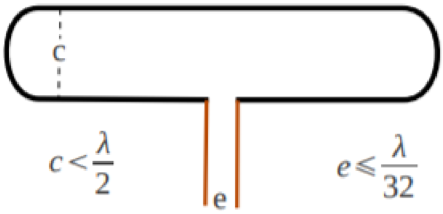


Figura 8. Dipolo plegado simétrico

Para los cálculos de cada uno de las partes de cada antena Yagi se usarán las siguientes fórmulas:

Directores.

$$m = 0.9\frac{\lambda}{2} = \frac{135}{f}[m]$$

$$n = 0.885\frac{\lambda}{2} = \frac{133}{f}[m]$$

$$p = 0.867\frac{\lambda}{2} = \frac{130}{f}[m]$$

$$q = 0.86\frac{\lambda}{2} = \frac{129}{f}[m]$$

$$s = 0.837\frac{\lambda}{2} = \frac{126}{f}[m]$$

(Ecuación 7)

Reflector.

$$\frac{\lambda}{2} = \frac{150}{f}[m]$$

(Ecuación 8)

Primer director.

$$0.9\frac{\lambda}{2} = \frac{135}{f}[m]$$

(Ecuación 9)

Separación.

Dipolo – Reflector: $0{,}18\lambda = \frac{54}{f}[m]$

Dipolo – 1er Director: $0{,}09\lambda = \frac{27}{f}[m]$

(Ecuación 10)

Directores consecutivos: $0{,}18\lambda = \frac{54}{f}[m]$

Tabla 1.

Ganancia y posicionamiento de directores de una antena Yagi

N Directores	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ganacia [dB]	**9**	**9,5**	**10**	**11**	**12**	**13,5**	**15**	**15,5**	**16**
2° Director	N	n	N	n	m	m	m	m	m
3° Director		p	P	p	n	n	n	n	n
4° Director			Q	q	p	n	n	n	n
5° Director				s	q	p	p	p	p
6° Director					s	q	p	p	p
7° Director						s	q	q	q
8° Director							s	q	q
9° Director								s	s
10° Director									s

Se termina con las fórmulas de las posiciones y tamaños que deben ser considerados en los elementos de la antena yagi.

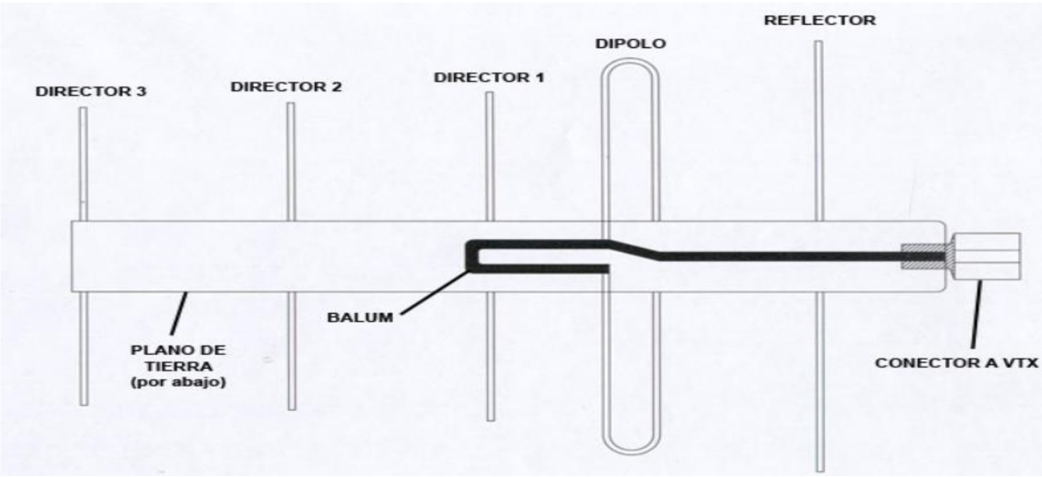


Figura 9. Antena Yagi.

Tomado de *(Ferraro, 2017)*

Concluidas las ecuaciones se obtendrá de manera individual antenas Yagi como se puede visualizar en la Figura 9.

1.5.4 Antenas de apertura.

Se consigue a partir del campo que generan las guías de onda. Existen antenas de apertura ejemplos de estas son; las bocinas (piramidales o cónicas), las aperturas sobre planos y ranuras sobre planos conductores y las guías de onda. una de sus características principales es que presenta un gran ancho de banda y facilidad al momento de su construcción, son las mostradas en la Figura 10. De acuerdo con la forma de la apertura, las bocinas pueden ser de dos tipos: piramidal y cónica. (Huidobro, 2013).

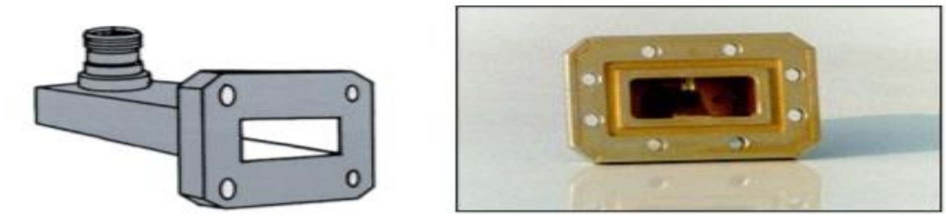


Figura 10. Guía de onda.
Tomado de *(Huidobro, 2013)*

1.5.5 Antenas Planas

Llamadas de esta forma por formar un agrupamiento plano de radiadores y un circuito el cual distribuye a señal. La estructura es utilizada para disipar la potencia recibida en forma de radiación. una de las ventajas es que gracias a su diseño se reduce el tamaño y peso. Su desventaja es que presentan un limitado ancho de banda, pero actualmente existen numerosos métodos para solventar este inconveniente, un ejemplo se muestra en la Figura 11.

Figura 11. Antena plana.
Tomado de *(Huidobro, 2013).*

1.5.6 Antena Parabólica

las diferentes señales no son recibidas, tampoco transmitidas directamente ya que disponen de un elemento captador que concentra toda la señal. En el caso de una antena receptora, su funcionamiento se basa en la reflexión de las ondas electromagnéticas, hacia el foco mientras que para la antena emisora las ondas electromagnéticas emanaran del foco. (Huidobro, 2013).
Todo mundo conoce las antenas parabólicas por lo general son utilizadas en los enlaces satelitales, se caracterizan por tener un plato en su base, y el foco que dependiendo del tipo de antena parabólica que sea, estará ubicado con dirección al plato

1.6 Balun

La antena Yagi es del tipo balanceada por lo que es necesario de la implementación de un balun al momento de su diseño, debido a que el cable coaxial es desbalanceado, existen diferentes factores para determinar la elección del mismo, ya que existen de diferentes tipos, directamente asociado con la relación de transformación necesaria para el balun.

La lógica indica que, conocidas la impedancia de la antena y del cable coaxial, se puede deducir la relación de transformación que se necesita para el balun. Cabe mencionar que este valor será solo orientativo, pues en la práctica la impedancia de la antena variará respecto al valor teórico en condiciones de espacio libre (Perez, 2012).

En efecto, la impedancia de la antena, ya instalada, puede ser parecida a la teórica, pero no será la misma: la resistencia puede variar e incluso aparecer cierta reactancia que no habíamos contemplado. Esto es así porque el entorno y la altura respecto al suelo van a influir decisivamente en el valor de la impedancia. (Perez, 2012)

El balun utilizado en el presente proyecto será el mostrado en la Figura 12.

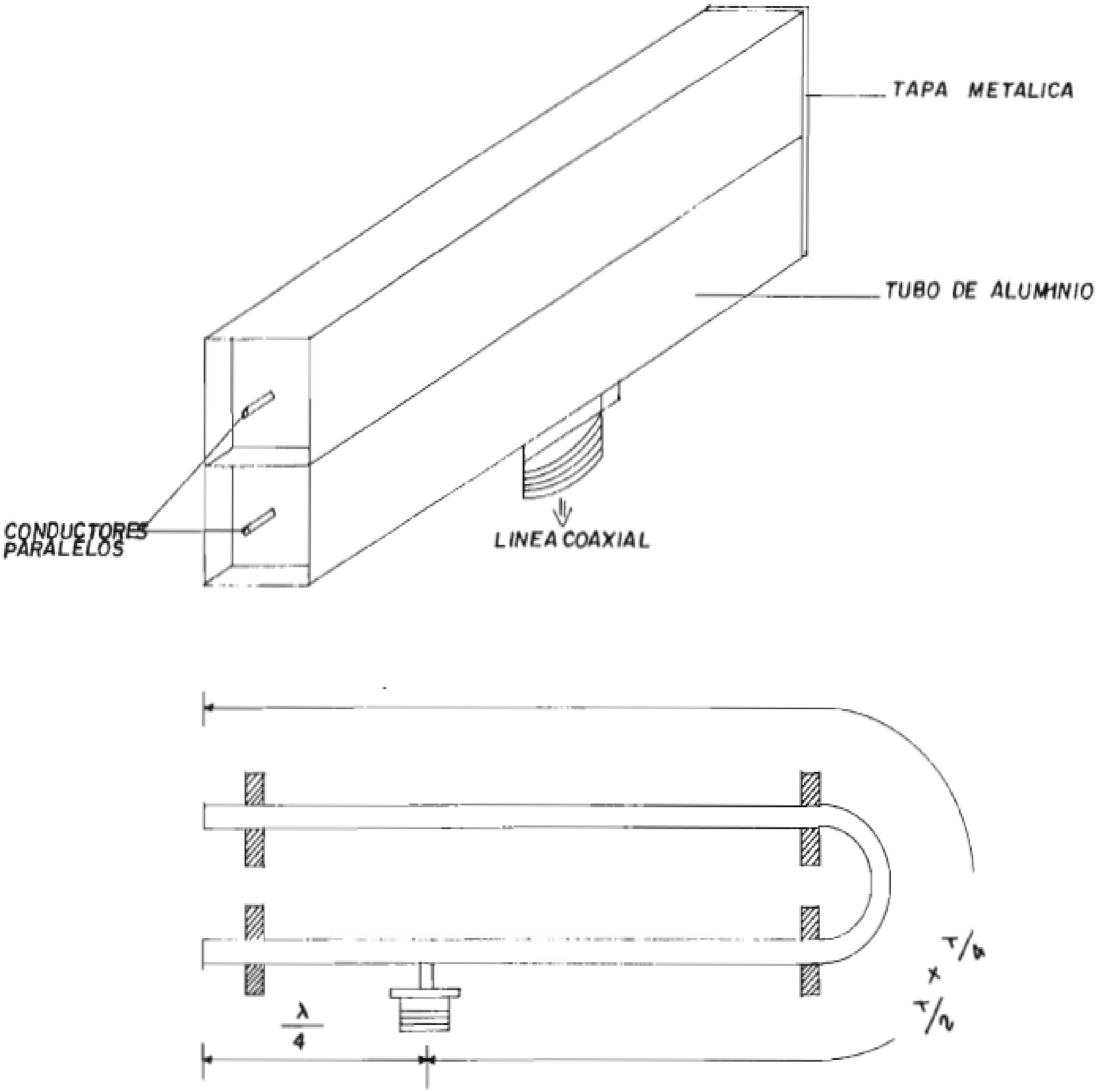


Figura 12. Diseño de Balun.
Tomado de *(Enriquez, 1990)*

Este tipo de Balun se lo puede construir de una manera fácil y rápida, además en las fórmulas que se revisara a continuación muestran que depende de las medidas de sus materiales, es decir, del conductor que se encuentra hecho y su caja metálica de la que se encuentra construida.

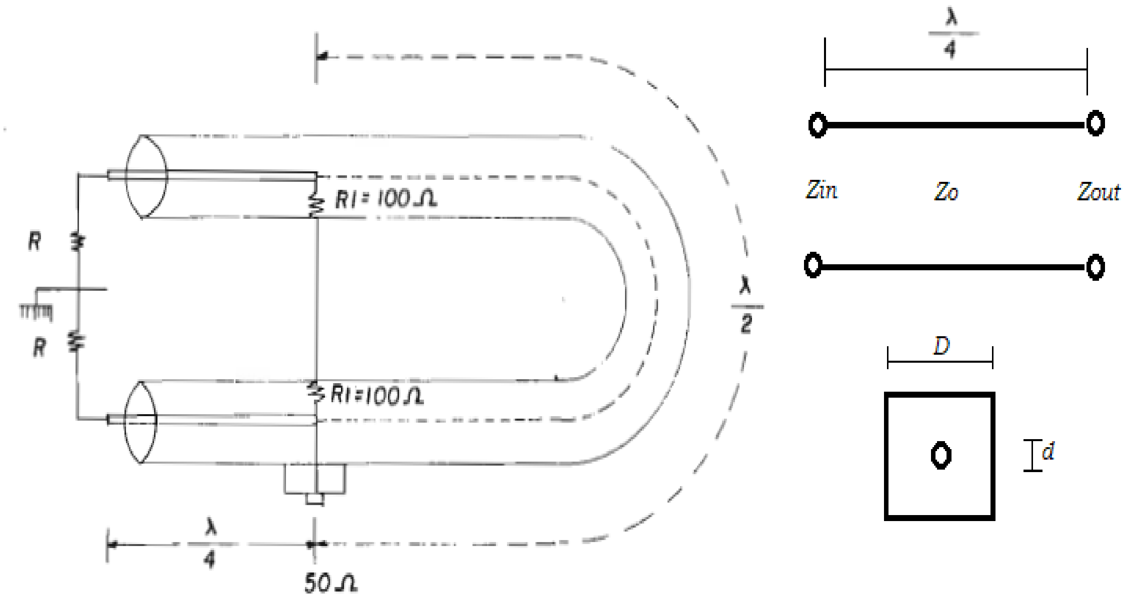


Figura 13. Estudio del Balun.
Tomado de *(Enriquez, 1990)*.

Este tipo de balun es conocido de 4:1 es decir, siempre se tendrá en la línea de λ/2 una impedancia conocida de 200 Ω, y a la salida, 50 Ohm, la sección de λ/4 es la que se pueden calcular ciertos valores como los que se verificaran a continuación.

$$Z_o = \sqrt{Z_{in} x Z_{Out}} \longrightarrow Z_{Out} = 200\Omega$$ *(Ecuación 11)*

$$Z_o = \frac{138}{\sqrt{\varepsilon}} \log 1{,}08 \frac{D}{d}$$ *(Ecuación 12)*

$$\therefore \ \varepsilon = permiabilidad\ dielectrica$$

$$D = longitud\ en\ mm\ de\ un\ lado\ del\ tubi\ cuadrado$$

$$d = longitud\ en\ mm\ del\ diametro\ del\ conductor$$

1.7 Arreglos de antenas

Un arreglo o array es una antena compuesta por un numero de radiadores idénticos ordenados conectados entre sí, de tal manera que las corrientes individuales están en relación de amplitud y fase, lo que permite que el arreglo actúe como una sola antena, con esto se mejora el direccionamiento y por ende la ganancia de la misma. (Sarmiento, 2018)

Existen diferentes tipos de arrays; los de tipo lineal, que tienen los elementos dispuestos sobre una línea, los del tipo plano, los cuales son agrupaciones bidimensionales cuyos elementos están sobre un plano y por último se tiene los arreglos conformados, que tienen las antenas sobre una superficie curva. (Ferrando & Valero, 2019)

El arreglo de antena más simple, es el que tiene dos radiadores idénticos, es decir un array conformado por dos antenas, en nuestro caso el tipo de antena escogido es Yagi, por lo que en el presente escrito se presentará toda la información referente a un arreglo de dos antenas Yagi.

1.7.1 Agrupaciones lineales de antenas

Se puede analizar las agrupaciones de antenas lineales aplicando la teoría de polinomios, en el presente documento se explica cómo se obtiene el polinomio de la agrupación.

Una agrupación lineal de antenas es un conjunto de antenas, todas orientadas en una misma dirección, alineadas a lo largo de una recta, como se observa en la en la Figura 14.

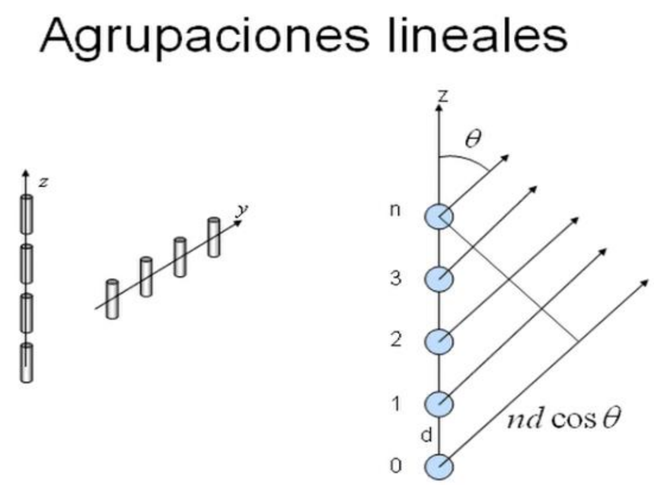


Figura 14. Agrupación lineal n antenas.
Tomado de *(Ferrando & Valero, 2019)*

Cuando se tiene un número de n antenas como se muestra en la Figura 14, se debe tener en cuenta que cada una de las antenas presenta cierta amplitud y fase, si se realiza una relación de corrientes con respecto al origen, el resultado será un numero complejo con parte real e imaginaria descritos de la siguiente forma:

$$\frac{I_n}{I_0} = a_n e^{jn\alpha}$$ *(Ecuación 13)*

Siendo:
I_0 = Corriente de la antena del origen
I_n = Corriente de la n antena
$a_n e^{jn\alpha}$ = numero complejo resultado de la relación de corrientes con amplitud y fase.

Cada una de las antenas tiene una fase progresiva con respecto a la anterior, pero viene representada por una fase total descrita de la siguiente forma:

$$\psi_z = k_z d + \alpha = kd\cos\theta + \alpha \;\rightarrow\; n\psi_z = k(nd\cos\theta) + n\alpha$$ *(Ecuación 14)*

Siendo:

$n\psi_z$ = Fase total

$kd\cos\theta$ = número de onda por la distancia de separación con el ángulo que se forma

α = fase de alimentación

En la Figura 14 se puede visualizar el arreglo lineal como vectores, para el factor de agrupación se toma en cuenta lo siguiente:

$$\vec{N} = \overrightarrow{N_0}(\vec{r}) \sum_{n=0}^{N-1} a_n\, e^{jn\psi_z}$$ *(Ecuación 15)*

Donde:

$\vec{N}$ = vector de radiación conjunto

$\overrightarrow{N_0}$ = vector radiación en el origen

$\sum_{n=0}^{N-1} a_n\, e^{jn\psi_z}$ = termino inferencia o factor de la agrupación

Simplificando, el vector de radiación total es igual al vector radiación ubicado en el origen multiplicado por la sumatoria del factor de la agrupación.

El campo total va hacer el vector campo ubicado en el origen multiplicado por el facto de agrupación.

$$\vec{E} = \overrightarrow{E_0}(\vec{r}) \sum_{n=0}^{N-1} a_n\, e^{jn\psi_z}$$ *(Ecuación 16)*

Siendo:

$\vec{E}$ =Campo eléctrico total

$\overrightarrow{E_0}$ =Campo eléctrico en el origen.

$\sum_{n=0}^{N-1} a_n\, e^{jn\psi_z}$ = termino inferencia o factor de la agrupación

Solo falta describir lo que es el factor de la agrupación, que viene representado por la siguiente expresión:

$$FA(\psi_z) = \sum_{n=0}^{N-1} a_n\, e^{jn\psi_z}$$ *(Ecuación 17)*

Siendo:

$\sum_{n=0}^{N-1} a_n\, e^{jn\psi_z}$= Suma de números reales con sus fases

Para expresar la agrupación de una forma más sencilla se realiza una sustitución de términos, y de esta forma expresarla en polinomio, de la siguiente forma:

$$z = e^{jn\psi_z}$$

$$p(z) = \sum_{n=0}^{N-1} a_n\, z^n$$ *(Ecuación 18)*

Siendo:

$p(z)$ = polinomio

$\sum_{n=0}^{N-1} a_n\, z^n$ =suma de números complejos de amplitudes y fases

El polinomio de la agrupación se muestra en la Figura 15, siendo el primer término asociado a la antena en el origen, el segundo término es una antena desplazada a una distancia d del origen, cada nuevo elemento en el polinomio es una nueva antena que se agrega al arreglo.

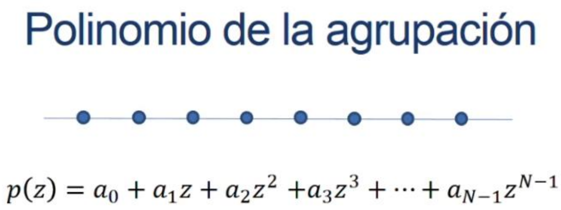


Figura 15. Polinomio de un arreglo lineal de antenas.

Se tiene las siguientes expresiones en polinomio y factor de agrupación:

$$p(z) = a_0 + a_1 z + a_2 z^2 + \cdots \ldots \ldots .. a_{N-1} z^{N-1}$$ *(Ecuación 19)*

$$FA(\Psi) = a_0 + a_1 e^{j\psi} + a_2 e^{j2\psi} + \cdots \ldots \ldots \ldots . a_{N-1} e^{j(N-1)\psi}$$ *(Ecuación 20)*

Siendo:

z=$e^{j\psi}$

$\psi = kd\cos\theta + \alpha$

Como se muestra con las sustituciones, el polinomio se puede re-escribir como una serie de furrier, cuyo resultado es una función periódica, de la cual se obtiene el diagrama de radiación, resolviendo la serie, y superponiendo los resultados se obtiene la siguiente Figura 16, donde se puede concluir que a mayor número de antenas el lóbulo principal tendrá mayor energía, por ende el sistema de transmisión será más eficiente.

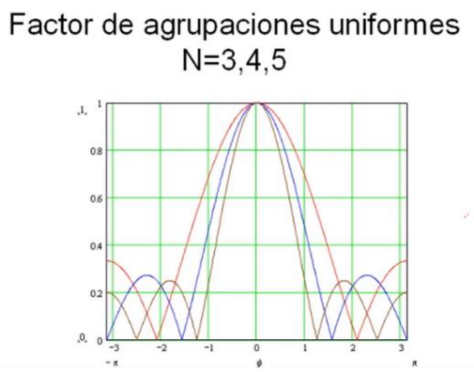


Figura 16. Agrupación de N antenas representadas en lóbulos.
Tomado de *(Ferrando & Valero, 2019)*

1.7.2 Arreglo de dos antenas

Cuando dos radiadores idénticos situados a lo largo de una línea con diferentes amplitudes y fases crean interferencias, las cuales separadas a cierta distancia forman una antena más eficiente, denominándose una agrupación de dos antenas.

1.7.2.1 Interferencia de ondas

El arreglo de antenas más simple es el de dos radiadores iguales cuando se encuentran en el espacio libre, como se visualiza en la Figura 17.

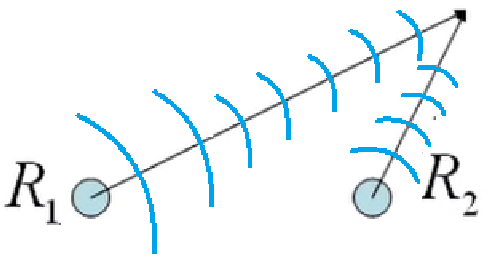


Figura 17. Interferencias de ondas esféricas.

Las ondas esféricas se propagan en el espacio, las dos tendrían variaciones de fase y amplitudes y la suma de las dos ondas indicara el campo en el destino, esto será representado por la siguiente ecuación.

$$\frac{e^{-jkR_1}}{4\pi R_1}+\frac{e^{-jkR_2}}{4\pi R_2} \qquad \textit{(Ecuación 21)}$$

Siendo:

$$jkR_1, jkR_2 = variaciones\ de\ fase$$

$$R_1, R_2 = variaciones\ de\ amplitud$$

Como se puede ver en la ecuación, los términos representan a cada punto de radiación, los exponentes indican el cambio de fase, mientras que el denominador muestra cual es el cambio en amplitud y la suma de ambas nos indican el campo cuando las dos se juntan.

Dependiendo donde se ubiquen los radiadores, uno con respecto a otro, estas generan ondas que se propagan en todas las direcciones del espacio, lo cual generan diagramas de radiación conocidos, como se observa en la Figura 18.

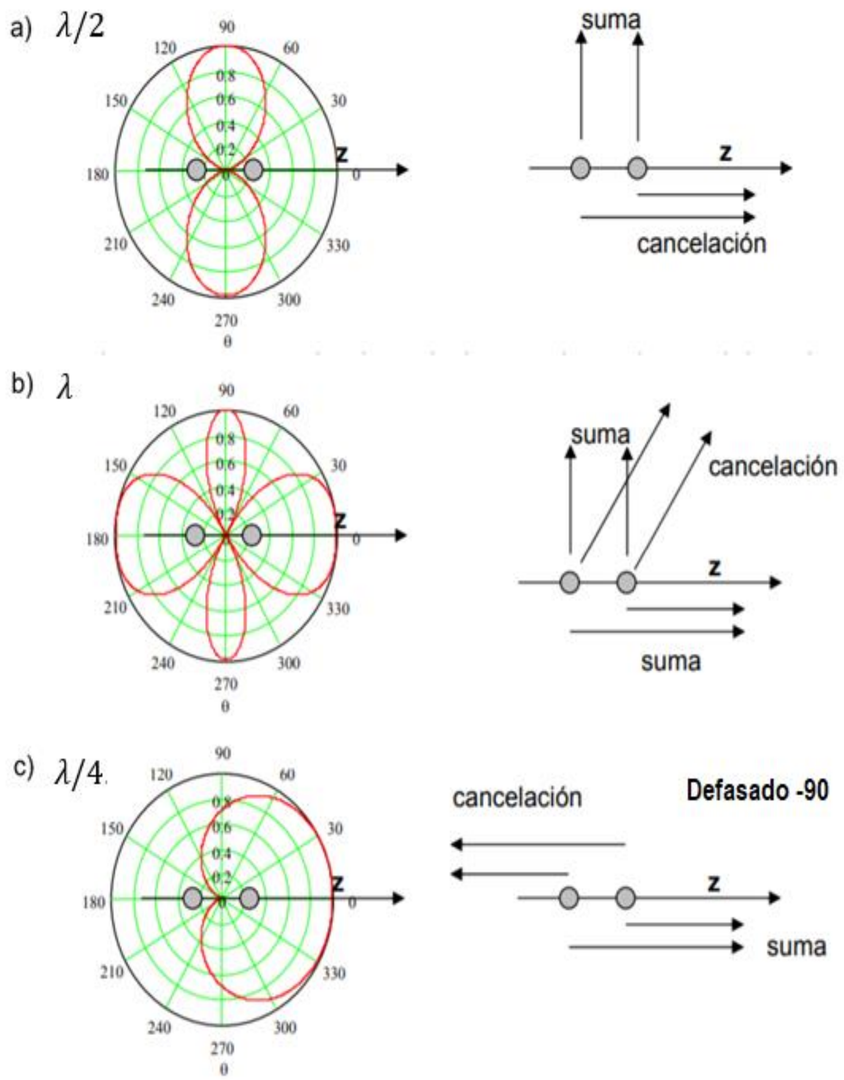


Figura 18. Dos antenas separadas $\lambda/2$, λ, $\lambda/4$.

Tomado de *(Ferrando & Valero, 2019)*

En la figura superior se puede visualizar cómo reaccionan los radiadores a tres distancias diferentes, en este caso a distancias de separadas $\lambda/2$, λ, $\lambda/4$ entre sí.

Para el primer caso ($\lambda/2$); cuando se separa a los radiadores una semilongitud de onda , se produce un máximo en la dirección perpendicular a la agrupación los caminos recorridos son iguales por esta razón, las señales se suman en fase, mientras que en la dirección del eje de la agrupación, existe la diferencia de caminos por lo que las señales se restan y con esto existe un nulo de radiación. (Ferrando & Valero, 2019)

Para el segundo caso (λ); Cuando la separación de los radiadores es una longitud de onda, tanto en la dirección perpendicular, como en el eje las señales se sumaran en fase, pero se produce una cancelación para un ángulo en el que ambas señales esté en oposición de fase, lo que sucede para la dirección que forma un ángulo de 60° con el eje de la agrupación. (Ferrando & Valero, 2019)

Para el tercer caso ($\lambda/4$); Cuando las dos antenas se encuentran separadas por $\lambda/4$, pero una de ellas se encuentra con un desfase de $-\pi/4$, las ondas se suman en la dirección del eje z en fase, y en –z en oposición de fase (Ferrando & Valero, 2019)

Cuando se varia los parámetros, sea sus fases o distancias relativas entre cada antena, el resultado será diagramas de radiación diferentes, por lo que dependiendo de la aplicación que se necesite, se varia la amplitud y fase de las mismas, se puede diseñar antenas que irradien en direcciones que se requiera, los casos más populares de radiación se pueden observar en la Figura 19.

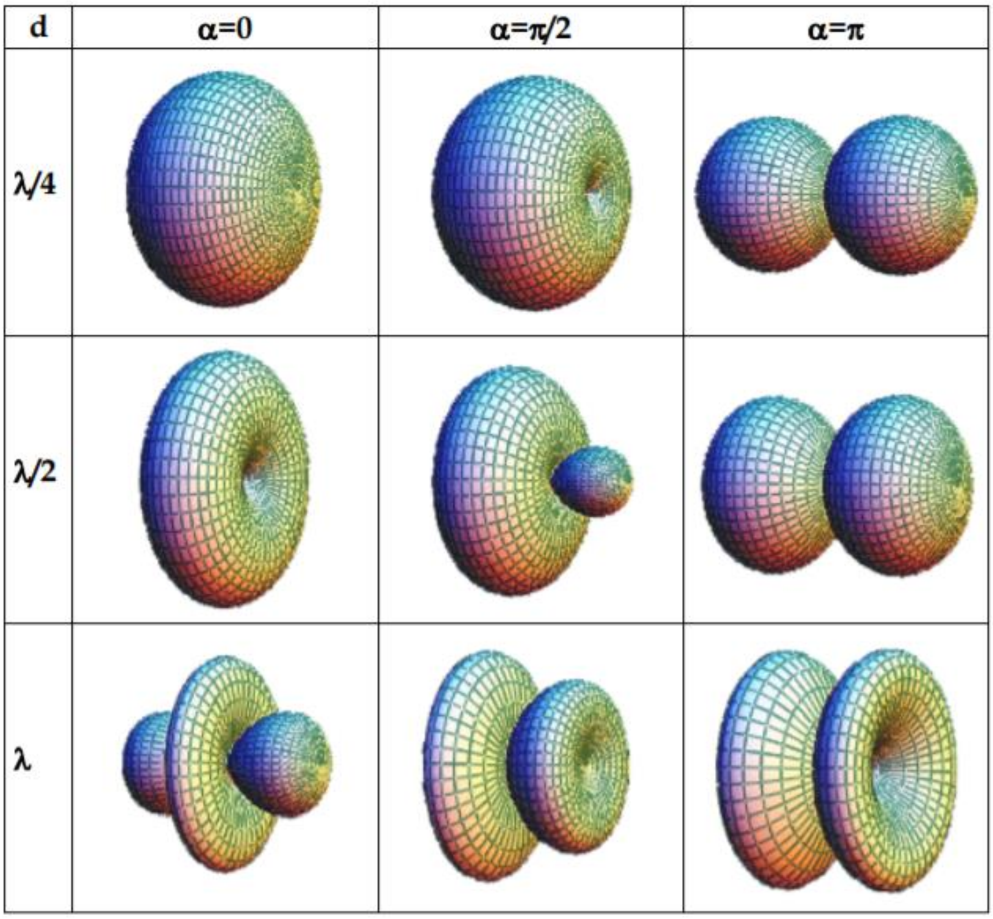


Figura 19. Diagramas de radiación de arreglo de dos antenas.
Tomado de *(Ferrando & Valero, 2019)*

1.8 Radioenlace

Se denomina radio enlace a la interconexión de equipos mediante ondas electromagnéticas. Además, se denominarán de tipo fijos, cuando los terminales se encuentran en un punto determinado y móvil, cuando se encuentra en movimiento, típicamente los enlaces fijos se explotan entre los 800 MHz y 42 GHz.

Los radio enlaces, que se utilizarán en el presente proyecto, se los realizará con radios digitales los cuales usan una transmisión del tipo dúplex, donde se deben transmitir dos portadoras moduladas: una para la transmisión y otra para la recepción.

Para tener una mayor eficiencia en los enlaces, se debe considerar en instalar los equipos en puntos altos, para que tengan una línea de vista libre. Para un correcto funcionamiento es necesario que los recorridos entre enlaces tengan una línea de vista libre para la propagación en toda época, se debe tomar en cuenta las variaciones de las condiciones atmosféricas de la región, otro aspecto en tomar en cuenta es la topografía del terreno, así como la altura y ubicación de los obstáculos que puedan existir en el trayecto, (Ruesca, Radio Comunicaciones , 2016) cabe mencionar que en la actualidad existen varios softwares especializados para poder darnos información acerca del tipo de enlace que se requiere, como el arreglo de antenas son directivas se debe siempre pensar en un enlace de radios tipo punto a punto.

1.8.1 Zona de Fresnel

Cuando se tiene un transmisor y un receptor, la onda electromagnética que viaja de principio a fin por este tramo debe tener una línea de vista que se encuentre libre de obstáculos, con el objetivo de que la señal no se reduzca significativamente, lo ideal es que la primera zona de Fresnel no esté obstruida, pero normalmente es suficiente despejar el 60% del radio de la primera zona para tener un enlace satisfactorio. En aplicaciones críticas, se recomienda hacer el cálculo también para condiciones anómalas de propagación, en la cuales las ondas de radio se curvan hacia arriba y por lo tanto se requiere altura adicional en las torres. Para grandes distancias hay que tomar en cuenta también la curvatura terrestre que introduce una altura adicional que deberán despejar las antenas (Buettrich, 2007). En la Figura 20 se observa de una manera gráfica como se representa la zona de Fresnel de un enlace.

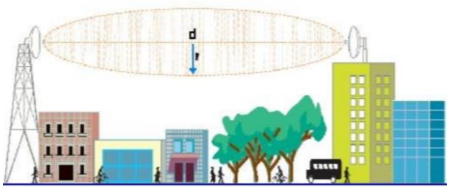


Figura 20. Zona de Fresnel.

Tomado de *(Buettrich, 2007)*

La fórmula para calcular la primera zona de Fresnel es la siguiente:

$$r = 17.32 * \sqrt{\frac{d_1 * d_2}{d * f}}$$ *(Ecuación 22)*

d_1= distancia al obstáculo desde el transmisor [Km]

d_2= distancia al obstáculo desde el receptor [Km]

d = distancia entre el transmisor y receptor [Km]

f = frecuencia [GHz]

r = radio [m]

1.8.2 Modelo de propagación por desvanecimiento

Es uno de los problemas que presentan los enlaces de microondas punto a punto. El desvanecimiento se puede dar por diferentes factores; uno de ellos son las reflexiones de las ondas electromagnéticas, producidas por el ambiente y la topología de los diferentes lugares donde se lleva a cabo el enlace, provocando ondas directas y reflejadas, la lluvia es otro elemento que puede atenuar la señal que se desea recibir, cuando las frecuencias superan los 10 GHz, para el enlace del presente proyecto la frecuencia a utilizarse será menor a esta frecuencia antes mencionada por lo que será nula. (Tercero & Rivera, 2013)

Las pérdidas producidas por el desvanecimiento debilitan el enlace, pero puede ser medido con la siguiente relación:

$$MD = P_R - NU$$ *(Ecuación 23)*

MD= Margen de desvanecimiento

P_R= Potencia recibida

NU = Nivel de umbral

El nivel umbral viene dado por el receptor, como se muestra en la Figura 21, el NU es una constante, pero la señal que se transmite, variara dependiendo del medio donde se propague, mientras llega la señal transmitida puede existir o no desvanecimiento de la señal, lo óptimo es que supere el nivel umbral, de no ser el enlace será considerado como cortado debido a encontrarse debajo del umbral del receptor.

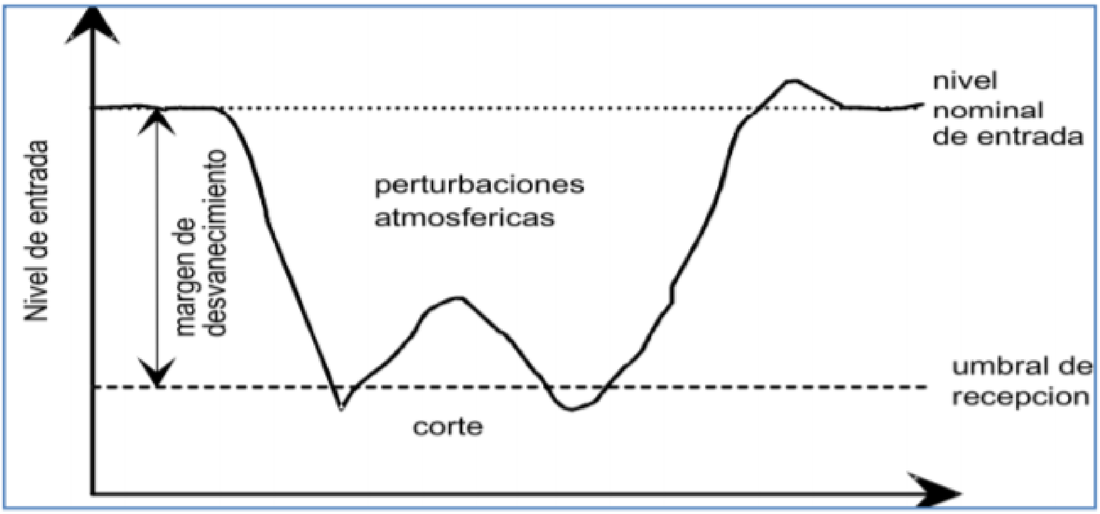


Figura 21. Señal transmitida en un tiempo establecido.
Tomado de *(Tercero & Rivera, 2013)*

1.8.3 Confiabilidad del enlace.

Corresponde al tiempo probabilístico en el cual el enlace se mantiene trabajando, es decir se encuentra transmitiendo y recibiendo información. El método utilizado para el cálculo es el de Vigants Barnett (Tercero & Rivera, 2013) que usa distintas constantes las cuales se pueden revisar en la siguiente ecuación.

$$P = 6 * 10^{-7} * a * b * f * d^3 * 10^{-MD/10}$$ *(Ecuación 24)*

$$R = (100 - P) * 100$$ *(Ecuación 25)*

P = Indisponibilidad

R = Confiabilidad

f = Frecuencia (MHz)

d = Distancia total del trayecto (Km)

MD = Margen de desvanecimiento (dB)

a = variables del tipo de terreno del enlace

b = Factor climático del lugar del enlace

Tabla 2.

Factor de Rugosidad.

A	**Tipo de terreno**
4	Terreno muy suave o agua
1	Terreno poco montañoso
1/4	Terreno montañoso

Tabla 3.

Factor Climático.

B	**Tipo de terreno**
1/2	Zonas con costas
1/4	Clima con temperatura normal
1/8	Zonas montañosas o muy secas

1.8.4 Perdidas en espacio libre.

Permite el cálculo de la potencia recibida en condiciones ideales, se puede decir que es la perdida de la señal en el trayecto del transmisor hacia el receptor, esta ecuación depende la distancia y frecuencia de transmisión.

$$Pel(dB) = 32.45 + 20\log_{10}(d) + 20\log_{10}(f)$$ *(Ecuación 26)*

Pel = Pérdida de propagación en el espacio libre (dB)

f = Frecuencia (MHz)

d = Distancia total del enlace (Km)

2. CAPITULO II. CALCULOS

En este capítulo se aprecia los cálculos de los diferentes elementos de la antena para realizar la construcción de la misma, además se realizará la simulación de la antena diseñada en el software especializado de nombre Mmana-gal.

2.1 Cálculo Del Arreglo

El arreglo elegido es de dos antenas Yagi, cada antena tendrá las mismas dimensiones en cada uno de sus elementos individuales, una con otra serán conectada en el dipolo doblado mediante un par de conductores, para mantener un sistema desbalanceado, para luego ser conectado con un Balun que transforme la impedancia que resulte del arreglo a una de 50 Ω que es con la que trabajan los equipos del arreglo diseñado.

2.1.1 Cálculo de antena Yagi.

Para realizar los diferentes cálculos solo se necesita de la frecuencia a la que se desea que trabaje la antena, en este caso como estará en un rango de frecuencias que oscila de los 915 a 928 MHz, se utilizara la frecuencia central de 921 MHz para todos los cálculos.

Los cálculos se realizan para un solo elemento, luego todos los resultados serán visualizados en una hoja Excel en la Tabla 4 siguiendo las fórmulas que están descritas en cada celda y detalladas en las ecuaciones dadas en el capítulo 1.

Cálculo del reflector (Ecuación 8):

$$\frac{\lambda}{2} = \frac{150}{f} = \frac{150}{921\ MHz} = 16{,}28[cm]$$

Cálculo de dipolo de media longitud de onda:

$$\frac{\lambda}{2} = \frac{150}{f} = \frac{150}{921\ MHz} = 16{,}28[cm]$$ *(Ecuación 27)*

Calculo del director (Ecuación 7):

$$m = 0.9\frac{\lambda}{2} = \frac{135}{921\ MHz} = [14{,}65cm]$$

Las ecuaciones se escriben en una hoja Excel obteniendo los siguientes resultados:

Tabla 4.

Cálculo para la antena Yagi

Cálculos para antena Yagi				
Frecuencia 921				
	Longitudes		**Separaciones**	
	Formula	**Resultado (cm)**	**Formula**	**Resultado**
Reflector	150/f	**16,28664495**	54/f	**5,86319218**
Dipolo	λ/2	**16,28664495**	27/f	**2,93159609**
Director 1	135/f	**14,65798046**	54/f	**5,86319218**
Director 2	135/f	**14,65798046**	54/f	**5,86319218**
Director 3	133/f	**14,44082519**	54/f	**5,86319218**
Director 4	133/f	**14,44082519**	54/f	**5,86319218**
Director 5	130/f	**14,11509229**	54/f	**5,86319218**
Director 6	129/f	**14,00651466**	54/f	**5,86319218**
Director 7	126/f	**13,68078176**	54/f	**5,86319218**

Para el cálculo del dipolo doblado o plegado se considera trabajar con uno de media longitud de onda, para poder tener una impedancia de 292Ω, si todos los valores los dibuja en la estructura de la antena, so obtiene algo parecido a lo mostrado en la Figura 22:

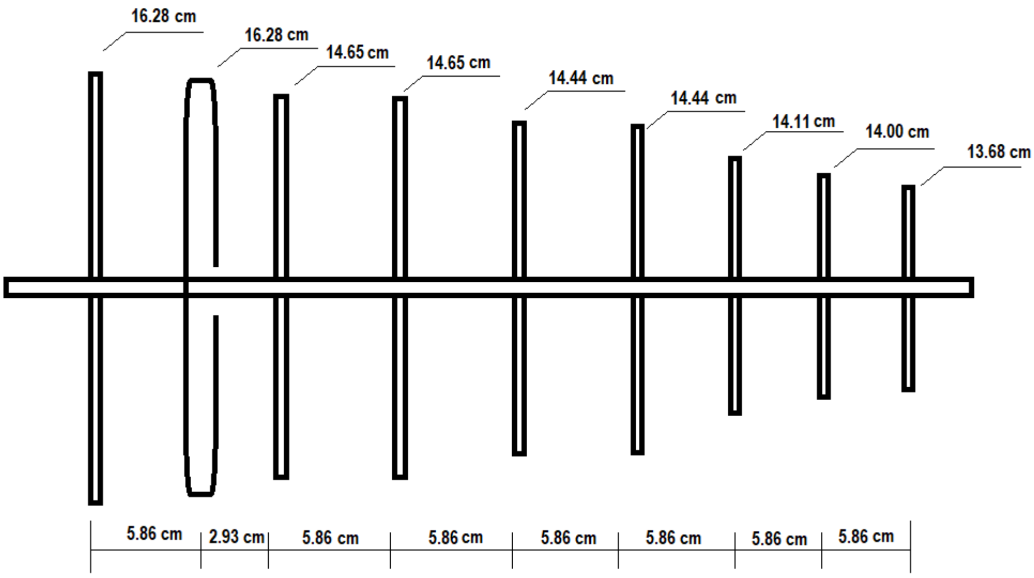


Figura 22. Medidas de antena Yagi

2.1.2. Dipolo doblado

Con el cálculo del dipolo doblado de media longitud de onda, de cada antena, se dobla el material para comparar con lo descrito en la Figura 8 del capítulo 1, como lo muestra la Figura 23. Primero usamos la Ecuación 27 para el cálculo de media longitud de onda.

$$\frac{\lambda}{2} = \frac{150}{f} = 16{,}28[cm]$$

Cuando se construye el dipolo se puede constatar los valores de c y e, con un flexómetro, luego se compara con la teoría dada en la Figura 8, para verificar si el dipolo se encuentra construido de una forma óptima.

$$c = 4\ cm$$

$$e = 1.01\ cm$$

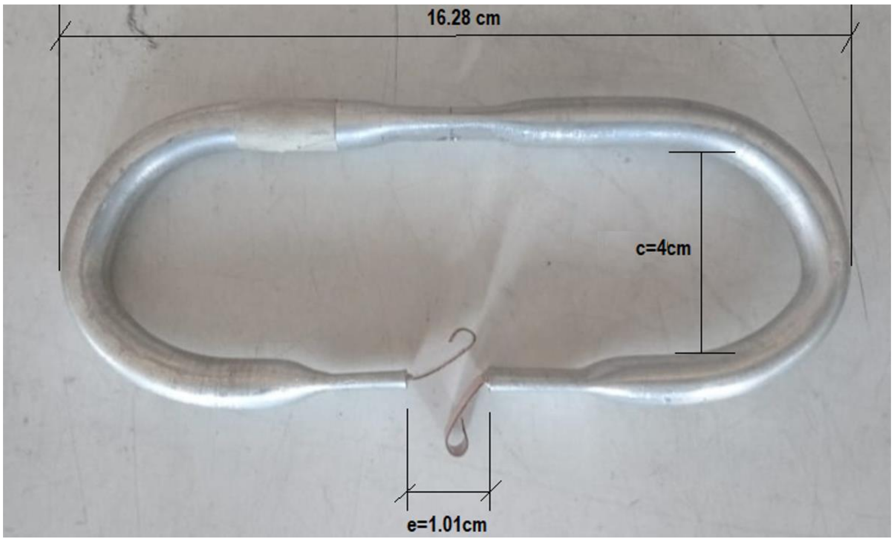


Figura 23. Diseño de dipolo doblado

Si se recuerda lo que se indica en la Figura 8, el valor de c debe ser menor a λ/2 y e, menor o igual a λ/32, tomando las medidas de estos elementos se puede deducir que el dipolo cumple con lo existente en la teoría, ya que c es de 4 cm, que es menor a media longitud de onda y la separación entre los bordes es de 1.01cm, igual a λ/32, con estos valores se puede continuar con el diseño y conservar su valor de impedancia teórico de 292Ω. Cabe recalcar que cada antena tendrá la impedancia del dipolo doblado para los cálculos, debido a que el reflector y directores se los considera con impedancias despreciables.

2.1.3. Separación e impedancia del arreglo de antenas

Como se propuso en la teoría, entre las dos antenas debe existir una diferencia de λ/4 realizando los cálculos se obtiene el siguiente resultado:

$$\frac{\lambda}{4} = \frac{c}{4xf} = \frac{3x10^8\ {}^{m}/_{s}}{4 * 921\ MHz} = 8{,}14[cm] \qquad \textit{(Ecuación 28)}$$

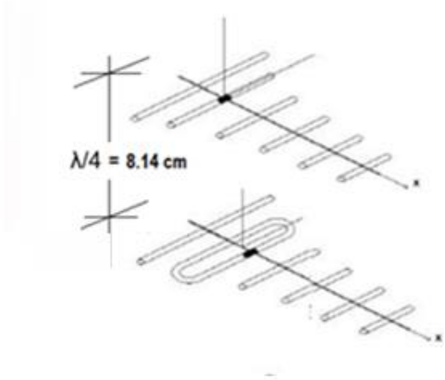


Figura 24. Distancia entre antenas para el arreglo.

En la
Figura 25 se visualiza el arreglo de impedancias que se debe resolver, además para obtener una interferencia constructiva, se necesita de un desfase en uno de los elementos, por lo que se pondrá un *Stub* que realice el desfase deseado.

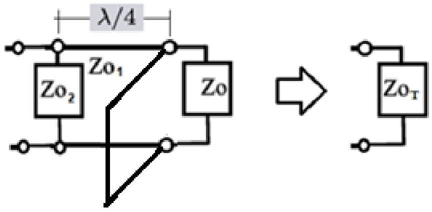


Figura 25. *Impedancias del arreglo de antenas Yagi.*

Para el circuito de la
Figura 25 se tiene los siguientes valores:

$$Zo = Zo_2 = 292\Omega \rightarrow \text{valor de la impedancia de la antena}$$

Pero al poner el *stub* se desea que la antena tenga en una de sus componentes un desfasaje de -90 grados por lo que primero se trabajara en este punto.

Como se desea que a la entrada del Stub se tenga; $(292|-90^0)$, el valor requerido ordenando en coordenadas rectangulares es de -292j y resolviendo mediante carta de Smith, sabiendo que la impedancia del cable es de 75 Ω, se obtiene lo siguiente:

$$Z' = \frac{-292j}{75} = -3{,}89j\Omega$$

Si se encuentra este valor en la carta de Smith como lo muestra la Figura 26 se visualiza la longitud del cable de 75 Ω que se debe colocar a la antena para tener el desfase deseado.

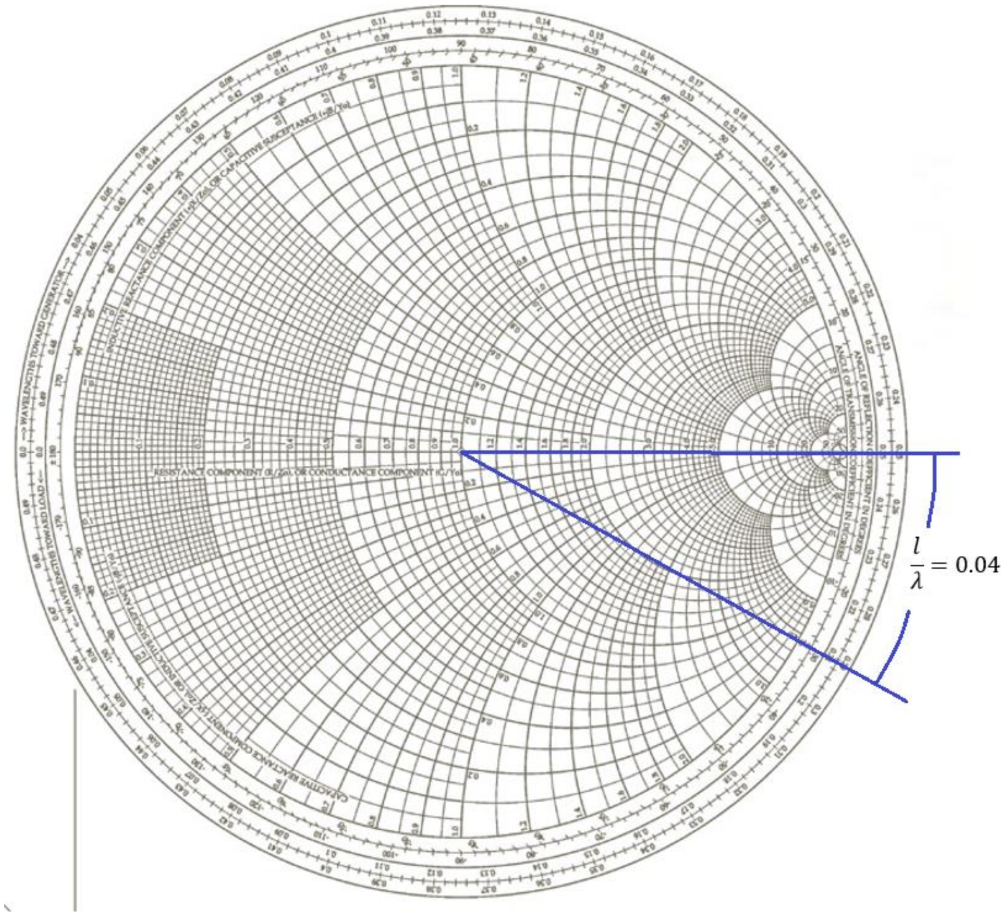


Figura 26. Resolución de carta de Smith

Encontrada la impedancia en la carta de Smith se traza una línea recta, para poder encontrar la longitud que se necesita en el cable para el desfase deseado.

$$\frac{l}{\lambda} = 0.04 \qquad \textit{(Ecuación 29)}$$

Resolviendo la ecuación 29 se obtiene el siguiente resultado:

$$l = 0.04\lambda = 0.04 * \frac{c}{f * \sqrt{2.25}} = 0.04 * \frac{3 * 10^8}{921 * 10^6 * \sqrt{2.25}} = 0.009m$$

Una vez calculado la longitud del *Stub* para obtener el desfase deseado de $(292|-90^0)$, se dispone a calcular la impedancia total del circuito, no se toma en cuenta la parte imaginaria del circuito, solo la parte real, por lo que los próximos cálculos solo se presentaran con valores reales no imaginarios.

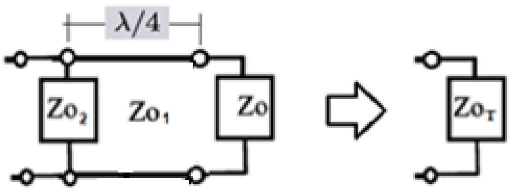


Figura 27. Impedancia total sin Stub

Se comienza a resolver el circuito de la Figura 27, se considera a las impedancias individuales y en paralelo, como se desea unir a la antena Yagi cuya impedancia es de 292 Ω, mediante una línea balanceada, es decir dos cables en paralelo unidos a los extremos del balun, se debe conocer el valor de la impedancia en los cables que serán de longitud λ/4, las formulas a utilizarse se muestran en la Figura 28 .

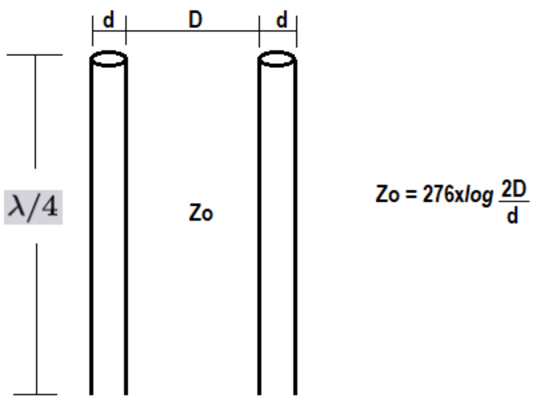


Figura 28. Impedancia característica para línea balanceada a $\lambda/4$

Para obtener el valor de la impedancia, se necesita conocer la distancia de separación entre las líneas y el área del conductor a utilizarse, para las uniones entre cada uno de los dipolos se planifica poner cable solido 16AWG, mediante tablas se puede conocer su diámetro, mientras que para la separación se decide que sea 35 mm, conocidos los datos se remplaza en la formula antes vista y se tiene lo siguiente.

Resolviendo la ecuación 12 se obtiene es siguiente resultado:

$$Zo_1 = 276x \log \frac{2x1.2908}{35} = 478.649\ \Omega$$

Como siguiente punto debemos resolver el paralelo entre las tres impedancias, esto se lo realiza de la siguiente forma:

$$Z_{0_{01}} = \frac{Zo_1 * Z_o}{Zo_1 + Z_o} = \frac{478.361 * 292}{478.649 + 292} = 181{,}361\ \Omega$$

$$Z_T = Z_{0_{01}} \parallel Z_{02} = \frac{181{,}361 * 292}{181{,}361 + 292} = 111{,}875\ \Omega$$

2.1.4. Diseño del Balun

Para la construcción del Balun se utilizará la teoría revisada en el Capítulo 1. Sabiendo que se necesita una salida de impedancia de 50 Ω sabiendo que es un Balun de 4:1, es decir; conociendo el valor que proviene del arreglo de antenas yagi, se adaptara el diseño para que a la salida se obtenga la impedancia deseada.

Primero se trabaja en la ecuación 11, debido a que se conoce la impedancia de salida y la de entrada, se puede calcular la impedancia en la línea.

$$Z_o = \sqrt{Z_{in} x Z_{Out}} \ \longrightarrow\ Z_{Out} = 200\Omega$$

$$Z_o = \sqrt{111{,}875 * 200} = 149{,}582\ \Omega$$

Una vez calculada la impedancia de la línea se puede usar la ecuación 11, debido a que también se conoce la distancia del lado del cuadrado metálico que es de 22 mm, con estos datos se puede calcular el diámetro del conductor a utilizarse para realizar el acople de impedancias.

Se tiene la ecuación 11:

$$Z_o = \frac{138}{\sqrt{\varepsilon}} \log\ 1{,}08\ \frac{D}{d}$$

Se despeja la distancia que se requiere:

$$d = 10^{\left(\log 1.08D - \frac{Z_o\sqrt{\varepsilon}}{138}\right)}$$

Resolviendo la ecuación se tiene el siguiente resultado:

$$d = 10^{\left(\log 1.08x22 - \frac{149.582*\sqrt{1}}{138}\right)} = 1{,}958\ mm$$

Con el diámetro de conductor calculado se verifica la tabla de calibres de conductores sólidos y se visualiza que existen dos posibles opciones que se pueden utilizar, debido a su cercanía con el valor calculado, estas son; el número 12 y 14AWG, por lo que se comprueba en la anterior ecuación con que diámetro se acerca más a la impedancia requerida:

Si se remplaza los valores obtenidos en la ecuación 11 se obtiene los siguientes resultados:

Para 12 AWG, tiene un diámetro de 2.05

$$Z_o = \frac{138}{\sqrt{\varepsilon}} \log\ 1{,}08\ \frac{D}{d}\ = \frac{138}{\sqrt{1}} \log\ 1{,}08\ \frac{22}{2.05} = 146.844\ \Omega$$

Para 14 AWG, tiene un diámetro de 1.63

$$Z_o = \frac{138}{\sqrt{\varepsilon}} \log\ 1{,}08\ \frac{D}{d}\ = \frac{138}{\sqrt{1}} \log\ 1{,}08\ \frac{22}{1.63} = 160.587\ \Omega$$

Como se puede visualizar con el número de cable 12 AWG la impedancia es aproximadamente igual, son tres ohmios de diferencia por lo que para la construcción se usara este conductor.

Ahora vamos a calcular las medidas que va a tener los cables del balun.

$$\frac{\lambda}{4} = 8.143\ cm$$

$$\frac{\lambda}{4} + \frac{\lambda}{2} = 8.143 + 16.286 = 24{,}429$$

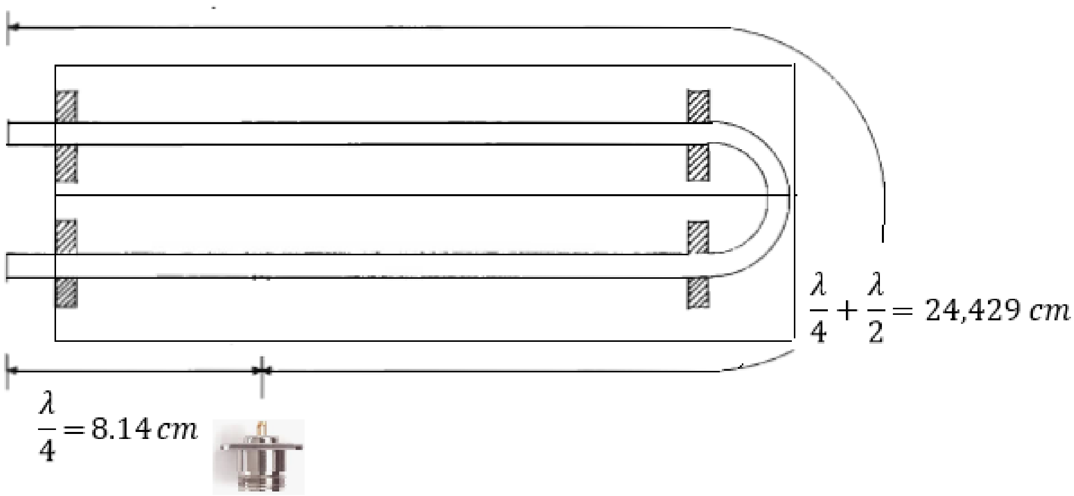


Figura 29. Medidas del Balun

En la Figura 29 se puede visualizar las dimensiones del Balun y como quedara estructurado, con el diseño de este elemento se concluye el diseño del arreglo de antenas. A continuación, se mostrará mediante la simulación en el software especializado Mmana-gal cómo reacciona el arreglo de antenas con las medidas que se obtuvieron en la teoría.

2.2. Simulacion en mmana-gal

En este tema se obtendrá la simulación de la antena con algunos de los parámetros presentados en la teoría.

2.2.1. Software Mmna-gal

Es un Software que se encuentra de manera gratuita en la red, desarrollado por Makoto Mari y mejorado por los alemanes, Alex Schewelew e Igor Gontcharenko, representa una ayuda para los radioaficionados que necesitan conocer características puntuales de la antena, como es ganancia, lóbulos de radiación y comportamiento de la antena en el espacio.
Este software presenta algunas desventajas, como que solo puede modelizar antenas que tengan conductores rectilíneos, no funciona bien cuando el conductor está a pocos metros del suelo y su modelización se basa solo en conductores desnudos.

2.2.2. Simulación

Con los valores obtenidos en la teoría se reemplaza para realizar la simulación, cabe recalcar que no se podrá realizar el dipolo plegado debido a que solo se permite modelizar con conductores rectilíneos.

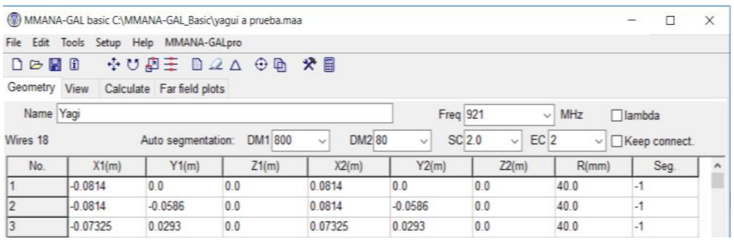
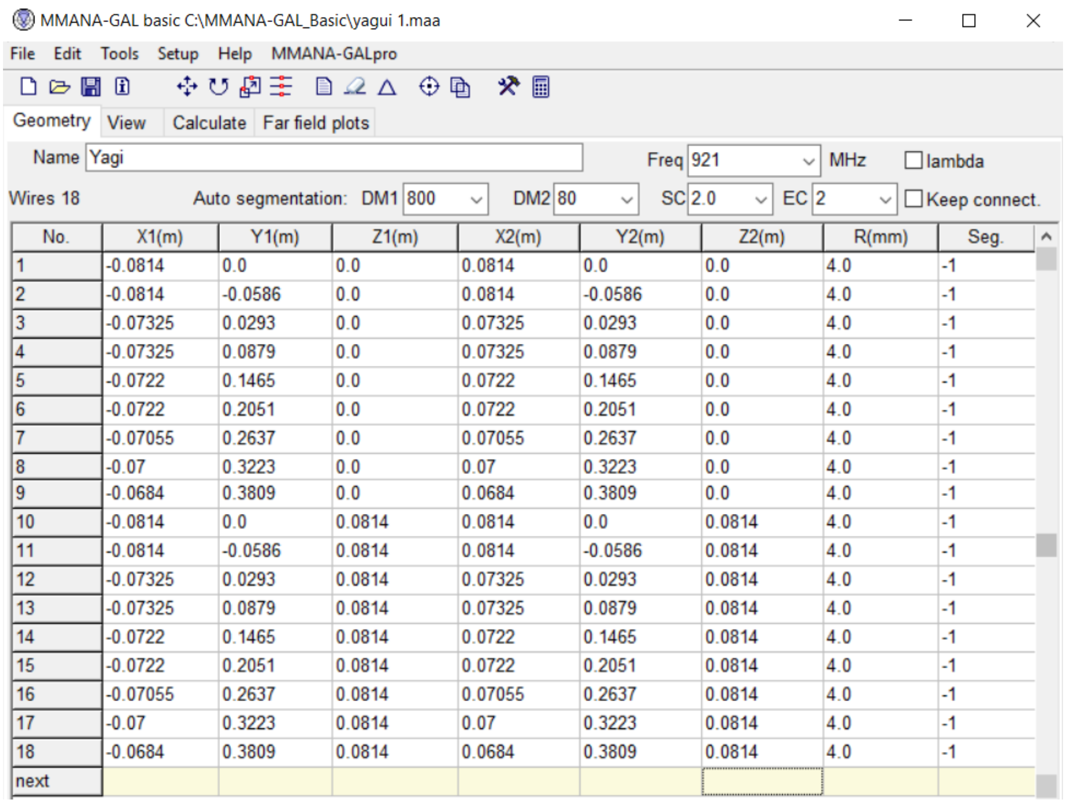


Figura 30. Mmana-gal dipolo de media longitud de onda

En la Figura 30, se coloca los valores que se tiene en el dipolo, luego el reflector y por ultimo uno de los directores, en este ejemplo se verifica que cada elemento de la antena viene desglosado mediante puntos en tres dimensiones, se debe trasformar las magnitudes a las requeridas por el software.

Además, se debe considerar que al ir construyendo el arreglo de antenas yagi, se toma como punto de origen el centro del dipolo, ya que en este punto entra la señal a ser trasmitida y desde el centro se tendrá que trabajar con los tres planos espaciales.

Una vez entendido como se realiza el ingreso de datos, se ingresa todo el arreglo de antenas en los tres planos como se muestra en la Figura 31.



No.	X1(m)	Y1(m)	Z1(m)	X2(m)	Y2(m)	Z2(m)	R(mm)	Seg.
1	-0.0814	0.0	0.0	0.0814	0.0	0.0	4.0	-1
2	-0.0814	-0.0586	0.0	0.0814	-0.0586	0.0	4.0	-1
3	-0.07325	0.0293	0.0	0.07325	0.0293	0.0	4.0	-1
4	-0.07325	0.0879	0.0	0.07325	0.0879	0.0	4.0	-1
5	-0.0722	0.1465	0.0	0.0722	0.1465	0.0	4.0	-1
6	-0.0722	0.2051	0.0	0.0722	0.2051	0.0	4.0	-1
7	-0.07055	0.2637	0.0	0.07055	0.2637	0.0	4.0	-1
8	-0.07	0.3223	0.0	0.07	0.3223	0.0	4.0	-1
9	-0.0684	0.3809	0.0	0.0684	0.3809	0.0	4.0	-1
10	-0.0814	0.0	0.0814	0.0814	0.0	0.0814	4.0	-1
11	-0.0814	-0.0586	0.0814	0.0814	-0.0586	0.0814	4.0	-1
12	-0.07325	0.0293	0.0814	0.07325	0.0293	0.0814	4.0	-1
13	-0.07325	0.0879	0.0814	0.07325	0.0879	0.0814	4.0	-1
14	-0.0722	0.1465	0.0814	0.0722	0.1465	0.0814	4.0	-1
15	-0.0722	0.2051	0.0814	0.0722	0.2051	0.0814	4.0	-1
16	-0.07055	0.2637	0.0814	0.07055	0.2637	0.0814	4.0	-1
17	-0.07	0.3223	0.0814	0.07	0.3223	0.0814	4.0	-1
18	-0.0684	0.3809	0.0814	0.0684	0.3809	0.0814	4.0	-1
next								

Figura 31. Arreglo de antenas en Mmana-gal

Una vez concluido el ingreso de datos del arreglo de antenas se lo puede visualizar en tres dimensiones, la forma del arreglo se lo muestra en la Figura 32.

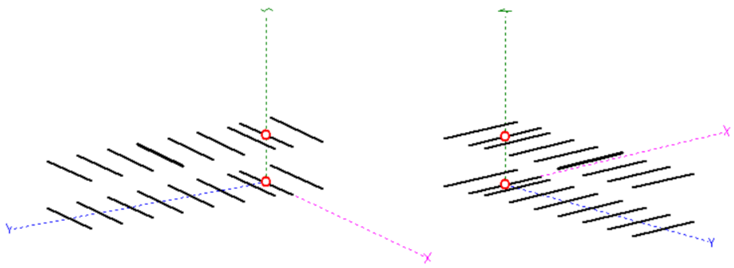


Figura 32. Arreglo de antenas en 3D.

El diagrama de radiación que se obtiene al alimentar las dos antenas y a la una con un desfase de -90 grados es el que se muestra en la Figura 33.

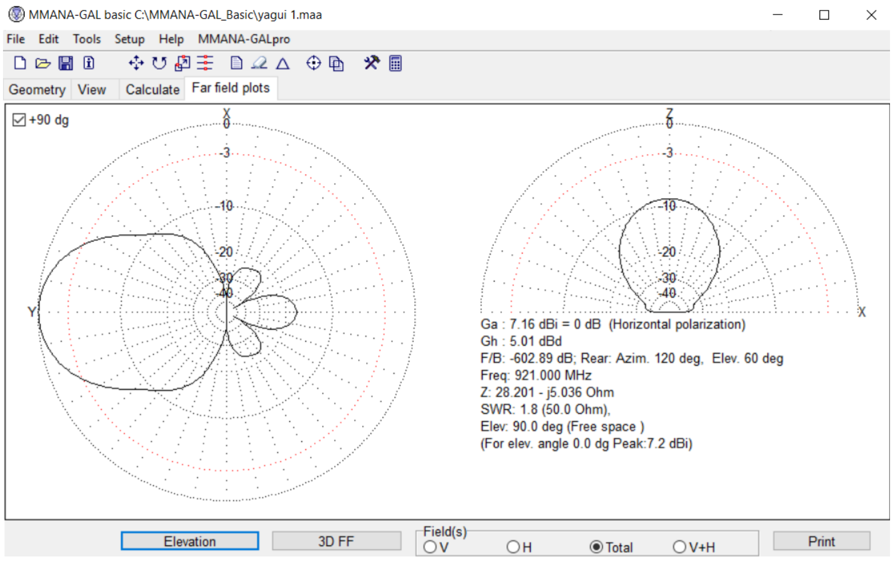


Figura 33. Diagrama de radiación de la antena.

Cabe recalcar que en la simulación no realizar la unión que se hace mediante el cable de longitud λ/4 y a las separaciones calculadas, no se puede colocar el Stub, tampoco el balun que se calculó para el acople de impedancias, por estas razones es que los datos que se puede sacar de la simulación no son satisfactorios como se los esperaba.

El resultado en tres dimensiones que resulta de la simulación se lo muestra en la Figura 34.

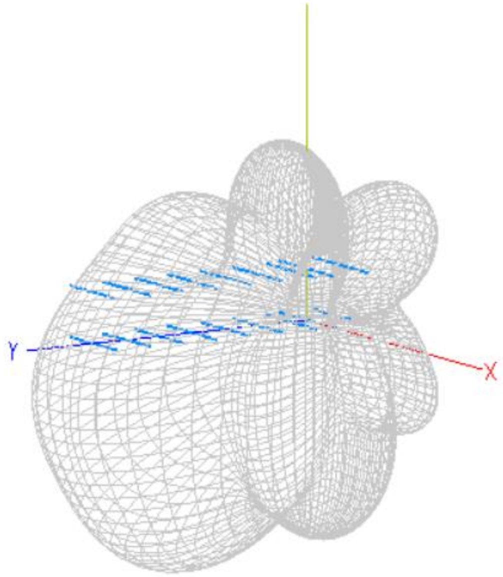


Figura 34. Radiación de la antena en tres planos.

Concluida la simulación, en el siguiente capítulo se visualiza como se construye el arreglo de antenas, en la Figura 35 se muestra el resultado de las mediciones experimentales a la mejor respuesta de VSWR, solo se presenta el grafico, posteriormente se explicara cómo se obtiene cada uno de los valores utilizados para generar las gráficas obtenidas.

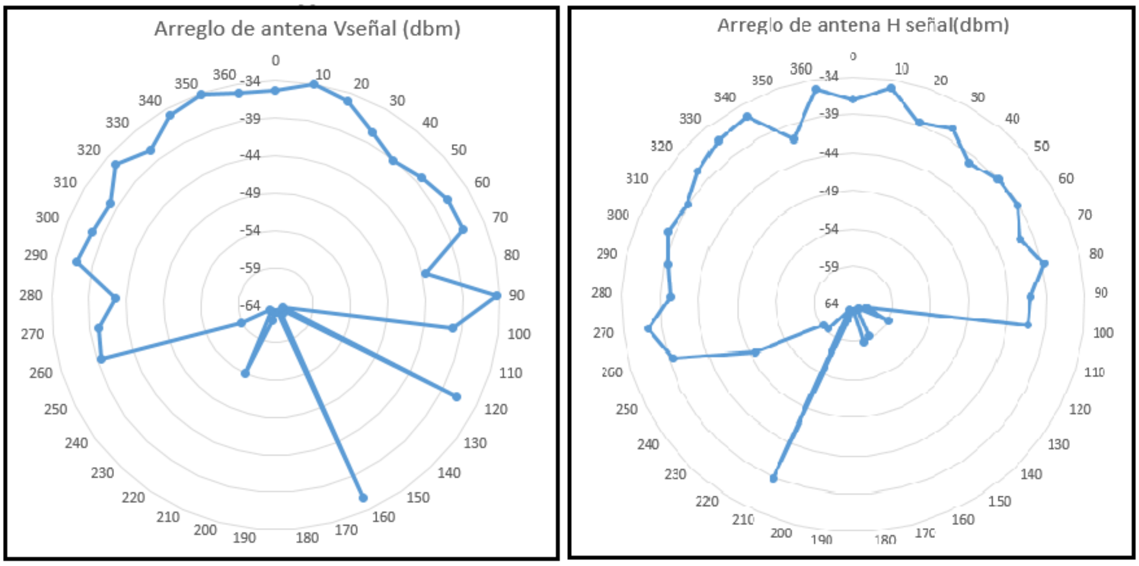


Figura 35. Resultado experimental de lóbulos del arreglo de antena.

3. CAPITULO III. CONSTRUCCIÓN

En este capítulo se mostrará paso a paso la construcción del arreglo, cada elemento creado será indicado mediante imágenes, además de las pruebas realizadas en los sitios donde se instale el nuevo arreglo.

3.1. Construcción del arreglo

Para la construcción del arreglo primero se necesita de tubos cuadrados y tubos cilíndricos de aluminio, con esto se construirá la estructura de la antena, cable coaxial de 75 ohmios para realizar el Stub en uno de los dipolos de las antenas, cable solido 16 AWG, conector tipo N para chasis, más otros elementos que servirán para terminar con la construcción.

3.1.1. Construcción de la antena Yagi

Para la construcción de la antena se dispone de dos tubos de aluminio cuadrados, cada uno con una longitud de 60 cm de largo y 22 mm de lado, servirá de estructura para los elementos individuales de la antena, mediante remaches se asegurara el reflector, dipolo plegador y los directores que tiene la antena, las medidas son las calculadas en el capítulo anterior, en la Figura 36 muestra la estructura y componentes cortados.

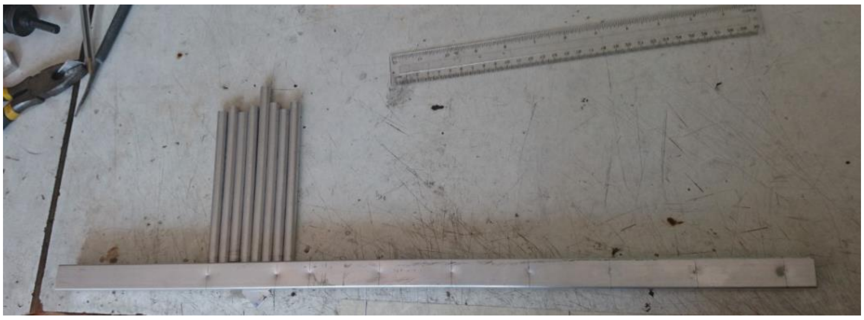


Figura 36. Tubos cilíndricos y cuadrados de formaran la antena

Cuando une los elementos y se remacha las dos antenas, se puede apreciar lo que se tiene en la Figura 37.

Figura 37. Antena Yagi construida.

3.1.2. Construcción del arreglo

Una vez construida las antenas de manera individual, para mayor facilidad se trabaja en el soporte donde se va a sostener la antena, para esto se construye con ángulos de aluminio, una vez cortados, se recubren con cinta para evitar interferencias producidas por el material de aluminio, es importante realizar con el taladro dos orificios con una separación de 10.8cm, el largo que se quiera realizar dependerá de donde se desee instalar el arreglo, el soporte se lo muestra en la Figura 38 .

Figura 38. Soporte de antenas.

Concluido con el soporte se debe trabaja en el dipolo doblado, se suelda las uniones entre cada dipolo con el cable solido de numero 16 AWG como se muestra en la Figura 39.

Figura 39. Unión de dipolos.

Una vez concluido el arreglo, se debe construir el balun para la antena, con los cálculos realizados en el capítulo anterior.

3.1.3. Construcción del Balun

El balun cumple el papel de adaptador de impedancias, para el caso de estudio realizado e necesita que adapte la impedancia del arreglo de las dos antenas yagi que tiene un valor de 111,87Ω, si se revisa la teoría del capítulo anterior por medio de la variación del diámetro del cable interno con el que se encuentra construido el balun, se espera que en la frecuencia de trabajo deseada el valor de impedancia a la salida de la antena, dé como resultado 50 Ω.

Para el balun se necesita un tubo de aluminio cuadrado, este es utilizado como protección, conductor 12 AWG que es el resultado de los cálculos en el capítulo 2, un conector tipo N para chasis, pega epoxy para aluminio y un tubo redondo como lo muestra la siguiente Figura 40.

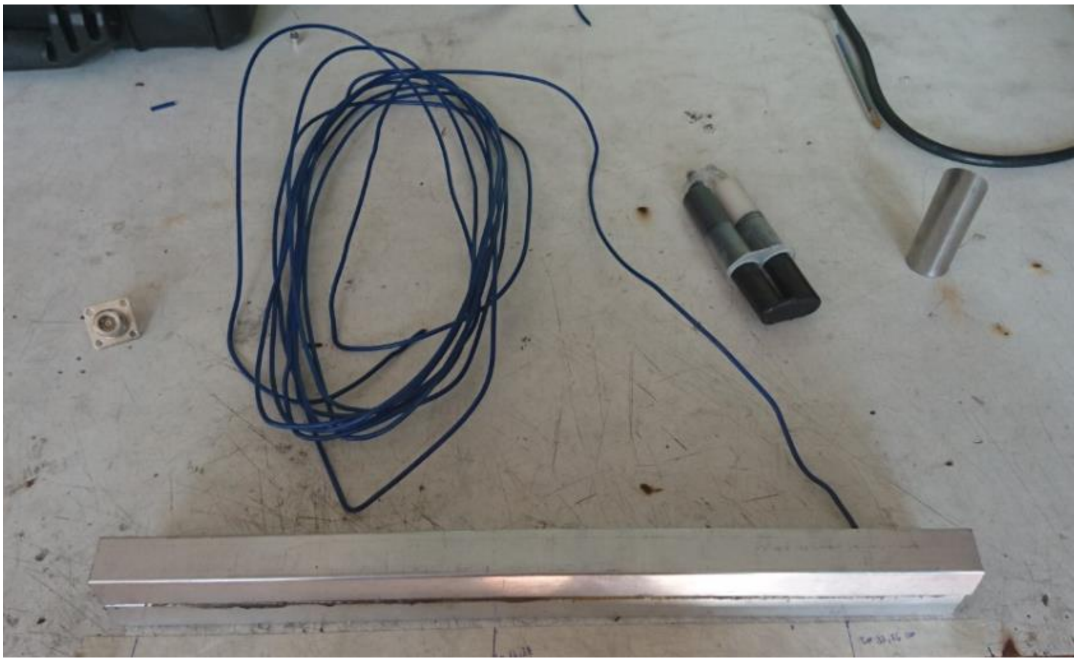


Figura 40. Materiales para el Balun.

Como primer paso es cortar el cable solido 12 AWG a 32,56 cm, extraer el revestimiento, enderezar el cable para luego doblarlo con la ayuda del tubo redondo, el resultado lo muestra la Figura 41.

Figura 41. Construcción de acople de impedancias, cable 12 AWG.

Ahora se construirá la carcasa para la protección del cable 12 AWG e instalar el conector tipo N para chasis; primero se cortan dos tubos de 15 cm cada uno, en uno de los extremos de un lado de cada tubo cuadrado se mide dos cm y se realiza un destaje, luego se procede a montar el conector tipo N para chasis con la ayuda de un taladro, cabe mencionar que para realizar la instalación de este conector es necesario superponer y tomar la medida de donde se realizara la soldadura como se muestra en la Figura 42.

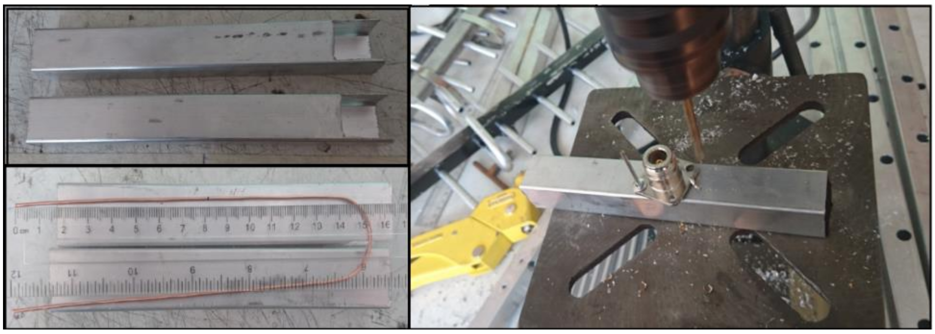


Figura 42. Construcción del Balun. Instalación del conector tipo N hembra.

Una vez puesto en conector tipo N macho para chasis, se coloca regatones en el extremo donde saldrá el cable para evitar el ingreso de impurezas hacia el interior del tubo, se unen los dos pedazos metálicos mediante la epoxy y lo deja reposar por poco tiempo para luego proceder a realizar la suelda del cable como lo muestra la Figura 43.

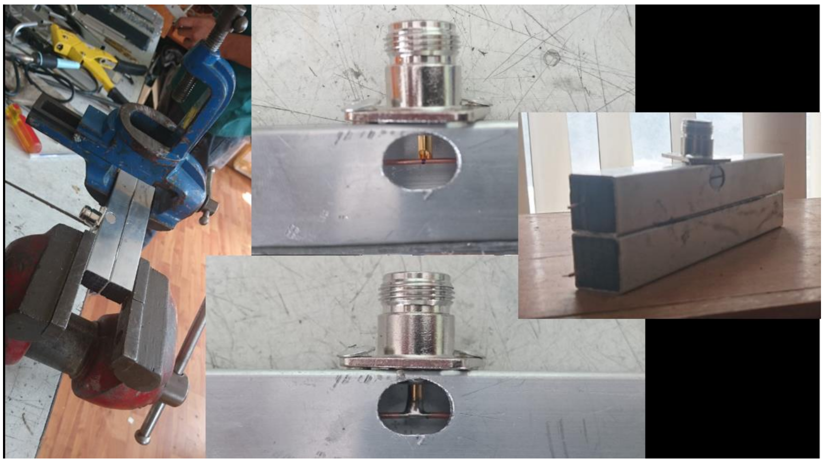


Figura 43. Construcción completa del Balun.

Por último se suelda el pedazo de coaxial a 75 Ω cuya medida fue calculada, que actúa como *Stub*, este trabajo queda como se muestra en la siguiente Figura 44 .

Figura 44. Conexión del *Stub*.

Una vez finalizado el proceso de construcción y como se muestra en Figura 45 se procede a realizar las diferentes pruebas para constatar el funcionamiento de la antena.

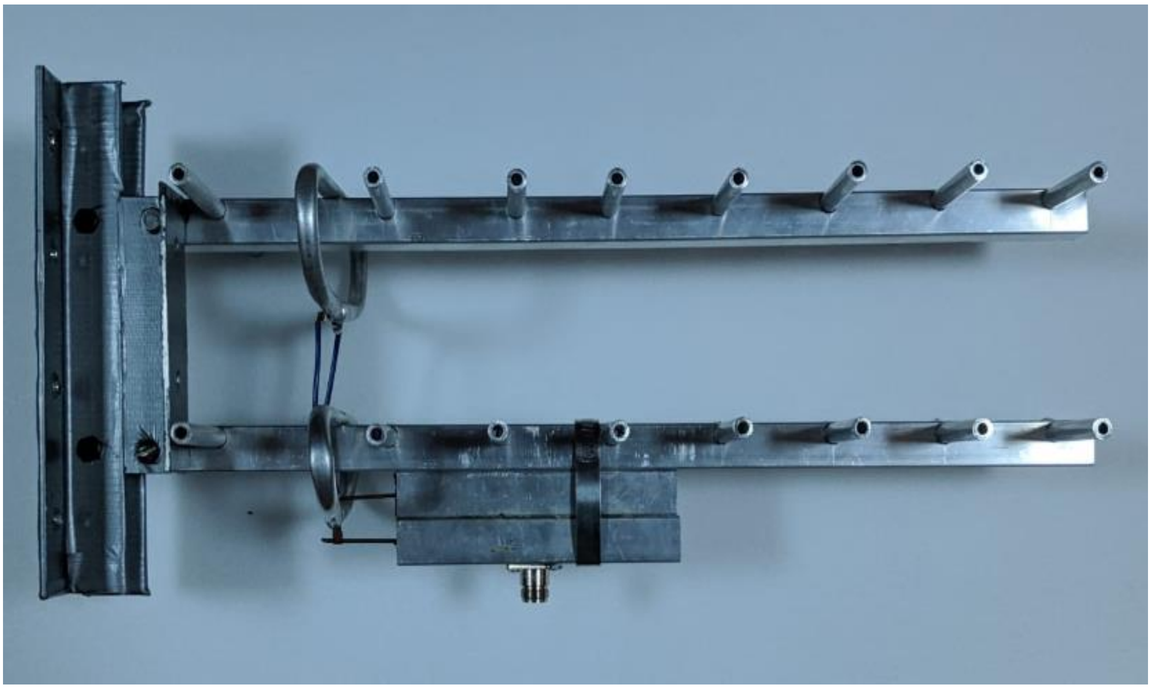


Figura 45. Arreglo de antenas construido.

3.1.4. Pruebas

Para las pruebas con el equipo especializado en antenas, medidor de cables y antenas marca Anritsu, se verificará el VSWR en los tramos y de manera gráfica se visualizará el ancho de banda que presenta la antena diseñada, luego se utilizarán dos radios digitales los cuales son configurados en un enlace punto a punto, se obtendrá la comparación entre una antena simple y el arreglo, además del lóbulo de radiación su lóbulo de radiación, en la siguiente Figura 46, se muestra los diferentes equipos cono los que se cuenta para asegurar que la antena diseñada esté funcionando.

Figura 46. Equipos a utilizarse en las pruebas del arreglo.

3.1.4.1. Vswr

También llamada pérdida de retorno (dB) es la relación que existe entre la señal de entrada y la señal de retorno, también puede ser explicado como la diferencia entre la potencia de una señal transmitida y la potencia de las reflexiones de la señal causados por las variaciones en enlace y la impedancia del canal, mientras más alta sea este valor, nos indica que la hay perdidas en retorno, por ende, mal acoplada y podría causar daños en los equipos conectados. (Poole, 2016)
La Primera medida se la realiza en polarización vertical, siendo los resultados los que se visualizan en la Figura 47.

Figura 47. VSWR polarización vertical.

Ahora se procede a realizar la prueba con una polarización horizontal como se visualiza en la Figura 48.

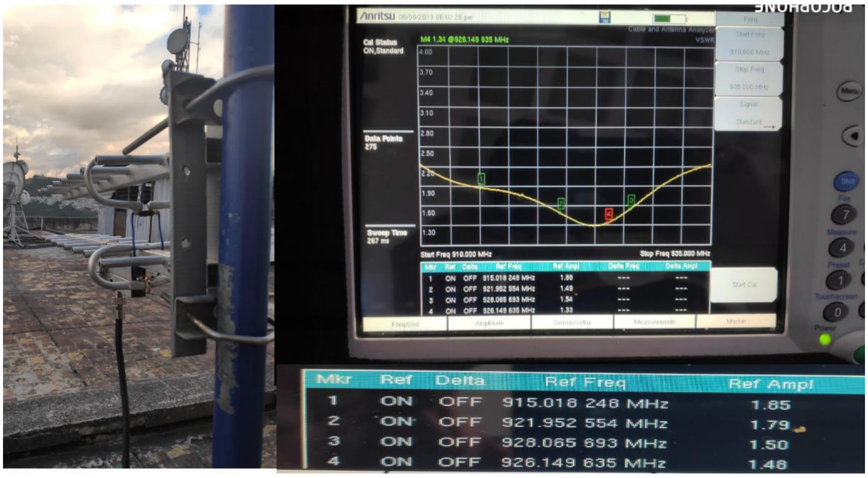


Figura 48. VSWR polarización horizontal.

Como se visualiza en los dos casos en que se probó el arreglo de antenas, la respuesta en una polarización vertical es mejor con respecto a una polarización horizontal, la diferencia entre las dos no se resalta demasiado, pero al momento de la instalación dependiendo de la polarización que se escoja, mejorara un poco el nivel de recepción en la transmisión de los datos.

Una vez soldada todas las piezas de la antena se desea medir nuevamente con un analizador vectorial para saber cómo reacciona a las mediciones con este equipo, el resultado es el siguiente:

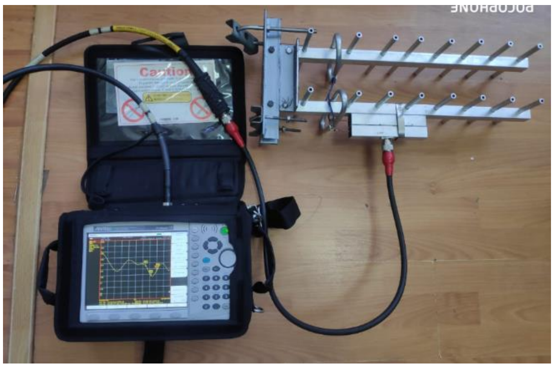


Figura 49. Pruebas con analizador vectorial.

Primero se calibra el analizador vectorial para que los valores que resultan de la antena sean reales, como se muestra en la Figura 50.

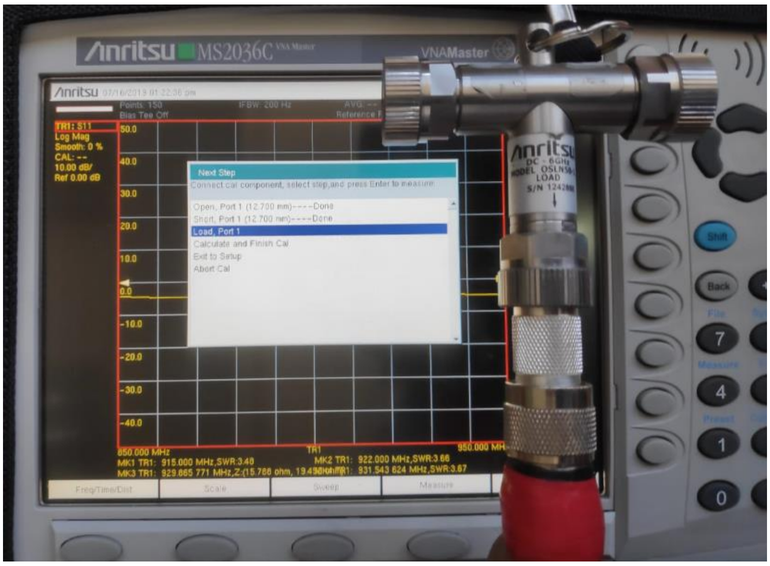


Figura 50. Calibración del analizador vectorial.

Cuando se realiza las mediciones se obtiene los siguientes resultados:

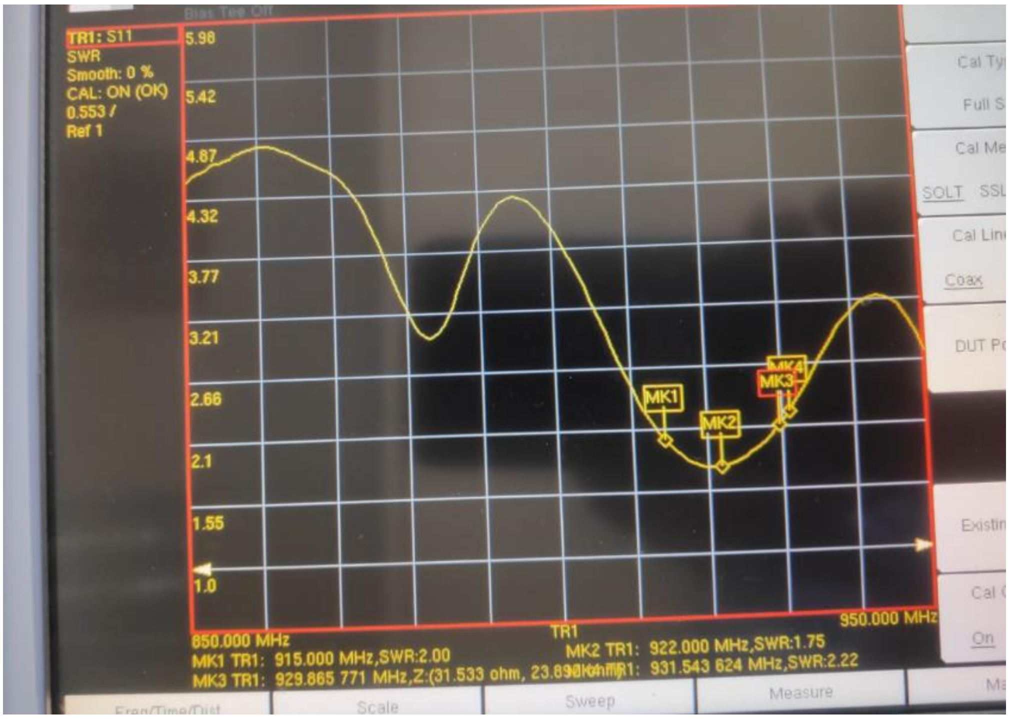


Figura 51. Respuesta del arreglo de antena en analizador vectorial.

Como se puede visualizar en la Figura 51, los mejores rangos de operación del arreglo cambiaron al momento de soldar todos los elementos que estaban sueltos, ahora el mejor rango de operación es des 921 a 932 MHz, esto indica que su rango de operación fue desplazado, por esta razón se debe considerar que el Balun es el elemento más importante en la realización de la antena, si realiza alguna modificación en su suelda o en sus medidas, afecta al arreglo de antenas.

El analizador vectorial permite visualizar cómo reacciona las diferentes antenas en la carta de Smith, es decir que se puede comprobar cómo está adaptada el arreglo de antenas en el acople de impedancias, a continuación, se muestran los resultados obtenidos:

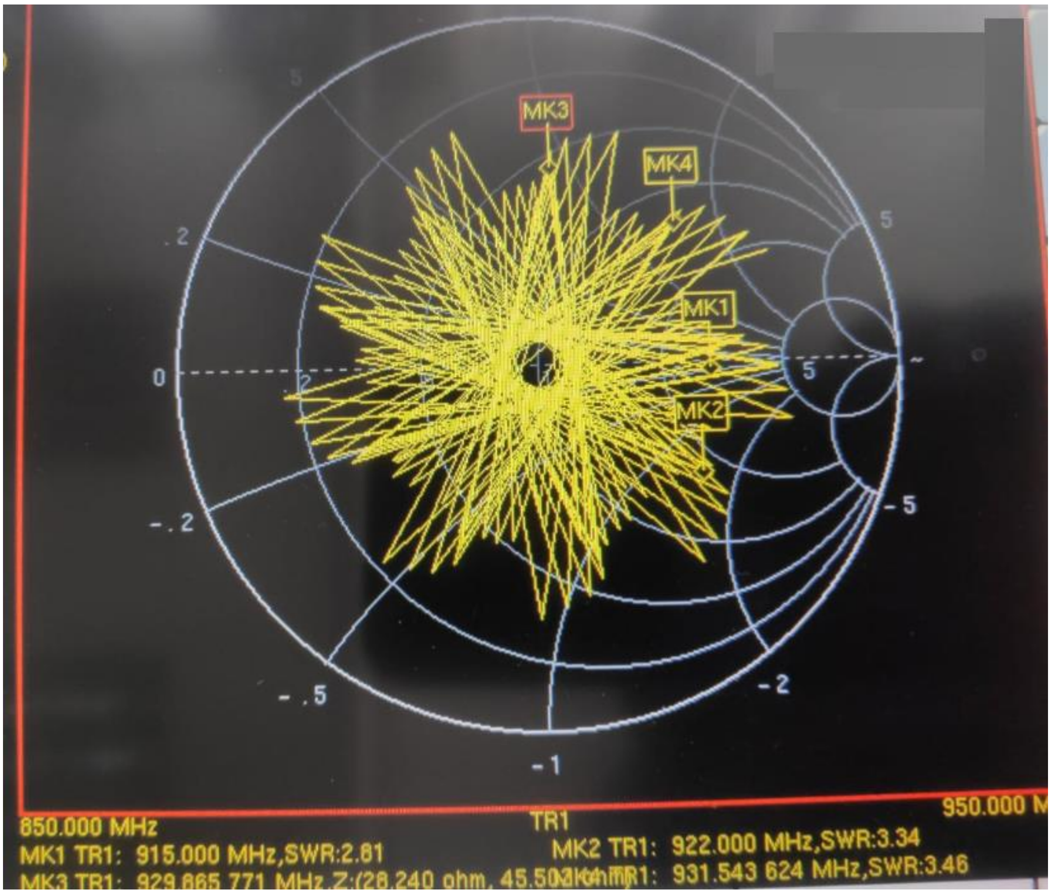


Figura 52. Arreglo de antena en la carta de Smith.

Como se puede visualizar en la Figura 52, a la frecuencia que fue diseñada la antena, la impedancia es de 27Ω mientras que para el valle donde se desplazó el rango de frecuencia de operación es de 51Ω, estas valores se pueden mejorar y adaptarlos mediante pruebas con la construcción de un nuevo Balun y trabajando conjuntamente con los diferentes dispositivos de medición de antenas, para poder tener resultados óptimos.

3.1.4.2. Pruebas con radios.

Para realizar las pruebas es necesario conocer un poco acerca de los radios a utilizarse, son digitales de marca *Freewave* que ofrece comunicaciones inalámbricas en RF de una confiabilidad muy alta, el modelo que se utilizara es el FGR2-PE la configuración es fácil, además cuenta con dos puertos ethernet y dos puertos COM, a continuación, se muestra como estarán configurados cada radio:

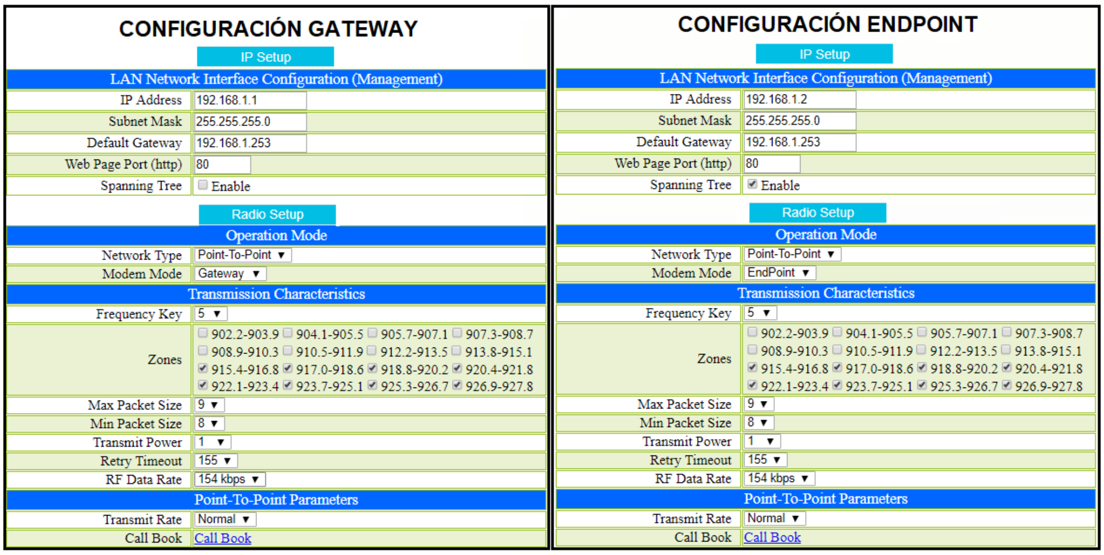


Figura 53. Configuración de radio Freewave punto a punto.

En la Figura 53 se visualiza como configurar dos radios digitales para un enlace punto a punto, dentro de la opción *Call Book* se debe ingresar el número de serie del radio a conectarse, con este paso adicional se concluye con la configuración.

El Instituto Geofísico de la Escuela Politécnica Nacional, cuenta con enlaces que llegan mediante radios *Freewave* a sus servidores, estos datos son recibidos con antenas yagi. Para dibujar el lóbulo de radiación del arreglo de antenas, se escoge un enlace que se encuentra a 10 Kilómetros de distancia, aproximadamente, se cambia la antena por el arreglo y se apunta hacia el azimut al que se encuentra dirigido, luego se rotara cada 10 grados, en polarización horizontal y vertical, estos datos serán tabulados y graficados de manera que se pueda encontrar la ganancia del arreglo de antenas.

Una de las utilidades de los radios *Freewave* es que permite visualizar el nivel de la señal que se recibe, estos valores cambiaran cuando se gire la antena los 360 grados que se necesita, como se muestra en la Figura 54.

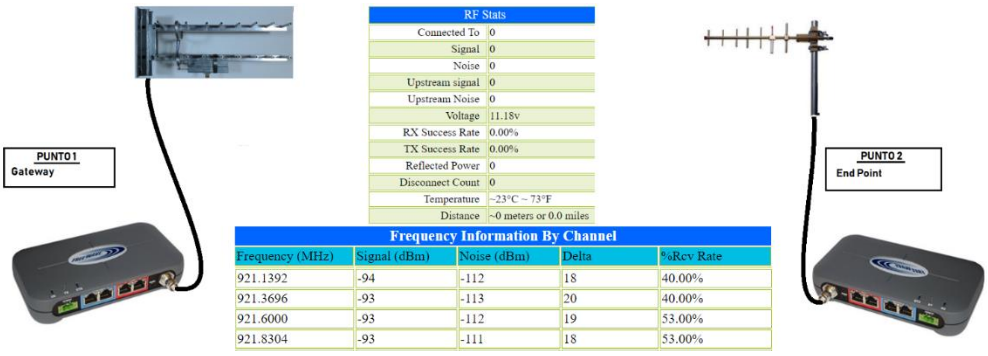


Figura 54. Medidas de telemetría del radio Freewave.

Los valores para 0 y 360 grados en polarización vertical se presenta a continuación.

El la Figura 55 se visualiza la pareja de radios Freewave que se encuentran instalados a 9867 metros, con una potencia reflejada alta, en estos equipos es aceptable el valor de 5, cabe mencionar que antes de colocar el arreglo de antenas este valor ya era alto por lo que se presume que el cable que se encuentra instalado se debería remplazar, este inconveniente no produce ningún tipo de error al medir lo que se desea, además se tiene la posibilidad de ver cuál es el nivel de señal recibida en frecuencias individuales, por lo que se tomara el promedio al que se encuentra la frecuencia que fue diseñado el arreglo de antenas.

RF Stats		RF Stats	
Connected To	9387997	Connected To	9388212
Signal	-90	Signal	-92
Noise	-109	Noise	-114
Upstream signal	0	Upstream signal	0
Upstream Noise	0	Upstream Noise	0
Voltage	11.18v	Voltage	11.81v
RX Success Rate	76.08%	RX Success Rate	0.00%
TX Success Rate	0.00%	TX Success Rate	0.00%
Reflected Power	5	Reflected Power	5
Disconnect Count	15	Disconnect Count	8
Temperature	~27°C ~ 81°F	Temperature	~12°C ~ 54°F
Distance	~9867 meters or 6.2 miles	Distance	~9867 meters or 6.2 miles

921.1392	-89	-111	22	66.00%
921.3696	-89	-109	20	80.00%
921.6000	-89	-109	20	86.00%
921.8304	-89	-112	23	86.00%

Figura 55. Datos del radio Freewave para diagrama del lóbulo radiación.

Una vez aclarado los valores a considerarse para graficar de los lóbulos, se procede a tabular teniendo los siguientes resultados.

Tabla 5.

Lóbulos de radiación

LÓBULOS DE RADIACIÓN			
VERTICAL		**HORIZONTAL**	
Grados	Señal (dBm)	Grados	Señal (dBm)
0	**-91**	0	**-92**
10	**-89**	10	**-91**
20	**-90**	20	**-92**
30	**-92**	30	**-90**
40	**-92**	40	**-93**
50	**-93**	50	**-94**
60	**-95**	60	**-96**
70	**-96**	70	**-97**
80	**-96**	80	**-102**
90	**-99**	90	**-112**
100	**-101**	100	**-114**
110	**-120**	110	**-120**
120	**-120**	120	**-120**
130	**-120**	130	**-120**
140	**-120**	140	**-120**

150	**-120**	150	**-120**
160	**-120**	160	**-120**
170	**-120**	170	**-120**
180	**-120**	180	**-120**
190	**-120**	190	**-120**
200	**-120**	200	**-120**
210	**-120**	210	**-120**
220	**-120**	220	**-120**
230	**-120**	230	**-120**
240	**-120**	240	**-120**
250	**-120**	250	**-120**
260	**-101**	260	**-114**
270	**-99**	270	**-112**
280	**-96**	280	**-102**
290	**-96**	290	**-97**
300	**-95**	300	**-96**
310	**-93**	310	**-94**
320	**-92**	320	**-93**
330	**-92**	330	**-90**
340	**-90**	340	**-90**
350	**-89**	350	**-91**
360	**-91**	360	**-91**

Tabulados los valores se procede a graficarlos, y se visualiza a los puntos de media potencia, es decir a -3 dB como se muestra en la Figura 56 .

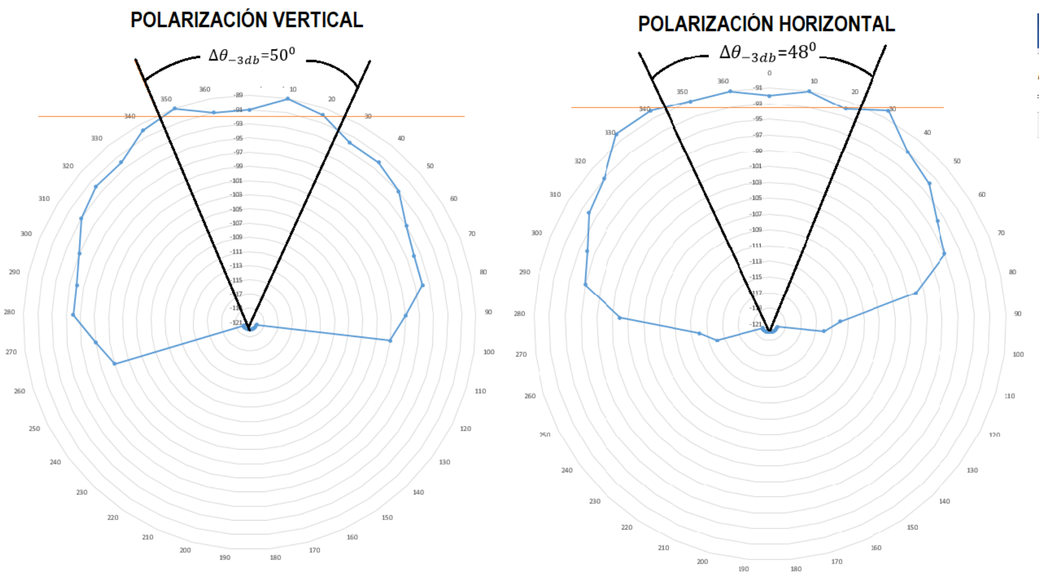


Figura 56. Lóbulos de radiación horizontal y vertical.

Como siguiente punto se debe calcular la ganancia práctica de la antena, para esto se utilizará la Ecuación 2 de la teoría vista en el capítulo 1.

$$G = \frac{4\pi}{\Delta\theta_{H_{-3db}} * \Delta\theta_{V_{-3db}}} = \frac{4\pi}{0.872665 * 0.837758} = 17.188\ dB$$

Además, se realizan pruebas con un medidor de potencia y con la frecuencia de 930 MHz.

Figura 57. Pruebas de la antena con un medidor de potencia.

Los resultados obtenidos tanto en posición horizontal como vertical son los siguientes:

Tabla 6.

Valores obtenidos con el medidor de potencia

VERTICAL		**HORIZONTAL**	
grados	señal (dbm)	grados	señal(dbm)
0	**-35,25**	0	**-37,04**
10	**-34,05**	10	**-35,15**
20	**-35,02**	20	**-38,7**
30	**-37,46**	30	**-37,46**
40	**-39,07**	40	**-40,02**
50	**-38,08**	50	**-39,06**
60	**-37,02**	60	**-39,15**
70	**-36,96**	70	**-40,75**
80	**-43,49**	80	**-38,75**
90	**-34,47**	90	**-41,01**
100	**-40,21**	100	**-41,24**
110	**-63**	110	**-62,3**
120	**-36,92**	120	**-58,87**
130	**-63**	130	**-63**

140	**-62,5**	140	**-63**
150	**-63**	150	**-63**
160	**-35,72**	160	**-59,24**
170	**-63**	170	**-58,67**
180	**-63**	180	**-63**
190	**-63**	190	**-63**
200	**-62**	200	**-62**
210	**-54,05**	210	**-38,7**
220	**-63**	220	**-63**
230	**-63**	230	**-59,35**
240	**-63**	240	**-59,25**
250	**-58,9**	250	**-49,8**
260	**-39,6**	260	**-39,54**
270	**-40,09**	270	**-37,25**
280	**-42,5**	280	**-40,24**
290	**-36,78**	290	**-39,54**
300	**-37,6**	300	**-38,2**
310	**-38,03**	310	**-38,9**
320	**-35,6**	320	**-37,42**
330	**-37,46**	330	**-36,24**
340	**-35**	340	**-35,75**
350	**-34,08**	350	**-41,07**
360	**-35,25**	360	**-35,25**

Con estos valores los diagramas de radiación son los siguientes:

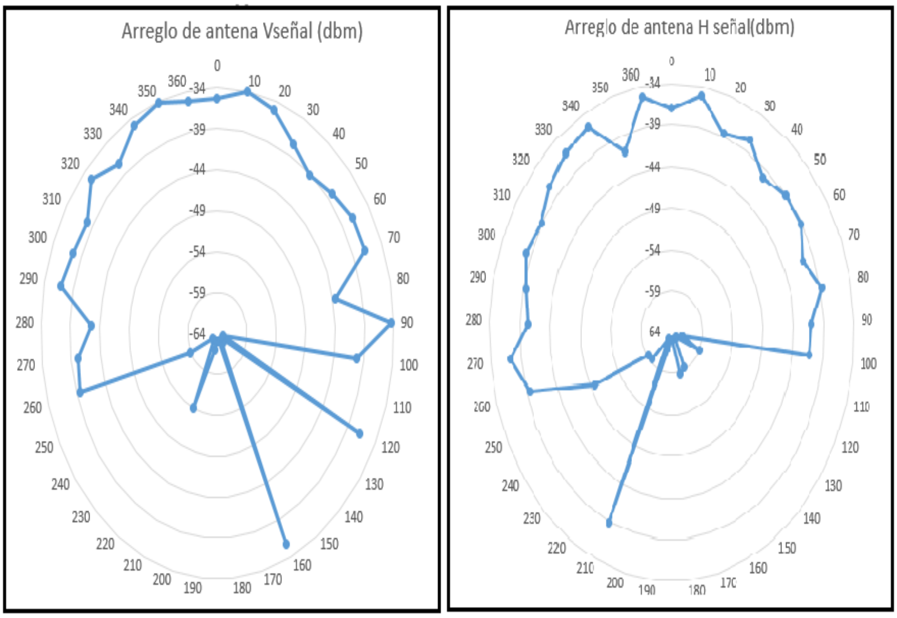


Figura 58. Resultado de los lóbulos de radiación obtenido del medidor de potencia.

3.2. Implementación del arreglo

3.2.1. Instalación en los puntos Lasso y Mariscal Sucre

El proyecto concluye con la instalación, para este punto se necesita conocer el sitio donde será instalado el arreglo de antenas, el Instituto Geofísico cuenta con las coordenadas de cada lugar donde existen equipos instalados y los datos consultados son mostrados en la Figura 59

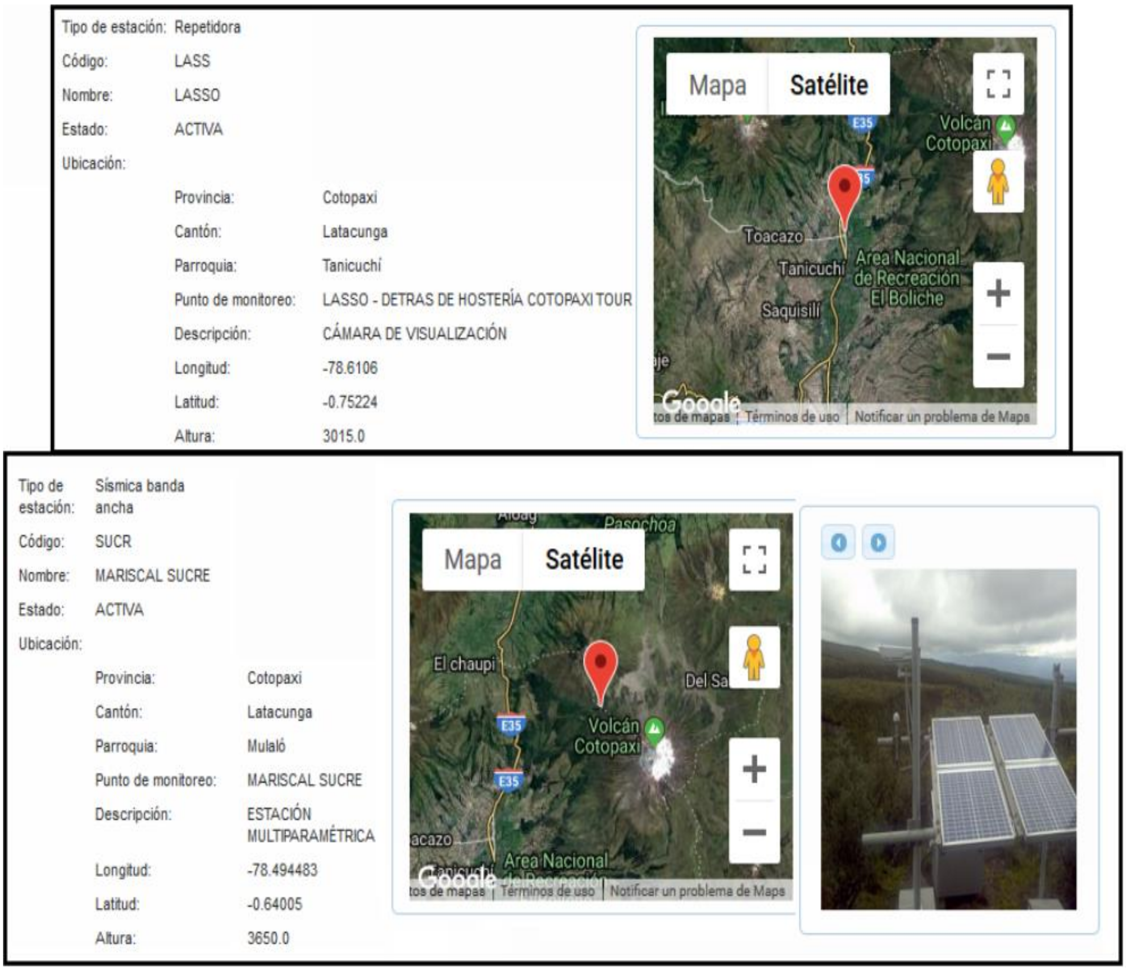


Figura 59. Coordenadas de enlace Lasso-Mariscal Sucre.

Las coordenadas consultadas son ingresadas al Radio Mobile, además se pone los parámetros de transmisión, se obtiene los resultados mostrados en la Figura 60.

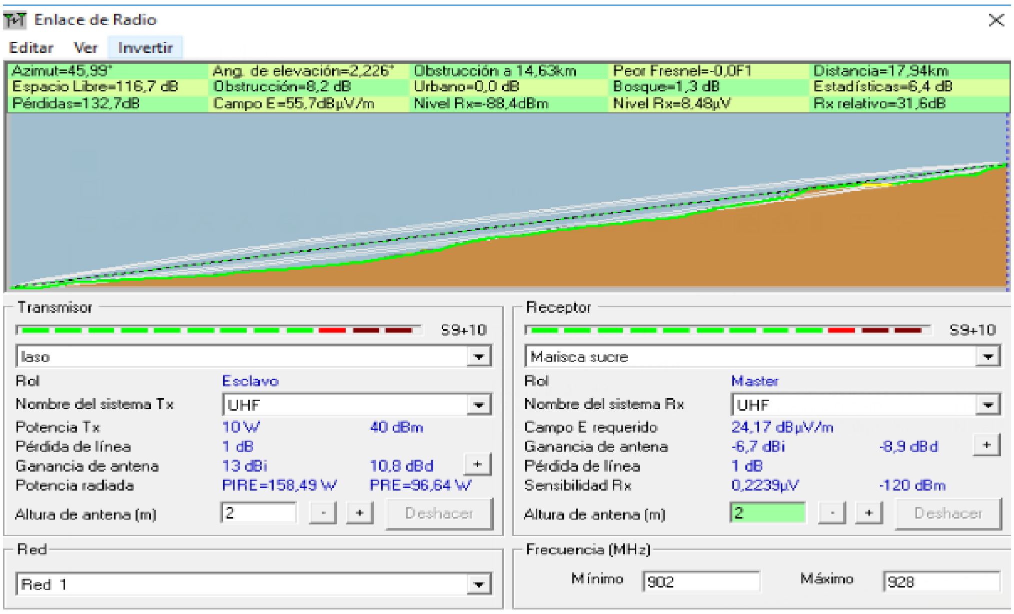


Figura 60. Enlace Lasso-Mariscal Sucre en Radio Mobile.

Una vez en el sitio se procede se ingresar al radio *Freewave* para verificar el estado del enlace que se encuentra al momento los resultados son mostrados en la Figura 61.

TRANSMISOR		RECEPTOR	
RF Stats		RF Stats	
Connected To	8423812	Connected To	8424226
Signal	-95	Signal	-94
Noise	-117	Noise	-112
Upstream signal	0	Upstream signal	0
Upstream Noise	0	Upstream Noise	0
Voltage	10.80v	Voltage	11.94v
RX Success Rate	0.00%	RX Success Rate	70.59%
TX Success Rate	0.00%	TX Success Rate	0.00%
Reflected Power	1	Reflected Power	2
Disconnect Count	0	Disconnect Count	189
Temperature	~30°C ~ 86°F	Temperature	~25°C ~ 77°F
Distance	~2482 meters or 1.6 miles	Distance	~2476 meters or 1.5 miles

Figura 61. Estado del enlace sin arreglo de antenas.

Como se puede verificar en el receptor, el contador de desconexión consta de un numero alto, por esta razón es que se desea cambiar la antena con la que recibe la estación por el arreglo creado, a continuación en la Figura 62 se muestra la instalación.

Figura 62. Instalación de la antena.

Una vez instalado el arreglo se espera unos minutos antes de conectarse al radio, para esperar que el enlace se estabilice y se pueda verificar los valores que presenta el enlace, a continuación, se muestra estos valores.

Figura 63. Estado del enlace con arreglo de antenas.

Se verifica en la Figura 63 que la señal cambia al momento de la instalación del nuevo arreglo, la diferencia no es mucha pero esto se debe a que los radios están configurados para funcionar desde las frecuencias de 902 a 928 MHz y esto hace que el promedio de la señal se vea deteriorado.

4. CONCLUSIONES Y RECOMENDACIONES

4.1 Conclusiones

En el presente proyecto se diseñó e implemento un arreglo de antenas que funciona en los rangos de 915 a 928Mhz, comprobado con el analizador de espectros de marca *Anritsu* y pruebas de enlace punto a punto entre Mariscal Sucre y Lasso.
En este proyecto se documentó la teoría que se debe tomar en cuenta cuando se trabajará con antenas y arreglos, además de presentar los cálculos matemáticos necesarios de cada elemento y de esta forma construir el arreglo de dos antenas Yagi.

El arreglo de dos antenas yagi se encuentra constituido de aluminio y la parte interna del balun de cobre, su elección fue debido a que estos materiales son de naturaleza conductora, fácil accesibilidad para su adquisición y ligeros.

En la construcción del balun, al soldar el conector tipo N para chasis con el cable de cobre se debe marcar el punto exacto de la unión, según los cálculos realizados, ya que la variación en milímetros de la misma, puede cambiar considerablemente la respuesta de la frecuencia de resonancia del arreglo de dos antenas.

Al visualizar la señal a ruido en frecuencias individuales mediante una herramienta que presentan los radios Freewave, se obtiene resultados satisfactorios a partir de 917MHz siendo el valor más alto en la frecuencia de 928MHz.

Este diseño de arreglo de antenas Yagi, servirá para cualquier enlace Punto a Punto que trabaje con radios digitales en los rangos de 915 a 928 MHz, sin embargo, la mejor respuesta que presenta la antena es en la frecuencia central de 931 MHz, según las mediciones experimentales que se obtuvieron con un analizador vectorial.

4.2 Recomendaciones

Encontrar un software que simule conductores con curvas y uniones en los dipolos, para poder comparar de mejor manera los nuevos diseños que se puedan crear.

El arreglo de antenas está constituido de aluminio, cuando se finaliza la construcción, se torna ligeramente pesado, cuando se instale en sitios altos puede causar cierta dificultad, por lo que sería útil encontrar algún tipo de material más ligero.

Si se desea realizar un arreglo de más de dos antenas se debe tener en cuenta donde se va a instalar, y que se va a utilizar para sostenerla.

Cuando se instale un arreglo se debe pensar en la puesta a tierra que debe tener el sitio, debido a que una descarga eléctrica atmosférica por lo general busca superficies metálicas por ende ingresara por la antena.

Se debe tener en cuenta que el balun es el elemento más sensible al momento de construcción del arreglo de antenas yagi, un cambio de dimensión en algún elemento del mismo afecta en la frecuencia de operación, al momento de soldar el cable con el conector tipo N para chasis también se lo debe realizar en el punto exacto.

REFERENCIAS

Buettrich, S. (2007). Calculo de radioenlace: Tricalcar. Recuperado el 2 de abril del 2019 de http://www.itrainonline.org/itrainonline/mmtk/wireless_es/files/06_es_calculo-de-radioenlace_guia_v02.pdf

Enriquez, W. (1990). *Arreglos de antenas omnidireccionales para el Instituto Geofísico de la Escuela Politecnica Nacional.* Quito: EPN.

Ferrando, M., & Valero, A. (2019). *Wwwupves.* Recuperado el 3 de abril del 2019 de Wwwupves: http://www.upv.es/antenas/Documentos_PDF/Notas_clase/Agrupaciones.pdf

Ferraro, S. (2017). Academia. Recueprado el 19 de abril del 2019 de https://www.academia.edu/34081715/COMO_FABRICAR_UNA_ANTENA_YAGI_DISE%C3%91O_Y_CONSTRUCCI%C3%93N_DE_LA_ANTENA

Harry, D., Hooton, & W6TYH. (1969). *Antenas para radioaficionados.* Buenos Aires: Arbo.

Hernandez. (s.f.). Recuperado el 28 de marzo del 2019 de http://catarina.udlap.mx/u_dl_a/tales/documentos/lem/hernandez_a_r/capitulo2.pdf

Huidobro, J. M. (2013). Antenas de Telecomunicaciones. *Revista digital de Acta*, 6-12.

Madrid, P. d. (2004). *OpenCourseWare.* Recuperado el 17 de abril del 2019 de http://ocw.upm.es/teoria-de-la-senal-y-comunicaciones-1/radiacion-y-propagacion/contenidos/apuntes/tema2_2004.pdf

Miguel, F. B. (2017). diagramas de radiacion. Recuperado el 10 de enero del 2019 de youtube.com: https://www.youtube.com/watch?v=g7DOyXL5wA8

Monachesi, E., Frenzel, A., & Chaile, G. (2011). Conceptos generales de Antenas. Tucumán: Editorial de la Universidad Tecnológica Nacional.

Recuperado el 9 de abril del 2019 de http://www.edutecne.utn.edu.ar/wlan_frt/antenas.pdf

Ocwupmes. (2004). *Ocwupmes.* Recuperado el 15 de julio del 2019 de http://ocw.upm.es/teoria-de-la-senal-y-comunicaciones-1/radiacion-y-propagacion/contenidos/apuntes/tema2_2004.pdf

Perez, A. (2012). *Blogspotcom*. Recuperado el 5 de febrero del 2019 de Blogspotcom: https://eb4hra-baluns.blogspot.com/2012/09/como-elegir-el-balununun.html?showComment=1540775973482#c9197017460573516573

Ronald Medina Garzón, O. M. (2011). *SlideShare*. Recuperado el 15 de junio del 2019 de https://es.slideshare.net/Arkso/antenas-yagi-uda-8639115

Ruesca, P. (2016). Radio Comunicaciones. Recuperado el 3 de febrero del 2019 de http://www.radiocomunicaciones.net/radio/antenas-dipolo/

Ruesca, P. (2016). Radio Comunicaciones . Obtenido de http://www.radiocomunicaciones.net/radio/radio-enlace-que-es-un-radioenlace/

Sarmiento, W. (2018). Academia*.* Recueprado el 4 de julio del 2019 de https://www.academia.edu/13089907/Arreglo_de_Antenas

Soriano, M. (s.f.). *Tiptiktak.* Recuperado el 19 de enero del 2019 de https://tiptiktak.com/26-ancho-de-banda.html

Tercero, M., & Rivera, R. (2013). Diseño de interconexión para enlace de microondas punto a punto entre las comunidades de San Carlos y el archipiélago de Solentiname: UNAN. Recuperado el 19 de febrero del 2019 de http://repositorio.unan.edu.ni/5398/1/68181.pdf

Udbedusv. (2011). *Udbedusv*. Recuperado el 23 de enero del 2019 de http://www.udb.edu.sv/udb/archivo/guia/electronica-ingenieria/propagacion-y-antenas/2011/ii/guia-1.pdf

ANEXOS

ANEXO 1

Manual de uso de Radio *Freewave*

(El contenido de este documento se presenta en el CD adjunto de forma Digital)

ANEXO 2

Manual de uso de Analizador de Antenas *Anritsu*

(El contenido de este documento se presenta en el CD adjunto de forma Digital)

ANEXO 3

Manual de uso de Software Mmana gal

(El contenido de este documento se presenta en el CD adjunto de forma Digital)

FGR2-PE User Manual

Version
1.0
LUM0024AB Rev A

Covering Firmware v. 2.19

FGR2-PE User Manual

SPREAD SPECTRUM WIRELESS DATA TRANSCEIVER USER MANUAL

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In no event will FreeWave Technologies Inc., its suppliers, and its licensors be liable for any damages arising from the use of or inability to use this Product. This includes business interruption, loss of business information, or other loss which may arise from the use of this Product. Please be advised that OEM customer's warranty periods may vary.

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2. If Product is used outside of FreeWave specifications.
3. If Product has been modified, repaired or altered by Customer unless FreeWave specifically authorized such alterations in each instance in writing. This includes the addition of conformal coating.

The Warranty period begins from the date of shipment and is defined per the Standard Warranty Policy stated above.

Special Rate Replacement Option:

A special rate replacement option is offered to non-warranty returns or upgrades. The option to purchase the replacement unit at this special rate is only valid for that RMA, (Return Material Authorization). The special replacement rate option expires if not exercised within 30 days of final disposition of RMA.

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FGR2-PE User Manual

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FCC NOTIFICATIONS

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: 1) This device may not cause harmful interference and 2) this device must accept any interference received, including interference that may cause undesired operation. This device must be operated as supplied by FreeWave Technologies, Inc. Any changes or modifications made to the device without the express written approval of FreeWave Technologies may void the user's authority to operate the device.

CAUTION: The model number FGR2-PE has a maximum transmitted output power of 955mW. It is recommended that the transmit antenna be kept at least 23 cm away from nearby persons to satisfy FCC RF exposure requirements.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Note: Whenever any FreeWave Technologies module is placed inside an enclosure a label ***must*** be placed on the outside of that enclosure which includes the module's FCC ID.

UL Notification

The FGR2-PE UL certification is pending.

IMPORTANT NOTICE

The FGR2-PE radio is compatible over-the-air with the FGRplusRE and the MM2-P-T radios.

The FGR2-PE radio is **NOT** compatible over-the-air with any other FreeWave radio products.

FGR2-PE User Manual

Table of Contents

Choosing Point-to-Point or Point-to-Multipoint Operation

A Point-to-Point network is limited to one Gateway and one Endpoint transceiver. Up to 4 Repeaters may be added to extend the reach of the network, but no other Gateway or Endpoint may be added.

In a Point-to-Multipoint network (also referred to as a Multipoint network) the transceiver, designated as a Gateway, is able to simultaneously communicate with numerous Endpoints. In its simplest form, a Multipoint network functions with the Gateway broadcasting its messages to all Endpoints and the Endpoints responding to the Gateway when given data by the device connected to the data port.

It is important to note the differences between Point-to-Point and Multipoint networks. In a Point-to-Point network all packets are acknowledged, whether sent from the Gateway to the Endpoint or from the Endpoint to the Gateway. In a Multipoint network, outbound packets from the Gateway or Repeater to Endpoint or other Repeaters are sent a set number of times determined by the user. The receiving transceiver, Endpoint or Repeater, will accept the first packet received that passes the 32 bit CRC. However, the packet is not acknowledged. On the return trip to the Gateway, all packets sent are acknowledged or retransmitted until they are acknowledged. Therefore, the return link in a Multipoint network is generally very robust.

Traditionally, a Multipoint network is used in applications where data is collected from many instruments and reported back to one central site. As such, the architecture of such a network is different from Point-to-Point applications. The number of radios in a Multipoint network is influenced by the following parameters:

- Size of the blocks of data. The longer the data blocks, the smaller the network capacity.
- Baud rate.
- The amount of contention between Endpoints. Polled Endpoints vs. timed Endpoints.
- Use of Repeaters. Using the Repeater setting in a Point-to-Point or a Point-to-Multipoint network will decrease overall network capacity by at least 50%.

For example, if the network will be polling Endpoints once a day to retrieve sparse data, several hundred Endpoints could be configured to a single Gateway. However, if each Endpoint will be transmitting data at greater levels, then fewer Endpoints should be linked to the Gateway. The overall network will be closer to capacity with fewer Endpoints.

For examples and additional information on data communication links, see the section Examples of Data Communication Links on page 75.

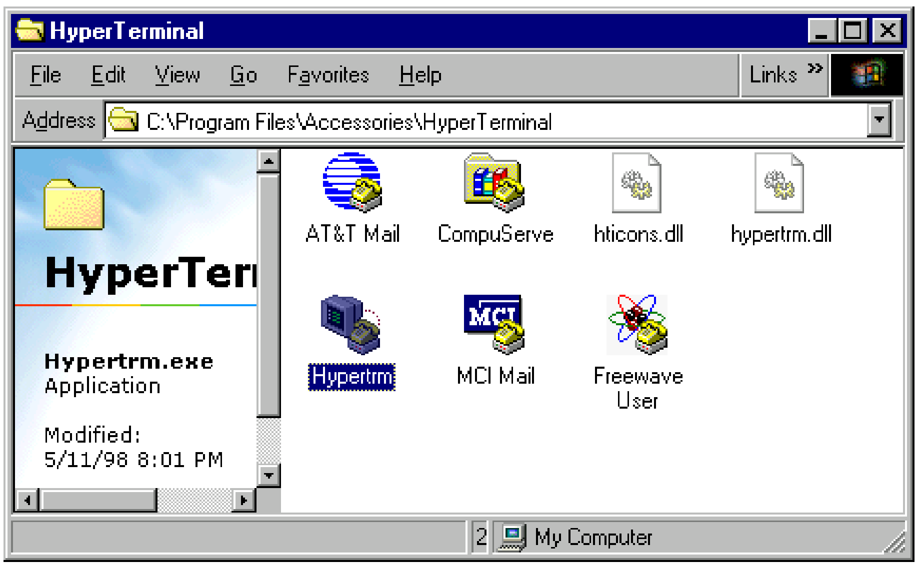
FreeWave Basic Setup via the Serial Port:

This section describes how to either set or determine the IP address of the FGR2-PE radio.
To determine or set the IP address of an FGR2-PE radio, plug a serial cable into **COM 1** (the left port), with the radio disconnected from the power. Then, follow the instructions below to open and setup HyperTerminal.

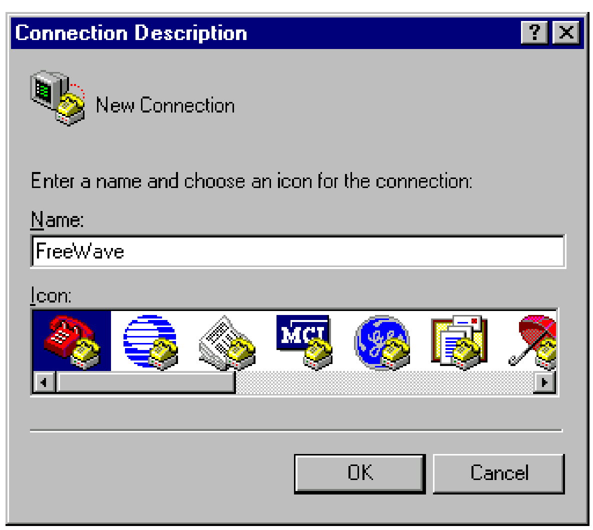
Accessing HyperTerminal's Setup Menu

Note: The following screen shots are taken from a computer using Windows XP. The display may vary slightly if using different operating systems.

Click on the **Start** button. A cascading menu appears. Select **Programs**, **Accessories**, **Communications** and then **HyperTerminal**. A window appears similar to the following:



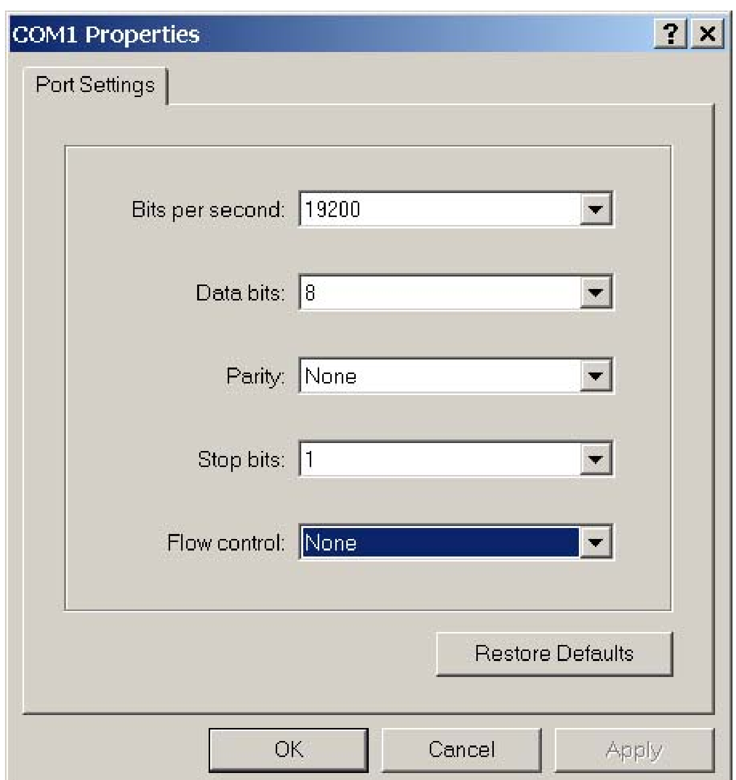
Double-click on the **Hypertrm.exe** icon. The following window appears.



In the Name text box, type in a descriptive name. Select an icon from the Icon selection box. Click on the **OK** button. The following "Connect To" dialog box appears:

Select the connection type to be used from the **Connect using** drop-down menu. In most cases the connection type will be either **Direct to Com1** or **Direct to Com2**.

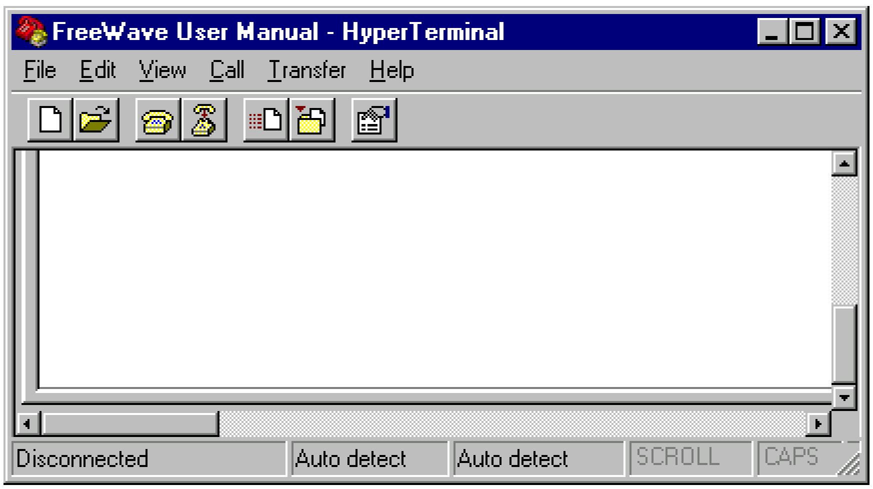
Click on the **OK** button. The Properties dialog box appears for the selected connection type.



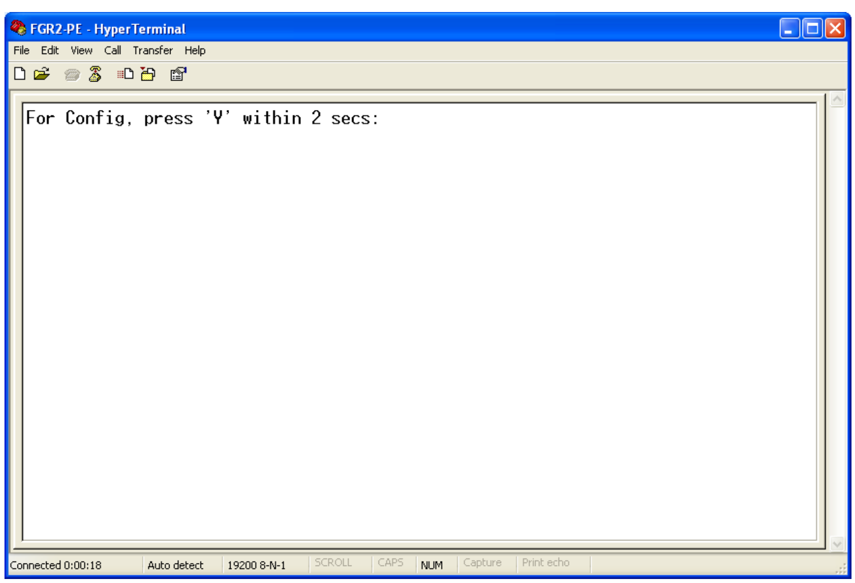
The following are the port settings which must be set for a proper connection:

	Menu Option to Select
Bits per second	19200
Data bits	8
Parity	None
Stop bits	1
Flow control	None

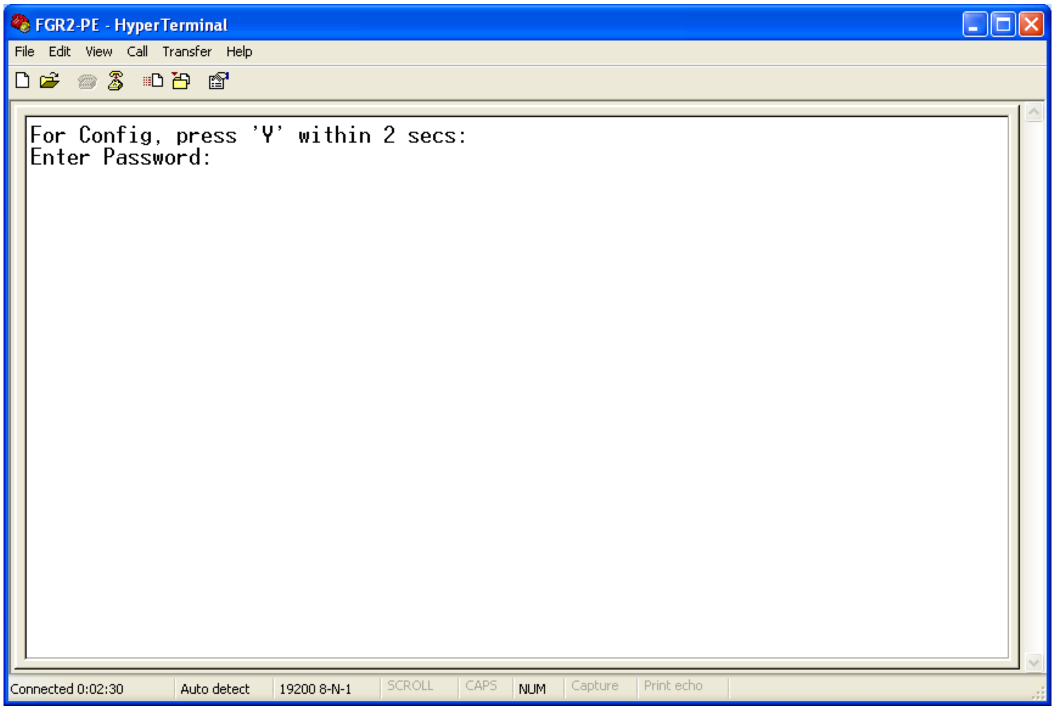
After selecting the appropriate menu items for each setting, click on the **OK** button. The following HyperTerminal dialog box appears:



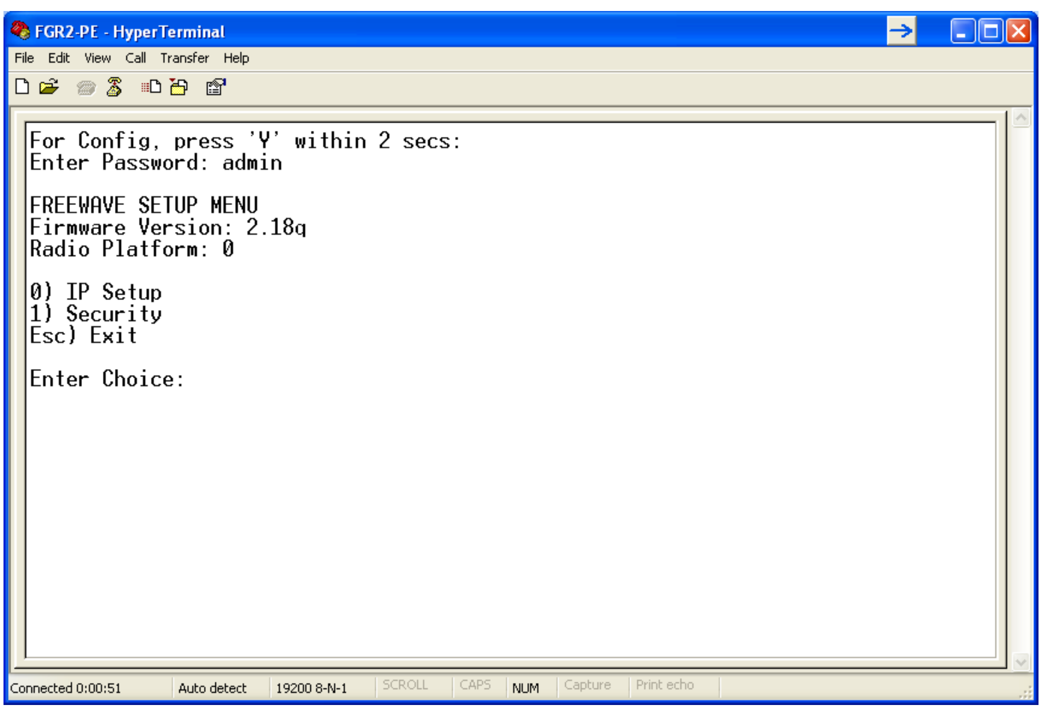
Connect power to the radio. After a few seconds, the following screen should appear in the HyperTerminal window:



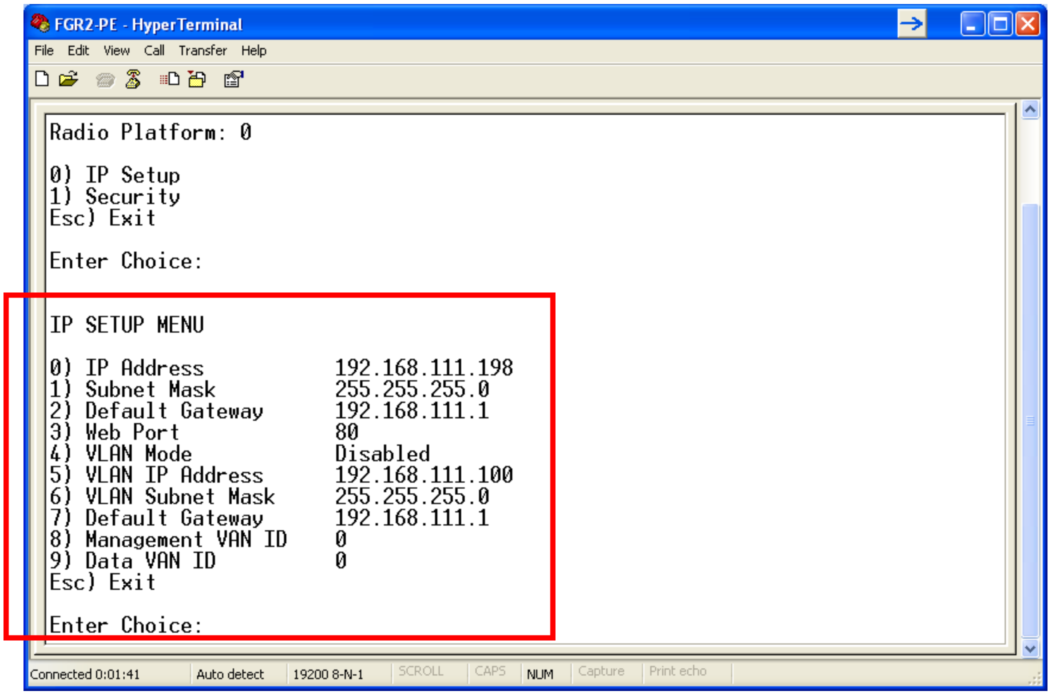
Enter a 'Y' or a 'y' **within 5 seconds** (even though the text says 2 seconds) to go into the IP setup of the radio. Any other key will exit, allowing the radio to complete the boot-up. Upon entering a 'Y', a password prompt will appear:



Entering the Administrator password (factory default is 'admin') will bring up the FreeWave Setup Menu:



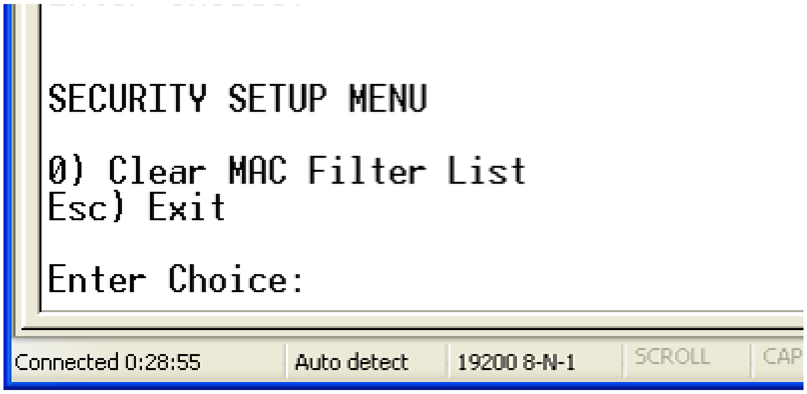
Choosing option 0 will bring up the IP Setup menu:



From this menu, the various IP Address and VLAN settings can be changed.

- Option 0 will change the IP Address of the radio. (*see p. 23*)
- Option 1 will change the Subnet Mask (also called Netmask) of the radio. (*see p. 23*)
- Option 2 will change the Default Gateway of the radio. (*see p. 23*)
- Option 3 will change the port number of the radio's Web-based configuration screens. (*see p. 24*)
- Option 4 will change the VLAN Mode (Disabled, Tagged, Untagged) of the radio. (*see p. 24*)
- Option 5 will change the Data VLAN IP Address. (*see p. 24*)
- Option 6 will change the Data VLAN Subnet Mask. (*see p. 24*)
- Option 7 will change the Data VLAN Default Gateway. (*see p. 25*)
- Option 8 will change the Management VLAN ID. (*see p. 25*)
- Option 9 will change the Data VLAN ID. (*see p. 25*)

Selecting option 5 from the main Setup Menu will bring up the Security menu:



From this menu, some of the various security options can be changed.

- Option 0 clears out the MAC Filter list, setting the radio back to allowing all Ethernet traffic.

Exiting the Setup Menu will initiate a reboot of the radio.

FreeWave Discovery Server

The IP Address of a FGR2-PE radio can also be set using the FreeWave Discovery Server. For more information on the FreeWave Discovery Server, please see **Appendix D** *(p. 89)*.

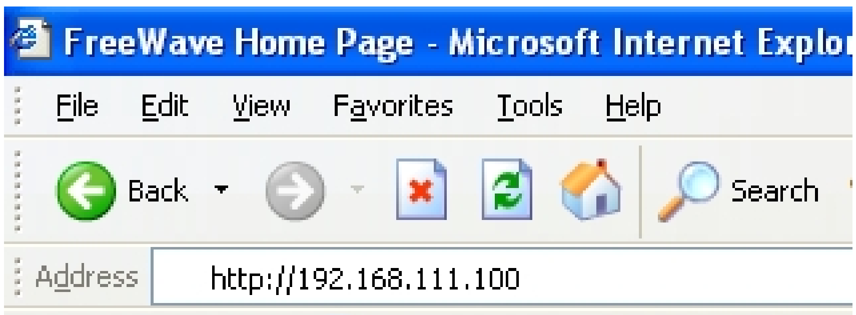
Resetting Radio to Default Settings:

Follow the steps for accessing Basic IP Setup as indicated on pages 11—14. When the **Enter Password:** prompt appears, the password 'default' can be entered. The radio will then reboot, and all of the radio settings will be reset to the factory defaults (*see p.73*).

Accessing Setup via the Built-in Web Server:

This section will discuss how to setup the settings in the FGR2-PE radio.

Plug the radio into either a computer or a switch/router using an RJ-45 cable. Open a web browser (IE, Netscape, Firefox, etc.) and type the IP address of the radio into the address bar. For example, to access an FGR2-PE radio with an IP address of 192.168.111.90, type "http://192.168.111.90" into the address bar of the web browser. A static IP address on the same subnet may need to be assigned to the router/switch and/or the computer to access the radio (*see **Appendix C**, p. 88*). The default IP address from the factory is **192.168.111.100**.



A prompt for a user name and password will appear. The default username for the Administrator login is '**admin**', the password is '**admin**'. The default username for the Guest login is '**guest**', the password is '**guest**'.

The Administrator login has full permission to change all settings on the radio, including Firmware upgrades. The Guest login can only view the settings. The Guest login can see the Status, IP Setup, Serial Gateway Setup, and Radio Setup pages. The Guest login cannot save any changes, cannot see the Security or Maintenance/Tools pages, and cannot reboot the radio.

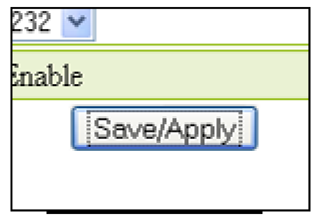
Navigating the FGR2-PE interface

Along the left side of all screens in the Web-based interface of the FGR2-PE is the **Pages List**. Clicking the items in this list allows navigation to the different configuration pages available in the FGR2-PE. The currently selected page is highlighted in teal.

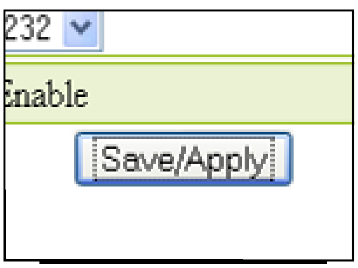
Below the **Pages List** is the **Reboot button**. Clicking this button forces a re-boot of the radio.

Pages List and Reboot button

When making changes on the various settings in the FGR2-PE, it is nec-essary to click the **Save/Apply button** before navigating away from that page or rebooting the radio. No changes will take effect until the **Save/ Apply button** is clicked. When the changes have been successfully saved and applied, the message "Change Succeeded" will appear be-neath the **Reboot button**.

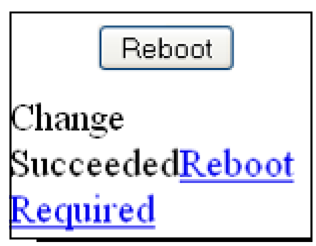


Save/Apply button



Change Succeeded message

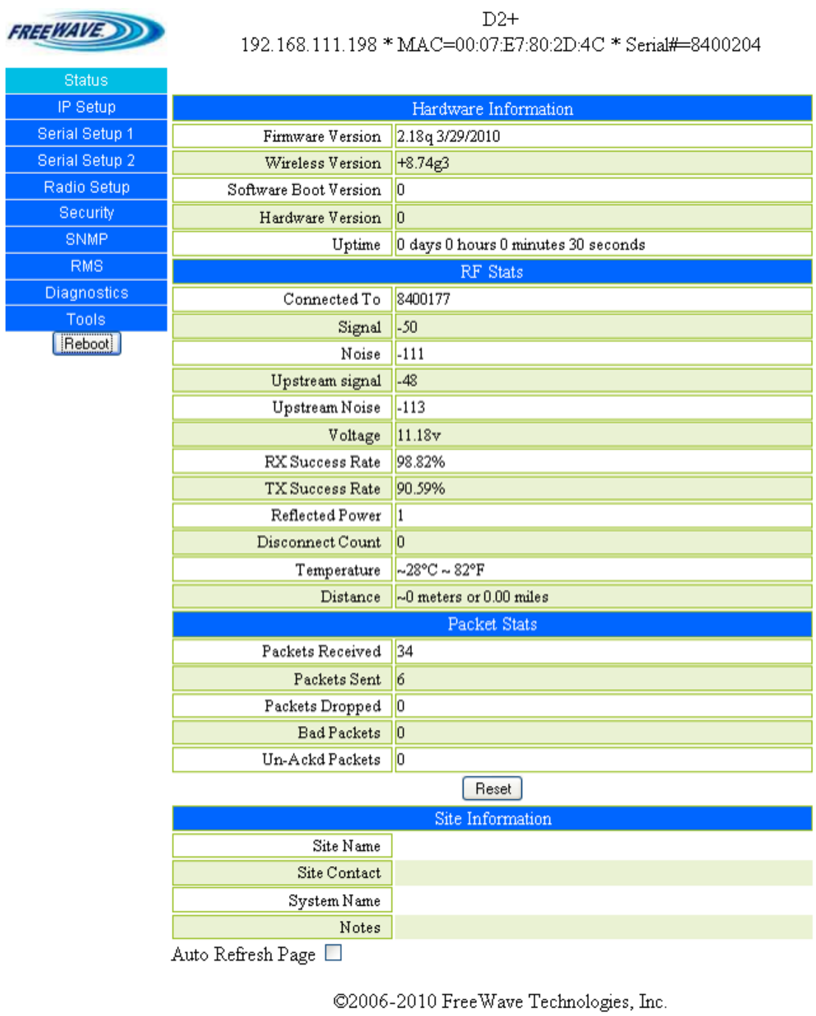
Some settings changes (such as changes to the **IP Setup** section) require a reboot to complete the changes. When such a change is made, the "Change Succeeded" message changes to include a link labeled "Reboot Required". Clicking either the "Reboot Requiured" link or the **Reboot button** will reboot the radio and apply the re-quested changes. If the user does not reboot the radio right away, the requested changes will not be made until the radio is rebooted.



Reboot required message

Status:

This page will include all of the device status information. Nothing on this screen is user adjustable. This page updates every 10 seconds.



Hardware Information	
Firmware Version	2.18q 3/29/2010
Wireless Version	+8.74g3
Software Boot Version	0
Hardware Version	0
Uptime	0 days 0 hours 0 minutes 30 seconds
RF Stats	
Connected To	8400177
Signal	-50
Noise	-111
Upstream signal	-48
Upstream Noise	-113
Voltage	11.18v
RX Success Rate	98.82%
TX Success Rate	90.59%
Reflected Power	1
Disconnect Count	0
Temperature	~28°C ~ 82°F
Distance	~0 meters or 0.00 miles
Packet Stats	
Packets Received	34
Packets Sent	6
Packets Dropped	0
Bad Packets	0
Un-Ackd Packets	0
Reset	
Site Information	
Site Name	
Site Contact	
System Name	
Notes	

Hardware Information

This is displayed at the top of every page in the radio setup. It displays the model name of the radio, the radio's IP address, the radio's MAC (hardware) address, and the radio's Serial Number.

Firmware Version

This displays the current version number of the firmware revision installed on the radio.

Wireless Version

This displays the current version number of the Radio Frequency module's firmware.

Software Boot Version & Hardware Version

These settings are for internal FreeWave use. When speaking with a Technical Support representative, they may ask for this information.

Uptime

This is the total time the radio has been running since the last reboot.

RF Stats

Connected To

This field will display the serial number of the radio's upstream connection (i.e. the Gateway or a Repeater). This statistic will display a '0' in a Multipoint Gateway.

Signal

The Signal field indicates the level of received signal at this transceiver. The signal source is the transceiver that transmits to this transceiver (shown in the **Connected To** field). The number is an average of the received signal levels measured at each frequency in the transceiver's frequency hop table. For a reliable link, the margin between the average signal level and average noise level should be 30dBm or more. Low average signal levels can often be corrected with higher gain antennas, better antenna placement and/or additional Repeaters.
Note: Please consult the install manual for antenna and FCC requirements.

Noise

The Noise field indicates the level of background noise and interference at this transceiver. The number is an average of the noise levels measured at each frequency in the transceiver's frequency hop table. Ideally, noise levels should be below –80dBm and the difference between the average signal level and average noise level should be 30dBm or more. Noise levels significantly higher than this are an indication of a high level of interference that may degrade the performance of the link. High noise levels can often be mitigated with band pass filters, antenna placement or antenna polarization.

Upstream Signal

The Upstream Signal field indicates the level of the signal received by the upstream radio (listed in the **Connected To** field) from this transceiver. The number is an average of the received signal levels measured at each frequency in the upstream radio's frequency hop table. This statistic is only valid in a Multipoint Endpoint or Multipoint Repeater.

Upstream Noise

The Upstream Noise field indicates the level of the RF noise at the upstream radio (listed in the **Connected To** field). The number is an average of the noise levels measured at each frequency in the upstream radio's frequency hop table. Ideally, noise levels should be below –80dBm and the difference between the average signal level and average noise level should be 30dBm or more. This statistic is only valid in a Multipoint Endpoint or Multipoint Repeater.

Voltage
This displays the voltage level of the power being supplied to the radio.

RX Success Rate
This statistic shows the percentage of packets successfully received by this radio. This statistic will show '0.00%' in a Multipoint Gateway. This statistic is only valid in a Multipoint network. FreeWave recommends a minimum of 75% for proper radio operation.

TX Success Rate
This statistic shows the percentage of packets sent by the radio that successfully reached the upstream radio (i.e. the Gateway or a Repeater). This statistic will show '0.00%' on a Multipoint Gateway or Multipoint Repeater. This statistic is only valid on Multipoint Endpoint radios. FreeWave recommends a minimum of 75% for proper radio operation.

Reflected Power
This is a measurement of the transmitted power that is reflected back into the transceiver from mismatched antennas, mismatched cables, or loose connections between the transceiver and the antenna. A reading of 0-5 is **good**. 5-29 is **acceptable to marginal**. 30+ is **unacceptable** and indicates that the connections should be inspected for loose connections and cable quality.

Disconnect Count
This statistic show the number of times the radio has lost its RF connection to its upstream radio. This statistic is not valid in Multipoint Gateways or Point-to-Point Repeaters.

Temperature
This indicates the current operating temperature of the radio in both degrees Celsius and degrees Fahrenheit.

Distance
This is the distance between this radio and the radio to which it is directly linked. Distances greater than 3/5 of a mile are typically accurate to within 100 feet. Shorter distances are not reported accurately.

Packet Stats
Packets Received
This statistic shows the number of Ethernet packets the radio has received over its radio link.

Packets Sent
This statistic shows the number of Ethernet packets the radio has sent over its radio link.

Packets Dropped
This statistic shows the number of Ethernet packets the radio has thrown away due to its data buffer being full.

Bad Packets
This statistic shows the number of Ethernet packets the radio has thrown away due to a bad CRC checksum.

Un-Acked Packets
This statistic shows the number of Ethernet packets sent using a broadcast MAC address. These packets are unacknowledged by the destination device.

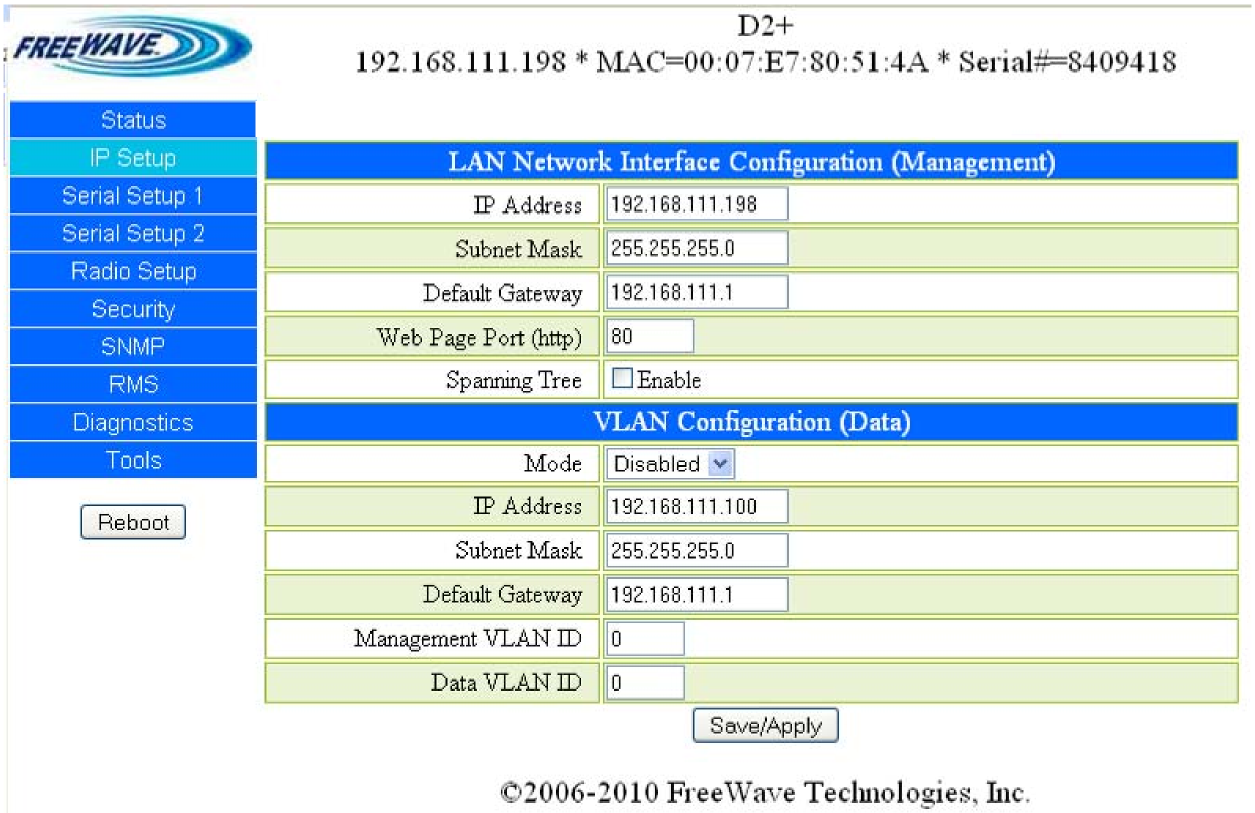
Reset Button
Clicking this button will reset all of the statistics in the **Ethernet Stats** section to 0. Power-cycling or rebooting the radio will also reset all the statistics.

Site Information
Site Name / Site Contact / System Name / Notes
These are user-defined fields. The values for these fields can be entered under the Tools page.

Auto Refresh Page
Checking this box causes the Status page to refresh its information every 10 seconds. By default, this box is not checked and the Status page does not refresh. Navigating away from the Status page will cause this box to revert to its unchecked default.

IP Setup:

This page will be used to setup the IP address, Subnet Mask, and Default Gateway of the radio. Please check with a Network Administrator before adjusting these settings. Many of these settings are also available through **Basic IP Setup** (*see p. 11*) or the **Discovery Server** (*see p. 89*).



LAN Network Interface Configuration (Management)

IP Address / Subnet Mask / Default Gateway

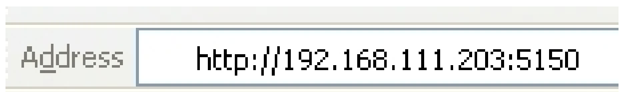
A unique IP address will need to be assigned to each FGR2-PE radio modem. The IP addresses must be in the proper subnet. A Network Administrator will be able to assign the proper IP addresses for the radios. It is also possible to have a transparent bridge with an IP address of 255.255.255.255, but serial port functionality, the Security features, and access to the Web-based setup pages will be lost. To reassign a valid IP address, follow the instructions in **Basic IP Setup** (*see p. 10*) or use the **FreeWave Discovery Server** *(see p. 89)*. The Subnet Mask and Default Gateway are normally assigned by a network administrator. **NOTE:** Putting multiple devices on the network with the same IP address can cause the whole network to crash.

When the VLAN **Mode** option (*see p. 24*) is set to *Tagged **or** Untagged*, this IP information will be assigned to the Management portion of the radio (Setup pages, SNMP, Discovery Server). Any communication with the FGR2-PE's Setup pages, SNMP, or changes via the Discovery Server will need to be addressed to this IP address and tagged with the **Management VLAN ID**.

Web Page Port

This setting allows the assigned port for the Web interface Setup pages to be changed. The default setting is port 80, the standard Web page port. If this setting is changed from port 80, the proper port number must be included when accessing the Setup pages:
http://<IP address>:<Port>, where **<IP address>** is the IP address of the FGR2-PE radio, and **<Port>** is the port number assigned in the IP Setup page. Any valid TCP port can be entered from 1 to 65535. If an invalid TCP port is entered, the FGR2-PE radio will default the Web Page Port setting to 80. In the example below, the Web Page port was changed to 5150.

Example:



Spanning Tree

Checking the **Enable** box will cause a Gateway radio to utilize Spanning Tree Protocol (IEEE 802.1D). This will eliminate the possibility of the radios creating a network loop, which can cause network-wide problems. Spanning Tree Protocol does use radio bandwidth, as any Spanning Tree radios are constantly communicating their network "location." FreeWave Technologies recommends leaving Spanning Tree **unchecked**, unless Spanning Tree Protocol is required by your application.

VLAN Configuration (Data)

Mode

This drop-down selects whether VLAN will be active and which mode will be utilized.

- **Disabled:** VLAN will not be used.
- **Tagged:** If the data coming into the radio's local Ethernet port is tagged with a VLAN ID, select this option. The radio will bridge the data, leaving the VLAN ID as-is.
- **Untagged:** If the data coming into the radio's local Ethernet port is **not** tagged with a VLAN ID, select this option. The radio will accept the data, tag it with the VLAN ID entered in the **Data VLAN ID** field, and send it across the radio link. Data arriving at this radio and being sent out of the local Ethernet port will have any VLAN tag removed before being sent out of the port

IP Address

When the VLAN **Mode** is set to *Tagged* or *Untagged*, the IP Address entered here will be assigned to the Data portion of the radio (Ethernet port traffic and terminal server communication). Any data destined for the FGR2-PE's serial port or its Ethernet port will need to be addressed to this IP address and tagged with the **Data VLAN ID**.

Subnet Mask

The appropriate subnet mask for the Data VLAN IP address (*above*) should be entered in this box.

Default Gateway

The appropriate default gateway for the Data VLAN IP address (*p. 24*) should be entered in this box.

Management VLAN ID

Computers and devices using the VLAN ID entered here will be able to access the radio's Setup Pages, receive SNMP information, send SNMP commands, and view the radio via the Free-Wave Discovery Server.

Data VLAN ID

Data using this VLAN ID will be allowed to come into or be sent out of the radio's local Ethernet port and will be allowed to access the serial ports via the terminal server.

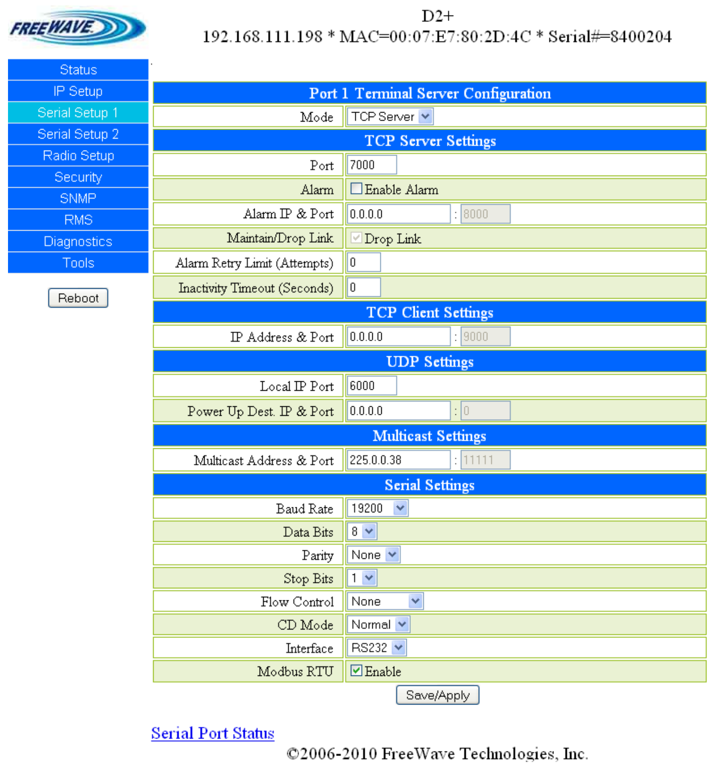
****NOTE**** Not every network needs or uses VLAN IDs. The **Mode** setting is normally kept at **Disabled**. Changes to these settings should be approved by a Network Administrator.

Save/Apply Button

Clicking this button saves any settings changes in the **IP Setup** page, and applies those changes to the radio. Before the changes become active, the radio requires a reboot. Navigating away from the **IP Setup** page without clicking this button discards any changes.

Serial Setup 1 and Serial Setup 2:

This is where the port numbers and data settings for each serial port can be assigned. These settings need to match the device to which each port is connected. The ports are independent of each other: they can have different baud rates, parity, protocol, etc. To access either port, a client will need to call the IP address of the radio plus the port number. If both ports are disabled, the Basic IP Setup will still work through Port 1. Each serial port is configured on its own page.



Port 1/Port 2 Terminal Server Configuration

Mode

This drop-down box selects the operating mode of the radio's terminal server. The available modes are described below.

Disable

Selecting this mode disables the associated serial port, preventing it from accepting data or a TCP connection.

TCP Server

Selecting this mode enables the radio as a TCP terminal server (its default mode). The number entered in the **Port** box in the **TCP Server Settings** section will be the TCP port that the radio listens to for connection requests. In the picture above, the server is set for port 7000.

TCP Client

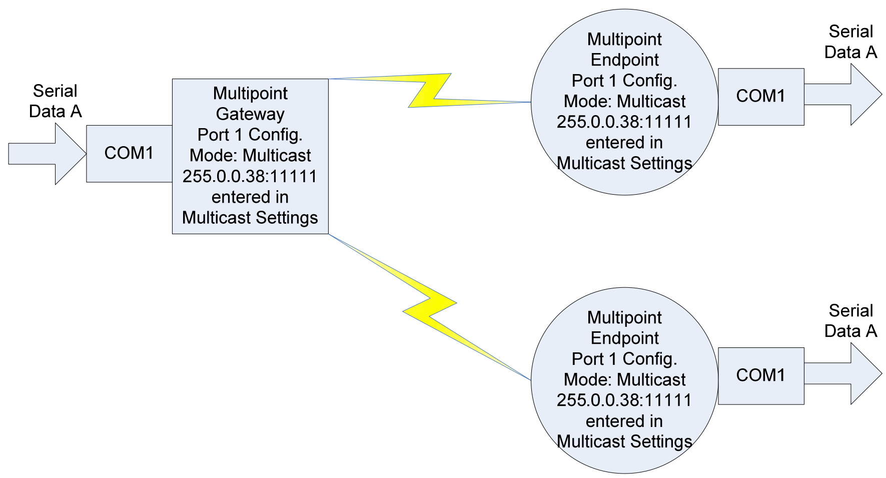
Selecting this mode causes the radio to act as a TCP client to the IP address and port number entered in the **TCP Client Settings** section. Upon booting up, the radio will create a persistent outgoing TCP connection to the entered IP address and port number. Any data sent to the associated serial port on the radio is automatically directed to the entered IP address and port number.

UDP

Selecting this mode enables the radio as a UDP terminal server using the port number entered in the **UDP Settings** section. The port number entered in the **UDP Settings** section will be the UDP port that the radio listens to for requests. Once a request comes into that port, the radio will send any incoming serial data to the IP address of the requesting device. The radio will continue doing so until a new device makes a request on that UDP port. The radio will always send the serial data to the address of the last successful requesting device.

Multicast

Selecting this mode will allow a one-to-many connection from the Multipoint Gateway's serial port to the interested Multipoint Repeaters' and/or Endpoints' serial ports.



In a Multipoint Gateway radio, selecting this mode will cause the radio to act as an IP Multicast Sender on the Multicast address and port entered in the **Multicast Settings** section.

In a Multipoint Repeater or Multipoint Endpoint, selecting this mode will register that radio's interest for any Multicast packets sent from the Multicast address and port entered in the **Multicast Settings** section.

TCP Server Settings

Port

The number entered in this box will be the TCP port the radio listens to for incoming TCP connections. Any valid TCP port number (0—65535) may be entered in this box.

Alarm

Checking the **Enable Alarm** box enables the port as an alarm client. To use this function, the **Alarm IP & Port** boxes must also be configured. The radio will act as a terminal server on the port specified in the **Port** box *(see also:* **Port***, p. 27)*. If there is no current TCP connection to this port and serial data is received on the local serial port, the radio will become a client and make a connection to the IP address and port number specified in the **Alarm IP & Port** line.

Alarm IP & Port

This line sets the IP address and TCP port number the radio will connect to when it becomes a client per the **Alarm** setting (above). The IP address is entered in the box to the left of the colon. The TCP port number is entered in the box to the right of the colon. The port number must be set to a valid TCP port (0—65535).

Maintain/Drop Link

Checking the **Drop Link** checkbox will cause the outgoing connection to the **Alarm IP & Port** to be dropped as soon as the serial data is sent. Unchecking the **Drop Link** checkbox will keep the connection to the remote IP Address and port number active until the radio is rebooted or the server side drops the link.

Alarm Retry Limit (Attempts)

This setting is the number of times the radio will attempt to create an outgoing TCP connection when acting as an alarm client (*see* **Alarm***, above*). When the radio reaches the number of retries listed in this setting without a successful connection, it will cease trying and act as if no alarm was received. The incoming data will be flushed from the radio's data buffer. If new incoming data is received, the radio will attempt to connect again. A setting of "0" means that the radio will continuously try to connect to the alarm server until the radio is rebooted.

Inactivity Timeout (Seconds)

This setting controls how long an incoming TCP connection must be idle (i.e. no data being transferred) before the radio drops the connection. This setting is in seconds. A setting of "0" means that the radio will never disconnect an idle connection—all disconnects will need to come from the client.

TCP Client Settings

IP Address & Port

This line sets the IP address and TCP port number the radio will create a connection to upon boot-up, when the radio is set to the **TCP Client** mode (*see* **TCP Client***, p. 27).* The IP address is entered in the box to the left of the colon. The TCP port number is entered in the box to the right of the colon. The port number must be set to a valid TCP port (0—65535).

UDP Settings

Local IP Port

The port number entered in this box is the UDP port the radio will listen to for connections when the Mode is set to **UDP**. The port number must be set to a valid UDP port (0—65535).

Power Up Dest. IP & Port

In this line, an IP Address and Port Number can be entered. In a radio set to a Mode of **UDP**, Before an incoming UDP request has been received by the radio, the IP Address and Port number entered here will be where the radio sends any serial data coming into its serial port. Once a UDP request is received, the radio will operate as listed above. The IP address is entered in the box to the left of the colon. The UDP port number is entered in the box to the right of the colon. The port number must be set to a valid UDP port (0—65535).

Multicast Settings

Multicast Address & Port

This line sets the IP address and port number that will be used for Multicast. In a Multipoint Gateway, this will be the sending address. In Multipoint Endpoints and Multipoint Repeaters, this will be the address they register interest in (*see* **Multicast***, p. 27*). The IP address is entered in the box to the left of the colon. The UDP port number is entered in the box to the right of the colon. The port number must be set to a valid UDP port (0—65535).

Any IP addresses used in this line must be designated Multicast addresses (**224.0.0.0** to **239.255.255.255**).

Serial Settings

Baud Rate

This setting is the communication rate between the serial port on the radio and the instrument to which it is connected. It is important to note that this is independent of the baud rate for any other transceivers in the network. It is also independent of the other serial port on the radio. For example, a pair of transceivers may be used in an application to send data from remote process instrumentation to an engineer's computer. In this application, the baud rate for the transceiver on the instrumentation might be set to 9600, and the transceiver on the engineer's computer might be set to 57,600. A serial radio may be attached to one port and an RTU/PLC/End Device attached to the other. In this case, one port might be set at 115,200 and the other might be set at 9,600. It is usually most desirable to set the baud rate to the highest level supported by the device to which it is connected. In certain circumstances, however, this may actually result in slower data communications (i.e.: trying to run higher baud rates [38400 and higher] without flow control).

Data Bits

This option sets the number of data bits the serial port will send. This should match the number of data bits the connected device requires or is set to. The available settings are: **5**, **6**, **7**, and **8**.

Parity

This option sets the parity type the serial port will use. This should match the parity required by the connected device's settings. The available settings are: **None**, **Even**, and **Odd**.

Stop Bits

This option sets the number of stop bits the serial port will send. This should match the number of stop bits required by the connected device's settings. The available settings are: **1** and **2**.

Flow Control

This option sets whether hardware flow control will be used on this serial port. The available settings are:

None Uses software flow control (XON / XOFF)
Hardware Hardware flow control (RTS / CTS)

CD Mode

This controls the function of the CD line on the serial port.

Normal CD is asserted when a TCP connection to the associated port is made, and de-asserted when the TCP connection is closed. Most serial devices will use this option.

Keyed CD asserts 500 µs before transmit, and de-asserts 1 ms after the transmission of the first bit of the last byte of data. This option should be used with serial devices that require the CD line to be asserted prior to the transmission of data.

Interface

This option sets the serial protocol the serial port will use. This should match the protocol required by the connected device. The available settings are: **RS232**, **RS485**, and **RS422**. See page 78 for pinout information.

Modbus RTU

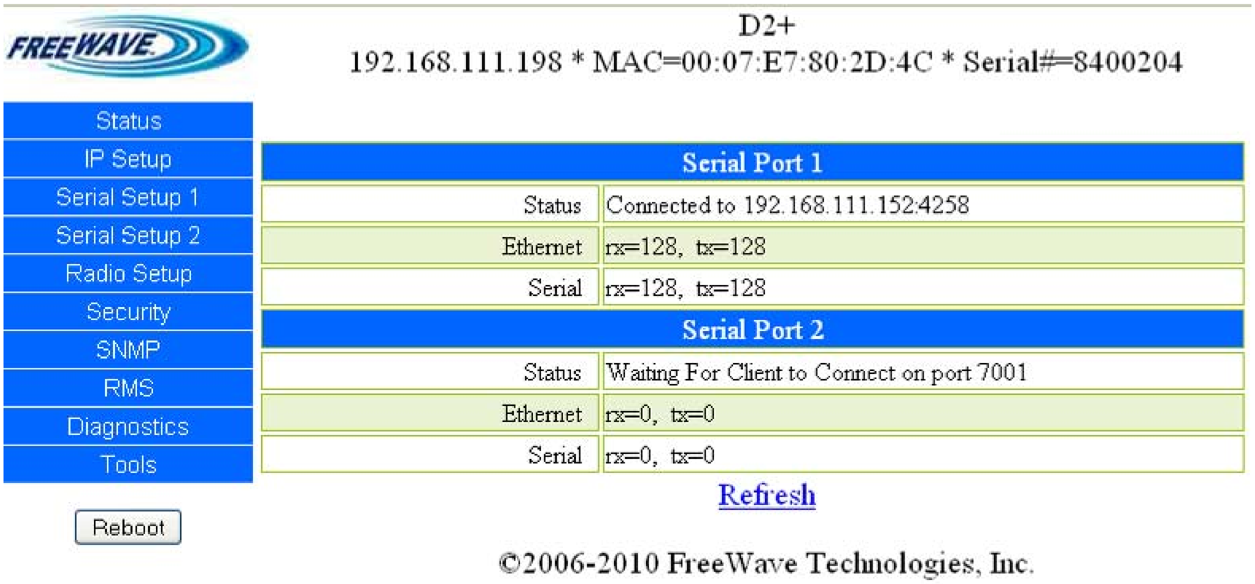
This option adjusts for Modbus RTU timing. When enabled, the radio will gather data on the serial port until there is a break in the data due to Modbus RTU timing (every 256 bytes). The data is then sent as one TCP packet.

Save/Apply Button

Clicking this button saves any settings changes in the **Serial Setup 1** or **Serial Setup 2** pages, and applies those changes to the radio. Navigating away from the **Serial Setup 1** page or the **Serial Setup 2** page without clicking this button discards any changes.

Serial Port Status

Clicking on the **Serial Port Status** link at the bottom of this page will open a new window (shown below) which displays Terminal Server Diagnostics. For each serial port, the current status of the Terminal Server is listed first (Waiting, Connected, etc.).



The **Ethernet** line shows the amount of data received (rx) and transmitted (tx) from the terminal server. Received (rx) data indicates data received on the radio from the serial port. Transmitted (tx) data indicates data sent from the radio out the serial port. This amount is in bytes.

The **Serial** line shows the amount of data received (rx) and transmitted (tx) from the serial port. Received (rx) data indicates data coming from the connected device into the serial port. Transmitted (tx) data indicates data sent out the serial port to the connected device. This amount is in bytes.

This page updates every 5 seconds.

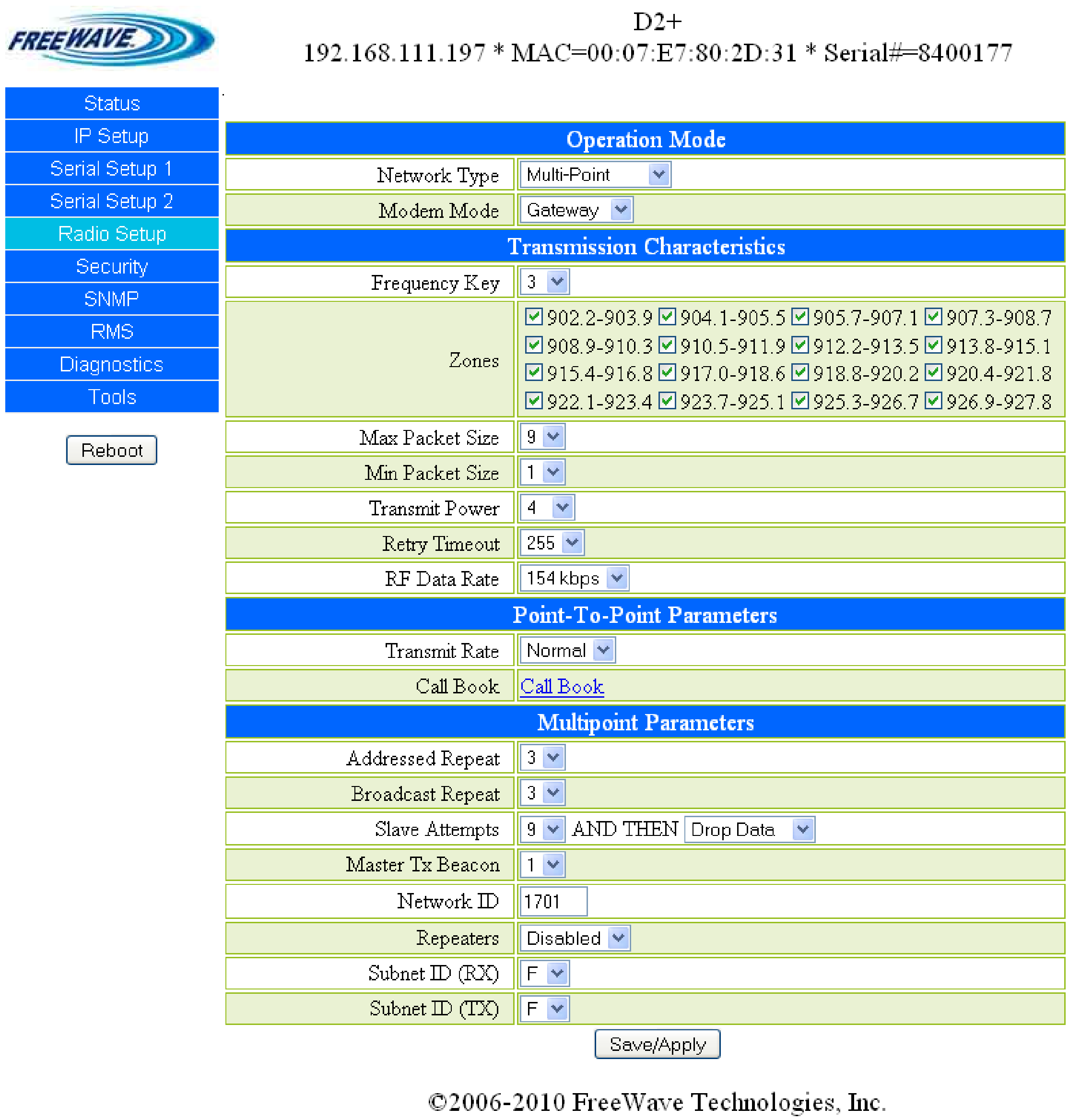
Radio Setup:

This page is where the radio's Operation Mode, Transmission Characteristics, Multipoint Parameters, and the Call Book can be set up.

When setting the operation mode, there are two menus: Network Type and Modem Mode. The Network Type is either Point-To-Point or Point-To-Multipoint. The Modem Mode is either Gateway, Repeater, or Endpoint.

In Point-To-Point mode, the repeater is not an Endpoint/Repeater. The Call Book must also be used in Point-To-Point mode.

In Point-To-Multipoint mode, either the Call Book or Network ID can be used. Any Repeater in a Point-To-Multipoint network will be an Endpoint/Repeater.



Operation Mode

Network Type / Modem Mode

The Network Type and Modem Mode options designate the method FreeWave transceivers use to communicate with each other. FreeWave FGR2-PE transceivers operate in a Gateway to Endpoint configuration. Before the transceivers can operate together, they must be set up to properly communicate.

In a standard configuration, the Gateway Mode should be used on the end which will be connected to the LAN. When setting up the transceiver, remember that a number of parameters are controlled by the settings in the Gateway. Therefore, deploying the Gateway on the communications end where it will be easier to access is strongly advised.

Operation Mode	Description
Point-to-Point & Gateway	This mode designates the transceiver as the Gateway in Point-to-Point mode. The Gateway may call any or all Endpoints designated in its Call Book. A quick method of identifying a Gateway is to power the transceiver. Prior to establishing a communication link with an Endpoint or Repeater, all three of the Gateway's lower LEDs (CD, TX, CTS) will be solid red.
Point-to-Point & Endpoint	This mode designates the transceiver as an Endpoint in Point-to-Point mode. The Endpoint communicates with any Gateway in its Call Book—either directly or through up to four Repeaters. When functioning as an Endpoint, the **Entry to Call** feature in the transceiver's Call Book is not operational.
Multipoint & Gateway	This mode designates the transceiver as a Gateway in Multipoint mode. This mode allows one Gateway transceiver to simultaneously be in communication with numerous Endpoints and Repeaters. A Multipoint Gateway communicates only with other transceivers designated as Multipoint Endpoints or Multipoint Repeaters.
Multipoint & End-Point	This mode designates the transceiver as an Endpoint in Multipoint mode. This mode allows the Endpoint to communicate with a Multipoint Gateway. The Endpoint may communicate with its Gateway through one or more Repeaters.
Point-to-Point & Repeater (Single-radio Repeater)	FreeWave allows the use of up to four Repeaters in a Point-to-Point communications link, significantly extending the operating range. When designated as a Point-to-Point Repeater, a transceiver behaves as a pass-through link. All settings for the call book, baud rates and radio transmission characteristics are disabled. A Repeater will connect with any Gateway that calls it. The Repeater must be set up properly in the Gateway's call book. **This Network Type and Modem Mode should be the ones used when operating the FGR2-PE as a terminal server only (no RF connectivity). Adding a repeater to the radio network results in greatly reduced throughput—over 50% less.**
Multipoint & Repeater (Single-radio Repeater)	This option allows the transceiver to operate as an Endpoint/Repeater in a Multipoint network. **Adding a repeater to the radio network results in greatly reduced throughput—over 50% less. Some advanced features of the FGR2-PE radio do not operate in networks containing Repeaters. FreeWave Technologies does not recommend the use of single-radio Repeaters.**

Transmission Characteristics

The Transmission Characteristics section of the Radio Setup page allows the user to modify several different parameters in the transceiver. Many of these parameters must be maintained throughout the network for proper functionality.

Note: This section is **only** for the advanced user who has a good understanding of the principles of radio data transmission.

In a Point-to-Point network, the settings for the Endpoints and Repeaters that are not determined by the Gateway are **Transmit Power** and **Retry Time Out**. All other settings in a Point-to-Point network are determined by the Gateway radio's settings.

Frequency Key

The Frequency Key setting in the Radio Setup menu allows the user to modify the hopping patterns of the transceiver. There are 15 choices available for the Frequency Key setting (0-9 and A-E), representing 15 different pseudo-random hop patterns. This is to minimize the interference with other FreeWave transceivers operating in the area. For instance, if there were 10 pairs of FreeWave transceivers operating on different networks in close proximity, setting a different Frequency Key value for each pair reduces the chance that transceivers will hop to the same frequency at the same time. If two networks were to hop to the same frequency by chance, the next hop would be to a different frequency for both networks.

Additional network separation can be gained by adjusting the Max and Min packet sizes.

Zones

The idea of frequency zoning is to divide the available band (902 MHz to 928 MHz) into smaller bands—in this case 16 smaller bands each consisting of 7 or 8 frequency channels. These 16 Zones are listed in the **Zones** line of the **Radio Setup** page. A checkmark indicates that zone will be used by the radio. A blank box indicates the radio will not use those frequencies. The zones listed are in MHz. The radio requires at least one zone active to operate. If all Frequency Zones are de-selected, the radio will operate as if all zones were selected.

Any Endpoint or Endpoint/Repeater radios will take their Frequency Zone settings from the Gateway radio, regardless of Network Type. Therefore, this section should only be changed on the Gateway radio.

Max Packet Size & Min Packet Size

The Max and Min Packet Size settings and the RF Data Rate determine the number of bytes in the packets. Throughput can be enhanced when packet sizes are optimized. In Point-to-Point mode, the Max and Min Packet Settings will not have material impact on throughput unless the full 92 Kbps data rate is desired. However, this may have an impact on latency. For example, if small amounts of data are sent and large packet sizes are selected, there would be a certain amount of time “wasted” between each packet.

The following tables provide the information to determine optimum setting values.

The default settings for Max packet size, Min packet size, and RF Data Rate on the FGR2-PE are 9, 1, and 154 Kbps, respectively.

The following table defines the Minimum packet size (in bytes) by way of charting the Min Packet Size setting versus the RF Data Rate setting. Using the default settings, the actual minimum packet size for the radios, in bytes, is 21.

Minimum Packet Size Definition FGR2-PE		
Min Setting	**Min Packet Size (bytes) RF Data Rate = 154 Kbps**	**Min Packet Size (bytes) RF Data Rate = 115 Kbps**
0	15	8
1	21	12
2	26	16
3	31	20
4	37	24
5	42	28
6	47	32
7	53	36
8	58	40
9	63	44

The following table defines the Maximum packet size (in bytes) by way of charting the Min Packet Size setting versus the Max Packet Size setting where the RF Data Rate is set to 154 Kbps. Using the default settings, the actual maximum packet size, in bytes, is 213.

Maximum Packet Size Definition with RF Date Rate of 154 kbps (in bytes)										
	Max Setting (Blank area = Not Recommended)									
Min Setting	0	1	2	3	4	5	6	7	8	9
0								165	186	207
1								170	191	213
2							154	175	197	218
3							159	181	202	223
4							165	186	207	229
5							170	191	213	234
6						154	175	197	218	239
7						159	181	202	223	245
8						165	186	207	229	250
9						170	191	213	234	255

Referencing the default settings, the Gateway will transmit up to 213 bytes on every hop. If fewer than 213 bytes are transmitted by the Gateway, the balance is allocated to the Endpoint's transmission, plus the quantity in the Min Packet Size Setting. For example: if a Gateway transmits 100 bytes, the Endpoint will then have a total of 134 bytes available [113 ("leftover bytes") + 21 (Min packet size)].

Maximum Packet Size Definition with RF Date Rate of 115 kbps (in bytes)										
	Max Setting (Blank area = Not Recommended)									
Min Setting	0	1	2	3	4	5	6	7	8	9
0						88	104	120	136	152
1						92	108	124	140	156
2					80	96	112	128	144	160
3					84	100	116	132	148	164
4					88	104	120	136	152	168
5					92	108	124	140	156	172
6				80	96	112	128	144	160	176
7				84	100	116	132	148	164	180
8				88	104	120	136	152	168	184
9				92	108	124	140	156	172	188

The above table defines the Maximum packet size (in bytes) by way of charting the Min Packet Size setting versus the Max Packet Size setting where the RF Data Rate is set to 115 Kbps.

Transmit Power

This option sets the transmit power of the radio. A setting of **10** is approximately 1W of output power in an FGR2-PE.

Setting	Power (in mW)
0	5
1	10
2	35
3	80
4	140
5	230
6	330
7	480
8	600
9	800
10	1000

Retry Time Out

The Retry Time Out parameter in an Endpoint or Repeater sets the delay the unit will wait before dropping the connection to a Gateway or Repeater in Multipoint mode. The factory default is set at the maximum of 255. The maximum setting means that if 1 packet in 255 is received successfully by that radio, the link will be maintained. The minimum setting is 8. This allows an Endpoint or Repeater to drop a connection if less than 1 in 8 consecutive packets is successfully received from the Gateway.

The function in the Gateway is effectively the same. With a setting of 255, the Gateway will allow an Endpoint or Repeater to stay connected as long as 1 packet in 255 is successfully received at the Gateway.

The Retry Time Out parameter is useful when a Multipoint network has a roving Gateway or Endpoint(s). As the link gets weaker, a lower setting will allow a poor link to break in search of a different link.

Note: Setting Retry Time Out to 20 is recommended in areas where several FreeWave networks exist. This setting will allow Endpoints and Repeaters to drop the connection if the link becomes too weak, while at the same time prevent errant disconnects due to interference from neighboring networks.

While intended primarily for Multipoint networks, the Retry Time Out parameter may also be modified in Point-to-Point networks. However, the value in Point-to-Point mode should not be set to less than 151.

RF Data Rate

FGR2-PE transceivers have two settings for the RF Data Rate: 154 Kbps and 115 Kbps. RF Data Rate should not be confused with the serial port Baud Rate. A setting of 154 Kbps should be used when the transceivers are close together and data throughput needs to be optimized. A setting of 154 Kbps must also be used when the full throughput of 92 Kbps is necessary. A setting of 115 Kbps should be used when the transceivers are farther away and a solid data link is preferred over data throughput.

The maximum available throughput in an FGR2-PE radio, assuming optimum signal strength, is:

- ≈70 kbps at an RF Data Rate of 115 kbps
- ≈92 kbps at an RF Data Rate of 154 kbps

Note: In Multipoint networks, the RF Data Rate must be set identically in all transceivers. Any transceiver with an RF Data Rate different from the Gateway will not establish a link. In Point-to-Point networks, the Gateway's RF Data Rate settings take precedence over the Endpoint.

Point-to-Point Parameters

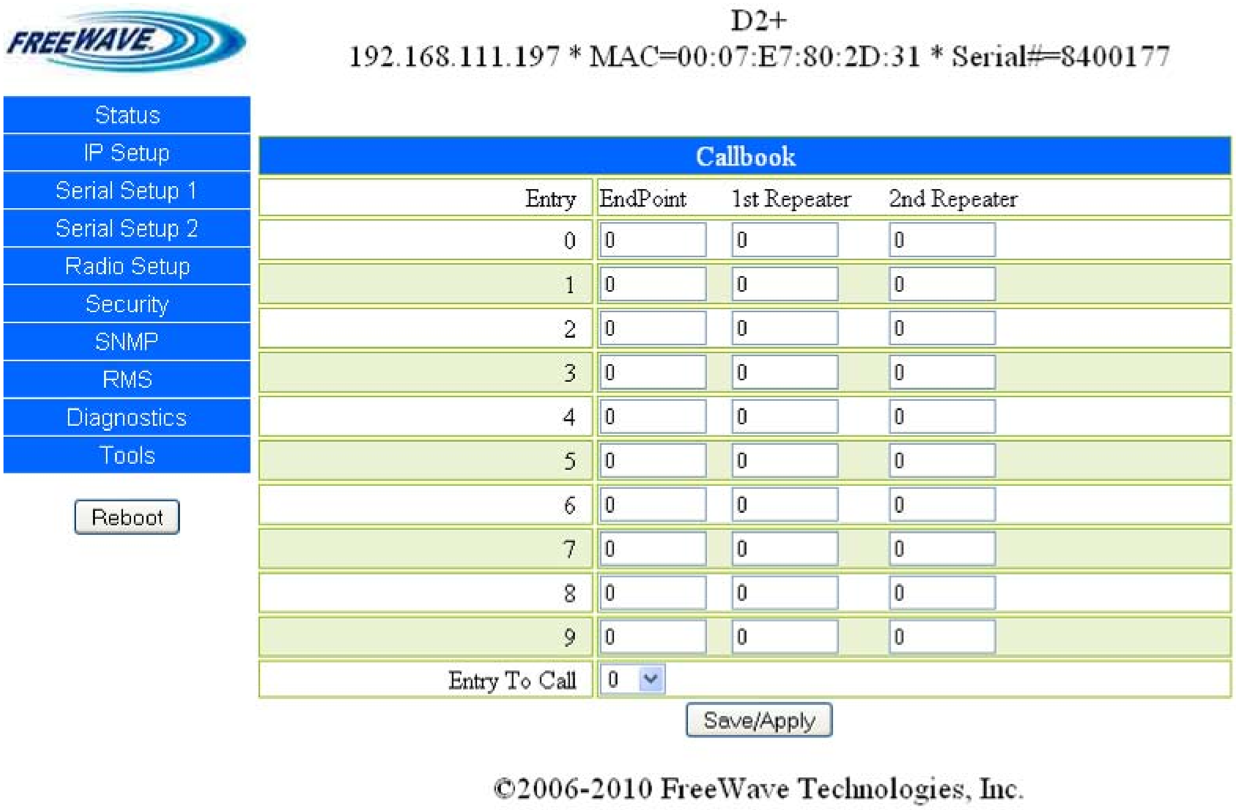
The items in this section are mainly set in Point-to-Point Networks, although they do have some usage in Multipoint networks.

Transmit Rate

There are two settings for the Transmit Rate parameter. The setting for normal operation of the transceiver is **Normal**. The Transmit Rate of **Diagnostics** is useful to qualitatively gauge signal strength in Point-to-Point mode. When set to **Diagnostics**, the transceivers will transmit back and forth continuously, whether or not the radios have received any actual data. In Point-to-Point operation, a Transmit Rate of **Diagnostics** should be used only as a diagnostic tool and not for normal operation. The strength of the signal may be gauged by the Clear to Send (CTS) LED. A solid red CTS LED indicates a strong signal; a blinking CTS LED indicates a weaker signal.

Call Book

Clicking the **Call Book** link opens the **Call Book** page.



Use of the Call Book is required in Point-to-Point networks. While the call book is an option in Point-to-Multipoint networks, the Network ID feature is strongly recommended in most applications.

The instructions provided in this section are for Point-to-Point mode only. Use of the Call Book for Multipoint networks is explained on **page 41** of this manual.

Using the Call Book offers both security and flexibility in determining how FreeWave transceivers communicate with each other.

Three settings must be made for two FreeWave transceivers to communicate in Point-to-Point mode:

- The Gateway's Serial Number must be listed in the Endpoint's Call Book (**EndPoint** column).
- The Endpoint's Serial Number must be listed in the Gateway's Call Book (**EndPoint** column).
- The Gateway must be programmed to call the Endpoint (**Entry to Call** drop-down box).

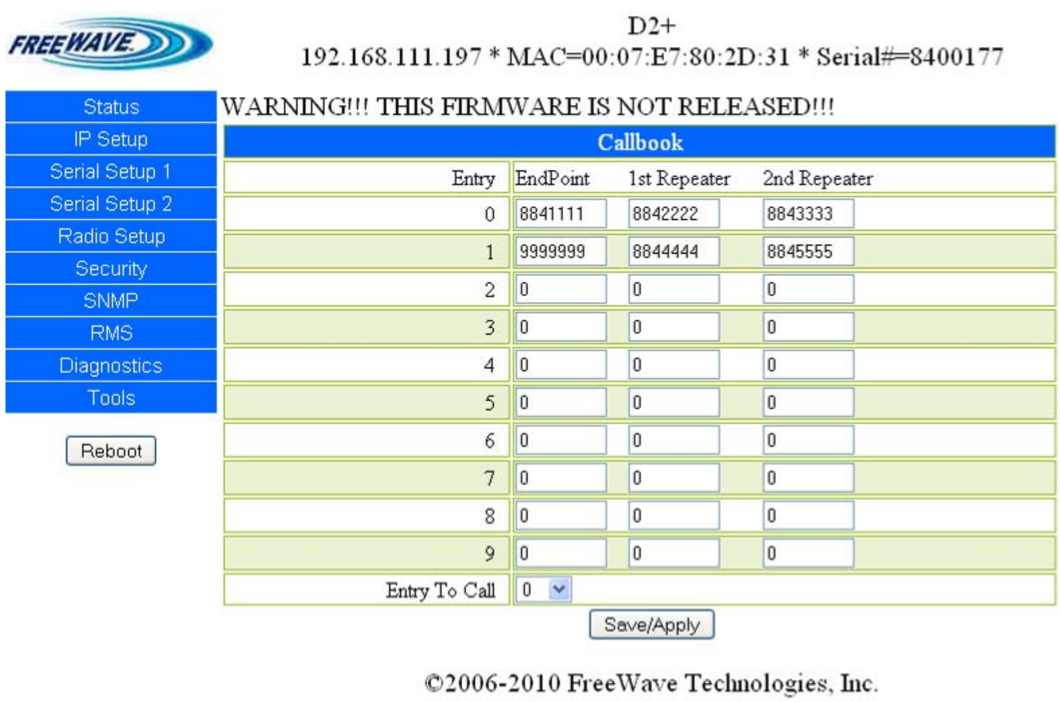
The Call Book allows users to incorporate up to 10 FreeWave transceivers, designate 1 to 4 Repeaters to be used with each transceiver, and designate which Endpoint the Gateway will call.

If a Call Book entry utilizes 3 or 4 Repeaters, then the total number of available Endpoint entries will be reduced, as an extra Call Book line would be in use for Repeaters #3 and #4. To set the **Entry to Call** option, choose the appropriate Entry number in the **Entry to Call** drop-down.

It is important that the Call Book slots (0-9) are filled sequentially starting with slot 0. When a Gateway is instructed to Call All, it will call all Endpoints listed until it reaches the first blank entry. If a valid serial number is entered after the blank entry or as a Repeater, it will not be recognized as a valid number by the Gateway.

Note: To call a Endpoint through one or more Repeaters, that Endpoint must be called individually. The line containing the Endpoint and Repeaters must be specifically selected in **Entry to Call**. With **Call All** selected, the Gateway will not connect with any Endpoints through Repeaters. This is because, when **Call All** is selected, the Gateway calls every Endpoint in the list and will connect with the first Endpoint that responds. When calling through a Repeater, the Gateway must first call that Repeater and establish a communication link with it prior to making contact with the Endpoint.

Programming Point-to-Point Extended Call Book to Use Three or Four Repeaters



In a Point-to-Point configuration, the FGR2-PE radios can utilize up to 4 Repeaters. To use 3 or 4 Repeaters, program the Call Book with the Endpoint's Serial Number, followed by the first 2 Repeaters. On the next line enter **9999999** as the transceiver to call. When prompted for the Repeaters enter the third and fourth Repeaters in the link.

The illustration above depicts a Point-to-Point link where an Endpoint is called through 4 Repeaters. In this example the Gateway is calling the Endpoint, **884-1111**, through Repeater 1, **884-2222**, then Repeater 2, **884-3333**, then Repeater 3, **884-4444**, and finally Repeater 4, **884-5555**. It is the entry of serial number **9999999** in line 1 that instructs the Gateway to continue calling through the Repeaters programmed on that line.

Programming Point-to-Multipoint Call Book

In a Multipoint network, the Endpoints and Repeaters are not listed in the Gateway's Call Book. An Endpoint must have the Gateway and any Repeater it is going to use in its Call Book.

Note: If the Network ID feature is used in a Multipoint network, no entries are needed in the Call Book of any of the transceivers. See the Network ID feature on **page 45** of this manual. The following example shows the Call Books of a Multipoint network comprised of a Gateway, Repeater and Endpoint in which the Endpoint can communicate either through the Repeater or directly to the Gateway:

Multipoint Gateway Call Book (Unit Serial Number 884-1111)

Entry	EndPoint Serial Number	1st Repeater Serial Number	2nd Repeater Serial Number
(0)	000-0000		
(1)	000-0000		

No serial number entries are necessary in the Gateway's Call Book.

Multipoint Repeater Call Book (Unit Serial Number 884-2222)

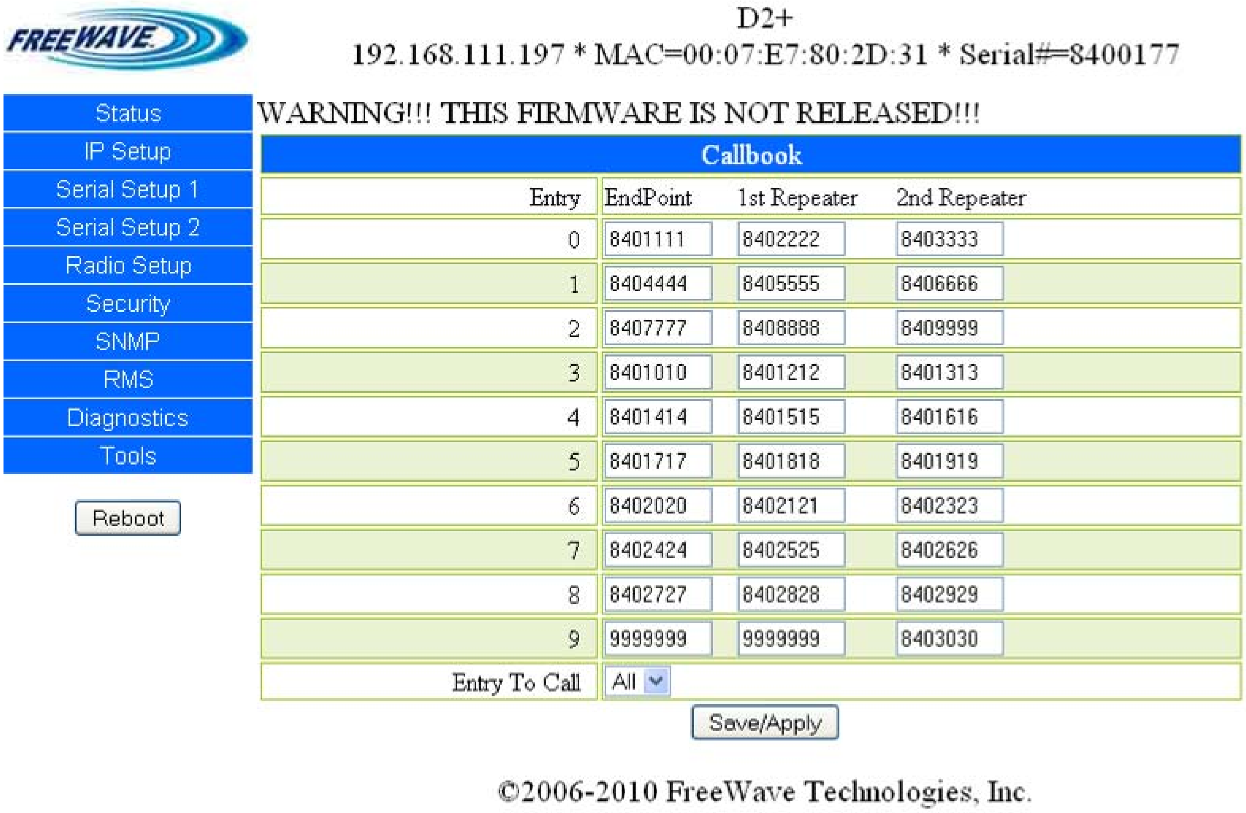
Entry	EndPoint Serial Number	1st Repeater Serial Number	2nd Repeater Serial Number
(0)	884-1111		
(1)	000-0000		

Multipoint Endpoint Call Book (Unit Serial Number 884-3333)

Entry	EndPoint Serial Number	1st Repeater Serial Number	2nd Repeater Serial Number
(0)	884-1111		
(1)	884-2222		
(2)	000-0000		

At times it may be desirable to force a Endpoint to go through a specific Multipoint Repeater. In this scenario, the Endpoint's Call Book should contain only the Serial Number for that Repeater as the entry on line 0.

Programming Point-to-Multipoint Extended Call Book



Entry	EndPoint	1st Repeater	2nd Repeater
0	8401111	8402222	8403333
1	8404444	8405555	8406666
2	8407777	8408888	8409999
3	8401010	8401212	8401313
4	8401414	8401515	8401616
5	8401717	8401818	8401919
6	8402020	8402121	8402323
7	8402424	8402525	8402626
8	8402727	8402828	8402929
9	9999999	9999999	8403030
Entry To Call	All		

In a Multipoint network, an Endpoint can be programmed to roam between Gateways and Repeaters using the Multipoint Extended Call Book function. An Endpoint with its Call Book configured as below will communicate with any transceiver whose serial number appears in any of the three columns. This functionality is enabled by setting Network ID to 255. Then, in the Call Book, enter 9999999 as the last entry in the **EndPoint** and **1st Repeater** columns, and set **Entry to Call** to ALL.

Save/Apply Button

Clicking this button saves any settings changes in the **Call Book** page, and applies those changes to the radio.

Multipoint Networks

When installing Multipoint networks it is important to do some up-front planning. Unlike Point-to-Point networks, a Point-to-Multipoint network requires that several parameters are set consistently on all transceivers in the network. This includes RF data rate, Min and Max Packet Size, and Frequency Key.

Note: If several independent Multipoint networks are to be located in close proximity, the planning becomes more critical. In such cases, it becomes very important to include as much frequency and time diversity as possible through use of different Frequency Key and Packet Sizes.

Multipoint Parameters

Addressed Repeat

In a Multipoint network where the **Repeaters** option is set to **Disabled**, most packets from the Gateway will be addressed to a specific MAC address. This allows the destination device to send an acknowledgement back to the Gateway that the packet was received successfully. The **Addressed Repeat** setting determines the maximum number of times the gateway will repeat its data packet if it does not receive an acknowledgement from the destination device. This is a "smart" repeat—the Gateway will only repeat its data if it does not receive an acknowledgement. Changing this setting to a higher number can increase the reliability of weaker radio links while keeping the maximum possible throughput for that link.
This setting **must** match between the **Gateway** and all **Repeaters**. This setting is ignored in **Endpoint** radios.

Broadcast Repeat

In a Multipoint network, Endpoints do not acknowledge transmissions from the Gateway that are addressed for broadcast MAC addresses. If Endpoints did acknowledge all broadcast MAC address transmissions, in a large network the Gateway would soon become overwhelmed with acknowledgments from the Endpoints. Without acknowledgements, there is not 100% confidence that every Endpoint has received every packet. To address this issue, the user may modify the Broadcast Repeat setting, assigning a value between 0 (the packet is transmitted once) to 9 (the packet is transmitted 10 times). For networks with solid RF links, this parameter should be set to a low value such as 1 or 2. If a network has some weak or marginal links, it should be set with higher values. If an Endpoint receives a good packet from a Gateway more than once, it will discard the repeated packets. Similarly, once a MultiPoint Repeater receives a good packet from the Gateway, it will discard any further repeated packets. In turn, the Repeater will send the packet out to the next Repeater or Endpoint(s) the number of times corresponding to its own Broadcast Repeat setting. Increasing the Broadcast Repeat setting will increase the probability of a packet getting through.

In a radio network that contains radios set as a Repeater, **all** packets from the Gateway are considered broadcast MAC address packets. Increasing the Broadcast Repeat setting in this type of network will increase the probability of a packet getting through, but it will also increase la-

tency and decrease Gateway-to-Repeater and Gateway-to-Endpoint throughput in the network because each packet from the Gateway or Repeater is being sent multiple times. Therefore, it is important to find the optimal mix between network robustness, throughput, and latency. In general, a setting of 2 to 3 will work well for most well designed networks.
This setting **must** match between the **Gateway** and all **Repeaters**. This setting is ignored in **Endpoint** radios.

Note: The Broadcast Repeat may be set to 0 if the user software is capable of, or requires, acknowledgment. In this case if a packet is sent by the Gateway and not received by the Endpoint, the user software will control the retries as needed.

Broadcast Repeat in Multipoint Networks with Repeaters

The Broadcast Repeat parameter must also be set in Multipoint Repeaters since a Repeater will appear as a Gateway to an Endpoint. Therefore, the Repeater will send the packet out the number of times corresponding to its own Broadcast Repeat parameter. If this parameter is set improperly, the reliability of the overall network may be diminished. For example, if a Gateway's Broadcast Repeat setting is 3, the link between the Gateway and Repeater should be robust. If the Repeater's Broadcast Repeat is set to 0, this could cause marginal communications between the Repeater and the Endpoints. The Endpoints communicating through this Repeater will only receive the initial packet from the Gateway with no repeats. Therefore, if the packet is not received on the first try, the Endpoint will not respond as expected. This setting should never be set higher on a Repeater than on its Gateway.

Slave Attempts

This setting controls how the Endpoint retries sending its data when it fails to receive an acknowledgement from the Gateway. The number in the first dropdown box is how many times in a row the Endpoint will retry. After that number of retries has been reached, the Endpoint will then take the action listed in the second dropdown box:

Drop Data: The Endpoint will throw away the current data it failed to send. The pattern begins again upon receipt of new data.

Drop Link: The Endpoint will drop its radio link with the Gateway or Repeater for a brief amount of time and then re-link.

Try Forever: The Endpoint will wait a brief amount of time before starting again with the data retries. It will keep retrying the same packet of data over and over until it succeeds.

Master Tx Beacon

This setting controls the Gateway radio's duty-cycle during idle times. By default, the Gateway transmits every frame, whether there is "payload" data or not. Choosing a number larger than 1 in the drop-down box will cause the Gateway to skip that number of transmit frames when it has no other data to send. This can reduce the power usage from the Gateway during idle times. If data does come into the Gateway radio, the Gateway will transmit that data regardless of this setting. This setting needs to be the same in every radio: Gateway, Repeater, and Endpoint.

NOTE: In any network that has FGRplus radios with a firmware version lower than 2.10, this setting must be 1.

NOTE: In a radio network that has the Repeaters option set to "Enabled", this setting must be set to 1.

Network ID

Network ID allows Multipoint networks to be established without using the Call Book. The default setting of 255 means "Disabled", and mandates using the Call Book instead of **Network ID**. To enable Network ID the value must be set between 0 and 4095 (excluding 255). Since the Network ID does not use serial numbers, Multipoint Gateways and Repeaters may be replaced without reprogramming all of the Endpoints in the network. Endpoints will link with the first Gateway or Repeater that it hears that has a matching Network ID. The Network ID function should be used in conjunction with the Subnet ID feature (if necessary).
Using Network ID instead of the Call Book, an Endpoint may establish communications with different Gateways, though not at the same time. This is can be useful in mobile Multipoint applications.

Repeaters

In a Multipoint network, it is critical to transmission timing to configure this parameter correctly. The value should be Disabled if there are no Repeaters in the network and Enabled if any number of Repeaters are present. This parameter needs to be set in the **Gateway** radio only.

Many advanced features of the FGR2-PE radio are restricted in networks where the "Repeaters" option is set to Enabled. For best operation, FreeWave Technologies does not recommend the use of single-radio Repeaters.

Subnet ID

The Subnet ID function only works in Multipoint Networks utilizing the **Network ID** option.
In a Multipoint Network with a Subnet ID of Tx=F Rx=F, an Endpoint or Repeater will connect with the first Repeater or Gateway that it hears with the same Network ID. There are scenarios, however, where communications need to be forced to follow a specific path. Subnet ID is particularly helpful to force two Repeaters in the same network to operate in series rather than in parallel, or, if desired, to force Endpoints to communicate to a specific Repeater for load balancing purposes. There are two components to the Subnet ID:

- **Rx Subnet ID**: This setting identifies which transceiver a Repeater or Endpoint will listen to.
- **Tx Subnet ID**: This setting identifies the ID on which this device transmits, and in turn which devices will listen to it. *The Tx Subnet ID parameter is relevant for Multipoint Gateways and Repeaters only.*

The default (disabled) setting for both Rx and Tx is F.

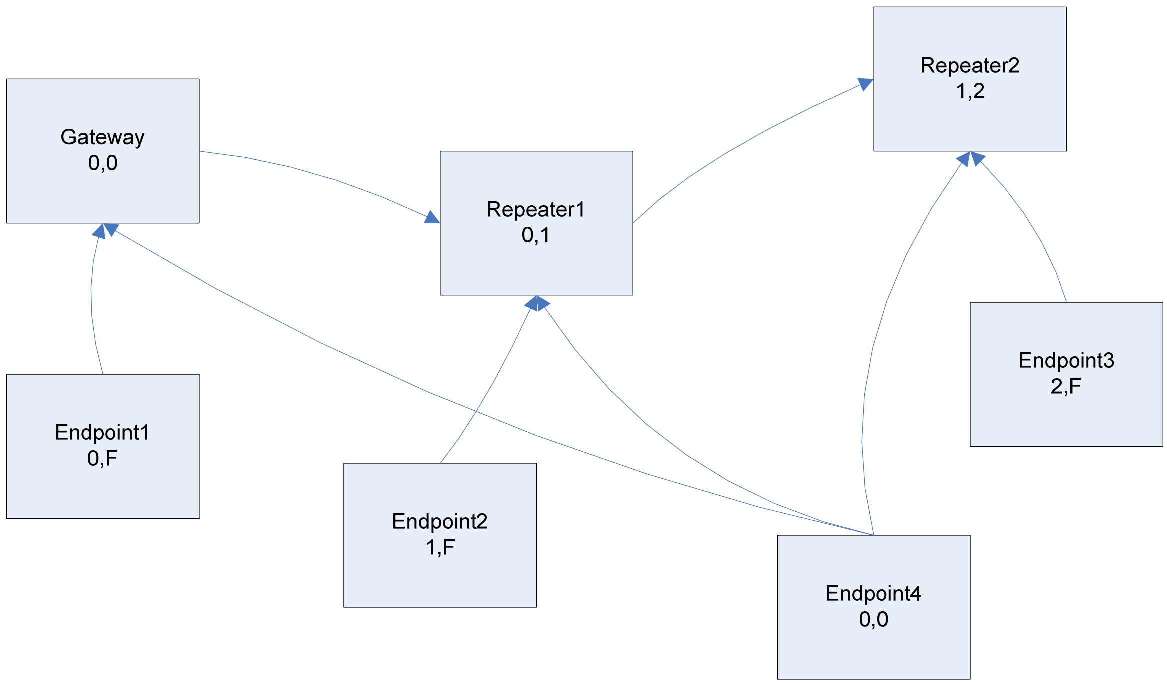
Notes:

In some Multipoint Networks, the Frequency Key will be at the same setting for all transceivers. In other networks, where parallel Repeaters are introduced, the Frequency

Key value will need to change. See the **Frequency Key** section *(p. 34)* for more information.

If both the Rx Subnet ID and the Tx Subnet ID are set to 0, this is known as **Roaming** mode. This setting will allow a mobile Endpoint to roam from subnet to subnet and possibly from network to network.

This drawing depicts a Network in which Subnet IDs are used to force communications. In this example, Repeater1 *must* talk directly to the Gateway; Repeater2 *must* talk directly to Repeater1. Endpoints 1, 2, and 3 are forced along the direction of the solid lines. Endpoint4 may link to the first Gateway or Repeater it hears. (Rx, Tx)



The respective Subnet ID diagram and settings are shown below.
Subnet IDs for the above example:

Transceiver	Rx Subnet ID	Tx Subnet ID	Other Information
Gateway	F	F	The Gateway uses 0,0.
Gateway	0-F	0-F	The Tx Subnet ID value may be set in the Gateway. The default settings (F, F) actually use 0, 0. The Rx Subnet ID on the Gateway has no effect on the network.
Repeater1	0	1	A 0 will force the transceiver to link only to the Gateway.
Repeater2	1	2	Rx SubnetID = 1 forces communication through Repeater1. Repeater1 transmits on SubnetID 1.
Endpoint1	0	F	Rx SubnetID = 0 forces communication through Gateway.
Endpoint2	1	F	Rx SubnetID = 1 forces communication through Repeater1.
Endpoint3	2	F	Rx SubnetID = 2 forces communication through Repeater2.
Endpoint4	0	0	The 0, 0 setting allows the Endpoint to link with the first Gateway or Repeater it hears with the correct Network ID.

Save/Apply Button

Clicking this button saves any settings changes in the **Radio Setup** page, and applies those changes to the radio. Navigating away from the **Radio Setup** page without clicking this button discards any changes.

Overlapping Multipoint Networks

Overlapping Multipoint networks may be set up effectively with FreeWave transceivers when several key parameters are set correctly. Overlapping Multipoint networks are defined as networks using different Gateways which share or overlap in a specific geographic area. It may also include co-located transceivers configured into different networks.

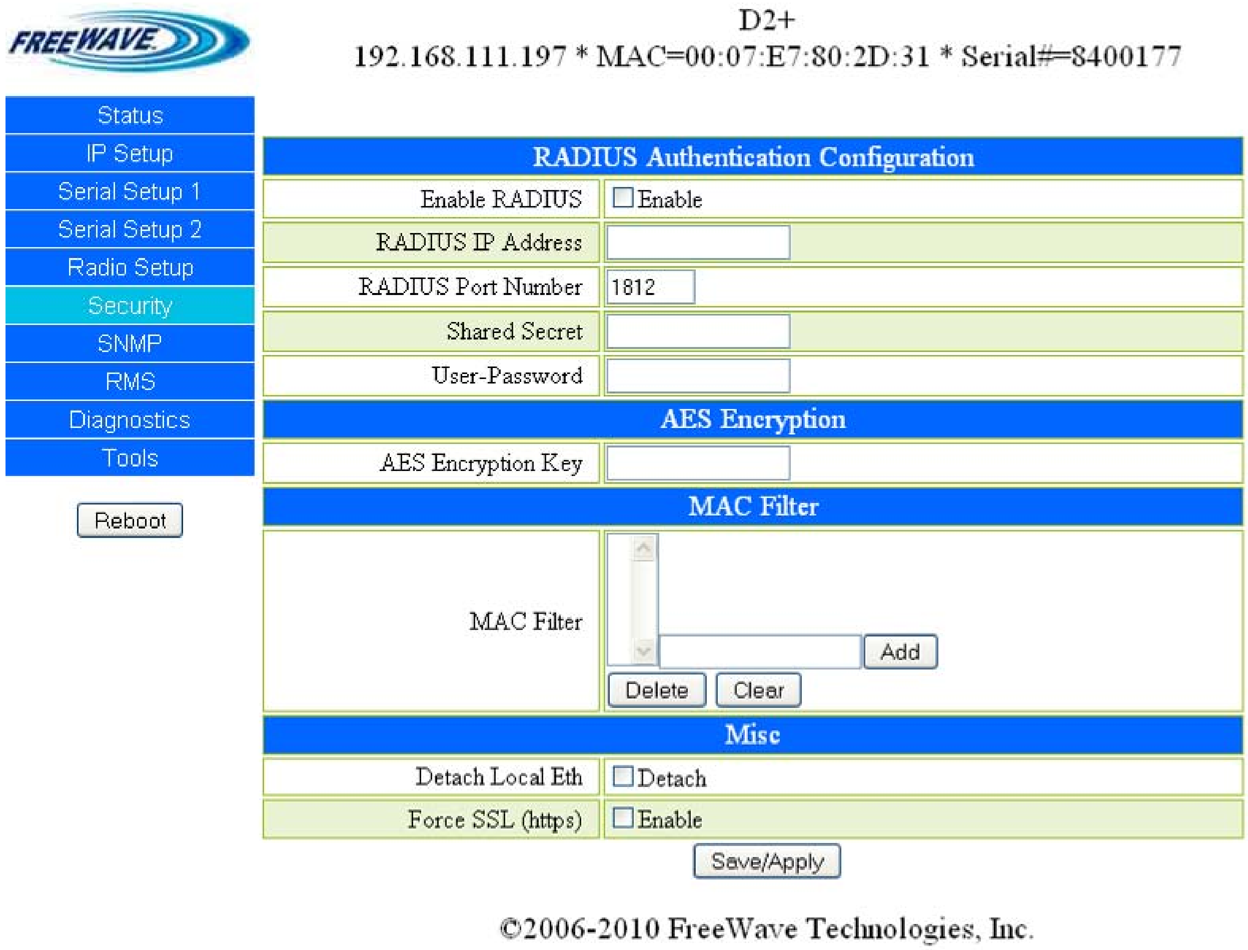
Co-located Multipoint networks require the following parameters be unique for each network:

- Network ID (unless using Call Book)
- Frequency Key
- Max Packet Size
- Min Packet Size

For more questions about the installation of Point-to-Multipoint networks, please contact FreeWave Technical Support at (303) 444-3862.

Security:

On this page, the RADIUS authentication information, MAC filtering, and the AES encryption key can be set.



RADIUS Authentication Configuration

The FGR2-PE radios have the capability to require Endpoint or Multipoint Repeater radios to authenticate to a central RADIUS server before being able to send or receive Ethernet data. The radios comply with the RADIUS standards set forth in RFC 2138. The authentication method used in the FGR2-PE radios is **PAP**.

RADIUS authentication allows the administrator control over which radios will be allowed to participate on the Ethernet network. Without authentication, an Endpoint or Multipoint Repeater radio will not be allowed to send or receive Ethernet data across its RF link.

Enable RADIUS

Checking this box enables RADIUS authentication from the Endpoint or Multipoint Repeater radios through the Gateway radio. This option is controlled from the Gateway radio only. It has no functionality on Endpoint or Multipoint Repeater radios.

Enabling RADIUS authentication on the Gateway will require all of its Endpoints and Multipoint Repeaters to authenticate to a central RADIUS server. The RADIUS server must be con-

nected to the same LAN segment the Gateway radio is connected to.
The radios will not accept any authentication packets through their own Ethernet port.
If the radios cannot contact the RADIUS server, no Ethernet traffic will be sent across their Ethernet port. The Setup pages of the radios can be accessed by connecting over the radio link through the Gateway. If the radios are denied access by the RADIUS server, Ethernet traffic will neither be sent via the Ethernet port, nor via the radio link.

RADIUS IP Address

The IP address of the RADIUS server should be entered in this box. DNS names are not accepted. This option is controlled from the Gateway radio only. It has no functionality on Endpoint or Multipoint Repeater radios.

RADIUS Port Number

The port number of the RADIUS server's authentication port should be entered here. By default, the port number is set to 1812. This option is controlled from the Gateway radio only. It has no functionality on Endpoint or Multipoint Repeater radios.

Shared Secret

The appropriate secret for the RADIUS server should be entered in this box. The IP address of the radio should be entered in the RADIUS server's "Clients" file. Each radio will act as a client when accessing the RADIUS server for authentication.
This option is used on Endpoint and Multipoint Repeater radios only. It has no functionality on Gateway radios.

User-Password

The RADIUS password for the radio should be entered in this box. An entry for the radio should be created in the RADIUS server's "Users" file. The radio will always report its **Serial Number**, minus any hyphens, as its username.
This option is used on Endpoint and Multipoint Repeater radios only. It has no functionality on Gateway radios.

AES Encryption

AES Encryption Key

A user-defined encryption key for the 128-bit AES encryption is entered in this box. Up to 16 alphanumeric characters can be entered for the encryption key. The encryption key must be the same on every radio in the FreeWave network.
128-bit AES encryption is always enabled, although the encryption key may be blank.

MAC Filter

MAC Filter

In this section, MAC filtering can be enabled. Entering a hardware (MAC) address in the box and clicking the **Add** button will put that MAC address into the **MAC Filter** list. This list is specific for each radio. Only devices with MAC addresses in the **MAC Filter** list will be permitted to communicate over the Ethernet port of the radio. Any other traffic will be refused.

Selecting a MAC address in the **MAC Filter** list and clicking the **Delete** button will remove that address from the list.

Clicking the **Clear** button will remove every entry in the **MAC Filter** list.

If the **MAC Filter** list is blank, all traffic will be allowed.

Detach Local Eth

Checking the **Detach** box disables the physical Ethernet port on the radio. With this setting enabled, the radio can only be contacted via the radio link.

Force SSL (https)

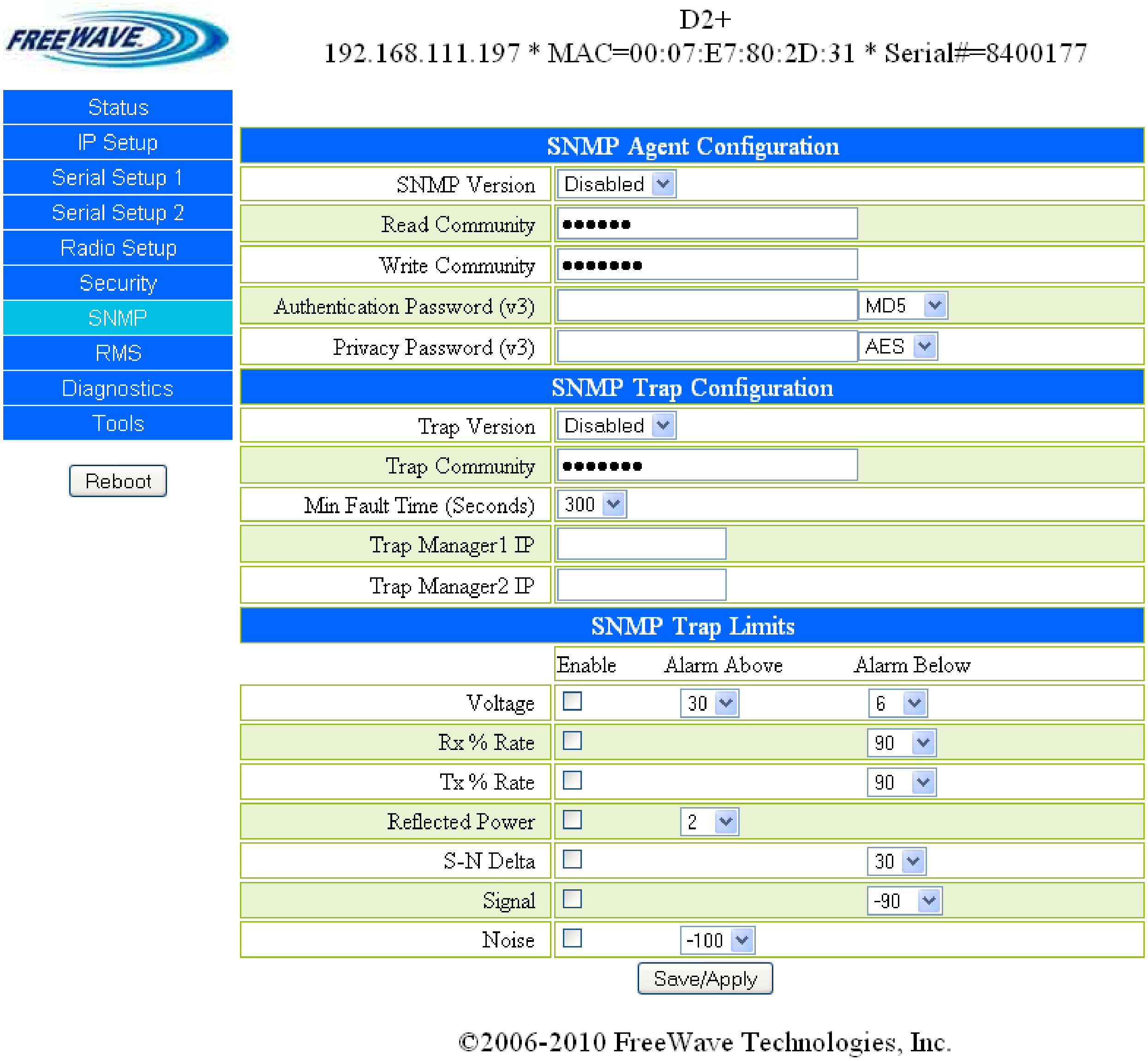
Checking the **Enable** box will redirect any HTTP requests to the configuration pages through an HTTPS link using SSL. Web page performance will be slower with this option enabled, due to the encryption requirements.

Save/Apply Button

Clicking this button saves any settings changes in the **Security** page, and applies those changes to the radio. Before the changes become active, the radio requires a reboot. Navigating away from the **Security** page without clicking this button discards any changes.

SNMP:

This page is where the SNMP management features of the FGR2-PE radio can be set. The FGR2-PE radio supports SNMP versions 1, 2, and 3. All of the SNMP-manageable objects for FreeWave's FGR2-PE radios are contained in a single MIB file: FREEWAVE-TECHNOLOGIES-MIB. This file is available from FreeWave Technologies upon request.



SNMP Agent Configuration

In this section, the proper SNMP version, Communities, and Passwords required by the SNMP Agent are entered.

SNMP Version

In this dropdown box, the desired version of SNMP can be selected. The available options are **v1-v2** and **v3**

Read Community
In this box, the SNMP Community name that has Read access should be entered.

Write Community
In this box, the SNMP Community name that has Write access should be entered.

Authentication Password (v3)
This option is only available when **v3** is selected in the **SNMP Version** setting. The password needed for SNMP v3 authentication should be entered in the text box. The proper encryption algorithm for the SNMP Agent should be selected in the dropdown box. The available options are **MD5** and **SHA1**.

Privacy Password (v3)
This option is only available when **v3** is selected in the **SNMP Version** setting. The password needed for SNMP v3 privacy should be entered in the text box. The proper encryption algorithm for the SNMP Agent should be selected in the dropdown box. The available options are **AES** and **DES**.

SNMP Trap Configuration
In this section, the version, Community, timing, and Managers for the available SNMP Traps are set.

Trap Version
In this dropdown box, the Trap Version supported by the SNMP Agent should be selected. The available options are **v1**, **v2**, and **Disabled**.

Trap Community
In this box, the SNMP Community name that has Trap access should be entered.

Min Fault Time (Seconds)
This dropdown box sets the amount of time a trap condition must be continuously present before an SNMP Trap is sent to the Trap Manager(s). The amount of time is in seconds. The available options are **30**, **60**, **90**, **120**, **150, 180**, **210**, **240**, **270**, and **300** seconds.

Trap Manager 1 IP & Trap Manager 2 IP
These boxes contain the IP Addresses of the authorized SNMP Trap Managers. DNS names are not accepted in these boxes.

SNMP Trap Limits

In this section, the limits for any available SNMP Traps can be set.

Voltage

This is a Trap for the supply voltage of the radio. Checking the **Enable** box will enable this specific Trap. The Trap Condition will be present if the voltage drops below the **Alarm Below** voltage, or is above the **Alarm Above** voltage. The available settings are the whole numbers between **6** and **30**. The numbers are in volts DC.

Rx % Rate

This is a Trap for the Receive Percent of the radio. Checking the **Enable** box will enable this specific Trap. The Trap Condition will be present if the Receive Percent drops below the **Alarm Below** percentage. The available settings are whole numbers from **50** to **100**, in increments of 5. The numbers are in percent.

Tx % Rate

This is a Trap for the Transmit Percent of the radio. Checking the **Enable** box will enable this specific Trap. The Trap Condition will be present if the Transmit Percent drops below the **Alarm Below** percentage. The available settings are whole numbers from **50** to **100**, in increments of 5. The numbers are in percent.

Reflected Power

This is a Trap for the Reflected Power of the radio. Checking the **Enable** box will enable this specific Trap. The Trap Conditions will be present if the Reflected Power is above the number set in the **Alarm Above** box. The available settings are whole numbers from **0** to **40**, in increments of 2. The numbers are in J-Units.

S-N Delta

This is a Trap for the calculated difference between the Signal level and the Noise level of the radio. Checking the **Enable** box will enable this specific Trap. The Trap Condition will be present if the Delta drops below the amount set in the **Alarm Below** box. The available settings are whole numbers from **10** to **40**, in increments of 5. The numbers are in dB.

Signal

This is a Trap for the Signal level reported by the radio. Checking the **Enable** box will enable this specific Trap. The Trap Condition will be present if the Signal level drops below the amount set in the **Alarm Below** box. The available settings are negative whole numbers between –**100** and **–70**, in increments of 5. The numbers are in dB.

Noise

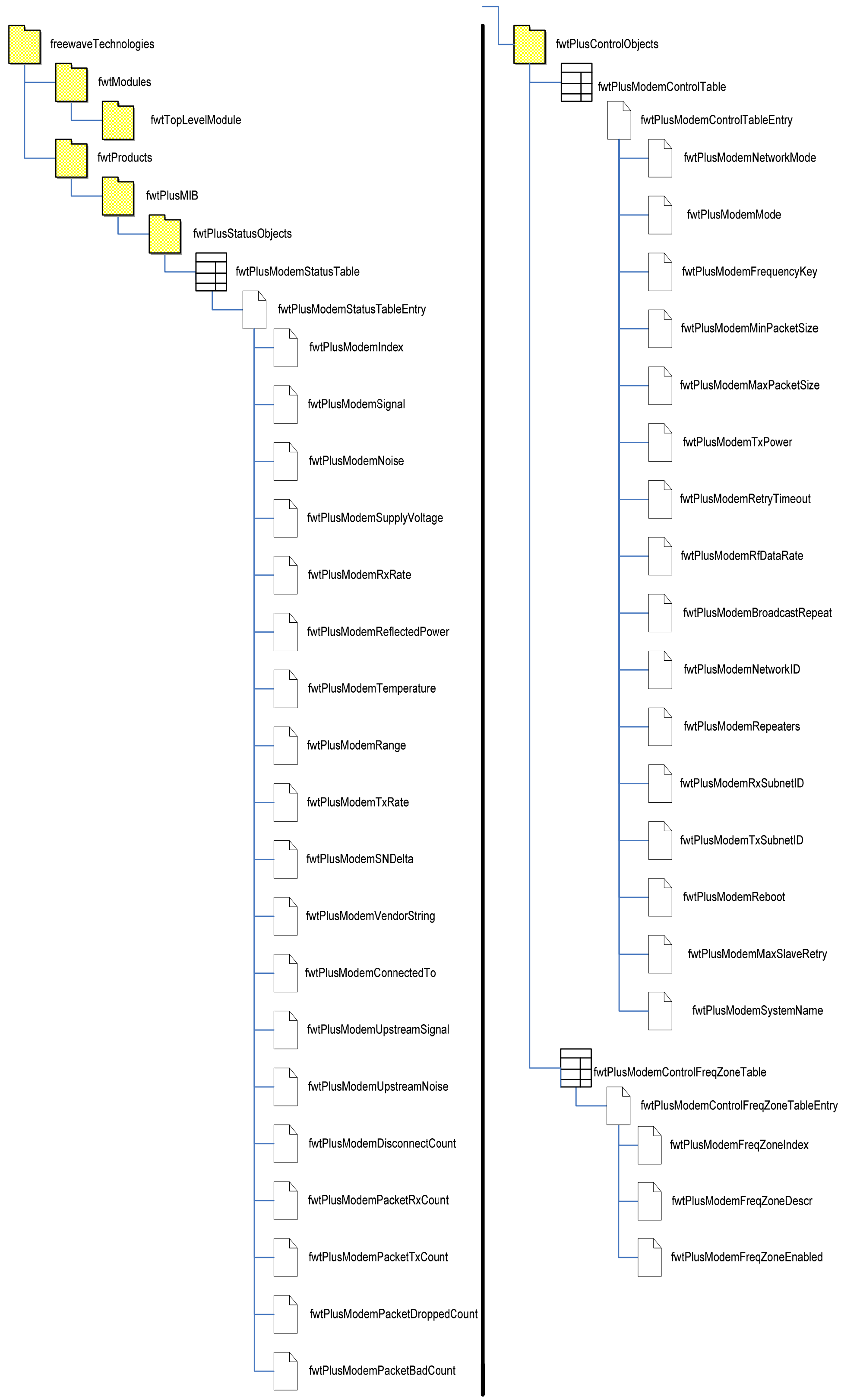
This is a Trap for the Noise level reported by the radio. Checking the **Enable** box will enable this specific Trap. The Trap Condition will be present if the Noise level rises above the amount set in the **Alarm Above** box. The available settings are –**100** to –**70**, in increments of 5. The numbers are in dB.

Save/Apply Button

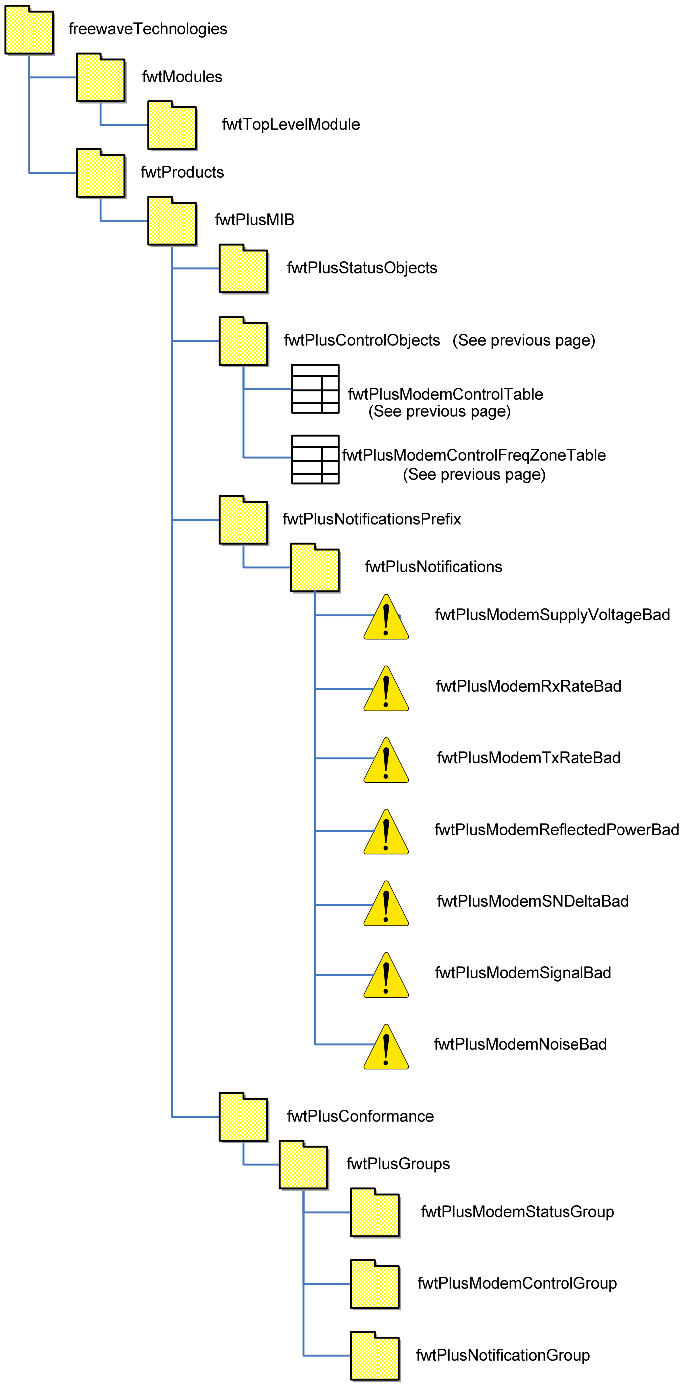
Clicking this button saves any settings changes in the **SMNP** page, and applies those changes to the radio. Navigating away from the **SMNP** page without clicking this button discards any changes.

Object Tree for FREEWAVE-TECHNOLOGIES-MIB

Column 1 **Column 2**



Object Tree for FREEWAVE-TECHNOLOGIES-MIB (continued)



Object List for FREEWAVE-TECHNOLOGIES-MIB

Object	Description	Access	Syntax
fwtPlusModemIndex	An index used to identify a specific radio modem within the system.	Not Accessible	Unsigned32
fwtPlusModemSignal	The received signal level for this radio modem, in dBm.	Read Only	Integer 32
fwtPlusModemNoise	The detected noise for this radio modem, in dBm.	Read Only	Integer 32
fwtPlusModemSupplyVoltage	The supply voltage to this radio modem, in units of one hundredth of a volt.	Read Only	Hundredth
fwtPlusModemRxRate	The current receive rate as a percentage of the maximum, in units of one hundredth of a percent.	Read Only	Hundredth
fwtPlusModemReflectedPower	The current amount of reflected RF power.	Read Only	Unsigned32
fwt ModemTemperature	The current temperature of this radio modem in degrees Celsius.	Read Only	Integer 32
fwtPlusModemRange	The current approximate range of this radio modem from its peer, in meters.	Read Only	Unsigned32
fwtPlusModemTxRate	The current transmit rate as a percentage of the maximum, in units of one hundredth of a percent.	Read Only	Hundredth
fwtPlusModemSNDelta	The current margin (absolute) between the received signal and the noise at this radio.	Read Only	Integer32
fwtPlusModemVendorString	The name of the vendor of this radio modem.	Read Only	DisplayString
fwtPlusModemConnectedTo	The serial number of the radio that we currently have an RF link with.	Read Only	Integer32

Object List for FREEWAVE-TECHNOLOGIES-MIB

Object	Description	Access	Syntax
fwtPlusModemUpstreamSignal	The received signal level that the upstream radio receives from this radio, in dBm.	Read Only	Integer32
fwtPlusModemUpstreamNoise	The Noise level that the upstream radio receives from this radio, in dBm.	Read Only	Integer32
fwtPlusModemDisconnectCount	The Number of times this radio has lost its RF link.	Read Only	Unsigned32
fwtPlusModemPacketRxCount	The Number of ethernet packets the radio has received over its RF link.	Read Only	Unsigned32
fwtPlusModemPacketTxCount	The Number of ethernet packets the radio has sent over its RF link.	Read Only	Unsigned32
fwtPlusModemDroppedCount	The Number of ethernet packets the radio has dropped	Read Only	Unsigned32
fwtPlusModemBadCount	The Number of BAD/corrupt ethernet packets the radio has received over its RF link.	Read Only	Unsigned32
fwtPlusModemNetworkMode	The network mode to be used by a radio modem.	Read/Write	INTEGER { pointToPoint (1) , multipoint (2) }
fwtPlusModemMode	The modem mode to be used by a radio modem.	Read/Write	INTEGER { gateway (1) , repeater (2) , endpoint (3) }
fwtPlusModemFrequencyKey	The frequency key to be used by a radio modem.	Read/Write	Unsigned32 (0..14)
fwtPlusModemMinPacketSize	The minimum packet size to be used by a radio modem.	Read/Write	Unsigned32 (0..9)

Object List for FREEWAVE-TECHNOLOGIES-MIB

Object	Description	Access	Syntax
fwtPlusModemMaxPacketSize	The maximum packet size to be used by a radio modem.	Read/Write	Unsigned32 (0..9)
fwtPlusModemTxPower	The transmit power to be used by a radio modem.	Read/Write	Unsigned32 (0..10)
fwtPlusModemRetryTimeout	How many times a radio modem should try to transmit a packet before timing out.	Read/Write	Unsigned32 (0..255)
fwtPlusModemRFDataRate	The RF data rate to be used by a radio modem. Permissible values are 1200,867,614,154,115 depending on the radio series radios.	Read/Write	Unsigned32
fwtPlusModemBroadcastRepeat	The number of times a Gateway will send out a packet of information before moving on to the next.	Read/Write	Unsigned32 (0..9)
fwtPlusModemNetworkID	A numerical ID that radios use to decide which network they are allowed to link to.	Read/Write	Unsigned32 (0..4095)
fwtPlusModemRepeaters	Allows for repeaters in the network, or not.	Read/Write	INTEGER { enabled (1) , disabled (2) }
fwtPlusModemRxSubnetID	A numerical ID that radios use to decide which subnet they are allowed to link to.	Read/Write	Unsigned32 (0..15)
fwtPlusModemTxSubnetID	A numerical ID that radios use to decide which subnet they will transmit on.	Read/Write	Unsigned32 (0..15)
fwtPlusModemReboot	Set to 1 to reboot radio. This will force any changes to take effect.	Read/Write	INTEGER (0..1)
fwtPlusModemMaxSlaveRetry	The maximum number of times an End-point can attempt to deliver data to the Gateway before it discards the data.	Read/Write	Unsigned32 (0..9)

Object List for FREEWAVE-TECHNOLOGIES-MIB

Object	Description	Access	Syntax
fwtPlusModemSystemName	A textual identifier for a given system.	Read/Write	DisplayString (SIZE (0..32))
fwtPlusModemFreqZoneIndex	An index used to identify a specific frequency zone for a specific radio modem.	Not Accessible	Unsigned32
fwtPlusModemFreqZoneDescr	A textual description of a specific frequency zone for a specific radio modem.	Read Only	DisplayString
fwtPlusModemFreqZoneEnabled	If the value of this object is true(1) then the referenced frequency zone is enabled for the relevant radio modem; if the value of this object is false(2), then the frequency zone is disabled.	Read/Write	TruthValue

Object List for FREEWAVE-TECHNOLOGIES-MIB

Group Object	Description	Objects
fwtPlusModemSupplyVoltageBad	This notification is generated when the supply voltage for a radio modem goes out of specification.	fwtPlusModemSupplyVoltage fwtPlusModemVendorString fwtPlusModemSystemName
fwtPlusModemRxRateBad	This notification is generated when the receive rate for a radio modem goes out of specification.	fwtPlusModemRxRate fwtPlusModemVendorString fwtPlusModemSystemName
fwtPlusModemTxRateBad	This notification is generated when the transmit rate for a radio modem goes out of specification.	fwtPlusModemTxRate fwtPlusModemVendorString fwtPlusModemSystemName
fwtPlusModemReflectedPowerBad	This notification is generated when the reflected power for a radio modem goes out of specification.	fwtPlusModemReflectedPower fwtPlusModemVendorString fwtPlusModemSystemName
fwtPlusModemSNDeltaBad	This notification is generated when the Signal to Noise delta for a radio modem goes out of specification.	fwtPlusModemSNDelta fwtPlusModemVendorString fwtPlusModemSystemName
fwtPlusModemSignalBad	This notification is generated when the Signal to Noise delta for a radio modem goes out of specification.	fwtPlusModemSNDelta fwtPlusModemVendorString fwtPlusModemSystemName
fwtPlusModemNoiseBad	This notification is generated when the Noise for a radio modem goes out of specification.	fwtPlusModemNoise fwtPlusModemVendorString fwtPlusModemSystemName

Object List for FREEWAVE-TECHNOLOGIES-MIB

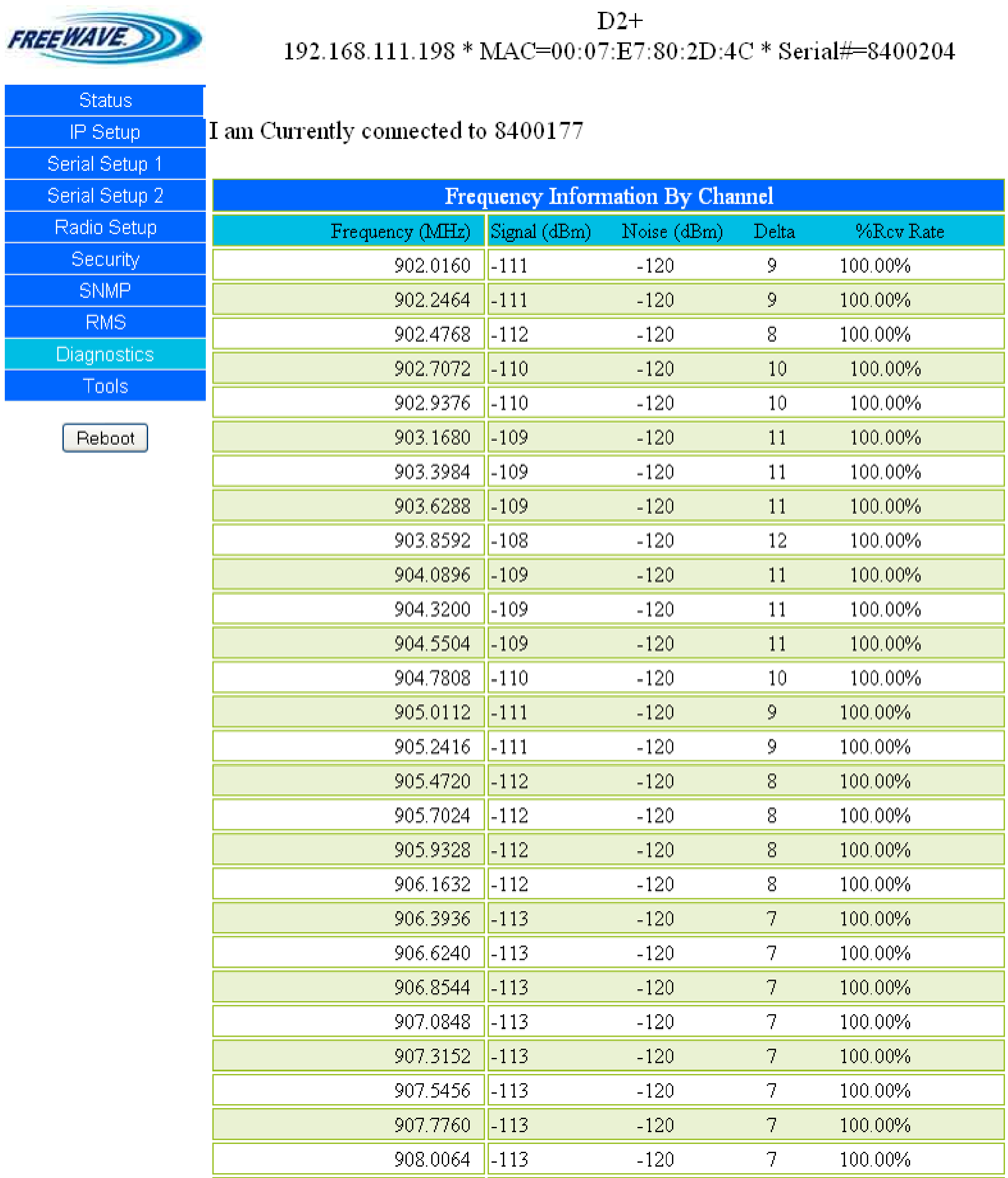
Group Object	Description	Objects
fwtPlusModemStatusGroup	A collection of objects concerned with the current status of a radio modem.	fwtPlusModemSignal fwtPlusModemNoise fwtPlusModemSupplyVoltage fwtPlusModemRxRate fwtPlusModemReflectedPower fwtPlusModemTemperature fwtPlusModemRange fwtPlusModemTxRate fwtPlusModemSNDelta fwtPlusModemVendorString fwtPlusModemConnectedTo fwtPlusModemUpstreamSignal fwtPlusModemUpstreamNoise fwtPlusModemDisconnectCount fwtPlusModemPacketRxCount fwtPlusModemPacketTxCount fwtPlusModemPacketDroppedCount fwtPlusModemPacketBadCount
fwtPlusModemControlGroup	A collection of objects concerned with the current status of a radio modem.	fwtPlusModemNetworkMode fwtPlusModemMode fwtPlusModemFrequencyKey fwtPlusModemMinPacketSize fwtPlusModemMaxPacketSize fwtPlusModemTxPower fwtPlusModemRetryTimeout fwtPlusModemRFDataRate fwtPlusModemBroadcastRepeat fwtPlusModemNetworkID fwtPlusModemRepeaters fwtPlusModemRxSubnetID fwtPlusModemTxSubnetID fwtPlusModemReboot fwtPlusModemMaxSlaveRetry fwtPlusModemSystemName fwtPlusModemFreqZoneDescr fwtPlusModemFreqZoneEnabled

RMS:

The settings on the RMS page are utilized in FreeWave Redundant Master System units. For details on these settings, please see the manual for the FreeWave Redundant Master System.

Diagnostics

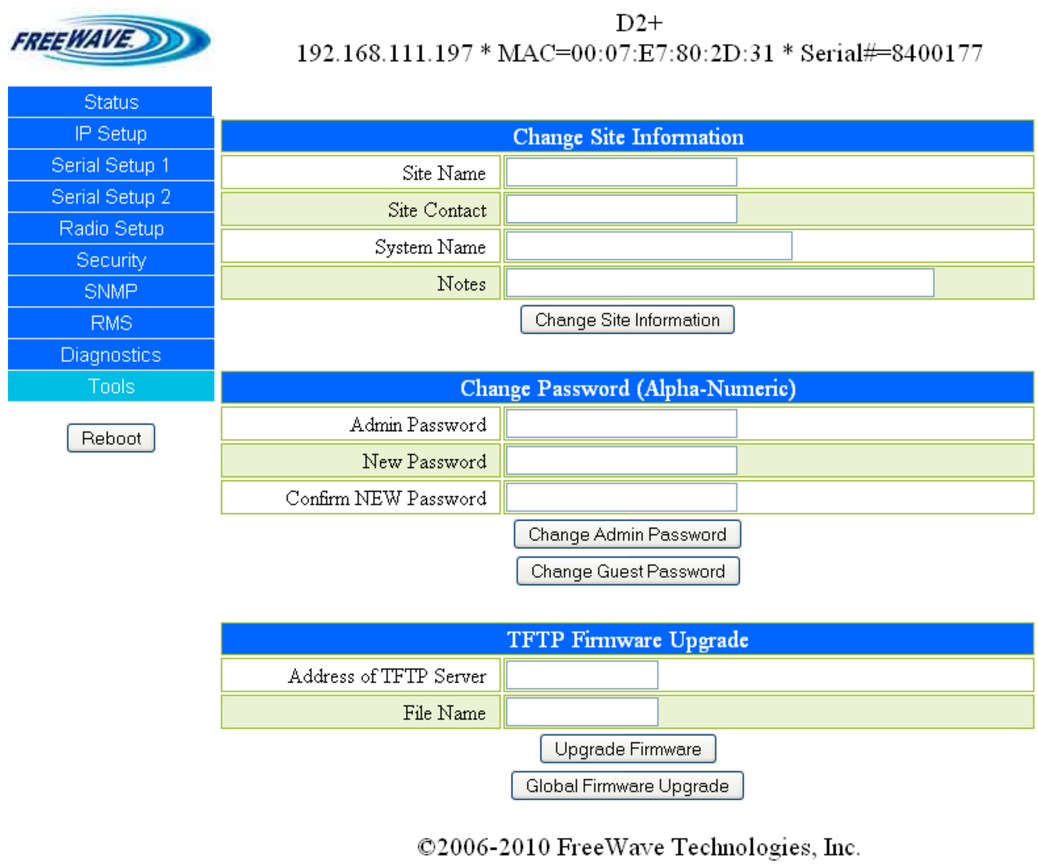
The **Diagnostics** page displays the signal level, noise level, signal-to-noise delta, and receive rate for each frequency available to the radio. The serial number of the Gateway or Repeater that this radio is connecting to appears above the chart (In a Point-to-Multipoint Gateway, this header always says, “**I am currently NOT connected.**”). This chart on this page displays each frequency the radio is using in MHz), along with the Signal (in dBm), Noise (in dBm), Signal-to-Noise Delta, and % Receive Rate for each individual frequency (*see pp. 20—21 for statistic descriptions*).



Frequency Information By Channel				
Frequency (MHz)	Signal (dBm)	Noise (dBm)	Delta	%Rcv Rate
902.0160	-111	-120	9	100.00%
902.2464	-111	-120	9	100.00%
902.4768	-112	-120	8	100.00%
902.7072	-110	-120	10	100.00%
902.9376	-110	-120	10	100.00%
903.1680	-109	-120	11	100.00%
903.3984	-109	-120	11	100.00%
903.6288	-109	-120	11	100.00%
903.8592	-108	-120	12	100.00%
904.0896	-109	-120	11	100.00%
904.3200	-109	-120	11	100.00%
904.5504	-109	-120	11	100.00%
904.7808	-110	-120	10	100.00%
905.0112	-111	-120	9	100.00%
905.2416	-111	-120	9	100.00%
905.4720	-112	-120	8	100.00%
905.7024	-112	-120	8	100.00%
905.9328	-112	-120	8	100.00%
906.1632	-112	-120	8	100.00%
906.3936	-113	-120	7	100.00%
906.6240	-113	-120	7	100.00%
906.8544	-113	-120	7	100.00%
907.0848	-113	-120	7	100.00%
907.3152	-113	-120	7	100.00%
907.5456	-113	-120	7	100.00%
907.7760	-113	-120	7	100.00%
908.0064	-113	-120	7	100.00%

Tools:

This page will allow the editing of the Site Information, changing of the login Password, and Upgrading of the radio's Firmware.



Change Site Information

Any text entered in these fields will show on the Status page. They can be used to help identify the radio, technical contact, etc.

Site Name

25 characters are allowed in this field. Any text entered here appears next to **Site Name** on the **Status Page**.

Site Contact

25 characters are allowed in this field. Any text entered here appears next to **Site Contact** on the **Status Page**.

System Name

32 characters are allowed in this field. Any text entered here appears next to **System Name** on the **Status Page**.

Notes

50 characters are allowed in this field. Any text entered here appears next to **Notes** on the **Status Page**.

Change Password (Alpha-Numeric)

This section is used to change the login password for the Admin and Guest accounts. The current Admin password must be entered in the **Admin Password** field. The new password is entered in the **New Password** field, and re-entered in the **Confirm NEW Password** field. Clicking the **Change Admin Password** button will change the Admin password to the one entered in the **New Password** field. Clicking the **Change Guest Password** button will change the Guest password to the one entered in the **New Password** field.

TFTP Firmware Upgrade

The FGR2-PE radio downloads its firmware updates via TFTP. To update the firmware, two things are required: the IP address of a TFTP server that contains the upgrade file, and the file name of the upgrade file.

Address of TFTP Server

Enter the IP address of the TFTP server that contains the upgrade file here. Only an IP address is accepted.

File Name

Enter the file name of the firmware upgrade file here. The file name must exactly match what is stored on the TFTP server.

Upgrade Firmware Button

Clicking this button begins the Firmware update process on this radio. The radio will download the Firmware file from the specified TFTP Server, load the file to memory, and then reboot. Once this button is clicked, status messages will be displayed on the webpage in place of the **Tools** page.

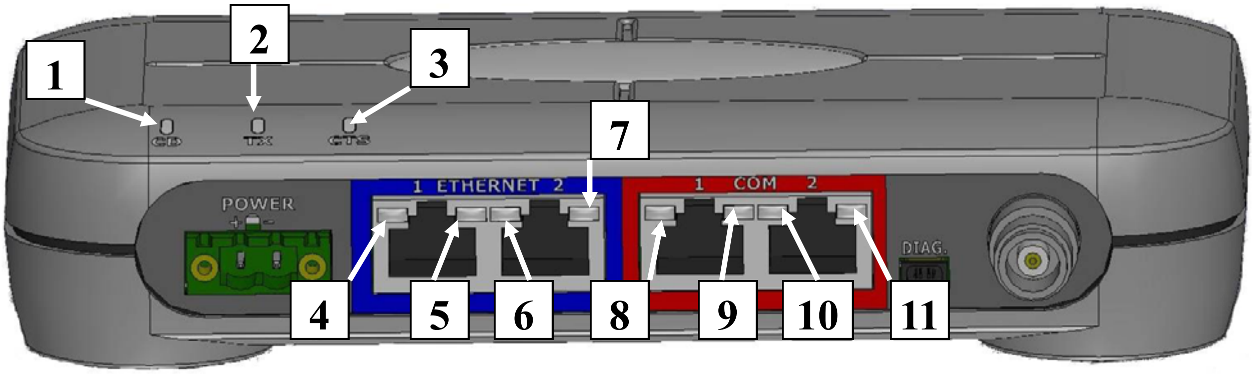
Global Firmware Upgrade Button

Clicking this button on a Gateway radio begins the Firmware update process on the Gateway radio. The radio will download the Firmware file from the specified TFTP Server. The Gateway will then send a copy of the Firmware update to all connected Endpoint and Multipoint Repeater radios. This Firmware information is sent to each radio in 1 KB sections. Each radio must successfully receive every section, or it will not upgrade its Firmware. Increasing the **Broadcast Repeat** setting (*see p. 43*) will increase the probability of success, but will slow down the overall process. Radios that successfully received the Firmware upgrade will load the file to memory, and then reboot. The reboot times are randomized within a short window, to keep every radio from restarting at the same time. The Gateway radio itself will not be upgraded during a Global Upgrade.

If the **GLOBAL Firmware Upgrade** button is selected on an Endpoint or a Multipoint Repeater, that individual radio will be not be upgraded, but it will send the upgrade file to its Gateway radio, which will be upgraded. No other radios will receive the file.

For locations that do not have a pre-existing TFTP server, please contact FreeWave for a copy of **FreeWave TFTP**. *(see* **Appendix B***, p. 84)*

Operation LEDs



Legend

1. CD
2. TX
3. CTS
4. Ethernet 1 10 baseT Link/Activity
5. Ethernet 1 100 baseT Link
6. Ethernet 2 10 baseT Link/Activity
7. Ethernet 2 100 baseT Link
8. COM 1 Data (C1)
9. Error 1 (E1)
10. COM 2 Data (C2)
11. Error 2 (E2)

Boot-up Sequence

As the radio powers up, the following LED sequence occurs:

- C1 lights solid green*
- C2 lights solid green*, C1 remains lit
- E2 lights solid green*, C1 and C2 remain lit
- C1 turns off
- C2 turns off
- E2 turns off

COM LEDs

Condition	CCOM 1 or COM 2 (C1/C2)
Data Streaming into Rx	Solid green bright*
Data Streaming out Tx	Solid green bright*

Error LEDs

Condition	Error Lights (E1 / E2)
Radio Buffer Overflow	E1 LED is Solid green*
Network Collision, Corrupt Ethernet Packet	E2 LED is Solid green*

Ethernet Port Lights

Status	10 baseT Link/Activity LED	100 baseT Link LED
Linked, Data Activity	Blinking/Flickering Green *	Solid Green (100baseT)*/Off (10baseT)
Linked, No Data Activity	Solid Green*	Solid Green (100baseT)*/Off (10baseT)
Not Linked. Check that cable is in good condition and plugged in.	Off	Off

Authentication-related LEDs

Condition	LED pattern
Endpoint cannot contact RADIUS server	Solid green* **E1** LED
Endpoint was denied authentication from the RADIUS server	Alternating green* **E1** and **E2** LED
Endpoint AES encryption key does not match Gateway encryption key	Alternating green* **E1** and **E2** LED

Point-to-Multipoint Operation LEDs.

	Gateway			Endpoint			Repeater		
Condition	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)
Powered, not linked	Solid red bright*	Solid red dim*	Off *	Solid red bright*	Off *	Blinking red	Solid red bright*	Off *	Blinking red Θ
Repeater and Endpoint linked to Gateway, no data	Solid red bright*	Solid red dim*	Off *	Solid green*	Off *	* Solid red bright*	Solid green*	Solid red dim*	* Solid red bright*
Repeater and Endpoint linked to Gateway, Gateway sending data to Endpoint	Solid red bright*	Solid red dim*	Off *	Solid green*	Off *	* Solid red bright*	Solid green*	Solid red dim*	* Solid red bright*
Repeater and Endpoint linked to Gateway, Endpoint sending data to Gateway	Solid green* RCV data or Solid red bright*	Solid red dim*	Intermit-tent flash red »o«	Solid green*	Intermit-tent flash red »o«	* Solid red bright*	Solid green*	Solid red bright*	* Solid red bright*
Gateway with diagnos-tics program running	Solid red bright*	Solid red dim*	Intermit-tent flash red »o«	Solid green*	Intermit-tent flash red »o«	* Solid red bright*	Solid green*	Solid red bright*	* Solid red bright*

- Clear to Send LED will be solid red* with a solid link, as the link weakens the Clear to Send LED light on the Repeater and Endpoint will begin to flash Θ.

Point-to-Point Operation LEDs

	Gateway			Endpoint			Repeater		
Condition	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)	Carrier Detect (CD)	Transmit (TX)	Clear to Send (CTS)
Powered, no link	Solid red bright *	Solid red bright*	Solid red bright*	Solid red bright*	Off *	Blinking red Θ	Solid red bright*	Off *	Blinking red Θ
Linked, no Re-peater, sending sparse data	Solid green*	Intermittent flash red »o«	Intermittent flash red »o«	Solid green*	Intermittent flash red »o«	Intermit-tent flash red »o«	n/a	n/a	n/a
Gateway calling Endpoint through Repeater	Solid red bright*	Solid red dim*	Solid red bright*	Solid red bright*	Off *	Blinking red Θ	Solid red bright*	Off *	Blinking red Θ
Gateway linked to Repeater, not to Endpoint	Flashing orange »o«	Solid red dim*	Solid red bright*	Solid red bright*	Off *	Blinking red Θ	Solid red bright*	Solid red dim*	Solid red bright*
Repeater linked to Endpoint	Solid green*	Intermittent flash red »o«	Intermittent flash red »o«	Solid green*	Intermittent flash red »o«	Intermit-tent flash red »o«	Solid green*	Intermittent flash red »o«	Intermit-tent flash red »o«
Mode 6 - waiting for ATD com-mand	Solid red bright*	Off *	Blinking red Θ	Solid red bright*	Off *	Blinking red Θ	n/a	n/a	n/a
Setup Mode	Solid green*	Solid green*	Solid green*	Solid green*	Solid green*	Solid green*	Solid green*	Solid green*	Solid green*

Choosing a Location for the Transceivers

Placement of the FreeWave transceiver is likely to have a significant impact on its performance. The key to the overall robustness of the radio link is the height of the antenna. In general, FreeWave units with a higher antenna placement will have a better communication link. In practice, the transceiver should be placed away from computers, telephones, answering machines and other similar equipment. The 6-foot Ethernet cable included with the transceiver usually provides ample distance for placement away from other equipment. To improve the data link, FreeWave Technologies offers directional and Omni-directional antennas with cable lengths ranging from 3 to 200 feet. When using an external antenna, placement of that antenna is critical to a solid data link. Other antennas in close proximity are a potential source of interference; use the Radio Statistics to help identify potential problems. The Radio Statistics are found on the Status Page. An adjustment of as little as 2 feet in antenna placement can resolve some noise problems. In extreme cases, such as when interference is due to a Pager or Cellular Telephone tower, a band pass filter may reduce this out-of-band noise.

Factory Default Settings

FreeWave FGR2-PE transceivers are shipped from the factory with the following Default Settings:

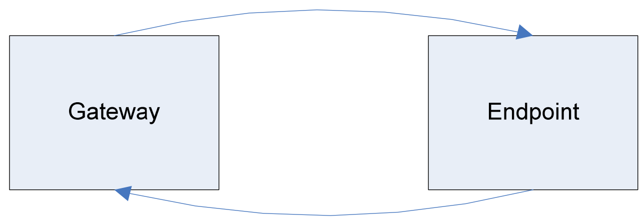
IP Setup	Default	
IP Address	192.168.111.100	
Subnet Mask	255.255.255.0	
Default Gateway	192.168.111.1	
Web Page Port	80	
Spanning Tree	Unchecked	
Serial Setup	**Serial Setup 1**	**Serial Setup 2**
Mode	TCP Server	TCP Server
Port	7000	7001
Alarm	Not Checked	Not Checked
Alarm IP & Port	0.0.0.0 : 8000	0.0.0.0 : 8001
Maintain/Drop Link	Not Checked	Not Checked
Alarm Retry Limit (Attempts)	0	0
Inactivity Timeout (Seconds)	0	0
IP Address & Port	0.0.0.0 : 9000	0.0.0.0 : 9001
Local IP Port	6000	6001
Power Up Dest. IP & Port	0.0.0.0 : 0	0.0.0.0 : 0
Multicast Address & Port	225.0.0.38 : 11111	225.0.0.38 : 22222
Baud Rate	19200	19200
Data Bits	8	8
Parity	None	None
Stop Bits	1	1
Flow Control	None	None
CD Mode	Normal	Normal
Interface	RS232	RS232
Modbus RTU	Checked	Checked
Radio Setup	**Default**	
Network Type	Point-to-Point	
Modem Mode	Gateway	
Frequency Key	5	
Frequency Zones	All checked	
Max Packet Size	9	
Min Packet Size	1	

Transmit Power	10
Retry Timeout	255
RF Data Rate	154 kbps
Point-to-Point Parameters	**Default**
Transmit Rate	Normal
Multipoint Parameters	**Default**
Addressed Repeat	3
Broadcast Repeat	3
Slave Attempts	9 / Try Forever
Master Tx Beacon	9
Network ID	255
Repeaters	Disabled
Subnet ID (RX)	F
Subnet ID (TX)	F
Security	**Default**
Enable RADIUS	Unchecked
RADIUS IP Address	Blank
RADIUS Port Number	1812
Shared Secret	Blank
User-Password	Blank
AES Encryption Key	Blank
MAC Filter	Blank
Detach Local Eth	Unchecked
Force SSL (https)	Unchecked
SNMP	**Default**
SNMP Version	Disabled
Read Community	Public
Write Community	Private
Authentication Password	Blank / MD5
Privacy Password	Blank / AES
Trap Version	Disabled

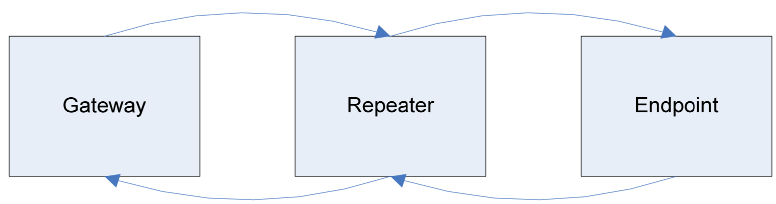
SNMP	Default
Trap Community	Blank
Min Fault Time	300
Trap Manager1 IP	Blank
Trap Manager2 IP	Blank
Voltage	Alarm Above: 30 Alarm Below: 6
Rx % Rate	Alarm Below: 90
Tx % Rate	Alarm Below: 90
Reflected Power	Alarm Above: 2
S-N Delta	Alarm Below: 30
Signal	Alarm Below: -90
Noise	Alarm Above: -100
RMS	**Default**
Mode	Disabled
Paired Radio IP	Blank
Min Fault Time (Seconds)	10
Voltage	Alarm Above: 30 Alarm Below: 6
Reflected Power	Alarm Above: 2

Examples of Data Communication Links

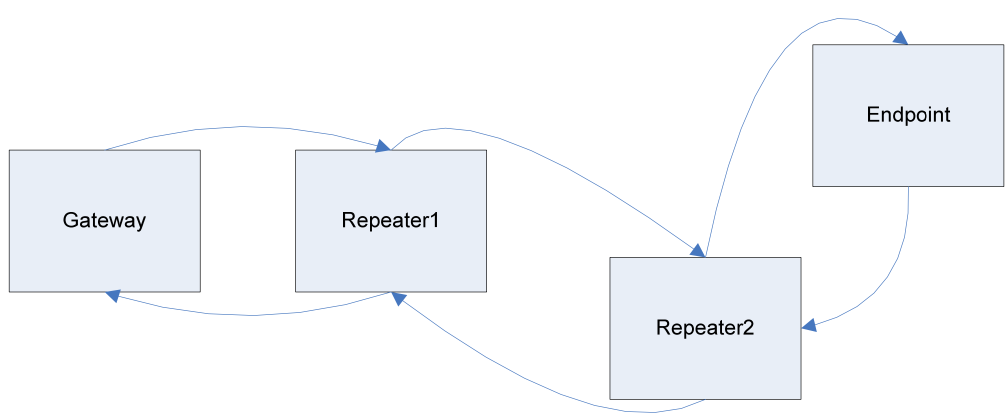
FreeWave transceivers' versatility allows data communication links to be established using a variety of different configurations.
The example below shows the most common and straightforward link; a Gateway communicating to a Endpoint in a Point-to-Point link.



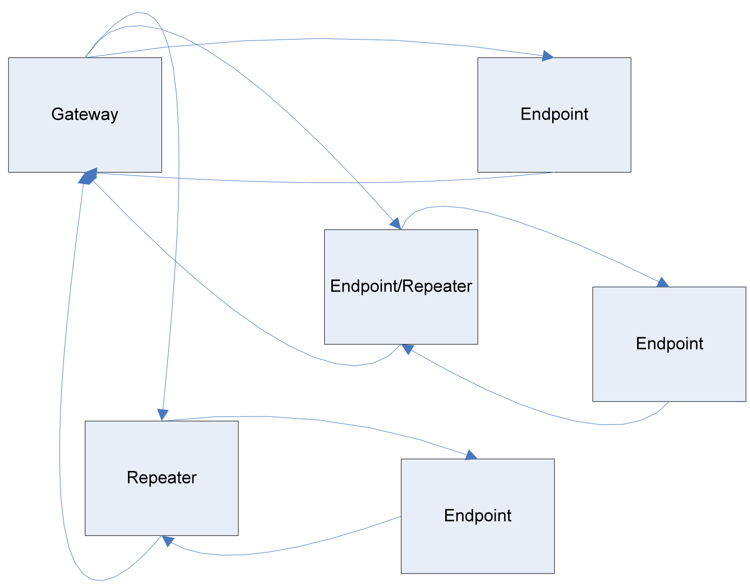
The example below shows how a link might be set up using a Repeater. The Repeater may be located on a hilltop or other elevated structure enhancing the link from the Gateway to the Endpoint. In this configuration, it may be desirable to use an external Omni-directional antenna at the Repeater. Yagi antennas may be used at both the Gateway and Endpoint transceivers.
When a Repeater is used, the RF throughput is cut in half.



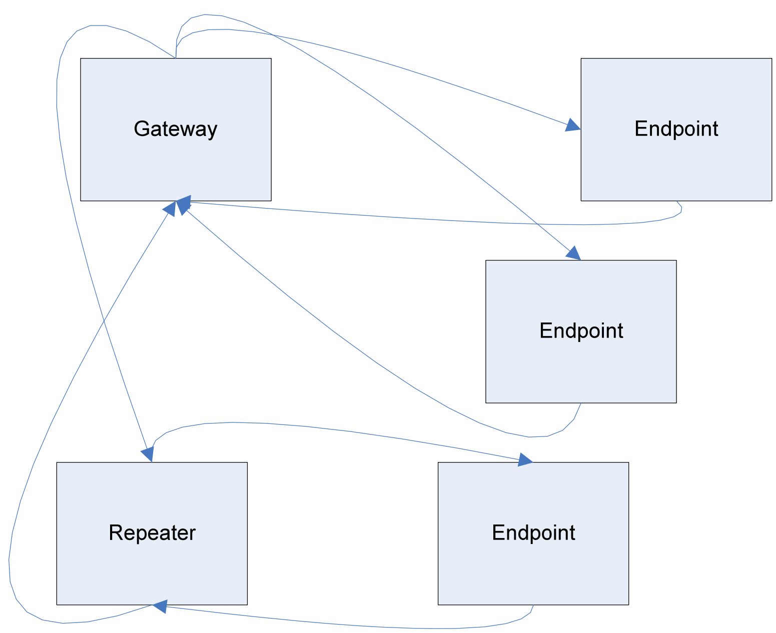
The example below shows a link with two Repeaters between the Gateway and Endpoint. With two Repeaters there is clearly more flexibility in getting around obstacles and greater total range is possible. Once again, it would be desirable to use external Omni-directional antennas with the Repeaters, and attaching a Yagi to the Gateway and Endpoint to increase the range of the link.
When two Repeaters are used there is no further degradation in the RF throughput of the link.



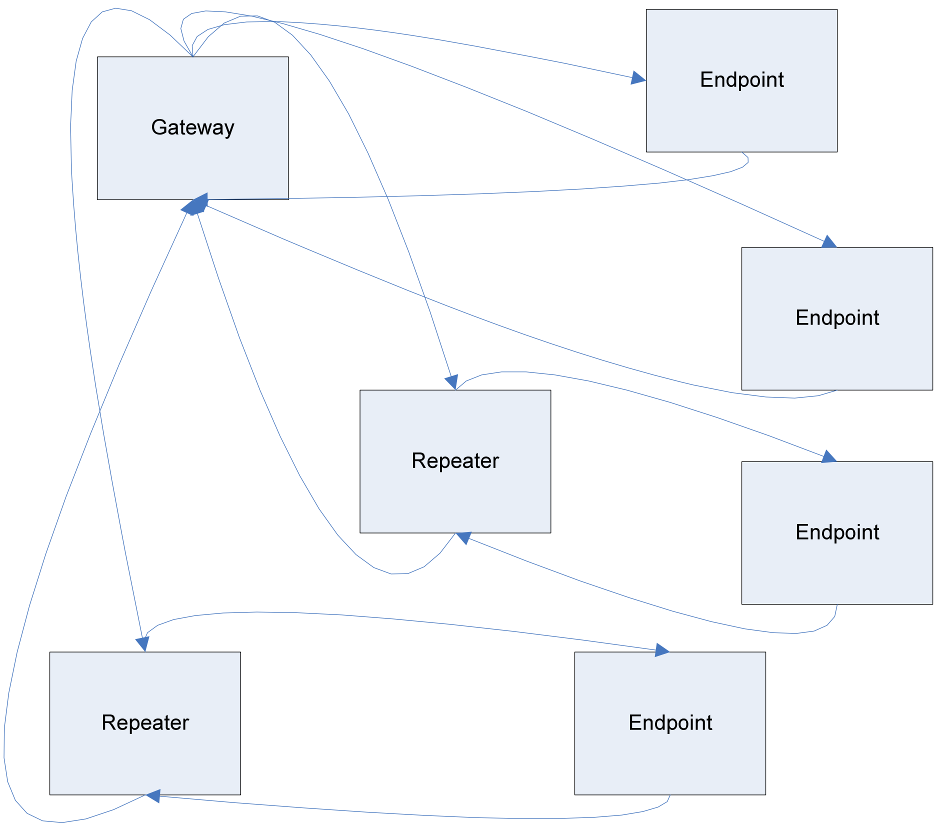
The example below shows a configuration where a Gateway routinely calls a number of End-points at different times. The Gateway is communicating with a transceiver designated as a Endpoint/Repeater that is connected to a remote device. Since this device is placed in an elevated location, the transceiver may also be used as a Repeater when it is not used as a Endpoint. At any time the Gateway may call any of the Endpoints, establish a connection, and send and receive data.



The next example depicts a standard Point-to-Multipoint network. From the Gateway, any data is broadcast to all three Endpoints, one of which receives it through a Multipoint Repeater. The data is in turn sent out of the serial port of each of the three Endpoint. The end device should be configured to interpret the serial message and act on it if necessary.



The last example is a Point-to-Multipoint network which uses one of the sites as an Endpoint/ Repeater. This network functions in the same manner as a standard Multipoint network with Repeaters. However, the number of radios may be reduced with the use of the Multipoint End-point/Repeater feature.



Operational RS-422 and RS-485 Information

For both RS-422 and RS-485, the FreeWave transceiver can drive 32 standard unit loads and loads the bus with only 1/8 unit load. This means the user can tie up to 256 devices on the bus if all of the line receivers have 1/8 unit load.

RS-422 is used for 4-wire or full duplex communication with one Gateway and multiple Endpoints. The FreeWave Gateway transceiver keeps the line driver asserted at all times. The maximum line length is 4,000 feet using two 120 ohm twisted pair cables with a 5th wire for data common.

RS-485 full duplex using 4 wire plus common is the same as RS-422, except the system can have multiple Gateways on the bus.

The most common operation of RS-485 is a two-wire comprised of a 120 ohm impedance single twisted pair. In this system the loading of the FreeWave transceiver is as described above which allows up to 256 1/8 unit load units on the bus. Maximum line length is also 4,000 feet with a third wire required for data common. The FreeWave transceiver will check the line to be certain no other device is transmitting before enabling the line driver for data transmission.

There is no provision for handshaking in any of the above modes of operation, so data rates of 57.6 KBaud and above are not recommended without a protocol that can handle error detection properly.

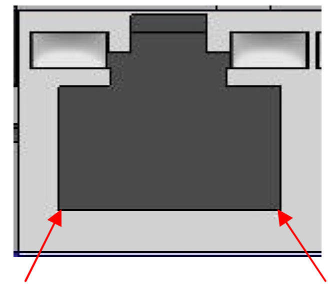
RS-422 and RS-485 Full Duplex Pin-Outs

Function	COM 1/2 RJ45 Pin Number
RX+	5
RX-	8
TX+	6
TX-	7
Signal Ground	4

RS-485 Half Duplex Pin-Outs

Function	COM 1/2 RJ45 Pin Number
Wire to both pins for Bus +	Short 5 and 6
Wire to both pins for Bus -	Short 7 and 8
Signal Ground	4

RJ-45 Ethernet connector on the FGR2-PE



COM 1 and COM 2 RJ45 Pin Assignments

Pin		Assignment	Signal	Definition
1	DSR	Data Set Ready	Output	Always high when the radio is powered from the Phoenix power connector. Indicates power is on to the radio.
2	CD	Carrier Detect	Output	Used to show an RF connection between transceivers.
3	DTR	Data Terminal Ready	Input	Not used.
4	GND	Ground		Signal return for all signal lines.
5	RX	Receive Data	Input	Used to receive data bits serially from the system device connected to the transceiver.
6	TX	Transmit Data	Output	Used to transmit data bits serially from the transceiver to the system device.
7	CTS	Clear to Send	Output	This signal is used to tell the system device connected to the transceiver that the transceiver is ready to receive data. When asserted, the transceiver will accept data, when de-asserted the transceiver will not accept data. This should always be used for data rates above 38.4KB or there will be a risk of lost data if an RF link is not very robust.
8	RTS	Request to Send	Input	The transceiver does not recognize RTS for flow control.

Technical Specifications

FGR2-PE 900 MHz Transceiver Specifications

Specification	
Frequency Range	902 to 928 MHz (FHSS)
Transmitter	
Output Power	5 mW to 1 W (+30 dBm)
Range—Line-of-Sight	Point-to-Point: 60 miles, Point-to-Multipoint: 60 miles
Modulation	2 level GFSK
Occupied Bandwidth	230.4 kHz
Hopping Channels	112
Frequency Zones	16 zones, 7—8 channels per zone
RF Connector	TNC Female
Receiver	
Sensitivity	-110 dBm for 10^{-4} bit error rate at 115 Kbps -106 dBm for 10^{-4} bit error rate at 154 Kbps
Selectivity	20 dB at fc ± 230 kHz
System Gain	140 dB
Data transmission	
Over-the-air data rate	96 Kbps sustained throughput* 48 Kbps sustained throughput with Repeaters*
Error detection	32 Bit CRC, retransmit on error
Data encryption	128-bit AES encryption, proprietary 256-bit Dynamic Key Substitution, SSL
Authentication	RADIUS, HTTP Password
Data interface	RS-232/RS422/RS485 300bps to 115.2Kbps, async, full duplex (2 ports) Ethernet 10/100BaseT, auto-sensing, auto-MDIX
Protocol	Ethernet: IEEE 802.3 TCP/IP, DHCP, ICMP, UDP, ARP, multicast TCP
Data Connector	Ethernet: 2x RJ45, Serial 2x RJ45
Power requirements	
Operating Voltage	6 to 30 VDC

Current (mA)

Mode	6 VDC	12 VDC	30 VDC
Transmit	1.1 A	550 mA	220 mA
Receive	252 mA	150 mA	63 mA
Idle	140 mA	71 mA	32 mA

* At 100% receive success rate. RF Data Rate setting of 154 Kbps.

	FGR2-PE (continued)
Operating Temperature Range	-40° C to +75° C
Dimensions	6.8 in L x 3.8 in W x 1.4 in H (17.3 cm L x 9.6 cm W x 3.5 cm H)
Weight	1.3 lbs. (0.6 kg)
Humidity	0 to 95% non-condensing

FreeWave Technical Support

For up-to-date troubleshooting information check the Support page at http://www.freewave.com.

FreeWave provides Technical Support, Monday through Friday, 7:30 AM to 5:30 PM, Mountain Time (GMT -7) Call us toll-free at **1-866-923-6168**, locally at **303-381-9200** or email us at moreinfo@freewave.com.

Appendix A—Errata

Known Issues:

FGR2-PE v. 2.19

- Initial Release

Appendix B—FreeWave TFTP Server Users Manual

Installation

Requires Microsoft Windows 98/2000/XP with Microsoft Windows Installer 2.0 or higher. To install FreeWave TFTP Server, execute the "fwTFTP Install.msi" program. If the defaults are accepted, the program will be installed in the "C:\Program Files\FreeWave Technologies\fwTFTP" folder.
The installer will automatically create an uninstall entry in the Add or Remove Programs list. To uninstall this software, open "Add or Remove Programs" in the Windows Control Panel, select "TFTP Server" from the list, then click Remove to uninstall it.

Using the Server

The illustration on the next page (Figure 1) shows the basic layout of the server. The icons at the top of the window control the server.

- To stop the server, click the **Stop server** button. No TFTP clients will be able to connect to the server, and any existing connections will be dropped.
- To restart the server, click the **Start server** button.
- To clear the log, click the **Clear log** button. This will clear the log display and also erase the log file.
- To configure the server, click the **Configure** button. This will open the configuration window described in Figure 2.
- To terminate the server program, close the TFTP Server window just like any other program: by clicking the close icon at the upper right of the window. All existing client connections will be dropped when the program closes. *Note that the log file will not be erased when the program is restarted. Only the **Clear log** button will erase the log.*

The top half of the window is a list of active client connections. Each connection shows the IP address of the client and the UDP port number the server is using to communicate with the client. The Action column shows what the client is doing. The progress column shows a green progress bar that indicates the progress of file transfers. The Kbytes/sec column shows the current transfer speed.

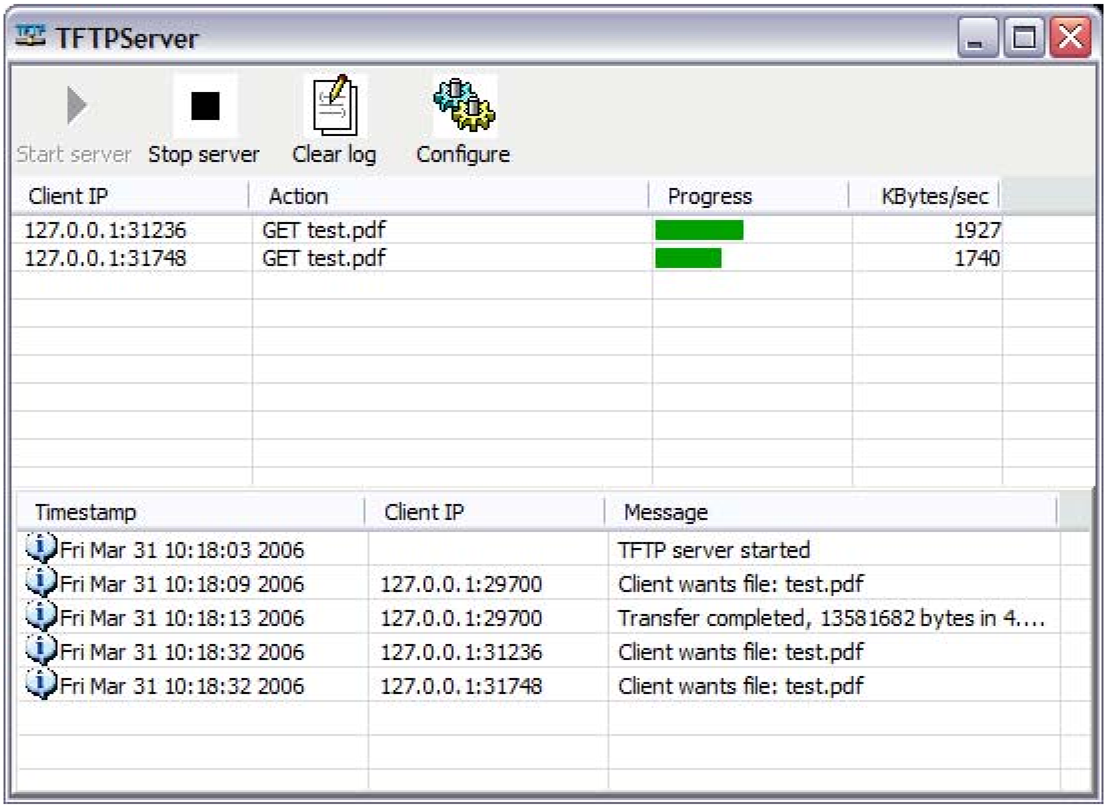


Figure 1: TFTP Server Window

The bottom half of the window is the log display. It shows log entries since the program was started. To the left of the timestamp is an icon to indicate the type of log entry. There are three types of log entries: Information (indicated by an 'i' in a balloon), Warning (indicated by a yellow warning sign), and Error (indicated by a red circle with an 'x' in it). Each log entry is timestamped and includes the IP address and UDP port of the client as well as a descriptive message indicating the reason for the log entry.

Server Configuration

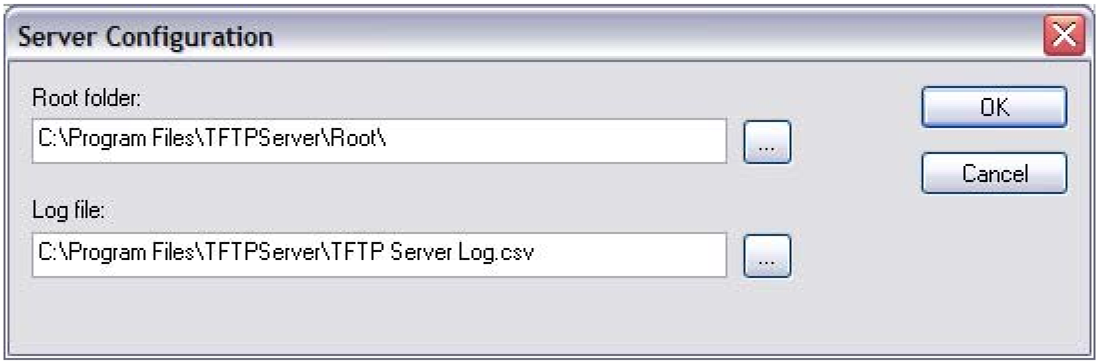


Figure 2: Server Configuration Window

Root folder

The root folder is where TFTP clients access their files. By default, the root folder is named Root and is created under the FreeWave TFTP Server folder in the Windows Program Files folder. The root folder can be directed to any other folder or drive on the computer by either typing in a path in the Root folder box or by clicking the "…" icon to the right to open a directory browser. Note that clients can only access files from the root folder or from subdirectories in the root folder.

Clients see the root folder as their root path. For example, if a client asks for a file named "sample.txt", the server will send the file if it is located in the server's root folder. If there is a folder in the root folder named Examples and it contains a file named "image.bmp", then the TFTP client would access that file using the path "examples/image.bmp".

Both forward and backward slashes are allowed to separate directory and file names. Filenames are case-insensitive. That is, the server does not check letter case when looking for files. "EXAMPLE", "Example", and "example" are all the same as far as the server is concerned.

Log file

The log file is created by default in the FreeWave TFTP Server program folder and is named "Log.csv". The log file can be moved, if desired, by either entering the desired filename in the log file path box or by clicking the "…" button to the right which will open a file browser. This is a CSV (Comma-Separated Value) format file and can be imported into Microsoft Excel for viewing or printing. The first line of the file contains column headers, and is followed by one line for each entry in the log.

Troubleshooting

Windows XP

If the Windows Firewall is enabled, the notice displayed in Figure 3 will appear when FreeWave TFTP Server is run for the first time. To allow the server to run under Windows XP, simply click the "Unblock" button. This issue does not occur if the Windows Firewall has been disabled.

Figure 3: Windows Firewall Security Alert

Appendix C—Changing the IP Address in Windows XP

NOTE: These instructions are for Windows XP. The displayed widows and available option may be different under other Operating Systems.

Figure 1

1. Click on **Start / Control Panel** or **Start / Settings / Control Panel**.
2. Double-click the **Network Connections** icon. *(Figure 1)*
3. Right-click on **Local Area Connection** and then click **Properties**. (*Figure 2)* NOTE: Depending on the Network setup, different icons may appear here. Please contact the IT Department if there are issues finding the proper icon.
4. Click on **Internet Protocol (TCP/IP)** to highlight it, then click the **Properties** button. *(Figure 3)*
5. Select the **Use the following IP address** radio button, and enter an appropriate IP address. Hit the **Tab** key, and Windows XP will enter a **Subnet Mask** of 255.255.255.0 automatically. They may be changed if necessary. Usually, the **Default Gateway**, **Preferred DNS Server**, and **Alternate DNS Server** entries can be left blank when the computer is being used solely for radio configuration. *(Figure 4)* If there are questions about these entries, please contact the IT Department.

Figure 2

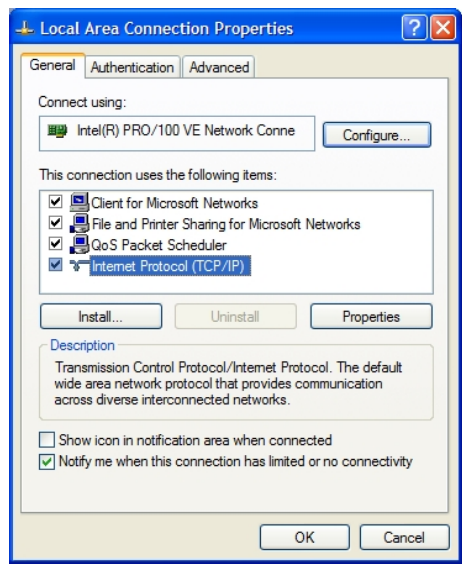


Figure 3

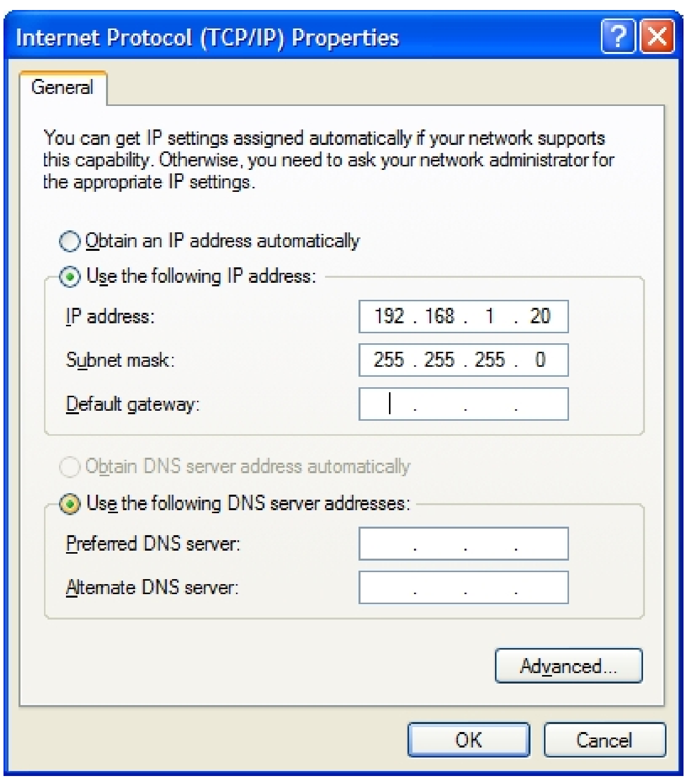
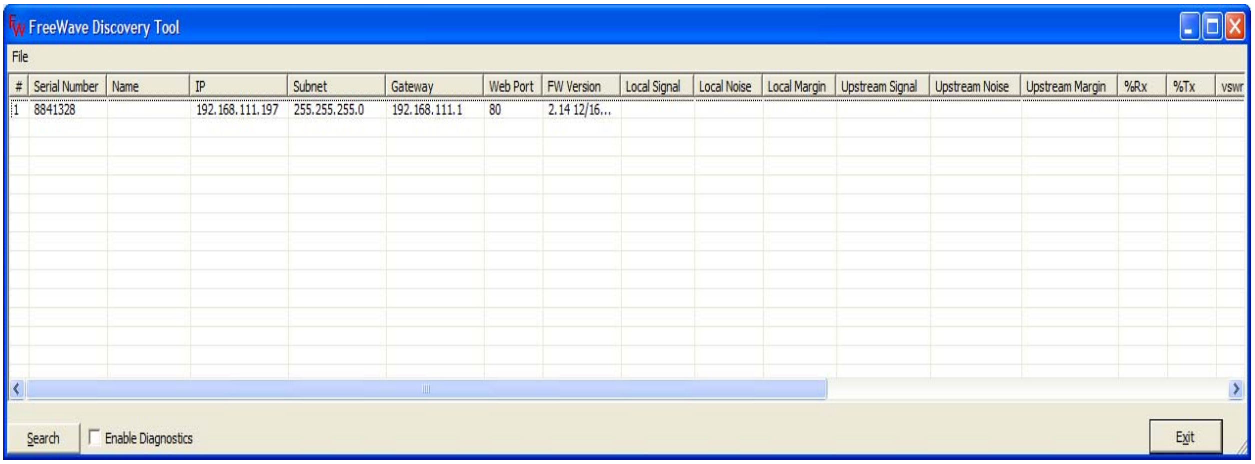


Figure 4

Appendix D—FreeWave Discovery Server v. 1.5

Plus-style radios with a Firmware version of 2.8 or higher will report its IP Address and other information to the FreeWave Discovery Tool, a free utility available from FreeWave.



Upon running the program, it will automatically attempt to discover any Plus-style radios connected via Ethernet. The radios broadcast this information, so they should be successfully discovered as long as they have a physical Ethernet connection to the network. Depending on an IT department's policies, broadcasts may be blocked through any routers, so the radio may need to be on the same LAN segment as the PC running the FreeWave Discovery Tool.

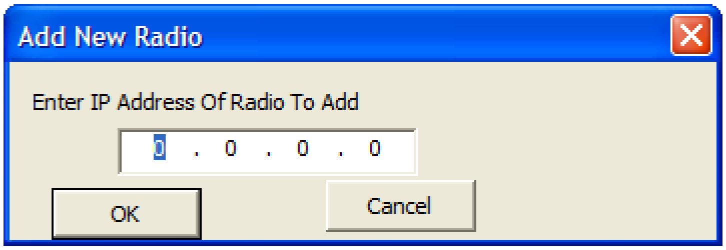
Firewall software, such as Windows Firewall and McAfee Personal Firewall can prevent the Discovery Server from operating properly. FreeWave Technologies recommends disabling any Firewall software prior to running the Discovery Server.

In firmware versions 2.13 and higher, Endpoint and Multipoint Repeater radios can only be discovered if the PC running Discovery Server is connected on the Gateway side of the radio network. If connected to an Endpoint or Multipoint Repeater in this situation, only that radio and the Gateway will be reported.

The FreeWave Discovery Tool will show the Serial Number, Radio Name (if assigned), IP Address, Subnet Mask, Default Gateway, Web Port, and Firmware Version for each discovered radio.

Choosing a radio from the discovered list and right-clicking on it will bring up a Context Menu with the following items: **Add**, **Delete**, **Open Web Page**, and **Change Basic Settings**.

Add



This option allows a radio to be manually added to the discovery list by its IP Address. The IP Address of the radio would be entered into the box, and then the **OK** button is clicked. Press the **CANCEL** button to close the window without entering an IP Address.

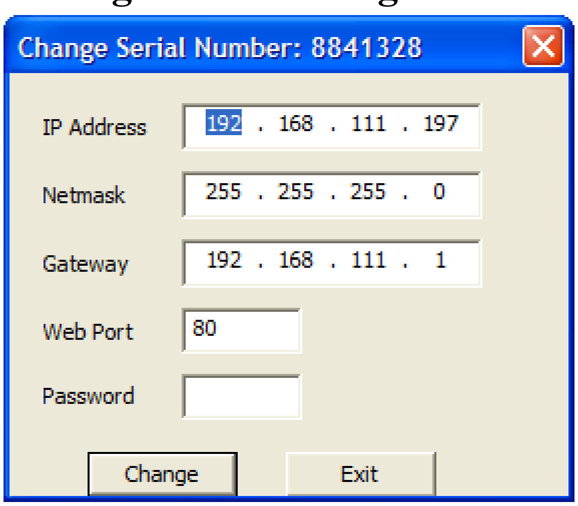
Delete

Selecting this option will delete the selected entry from the Discovery Server list. If the radio is still connected to the Ethernet link, the entry will reappear upon the radio's next broadcast.

Open Web Page

Choosing this option opens the computer's default web browser and enters the selected radio's IP Address in the address bar. If the computer can communicate with that IP Address via HTTP, the radio's login information will come up. Logging in will display the radio's settings pages.

Change Basic Settings



Selecting this option brings up a window that allows the changing of the basic IP settings of the radio. In this section, the **IP Address**, **Netmask (Subnet Mask)**, **Gateway**, and **Web Port** can be changed. If changes are made, the Administrator password for the radio must be entered in the **Password** box and then the **Change** button should be clicked. If the password is correct, the radio will reboot and apply the requested changes. Otherwise, the radio will ignore the change request. ***NOTE:*** *Radios with a firmware version of 2.14 and lower will only accept 'admin' as the valid password. This is corrected in newer versions of firmware..*

File Menu

The following options appear on the **File** menu in the Discovery Server Window: **Export to CSV**, **Save Network File**, **Import Network File**, **Clear Radio List**, and **Exit**.

Export to CSV

This menu options saves the current radio entries in a comma-delimited (.CSV) file. The file contains all the information currently displayed in the Discovery Server program, including Radio Name and all the Diagnostic columns.

Save Network File

This menu option saves the current radio list as a Network File (.PNF) that can be imported into other copies of the Discovery Server. The Network File only saves a list of the radio IP Addresses—no other information is saved.

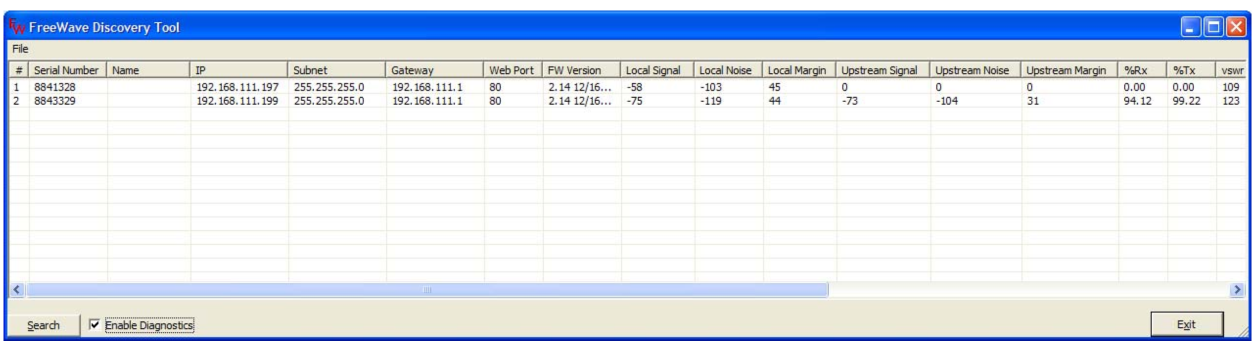
Import Network File

This menu option loads a selected Network File (.PNF) into the Discovery Server. Only the radio IP Addresses will be displayed until a broadcast is received from the listed radios (when the radios are rebooted, or when the **Search** button is clicked) or until the **Diagnostics** box is checked.

Exit

Selecting this menu option closes the FreeWave Discovery Server

Enable Diagnostics



Checking this box will cause the Discovery Server to request diagnostics information from any discovered radio. Diagnostics will only be reported from radios with a firmware version of **2.11** and higher. The following diagnostics information is listed in the Discovery Server: **Local Signal**, **Local Noise**, **Local Margin**, **Upstream Signal**, **Upstream Noise**, **Upstream Margin**, **% Rx**, **% Tx**, **VSWR (Reflected Power)**, **Temp**, **Voltage**, **Distance**, and **Connected To**. Specifics on these statistics can be found on **pages 20—21** of this manual. Diagnostics will be regularly updated as long as the **Enable Diagnostics** box is checked. When that box is unchecked, the last reported diagnostic information remains in the window, but it is no longer updated. The **Upstream** statistics will only show in radios with a firmware version of 2.13 or higher.

User Guide

Anritsu

Site Master

S331E, S332E, S361E, and S362E

Cable and Antenna Analyzer
Spectrum Analyzer

User Guide

Site Master
Cable and Antenna Analyzer
with Spectrum Analyzer

S331E, 2 MHz to 4 GHz
S332E, 2 MHz to 4 GHz, Spectrum Analyzer, 100 kHz to 4 GHz
S361E, 2 MHz to 6 GHz
S362E, 2 MHz to 6 GHz, Spectrum Analyzer, 100 kHz to 6 GHz

Appendix A provides a list of supplemental documentation for the Site Master features and options. The documentation set is available as PDF files on the documentation disc and the Anritsu web site.

Anritsu Company
490 Jarvis Drive
Morgan Hill, CA 95037-2809
USA

Part Number: 10580-00252
Revision: F
Published: October 2012

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The Anritsu product(s) listed on the title page is (are) warranted against defects in materials and workmanship for one year from the date of shipment.

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UPDATES

Updates, if any, can be downloaded from the Documents area of the Anritsu Website at:
http://www.us.anritsu.com

For the latest service and sales contact information in your area, please visit:
http://www.anritsu.com/contact.asp

DECLARATION OF CONFORMITY

Manufacturer's Name: ANRITSU COMPANY

Manufacturer's Address: Microwave Measurements Division
490 Jarvis Drive
Morgan Hill, CA 95037-2809
USA

declares that the product specified below:

Product Name: Site Master

Model Number: S331E, S332E, S361E, S362E

conforms to the requirement of:

EMC Directive: 2004/108/EC
Low Voltage Directive: 2006/95/EC

Electromagnetic Compatibility: EN61326:2006

Emissions: EN55011: 2007 Group 1 Class A

Immunity:	EN 61000-4-2:1995 +A1:1998 +A2:2001	4kV CD, 8kV AD
	EN 61000-4-3:2006 +A1:2008	3V/m
	EN 61000-4-4:2004	0.5kV SL, 1kV PL
	EN 61000-4-5:2006	0.5kV L-L, 1kV L-E
	EN 61000-4-6: 2007	3V
	EN 61000-4-11: 2004	100% @ 20msec

Electrical Safety Requirement:

Product Safety: EN 61010-1:2001

Eric McLean, Corporate Quality Director

Morgan Hill, CA

21 July 2007
Date

European Contact: For Anritsu product EMC & LVD information, contact Anritsu LTD, Rutherford Close, Stevenage Herts, SG1 2EF UK, (FAX 44-1438-740202)

产品中有毒有害物质或元素的名称及含量 For Chinese Customers Only YLYB

部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 [Cr(VI)]	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
印刷线路板 (PCA)	×	○	×	×	○	○
机壳、支架 (Chassis)	×	○	×	×	○	○
LCD	×	×	×	×	○	○
其他（电缆、风扇、连接器等）(Appended goods)	×	○	×	×	○	○

○：表示该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T11363-2006 标准规定的限量要求以下。
×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T11363-2006 标准规定的限量要求。

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注）电池的环保使用期限是 5 年。生产日期标于产品序号的前四码
（如 S/N 0728XXXX 为 07 年第 28 周生产）。

Equipment marked with the Crossed-out Wheelie Bin symbol complies with the European Parliament and Council Directive 2002/96/EC (the "WEEE Directive") in the European Union.

For Products placed on the EU market after August 13, 2005, please contact your local Anritsu representative at the end of the product's useful life to arrange disposal in accordance with your initial contract and the local law.

CE Conformity Marking

Anritsu affixes the CE Conformity marking onto its conforming products in accordance with Council Directives of The Council Of The European Communities in order to indicate that these products conform to the EMC and LVD directive of the European Union (EU).

C-tick Conformity Marking

Anritsu affixes the C-tick marking onto its conforming products in accordance with the electromagnetic compliance regulations of Australia and New Zealand in order to indicate that these products conform to the EMC regulations of Australia and New Zealand.

N274

Notes On Export Management

This product and its manuals may require an Export License or approval by the government of the product country of origin for re-export from your country.

Before you export this product or any of its manuals, please contact Anritsu Company to confirm whether or not these items are export-controlled.

When disposing of export-controlled items, the products and manuals need to be broken or shredded to such a degree that they cannot be unlawfully used for military purposes.

Mercury Notification

This product uses an LCD backlight lamp that contains mercury. Disposal may be regulated due to environmental considerations. Please contact your local authorities or, within the United States, the Electronics Industries Alliance (www.eiae.org) for disposal or recycling information.

To prevent the risk of personal injury or loss related to equipment malfunction, Anritsu Company uses the following symbols to indicate safety-related information. For your own safety, please read the information carefully *before* operating the equipment.

Symbols Used in Manuals

Danger

This indicates a very dangerous procedure that could result in serious injury or death, or loss related to equipment malfunction, if not performed properly.

Warning

This indicates a hazardous procedure that could result in light-to-severe injury or loss related to equipment malfunction, if proper precautions are not taken.

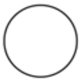
Caution

This indicates a hazardous procedure that could result in loss related to equipment malfunction if proper precautions are not taken.

Safety Symbols Used on Equipment and in Manuals

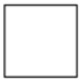
The following safety symbols are used inside or on the equipment near operation locations to provide information about safety items and operation precautions. Ensure that you clearly understand the meanings of the symbols and take the necessary precautions *before* operating the equipment. Some or all of the following five symbols may or may not be used on all Anritsu equipment. In addition, there may be other labels attached to products that are not shown in the diagrams in this manual.

This indicates a prohibited operation. The prohibited operation is indicated symbolically in or near the barred circle.



This indicates a compulsory safety precaution. The required operation is indicated symbolically in or near the circle.

This indicates a warning or caution. The contents are indicated symbolically in or near the triangle.



This indicates a note. The contents are described in the box.

These indicate that the marked part should be recycled.

Warning

Always refer to the operation manual when working near locations at which the alert mark, shown on the left, is attached. If the operation, etc., is performed without heeding the advice in the operation manual, there is a risk of personal injury. In addition, the equipment performance may be reduced. Moreover, this alert mark is sometimes used with other marks and descriptions indicating other dangers.

Warning

or

When supplying power to this equipment, connect the accessory 3-pin power cord to a 3-pin grounded power outlet. If a grounded 3-pin outlet is not available, use a conversion adapter and ground the green wire, or connect the frame ground on the rear panel of the equipment to ground. If power is supplied without grounding the equipment, there is a risk of receiving a severe or fatal electric shock.

Warning

WARNING

This equipment can not be repaired by the operator. Do not attempt to remove the equipment covers or to disassemble internal components. Only qualified service technicians with a knowledge of electrical fire and shock hazards should service this equipment. There are high-voltage parts in this equipment presenting a risk of severe injury or fatal electric shock to untrained personnel. In addition, there is a risk of damage to precision components.

Caution

Electrostatic Discharge (ESD) can damage the highly sensitive circuits in the instrument. ESD is most likely to occur as test devices are being connected to, or disconnected from, the instrument's front and rear panel ports and connectors. You can protect the instrument and test devices by wearing a static-discharge wristband. Alternatively, you can ground yourself to discharge any static charge by touching the outer chassis of the grounded instrument before touching the instrument's front and rear panel ports and connectors. Avoid touching the test port center conductors unless you are properly grounded and have eliminated the possibility of static discharge.

Repair of damage that is found to be caused by electrostatic discharge is not covered under warranty.

Warning

This equipment is supplied with a rechargeable battery that could potentially leak hazardous compounds into the environment. These hazardous compounds present a risk of injury or loss due to exposure. Anritsu Company recommends removing the battery for long-term storage of the instrument and storing the battery in a leak-proof, plastic container. Follow the environmental storage requirements specified in the product data sheet.

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Chapter 4—File Management

Chapter 5—System Operations

Chapter 6—GPS (Option 31)

Chapter 7—Ethernet Connectivity (Option 411)

Chapter 8—Bias Tee (Option 10)

Chapter 9—Anritsu Tool Box and Line Sweep Tools

Chapter 10—Master Software Tools

Appendix A—Measurement Guides

Index

Chapter 1 — General Information

1-1 Introduction

This chapter provides information about frequency range, available options, additional documents, general overview, preventive maintenance, and annual verification requirements for the Anritsu Handheld S331E, S361E, S332E, and S362E Site Master models. Throughout this manual, the term Site Master will refer to the S331E, S361E, S332E, and S362E.

1-2 Chapter Overview

1-3 Available Models

Table 1-1 lists the Site Master models and frequency ranges described in this User Guide.

Table 1-1. Site Master Models

Model	Frequency Range
S331E	Cable & Antenna Analyzer, 2 MHz to 4 GHz
S361E	Cable & Antenna Analyzer, 2 MHz to 6 GHz
S332E	Cable & Antenna Analyzer, 2 MHz to 4 GHz, Spectrum Analyzer, 100 kHz to 4 GHz
S362E	Cable & Antenna Analyzer, 2 MHz to 6 GHz, Spectrum Analyzer, 100 kHz to 6 GHz

1-4 Available Options

Available options for the Site Master models are shown in Table 1-2.

Table 1-2. Available Options

S331E	S332E	S361E	S362E	Description
	S332E-0419		S362E-0419	PIM Analyzer
S331E-0021	S332E-0021	S361E-0021	S362E-0021	2-Port Transmission Measurement
S331E-0010	S332E-0010	S361E-0010	S362E-0010	Bias-Tee (Requires Option 0021 on S331E and S361E)
S331E-0031	S332E-0031	S361E-0031	S362E-0031	GPS Receiver (Requires Anritsu GPS Antenna)
S331E-0019	S332E-0019	S361E-0019	S362E-0019	High-Accuracy Power Meter(1)
	S332E-0029		S362E-0029	Power Meter
	S332E-0025		S362E-0025	Interference Analyzer(2)
	S332E-0027		S362E-0027	Channel Scanner
	S332E-0431		S362E-0431	Coverage Mapping(2)
	S332E-0090		S362E-0090	Gated Sweep
	S332E-0028		S362E-0028	C/W Signal Generator (Requires CW Signal Generator Kit)
	S332E-0509		S362E-0509	AM/FM/PM Analyzer
S331E-0411	S332E-0411	S361E-0411	S362E-0411	Ethernet Connectivity
S331E-0098	S332E-0098	S361E-0098	S362E-0098	Standard Calibration to (ANSI 2540-1-1994)
S331E-0099	S332E-0099	S361E-0099	S362E-0099	Premium Calibration to Z540 plus test data

1. Requires External Power Sensor.
2. Requires Option 0031.

1-5 Standard Accessories

The Anritsu Site Master includes a one year warranty which includes: battery, firmware, software, and Certificate of Calibration and Conformance.

The Site Master Technical Data Sheet (P/N 11410-00484) contains a list and description of the standard accessories.

Caution	When using the Automotive Cigarette Lighter Adapter, always verify that the supply is rated for a minimum of 60 Watts at 12 VDC, and that the socket is clear of any dirt or debris. If the adapter plug becomes hot to the touch during operation, then discontinue use immediately.

1-6 Optional Accessories

The Site Master Technical Data Sheet (P/N 11410-00484) also contains a list and description of available optional accessories. The data sheet is provided with the instrument and available on the Anritsu website: http://us.anritsu.com.

1-7 Additional Documents

This user guide is specific to the Site Master and includes a general description about the Site Master. For information about Cable & Antenna Measurement, Spectrum Analysis, Interference Analysis, 2-port Transmission Measurements, Power Meter, Coverage Mapping, PIM Analysis, Line Sweep Tools, and Master Software Tools, refer to the individual Measurement Guides listed in Appendix A, “Measurement Guides”.

1-8 General Description

The Site Master S331E/S361E is a hand held cable and antenna analyzer designed to make Return Loss, VSWR, Cable Loss, and Distance-To-Fault (DTF) measurements in the field. The cable and antenna analyzer also includes 1-port phase and smith chart measurements. The 2-port transmission measurement option includes two power levels and access to a built-in 32 volt bias tee (Option 10).

The S332E/S362E is an integrated multi-functional test instrument that eliminates the need to carry and learn multiple test sets. In addition to the cable & antenna measurements, the S332E/S362E can be configured to include a Spectrum Analyzer, 2-port Transmission Measurement, Interference Analyzer with Interference Mapping capabilities, Coverage Mapping, Channel Scanner, CW Signal Generator, AM/FM/PM Analyzer, PIM Analyzer, Power Meter, and High Accuracy Power Meter. A GPS receiver can be added to both the S331E/S361E and the S332E/S362E Site Master models.

The bright 8.4" TFT color display provides easy viewing in a variety of lighting conditions and the combination of a touch screen and keypad enables users to navigate menus with the touch screen and enter numbers with the keypad. All Site Master models are equipped with a Li-Ion battery delivering more than four hours of battery life for the S331E/S361E and more than three hours of battery life for the S332E/S362E Site Masters.

The internal memory is large enough to store approximately 2,000 traces or setups. Measurements and setups can also be stored in a USB flash drive or transferred to a PC using the included USB cable. Ethernet connectivity is available using Option 0411.

Note	Not all after-market USB drives are compatible with the instrument. Many drives come with a second partition that contains proprietary firmware. This partition must be removed. Only one partition is allowed. Refer to the individual manufacturer for instructions on how to remove it. Some drives can be made to work by reformatting them using the FAT32 format.

Master Software Tools (MST), a PC based software program, can be used to create reports, view and organize data, analyze historical data, add markers and limit lines, rename traces and trace analysis. Refer to Chapter 10 for a brief overview of Master Software Tools and the Master Software Tools Users Guide (.pdf file is available on the MST CD-ROM) for additional information. (.DAT files can be opened with the legacy Handheld Software Tools (HHST) application.)

1-9 Site Master Specifications

Refer to the Site Master Technical Data Sheet (P/N 11410-00484) for general specifications, detailed measurement specifications for all available measurement modes, ordering information, power sensors, and available accessories. The data sheet is included with the instrument and is also available on the Anritsu website: http://us.anritsu.com.

1-10 Preventive Maintenance

Site Master preventive maintenance consists of cleaning the unit and inspecting and cleaning the RF connectors on the instrument and all accessories. Clean the Site Master with a soft, lint-free cloth dampened with water or water and a mild cleaning solution.

Caution	To avoid damaging the display or case, do not use solvents or abrasive cleaners.

Clean the RF connectors and center pins with a cotton swab dampened with denatured alcohol. Visually inspect the connectors. The fingers of the N(f) connectors and the pins of the N(m) connectors should be unbroken and uniform in appearance. If you are unsure whether the connectors are undamaged, gauge the connectors to confirm that the dimensions are correct.

Visually inspect the test port cable(s). The test port cable should be uniform in appearance, and not stretched, kinked, dented, or broken.

1-11 Calibration Requirements

Anritsu recommends annual calibration and performance verification by local Anritsu service centers. The Cable and Antenna Analyzer mode requires calibration standards for OPEN, SHORT, and LOAD (OSL) or InstaCal module, which are sold separately.

Note	Anritsu recommends allowing the instrument to warm up to typical operation temperature (~15 minutes) before calibrating.

1-12 Annual Verification

Anritsu recommends an annual calibration and performance verification of the Site Master and the OSL calibration components and InstaCal module by local Anritsu service centers.

The Site Master is self-calibrating and there are no field-adjustable components. The OSL calibration components are crucial to the integrity of the calibration. As a result, they must be verified periodically to ensure performance conformity. This is especially important if the OSL calibration components have been accidentally dropped or over-torqued.

Contact information for Anritsu Service Centers is available at:

http://www.anritsu.com/Contact.asp

1-13 ESD Caution

The Site Master, like other high performance instruments, is susceptible to electrostatic discharge (ESD) damage. Coaxial cables and antennas often build up a static charge, which (if allowed to discharge by connecting directly to the Site Master without discharging the static charge) may damage the Site Master input circuitry. Site Master operators must be aware of the potential for ESD damage and take all necessary precautions.

Operators should exercise practices outlined within industry standards such as JEDEC-625 (EIA-625), MIL-HDBK-263, and MIL-STD-1686, which pertain to ESD and ESDS devices, equipment, and practices. Because these apply to the Site Master, it is recommended that any static charges that may be present be dissipated before connecting coaxial cables or antennas to the Site Master. This may be as simple as temporarily attaching a short or load device to the cable or antenna prior to attaching to the Site Master. It is important to remember that the operator may also carry a static charge that can cause damage. Following the practices outlined in the above standards will ensure a safe environment for both personnel and equipment.

1-14 Battery Replacement

The battery can be replaced without the use of tools. The battery compartment is located on the lower left side of the instrument (when you are facing the measurement display). To remove the battery:

1. Slide the catch toward the bottom of the instrument
2. Pull the top of the door away from the unit
3. Lift out the battery door.
4. Remove the battery pack from the instrument by grabbing the battery lanyard and pulling out.

Replacement is the opposite of removal. The battery key side (slot below the contacts) should be facing the front on the unit and slide in first.

Note	When inserting the battery the battery label should face the back of the instrument and the guide slot on the battery should be below the contacts. If the battery door does not latch closed, the battery may be inserted incorrectly.

Figure 1-1. Battery Compartment

The battery that is supplied with the Site Master may need charging before use. The battery can be charged while it is installed in the Site Master by using either the AC-DC Adapter or the DC adapter, or outside the Site Master with the optional Dual Battery Charger. Refer to "Battery Symbols" on page 2-11 for a description of battery symbols.

Note	Use only Anritsu Company approved batteries, adapters, and chargers with this instrument. Anritsu Company recommends removing the battery for long-term storage of the instrument.

Caution	When using the Automotive Cigarette Lighter Adapter, always verify that the supply is rated for a minimum of 60 Watts @ 12 VDC, and that the socket is clear of any dirt or debris. If the adapter plug becomes hot to the touch during operation, then discontinue use immediately.

1-15 Soft Carrying Case

The Site Master can be operated while in the soft carrying case. On the back of the case is a large storage pouch for accessories and supplies.

To install the instrument into the soft carrying case:

1. The front panel of the case is secured with hook-and-loop fasteners. Fully close the front panel of the case. When closed, the front panel supports the shape of the case while you are inserting the Site Master.
2. Place the soft carrying case face down on a stable surface, with the front panel fully closed and laying flat.

Note	The soft case has two zippers near the back. The zipper closer to the front of the case opens to install and remove the instrument. The zipper closer to the back of the case opens an adjustable support panel that can be used to provide support for improved stability and air flow while the instrument is in the case. This support panel also contains the storage pouch.

3. Open the zippered back of the case.
4. Insert the instrument face down into the case, take care that the connectors are properly situated in the case top opening. You may find it easier to insert the connectors first, then pull the corners over the bottom of the Site Master.

Figure 1-2. Instrument Inserted into the Soft Carrying Case

5. Close the back panel and secure with the zipper to secure the Site Master.

The soft carrying case includes a detachable shoulder strap, which can be connected to the D-rings of the case.

Caution	The soft case has panel openings for the fan inlet and exhaust ports. Do not block the air flow through the panels when the unit is operating.

1-16 Tilt Bail Stand

A Tilt Bail is attached to the back of the Site Master for desktop operation. The tilt bail provides two settings of backward tilt for improved stability. To deploy the tilt bail, pull the bottom of the tilt bail away from the back of the instrument. To store the tilt bail, push the bottom of the bail towards the back of the instrument until it attaches to the Site Master.

Note	Do not use the tilt bail while the instrument is in the soft case. The soft case has an adjustable support panel in the back zipper.

Figure 1-3. Tilt Bail Extended

1-17 Secure Environment Workplace

This section details the types of memory in the Site Master, how to delete stored user files in internal memory, and recommended usage in a secure environment workplace.

Site Master Memory Types

The instrument contains non-volatile disk-on-a-chip memory, EEPROM, and volatile DRAM memory. The instrument does not have a hard disk drive or any other type of volatile or non-volatile memory.

Disk-On-A-Chip (DOC)

DOC is used for storage of instrument firmware, factory calibration information, user measurements, setups, and .jpg screen images. User information stored on the DOC is erased by the master reset process described below.

EEPROM

This memory stores the model number, serial number, and calibration data for the instrument. Also stored here are the user-set operating parameters such as frequency range. During the master reset process all operating parameter stored in the EEPROM are set to standard factory default values.

RAM Memory

This is volatile memory used to store parameters needed for the normal operation of the instrument along with current measurements. This memory is reset whenever the instrument is restarted.

External USB Flash Drive (not included with the instrument)

This memory may be selected as the destination for saved measurements and setups for the instrument. The user can also copy the contents of the internal disk-on-chip memory to the external flash memory for storage or data transfer. The external Flash USB can be reformatted or sanitized using software on a PC.

Refer to the Chapter 4, “File Management” for additional information on saving and copying files to the USB flash drive.

Erase All User Files in Internal Memory

Perform a Master Reset:

1. Turn the instrument on.
2. Press the **Shift** button then the **System** (8) button.
3. Press the System Options submenu key.
4. Press the Reset key, then the Master Reset key.
5. A dialog box will be displayed on the screen warning that all settings will be returned to factory default values and all user files will be deleted. This deletion is a standard file delete and does not involve overwriting exiting information.
6. Press the **ENTER** button to complete the master reset.
7. The instrument will reboot and the reset is complete.

Recommended Usage in a Secure Environment

Set the Site Master to save files to an external USB Flash drive:

1. Attach the external Flash drive and turn the instrument on.
2. Press the **Shift** button then the **File** (7) button.
3. Press the Save submenu key.
4. Press the Change Save Location submenu key, then select the USB drive with the rotary knob, **Up/Down** arrow keys, or the touchscreen.
5. Press the Set Location submenu key.

The external USB drive is now the default location for saving files.

Note	Not all USB drives are compatible with the instrument. Many drives come with a second partition that contains proprietary firmware. This partition must be removed. Only one partition is allowed. Refer to the individual manufacturer for instructions on how to remove it. Some drives can be made to work by reformatting them using the FAT32 format.

Chapter 2 — Instrument Overview

2-1 Introduction

This chapter provides a brief overview of the Anritsu Site Master. The intent of this chapter is to acquaint the user with the instrument. For detailed measurement information, refer to a specific measurement guide listed in Appendix A, "Measurement Guides".

2-2 Chapter Overview

2-3 Turning On the Site Master

The Anritsu Site Master S331E/S361E models are capable of approximately four hours and the S332E/S362E models are capable of approximately three hours of continuous operation from a fully charged, field-replaceable battery (see Section 1-14 "Battery Replacement" on page 1-6).

The Site Master can also be operated from a 12 Vdc source (which will also simultaneously charge the battery). This can be achieved with either the Anritsu AC-DC Adapter or the Automotive Cigarette Lighter Adapter. Both items are included with the Site Master.

Caution	When using the Automotive Cigarette Lighter Adapter, always verify that the supply is rated for a minimum of 60 Watts @ 12 VDC, and that the socket is clear of any dirt or debris. If the adapter plug becomes hot to the touch during operation, discontinue use immediately.

To turn on the Site Master, press the green **On/Off** button on the front panel (Figure 2-1)

Figure 2-1. Site Master Overview

The Site Master takes approximately sixty seconds to complete power warm-up and to load the application software. At the completion of this process, the instrument is ready for use.

2-4 Front Panel Overview

The Site Master menu-driven interface is easy to use and requires little training. The Site Master uses a touch screen and keypad for data input. The five bottom menu keys and eight submenu keys on the right side are touch screen keys. The menu and submenu keys will vary depending upon the selected mode of operation, see "Mode Selector Menu" on page 2-14.

Numeric keys 1 through 9 are dual purpose, depending upon the current mode of operation. The dual-purpose keys are labeled with a number on the key itself and the alternate function is printed in blue above each of the keys. Use the blue **Shift** key to access the functions printed on the panel. The **Escape** key, used for aborting data entry, is the oval button located above numeric key 9. The rotary knob, the four arrow keys, and the keypad can be used to change the value of an active parameter.

The Menu key provides graphical icons of all the installed measurement modes and user defined short-cuts (see "Menu Key" on page 2-3). The locations of the keys are shown in Figure 2-1.

Note	Keep the fan inlet and exhaust ports clear of obstructions at all times for proper ventilation and cooling of the instrument.

Front Panel Keys

Menu Key

Press this key to display a grid of shortcut icons for installed measurement modes and user selected menus and setup files.

Figure 2-2 shows the **Menu** key screen with shortcut icons for the installed measurement modes. Touch one of the icons in the top two rows to change modes. These icons are preinstalled and can not be moved or deleted.

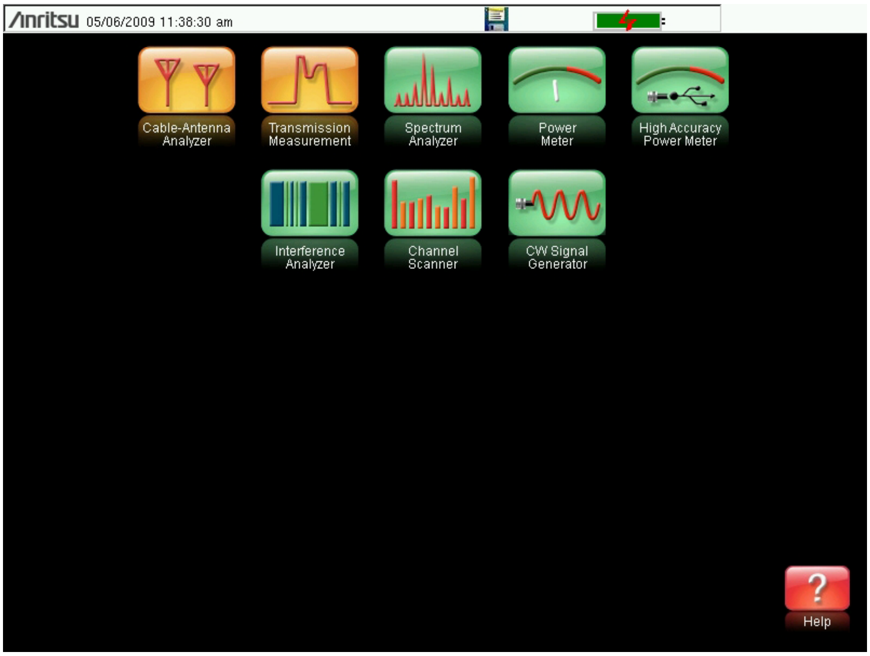


Figure 2-2. Menu Key Screen, Icons for Installed Measurements

Note	The display of the Menu screen will vary depending on Site Master model and installed options.

Figure 2-3 shows the **Menu** key screen with shortcut icons for the installed measurement modes and four rows of user-defined shortcuts to menus and setup files.

Press and hold down any key for a few seconds to add a shortcut to this screen.To add shortcut setup files (.stp), open the recall menu and hold down on the file name for several seconds. Then select the location for the shortcut.

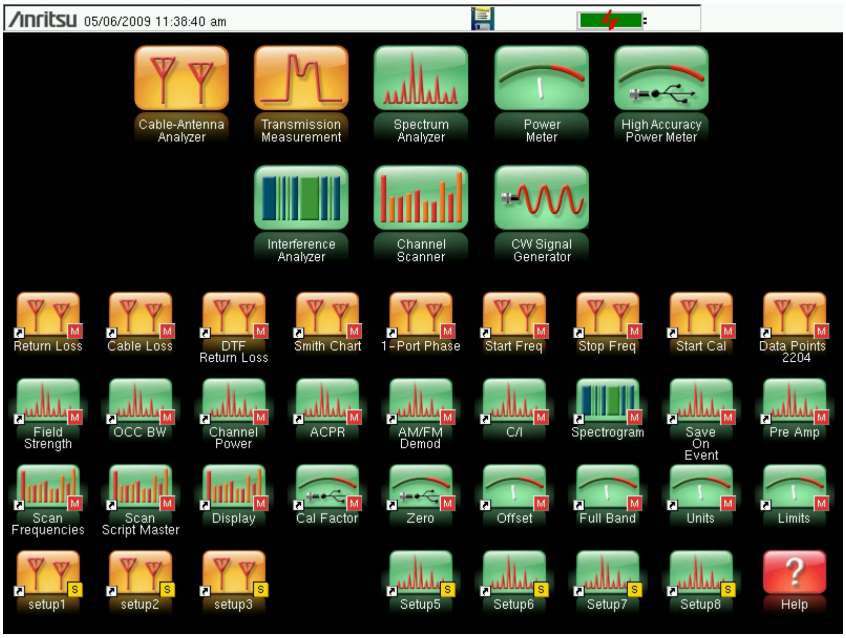


Figure 2-3. Menu Key Screen

User-defined shortcuts will stay in memory until deleted. To delete or move a shortcut button, press the **Menu** key then press and hold the shortcut for approximately 3 seconds. The Customize Button dialog box will open to allow a button to be deleted or moved. Press **Esc** to exit the Menu shortcut display.

Note	The Factory Default reset will delete all user created shortcut icons from the Menu screen. Refer to the "Reset Menu" on page 5-7 for additional information.

Help for the Menu shortcut screen is available by pressing the icon in the lower-right corner of the display.

Esc Key

Press this key to cancel any setting that is currently being made.

Enter Key

Press this key to finalize data input or select a highlighted item from a list.

Arrow Keys

The four arrow keys (around the **Enter** key) are used to scroll up, down, left, or right. The arrow keys can often be used to change a value or to change a selection from a list. This function is similar to the function of the rotary knob. The arrow keys are also used to move markers.

Shift Key

Pressing the **Shift** key and then a number key executes the function that is indicated in blue text above the number key. When the **Shift** key is active, its icon is displayed at the top-right of the measurement display area by the battery charge indicator.

Figure 2-4. Shift Key Icon

Number Keypad

The Number keypad has two functions: The primary function is number entry. The secondary function of the number keypad is to list various menus. See "Keypad Menu Keys (1 to 9)" on page 2-5.

Rotary Knob

Turning the rotary knob changes numerical values, scrolls through selectable items from a list, and moves markers. Values or items may be within a dialog box or an edit window.

Touch Screen Keys

Main Menu Touch Screen Keys

These five main menu keys are horizontally arranged along the lower edge of the touch screen. The main menu key functions change to match specific instrument Mode settings. The main menu keys generate function-specific submenus. The various measurement modes are selected by pressing the **Shift** key and then the **Mode** (9) key. Descriptions of the various measurement modes can be found in the applicable Measurement Guides listed in Appendix A, "Measurement Guides".

Note	Available measurement modes are based on model and options purchased. Refer to Table 1-1 and Table 1-2 for additional information.

Submenu Touch Screen Keys

These submenu keys are arranged along the right-hand edge of the touch screen. The submenu labels change as instrument measurement settings change. The current submenu title is shown at the top of the submenu key block.

Keypad Menu Keys (1 to 9)

Pressing the **Shift** key and then a number key selects the menu function that is printed in blue characters above the number key. See Figure 2-1 on page 2-2.

Not all Secondary Function Menus are active in various measurement modes. If any one of these menus is available in a specific instrument mode of operation, then it can be called from the number keypad. It may also be available from a main menu key or a submenu key.

The Preset Menu (1) and System Menu (8) are described in Chapter 5, "System Operations ". The Sweep Menu (3), Measure Menu (4), Trace Menu (5), and Limit Menu (6) vary depending on measurement mode, see the Measurement Guides listed in Appendix A for information. The File Menu (7) is described in Chapter 4, "File Management". The Mode Menu (9) is described in "Mode Selector Menu" on page 2-14.

LED Indicators

Power LED

The Power LED is located to the left of the **On/Off** key. The LED is solid green when the unit is on and slowly blinks when the unit is off but has external power.

Charge LED

The Charge LED is located to the right of the **On/Off** key. The LED slowly blinks when the battery is charging and is solid green when the battery is fully charged.

2-5 Display Overview

Figure 2-5 and Figure 2-6 illustrate some of the key information areas of the Site Master in Cable and Antenna mode and Spectrum Analyzer mode. For detailed information on either mode, refer to the Measurement Guides listed in Appendix A, “Measurement Guides”.

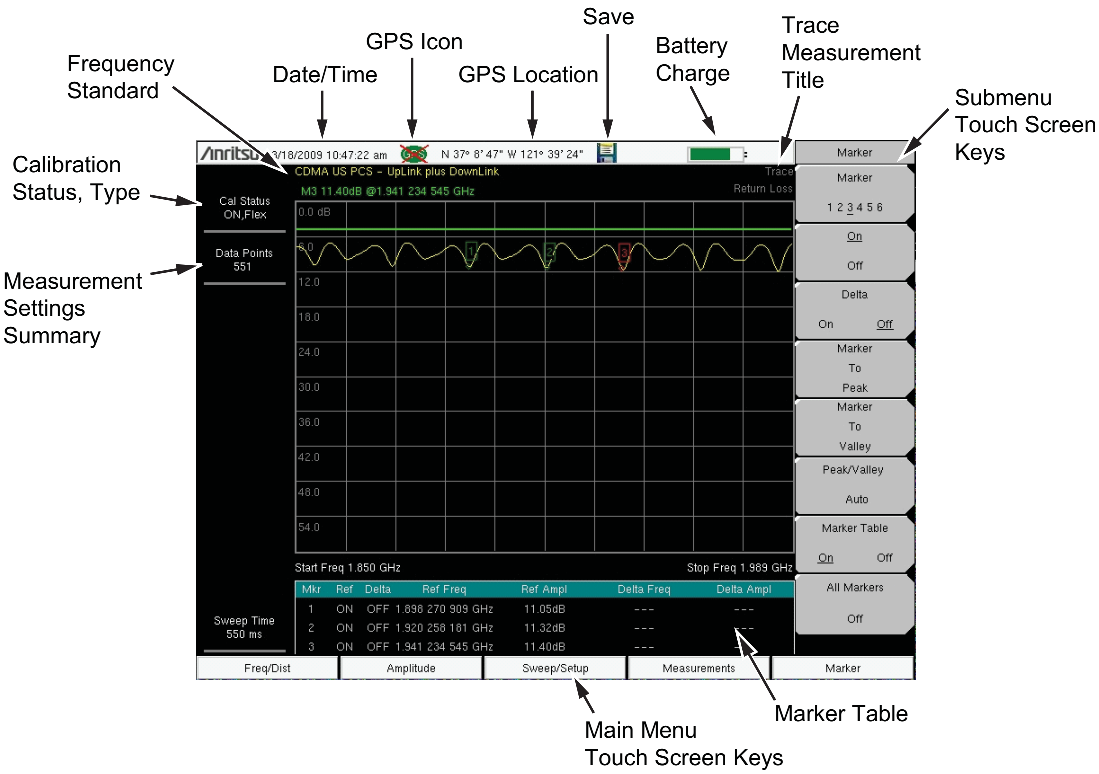


Figure 2-5. Cable and Antenna Analyzer Return Loss Measurement Display

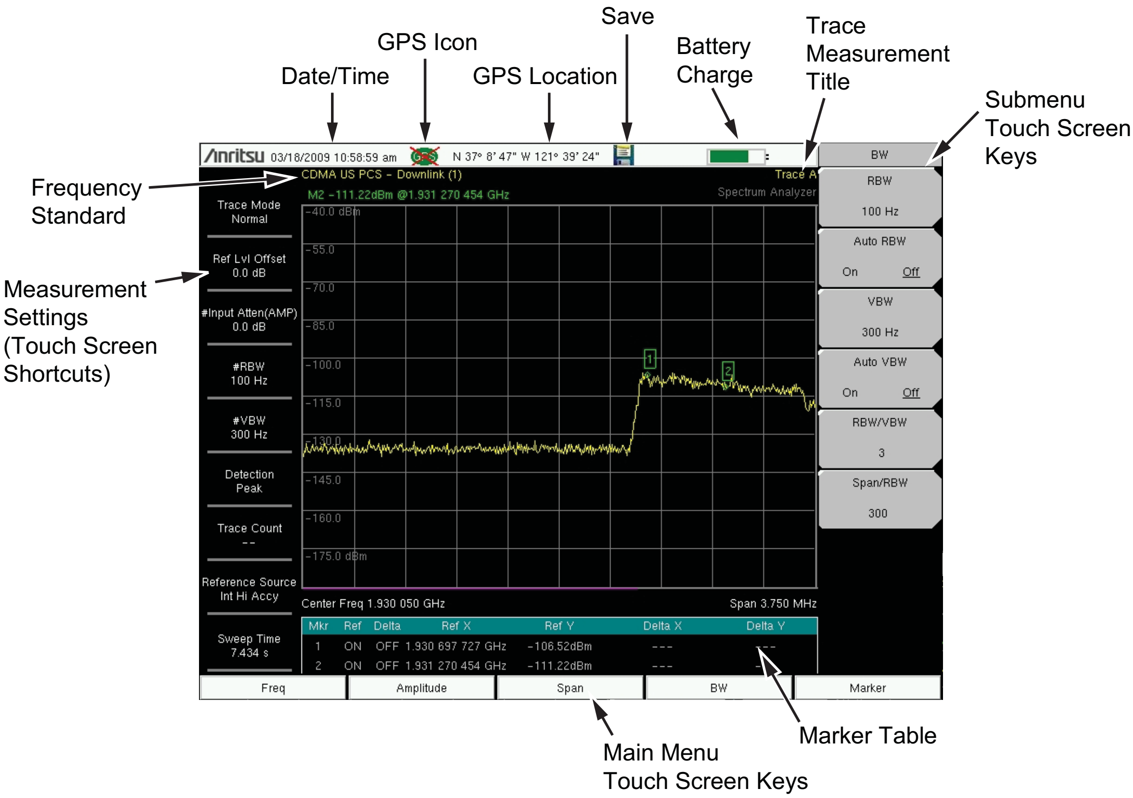


Figure 2-6. Spectrum Analyzer Display (S332E and S362E only)

Note	Many of measurement settings are used as touch screen shortcuts. Use the touch screen to select a measurement setting to edit.

In addition to the default color display, Site Master offers the following display settings:

Black & White for printing and viewing in broad daylight conditions

Night Vision optimized for night-time viewing

High Contrast for other challenging viewing conditions

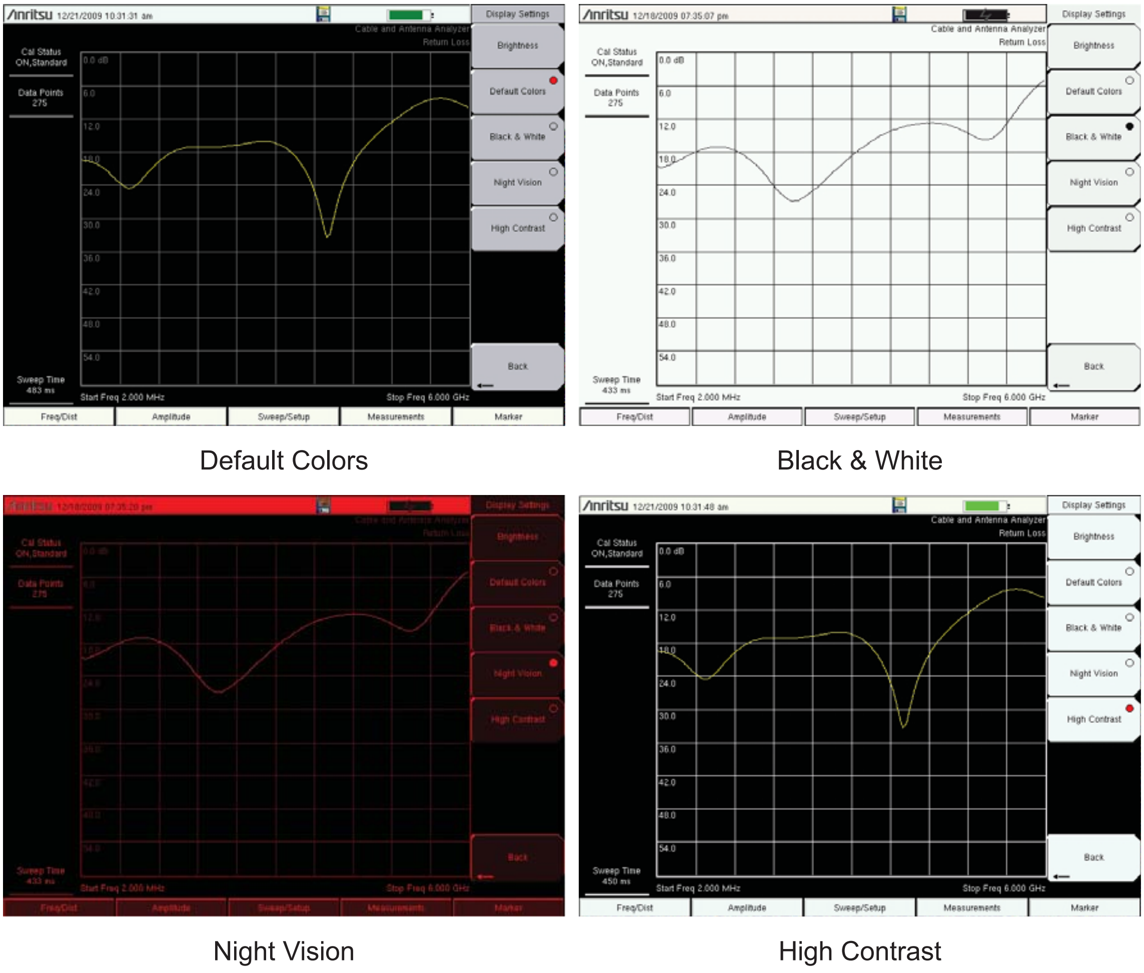


Figure 2-7. Site Master Display Settings

2-6 Test Panel Connector Overview

Test panel connectors for the Site Master S332E are shown in Figure 2-8.

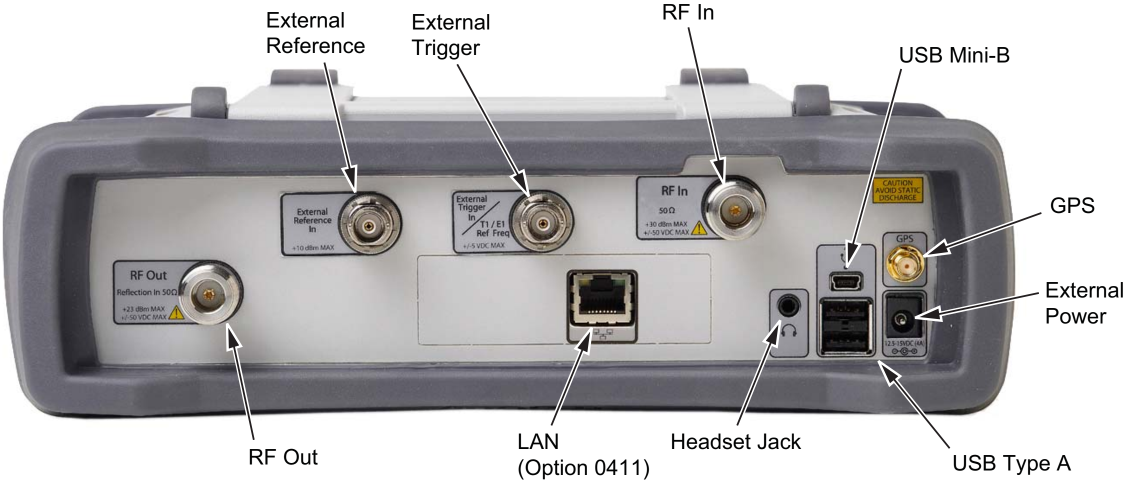


Figure 2-8. S332E Test Panel Connector

External Power

The external power connector is used to power the unit and for battery charging. Input is 12 VDC to 15 VDC at up to 5.0 A. The green flashing Power LED near the power switch indicates that the instrument has external power.

Warning	When using the AC-DC Adapter, always use a three-wire power cable that is connected to a three-wire power line outlet. If power is supplied without grounding the equipment in this manner, then the user is at risk of receiving a severe or fatal electric shock.

LAN Connection (Option 0411)

The RJ-45 connector is used to connect the Site Master to a local area network or directly to a PC with an ethernet crossover cable. Integrated into this connector are two LEDs. The amber LED shows the presence of a 10 Mbit/s LAN connection when on, and a 100 Mbit/s LAN connection when off. The green LED flashes to show that LAN traffic is present. For additional information about the LAN connection, Ethernet connection, and DHCP, refer to Chapter 7, “Ethernet Connectivity (Option 411)”.

USB Interface – Type A

The Site Master has two Type A USB connectors that accept USB Flash Memory devices for storing measurements, setups data, and screen images.

USB Interface – Mini-B

The USB 2.0 Mini-B connector can be used to connect the Site Master directly to a PC. The first time the Site Master is connected to a PC, the normal USB device detection by the computer operating system will take place. The CD-ROM that is shipped with the instrument contains a driver for Windows XP that is installed when Master Software Tools is installed. Drivers are not available for earlier versions of the Windows operating system. During the driver installation process, place the CD-ROM in the computer drive and specify that the installation wizard should search the CD-ROM for the driver.

Note	For proper detection, Master Software Tools should be installed on the PC prior to connecting the Site Master to the USB port.

Headset Jack

The headset jack provides audio output from the built-in AM/FM/SSB demodulator for testing and troubleshooting wireless communication systems. The jack accepts a 2.5 mm 3-wire miniature phone plug such as those commonly used with cellular telephones.

Ext Trigger In (S332E, S362E Models)

A TTL signal that is applied to the External Trigger female BNC input connector causes a single sweep to occur. In the Spectrum Analyzer mode, it is used in zero span, and triggering occurs on the rising edge of the signal. After the sweep is complete, the resultant trace is displayed until the next trigger signal arrives.

RF In

50 Ω Type-N female connector. Maximum input is +26 dBm at 50 VDC.

RF Out/Reflection In

RF output, 50 impedance, for reflection measurements. Maximum input is +23 dBm at ±50 VDC.

GPS Antenna Connector (Option 0031)

The GPS antenna connection on the Site Master is type SMA-female. GPS function is described in Chapter 6, “GPS (Option 31) ”.

2-7 Symbols and Indicators

The following symbols and indicators indicate the instrument status or condition on the display.

Calibration Symbols

The current calibration status and type is displayed in the upper-left of the screen when in Cable & Antenna Analyzer mode. See Figure 2-5 on page 2-6. The five status messages are described next.

Cal Status: ON, Flex

The Site Master has been calibrated with discrete Open, Short, and Load components. This is a FlexCal calibration indicating it is possible to change the frequency range after calibration.

Cal Status: ON, Standard

The Site Master has been calibrated with discrete Open, Short, and Load components. This is a Standard calibration indicating it is not possible to change the frequency range after calibration without performing another calibration.

Cal Status: ON, Flex, Insta

The Site Master has been calibrated with the InstaCal module. This is a FlexCal calibration indicating it is possible to change the frequency range after calibration.

Cal Status: ON, Standard, Insta

The Site Master has been calibrated with the InstaCal module. The Site Master has been calibrated with discrete Open, Short, and Load components. This is a Standard calibration indicating it is not possible to change the frequency range after calibration without performing another calibration.

Cal Status Off:

The Site Master has not been calibrated.

For calibration procedures refer to the Cable & Antenna Measurement Guide (PN: 10580-00241) listed in Appendix A.

Battery Symbols

The battery symbol above the display indicates the charge remaining in the battery. The colored section inside the symbol changes size and color with the charge level.

Figure 2-9. Battery Status

Green: Battery is 30% to 100% charged

Yellow: Battery is 10% to 30% charged

Red: Battery 0% to 10% charged

Lightning Bolt: Battery is being charged (any color symbol)

Detailed battery information is also available in the Status dialog box (**System** > Status).

When either the AC-DC Adapter or the Automotive Cigarette Lighter Adapter is connected, the battery automatically receives a charge, and the battery symbol with the lightning bolt is displayed (Figure 2-10).

Figure 2-10. Battery Charging Icon

The green Charge LED flashes when the battery is charging, and remains on steady when the battery is fully charged.

Caution	Use only Anritsu-approved batteries, adapters, and chargers with this instrument.

When operating from external power without a battery installed, the battery symbol is replaced by a red plug body (Figure 2-11).

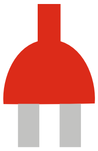


Figure 2-11. Battery Not Installed

Additional Symbols

Single Sweep

Single Sweep is selected. Press Continuous in the **Sweep** menu to resume continuous sweeping.

Floppy Icon

Shortcut to the Save submenu. Touch the icon to open the touch screen keyboard for saving measurements, setups, or screen displays.

Figure 2-12. Floppy Icon

2-8 Data Entry

Numeric Values

Numeric values are changed using the rotary knob, arrow keys, or the keypad. Pressing one of the main menu keys will display a list of submenus on the right side of the touch screen. When the value on a submenu key is displayed in red, it is ready for changing. When using the rotary knob or arrow keys the changing value is shown on the submenu and in red on the graticule. When using the keypad, the new value is shown in red on the graticule and the submenu changes to Units. Selecting a unit for the new value completes the entry.

Parameter Setting

Pop-up list boxes or edit boxes are used to provide selection lists and selection editors. Scroll through a list of items or parameters with the arrow keys, the rotary knob, or the touch screen. These list boxes and edit boxes frequently display a range of possible values or limits for possible values.

Finalize the input by pressing the **Enter** key. At any time before finalizing the input, press the escape (**Esc**) key to abort the change and retain the previously existing setting.

Some parameters (such as for antennas or couplers) can be added to list boxes by creating them and importing them using Master Software Tools.

Text Entry

When entering text, as when saving a measurement, the touch screen keyboard is displayed (Figure 2-13). Characters are entered directly with the touch screen keyboard. The keypad can be used for numeric entry. The left and right arrow keys will scroll the cursor through the filename. See “Save Menu” on page 4-9 for additional information.

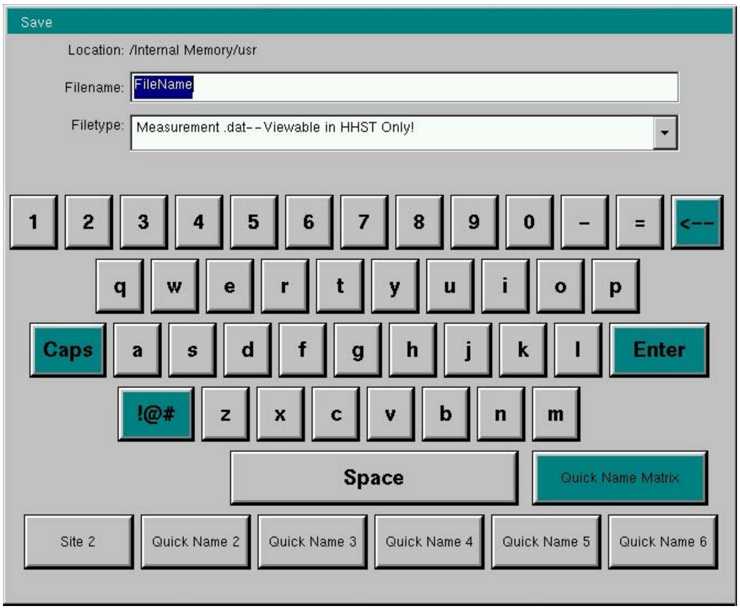


Figure 2-13. Touch Screen Keyboard

2-9 Mode Selector Menu

To access the functions under the Mode menu, select the **Shift** key, then the **Mode** (9) key. Use the directional arrow keys, the rotary knob, or the touch screen to highlight the selection, and press the **Enter** key to select. The list of modes that appear in this menu will vary depending upon the options that are installed and activated in the instrument. Figure 2-14 is an example of the Mode menu. Your instrument may not show the same list. The current mode is displayed below the battery symbol.

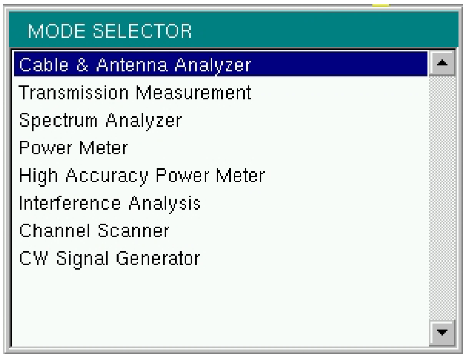


Figure 2-14. Mode Selector Menu

Note	The display of the Mode Selector will vary depending on Site Master model and installed options.

The **Menu** key is another option to quickly change measurement modes. Press the **Menu** key then select one of the Measurement icons in the top two rows (Figure 2-2 on page 2-3).

Chapter 3 — Quick Start Guide

3-1 Introduction

This chapter provides a brief overview of basic measurement setups. For detailed measurement information, refer to a specific measurement guide listed in Appendix A, “Measurement Guides”. This chapter provides quick start measurement information for the following measurement modes:

- Section 3-3 “Cable & Antenna Analyzer” on page 3-2
- Section 3-4 “Spectrum Analyzer” on page 3-7

3-2 Measurement Mode Selection

Press the **Menu** key and use the touch screen to select the appropriate measurement icon.

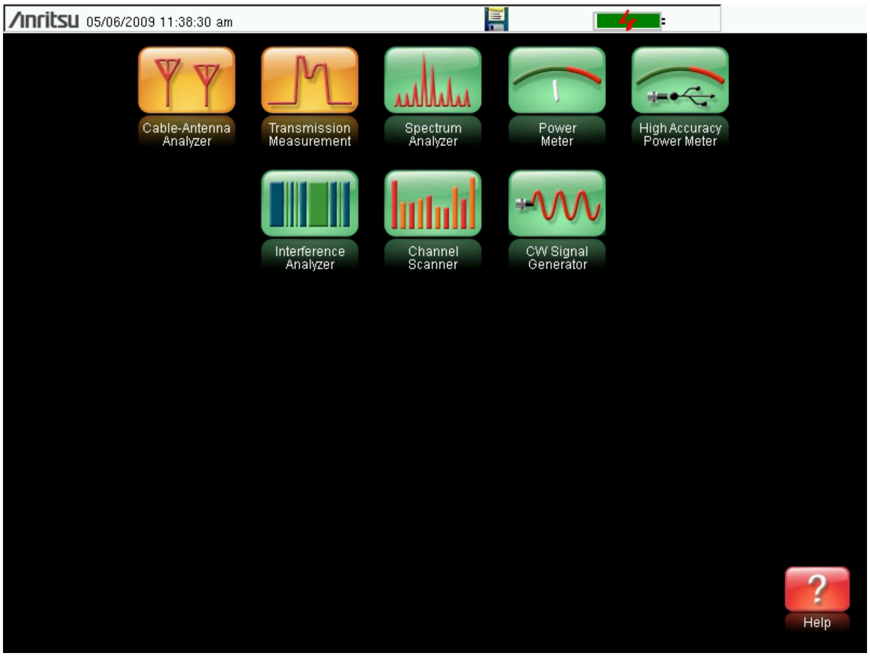


Figure 3-1. Menu Screen with Icons for Installed Measurement Modes

Note	The display of the Menu screen will vary depending on installed options.

3-3 Cable & Antenna Analyzer

Set the instrument to Cable & Antenna Analyzer mode as described in the previous section.

Select the Measurement Type

Press the **Measurement** main menu key and select the appropriate measurement.

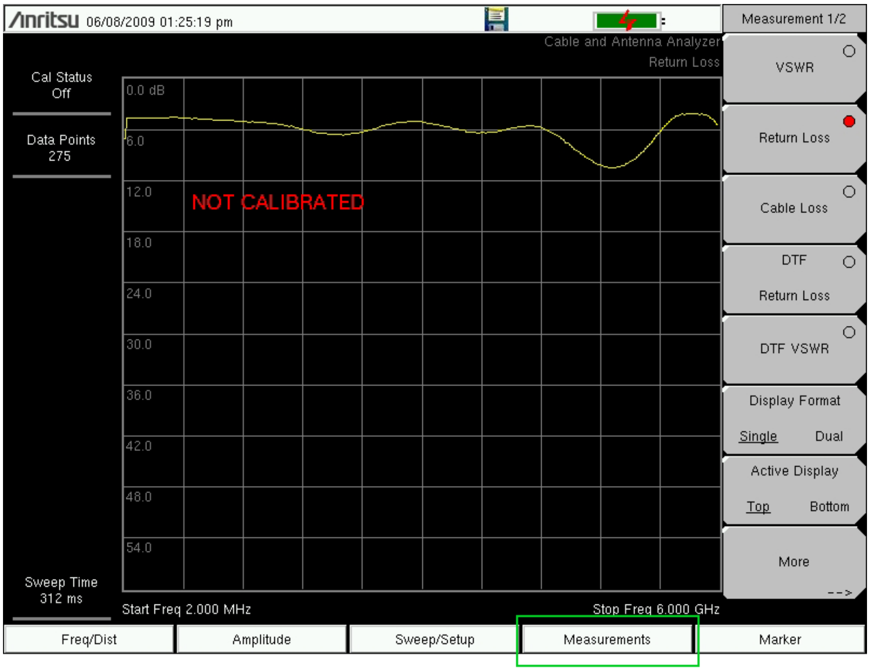


Figure 3-2. Measurement Menu

Set the Frequency

1. Press the **Freq/Dist** main menu key.
2. Press the Start Freq submenu key and use the keypad, rotary knob, or the arrow keys to enter the start frequency.
3. Press the Stop Freq submenu key and use the keypad, rotary knob, or the arrow keys to enter the stop frequency.

Set the Amplitude

1. Press the **Amplitude** main menu key.
2. Press the Top submenu key and use the keypad, rotary knob, or the arrow keys to edit the top scale value. Press **Enter** to set.
3. Press the Bottom submenu key and use the keypad, rotary knob, or the arrow keys to edit the bottom scale value. Press **Enter** to set.

Note	For Amplitude in Smith Chart measurements, refer to “Smith Chart” on page 2-23 of the Cable & Antenna Measurement Guide listed in Appendix A.

Turn on Markers

1. Press the **Marker** main menu key.
2. Press the Marker 1 2 3 4 5 6 submenu key and select the marker number 1 button using the touch screen. The underlined number on the Marker submenu key indicates the active marker.
3. Use the arrow keys, the keypad, or the rotary knob to move the marker. The current value for the selected marker is shown above the upper-left corner of the graph. It is also possible to drag the marker using the touch screen.
4. Delta Markers are available for each of the six reference markers. For the selected marker, Toggle the Delta On/Off submenu key to turn on the Delta marker.

Peak/Valley Auto Markers

When making Return Loss and VSWR measurements, the Peak/Valley Auto feature can be used to automatically turn on Marker 1 to peak, Marker 2 to valley, and display M1 and M2 in the Marker Table. This feature is not available for DTF measurements.

1. Press the **Marker** main menu key.
2. Press the Peak/Valley Auto key.

Single Limit Line

1. Press **Shift** and then **Limit** (6) to enter the Limit menu.
2. Press the Limit On/Off key to turn on the Limit.
3. Press Single Limit and then use the numeric keypad, the arrow keys, or the rotary knob to change the limit value and then press **Enter**.

Note	Refer to the Cable & Antenna Measurement Guide listed in Appendix A for creating multi-segment limit lines.

4. Press the Limit Alarm key to turn on or off the Limit Alarm.

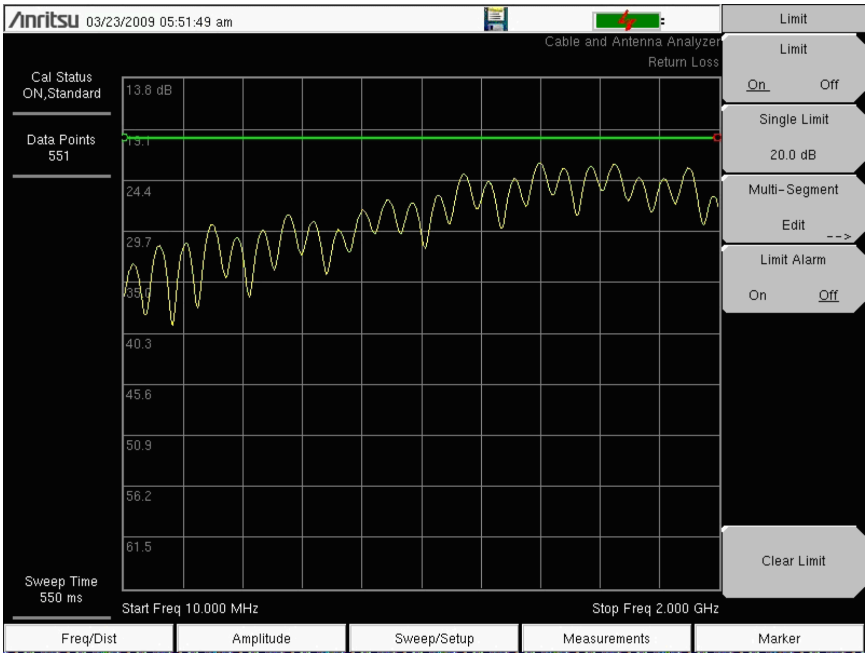


Figure 3-3. Single Limit Lines

DTF Setup

1. Press the **Measurements** main menu key and select DTF Return Loss or DTF VSWR.
2. Press the **Freq/Dist** main menu key.
3. Press the Units submenu key and select m to display distance in meters or ft to display distance in feet.
4. Press DTF Aid and use the touch screen, or arrow keys to navigate through all the DTF parameters.
    a. Set Start Distance and Stop Distance. Stop Distance needs to be smaller than Dmax.
    b. Enter the Start and Stop frequencies.
    c. Press Cable, select the appropriate cable from the cable list and press **Enter**.
    d. Press Continue.

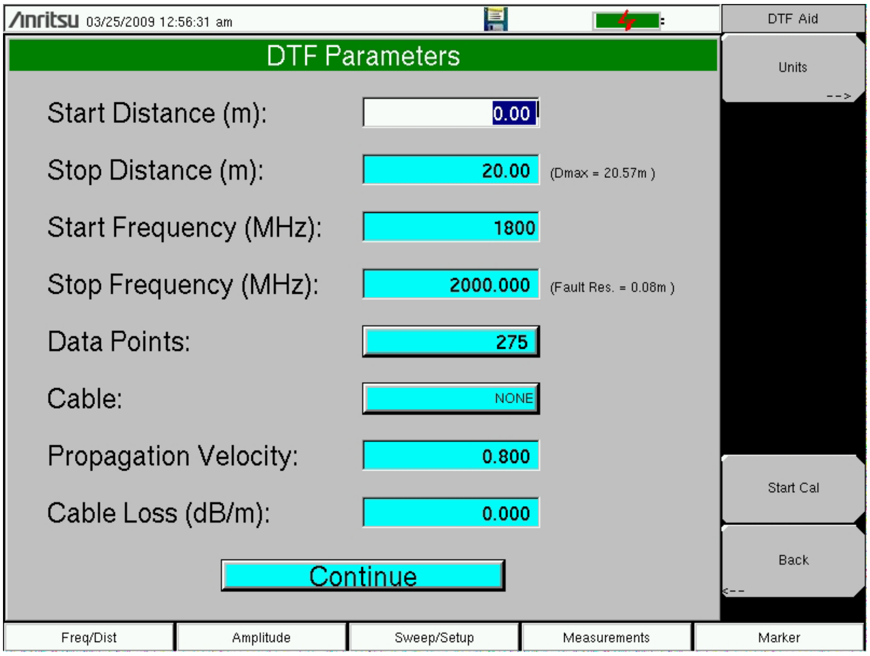


Figure 3-4. DTF Aid

5. Press **Shift** then **Calibrate** (2) to calibrate the instrument. Refer to "Calibrate with OSL Calibration" on page 3-6 for additional information.
6. Press the **Marker** main menu key and set the appropriate markers.
7. Press **Shift** and **Limit** (6) to enter and set the appropriate limit lines.
8. Press **Shift** and **File** (7) to save the measurement. See the User Guide for details.

Calibrate with OSL Calibration

Note	Refer to the Cable & Antenna Measurement Guide listed in Appendix A for calibration details.

1. Press the **Freq/Dist** main menu key and enter the appropriate frequency range
2. Press **Shift** then **Calibrate** (2) key.
3. Select Standard or FlexCal.
4. Press Start Cal and follow instructions on screen.
5. Connect Open to RF Out and press the **Enter** key.
6. Connect Short to RF Out and press the **Enter** key.
7. Connect Load to RF Out and press the **Enter** key.
8. Verify that the calibration has been properly performed by checking that the Cal Status message is now displaying "ON, Standard" or "ON, FlexCal".

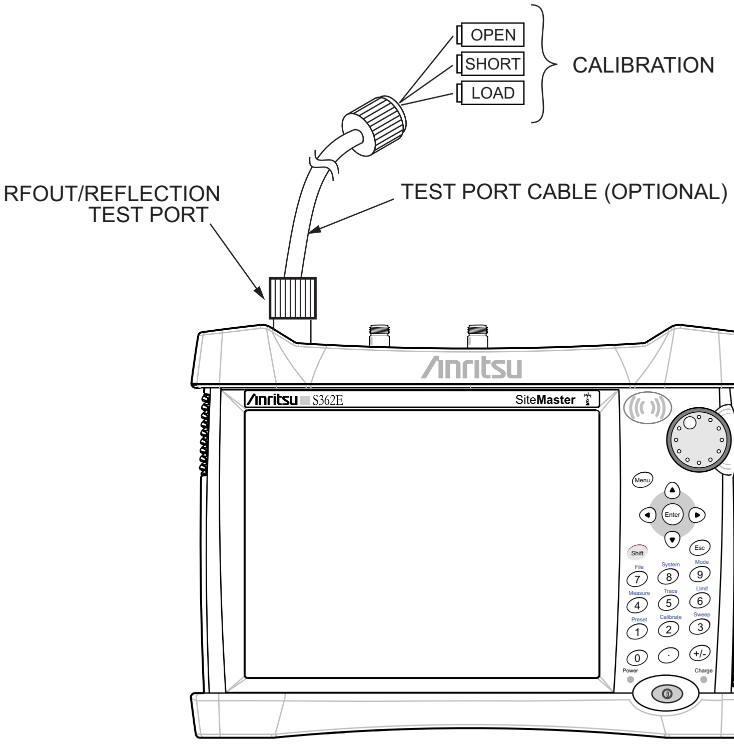


Figure 3-5. Calibration Setup with OSL Cal

3-4 Spectrum Analyzer

Set the instrument to Spectrum Analyzer mode as described in Section 3-2 “Measurement Mode Selection” on page 3-1.

Set Start and Stop Frequencies

1. Press the **Freq** main menu key.
2. Press the Start Freq submenu key.
3. Enter the desired start frequency using the keypad, the arrow keys, or the rotary knob. When entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate unit key. Pressing the **Enter** key has the same affect as pressing the MHz submenu key.
4. Press the Stop Freq submenu key.
5. Enter the desired stop frequency.

Enter the Center Frequency

1. Press the **Freq** main menu key.
2. Press the Center Freq submenu key.
3. Enter the desired center frequency using the keypad, the arrow keys, or the rotary knob. When entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate unit key. Pressing the **Enter** key has the same affect as pressing the MHz submenu key.

The center frequency and span is shown at the bottom of the screen.

Select a Signal Standard

1. Press the **Freq** main menu key.
2. Press the Signal Standard submenu key. The Signal Standards dialog box opens.
3. Highlight a signal standard and press **Enter** to select.
4. Press the Channel submenu key to change the channel value in the Channel Editor.

The signal standard is shown in yellow at the top of the screen.

Set the Measurement Frequency Bandwidth

1. Press the **BW** main menu key to display the BW menu.
   - Press the RBW and/or the VBW submenu key to manually change the values.
   - Set RBW and VBW automatically by pressing the Auto RBW submenu key or the Auto VBW submenu key.
2. Press the RBW/VBW submenu key to change the resolution bandwidth and video bandwidth ratio.
3. Press the Span/RBW submenu key to change the span width to resolution bandwidth ratio.

Set the Amplitude

Press the **Amplitude** main menu key to display the Amplitude menu.

Set Amplitude Reference Level and Scale

1. Press the Reference Level submenu key and use the arrow keys, rotary knob, or the keypad to change the reference level. Press **Enter** to set the reference level value.
2. Press the Scale submenu key and use the arrow keys, rotary knob, or the keypad to enter the desired scale. Press **Enter** to set the scale value.

Set Amplitude Range and Scale

1. Press the Auto Atten submenu key to set an optimal reference level based on the measured signal.
2. Press the Scale submenu key.
3. Enter the desired scale units by using the keypad, the arrow keys, or the rotary knob. Press **Enter** to set. The y-axis scale is automatically renumbered.

Power Offset Set Up for Compensating External Loss

To obtain accurate results, compensate for any external attenuation by using power offset. In power offset mode, the compensation factor is in dB. (External attenuation can be created by using an external cable or an external high power attenuator.)

Press the RL Offset submenu key and use the keypad, the arrow keys, or the rotary knob to enter the desired offset value. When using the rotary knob, the value changes in increments of 0.1 dB. Using the **Left/Right** arrow keys changes the value in 10% increments of the value shown on the Scale submenu key. When using the **Up/Down** arrow keys, the value changes in the increment shown on the Scale submenu key. When using the keypad, enter the new value then press **Enter** or the dB submenu key to set the value. The power offset is displayed in the instrument settings summary column on the left side of the measurement display.

Set the Span

1. Press the **Span** main menu key or the **Freq** main menu key followed by the Span submenu key.
2. To select full span, press the Full Span submenu key. Selecting full span overrides any previously set Start and Stop frequencies.
3. For a single frequency measurement, press the Zero Span submenu key.

Note	To quickly move the span value up or down, press the Span Up 1-2-5 or Span Down 1-2-5 submenu keys These keys facilitate a zoom-in, zoom-out feature in a 1-2-5 sequence.

Single Limit Line

Press the **Limit** menu key to display the Limit menu.

1. Press the Limit (Upper / Lower) submenu key to select the desired limit line, Upper or Lower.
2. Activate the selected limit line by pressing the On Off submenu key so that On is underlined.
3. Press the Limit Move submenu key to display the Limit Move menu. Press the first Move Limit submenu key and use the arrows keys, rotary knob, or keypad to change the dBm level of the limit line.
4. Press the Back submenu key to return to the Limit menu.
5. If necessary, press the Set Default Limit submenu key to redraw the limit line in view.

Create a Limit Envelope

1. Press **Shift** then **Limit** (6) to open the Limit menu.
2. Select Limit Envelope.
3. Press the Create Envelope key.

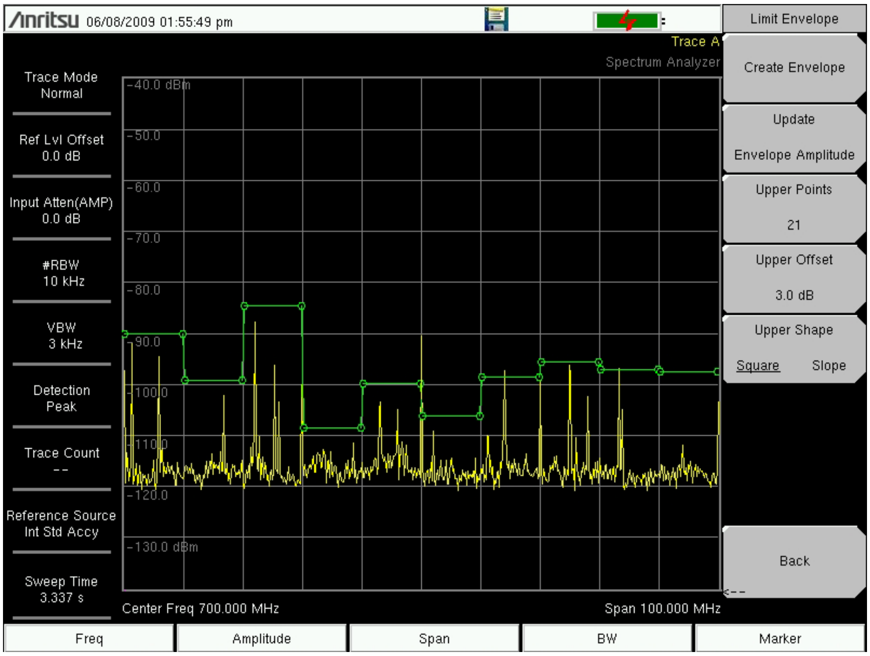


Figure 3-6. Limit Envelope

Setting Up Markers

Press the **Marker** main menu key to display the Marker menu.

Selecting, Activating, and Placing a Marker

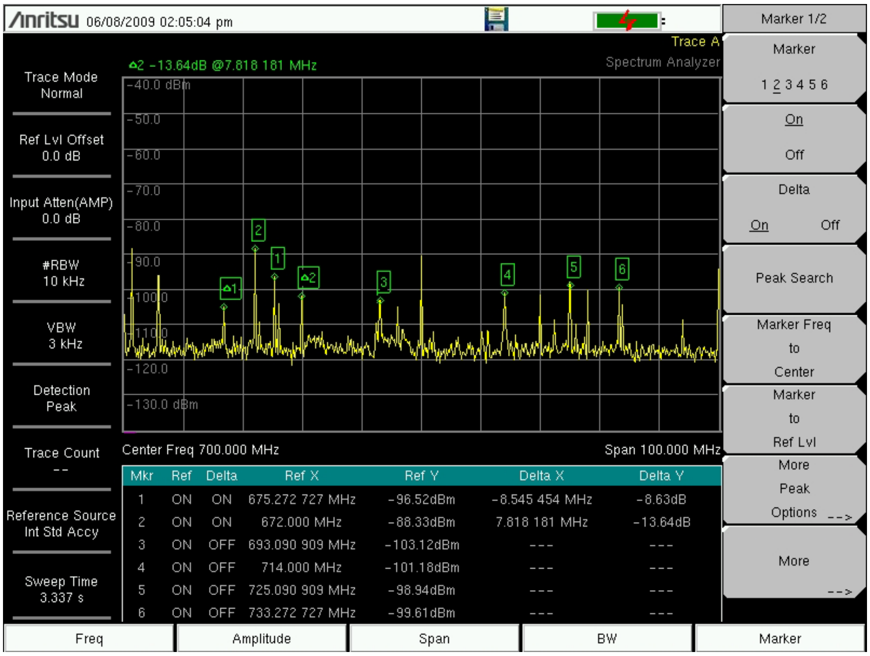
1. Press the Marker 1 2 3 4 5 6 submenu key and then select the desired marker using the touch screen marker buttons. The selected marker is underlined on the Marker submenu key.
2. Press the On Off submenu key so that On is underlined. The selected marker is displayed in red and ready to be moved.
3. Use the rotary knob to place the marker on the desired frequency.
4. Repeat steps 1 through 3 to activate and move additional markers.

Selecting, Activating, and Placing a Delta Marker:

1. Press the Marker 1 2 3 4 5 6 submenu key and select the desired delta marker. The selected marker is underlined.
2. Press the Delta On Off submenu key so that On is underlined. The selected marker is displayed in red and ready to be moved.
3. Use the rotary knob to place the delta marker on the desired frequency.
4. Repeat steps 1 through 3 to activate and move additional markers.

Viewing Marker Data in a Table Format

1. Press the More submenu key.
2. Press the Marker Table On Off submenu key so that On is underlined. All marker and delta marker data are displayed in a table under the measurement graph.



Mkr	Ref	Delta	Ref X	Ref Y	Delta X	Delta Y
1	ON	ON	675.272 727 MHz	-96.52dBm	-8.545 454 MHz	-8.63dB
2	ON	ON	672.000 MHz	-88.33dBm	7.818 181 MHz	-13.64dB
3	ON	OFF	693.090 909 MHz	-103.12dBm	---	---
4	ON	OFF	714.000 MHz	-101.18dBm	---	---
5	ON	OFF	725.090 909 MHz	-98.94dBm	---	---
6	ON	OFF	733.272 727 MHz	-99.61dBm	---	---

Figure 3-7. Marker Table

Select a Smart Measurement Type

In Spectrum Analyzer mode, press **Shift** then **Measure** (4) and select a smart measurement using the submenu keys.

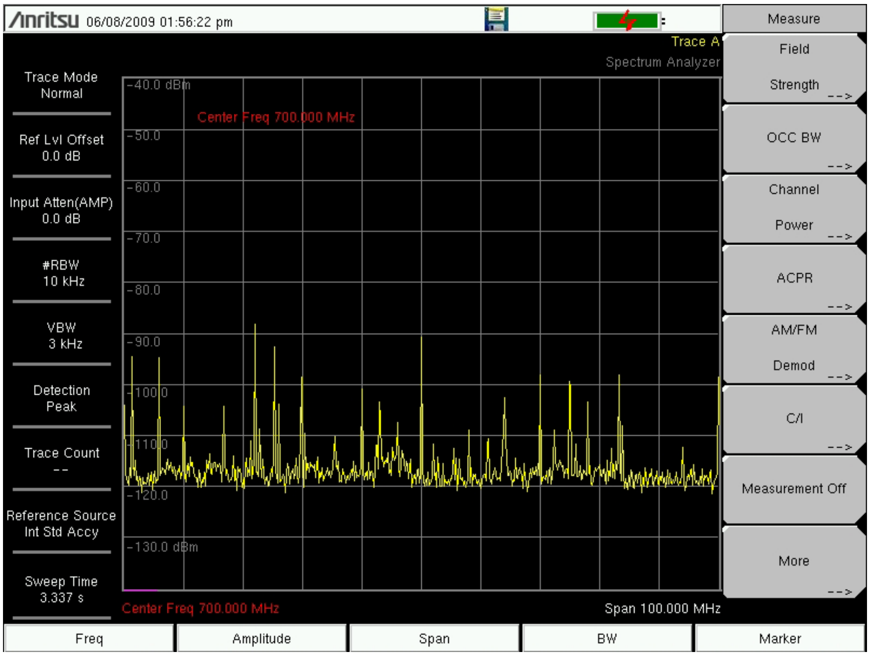


Figure 3-8. Spectrum Analyzer Measure Menu

3-5 Saving Measurements

Measurement files can be stored in the following formats:

.VNA or .DAT for Cable and Antenna analyzer measurements

.SPA for Spectrum Analyzer measurements

Saving files in .VNA or .SPA is recommended as it enables users to edit, view, and analyze traces with Master Software Tools (MST).

Note	Anritsu recommends saving files to the internal memory and then transferring the files to an external USB memory device if needed. Refer to Chapter 4, “Copying Files” for more details. The .DAT file format is only recommended for users who need to work with this format or prefer using Handheld Software Tools (HHST). Traces saved as .DAT can be viewed, edited, and analyzed with Handheld Software Tools. If the DUAL measurement display is turned on, files will be saved as Filename_1 and Filename_2. .DAT is only supported for Return Loss, VSWR, Cable Loss, DTF RL, DTF VSWR and only supports 137, 275, 551 data points. 1102 and 2204 data points are not supported in the .DAT file format. Use the .VNA file format if these resolutions are required. .DAT files cannot be recalled to the instrument for viewing. If this is required, use the .VNA file format.

Procedure for saving files:

1. Press **Shift** then File (#7).
2. Press Save Measurement.
3. Press Change Save Location and set the current location to be the USB flash drive or internal memory, and then press Set Location.
4. Press Change Type (Setup/JPG/…) and select Measurement .VNA or Measurement .DAT or Measurement (when in Spectrum Analyzer mode).
5. Enter the file name using the keyboard and press Enter.

Refer to Chapter 4, “File Management” for more details about working with files.

3-6 Useful MST Utilities

Converting Files to .DAT File Format

1. Establish a connection with MST.
2. Download measurements:
   a. Go to Sync | Download all measurements.
   b. Select the folder on the computer or select Local, and then set the location.
   c. Click Device and drag all of the traces into the measurement window. All of the traces will automatically be saved in the selected “Local” location.
3. To convert all of the files in a folder, select File | Save Folder as .DAT, and then select the folder used above. To convert files one-by-one, select File | Save As, and then change the extension to .DAT to convert the trace.

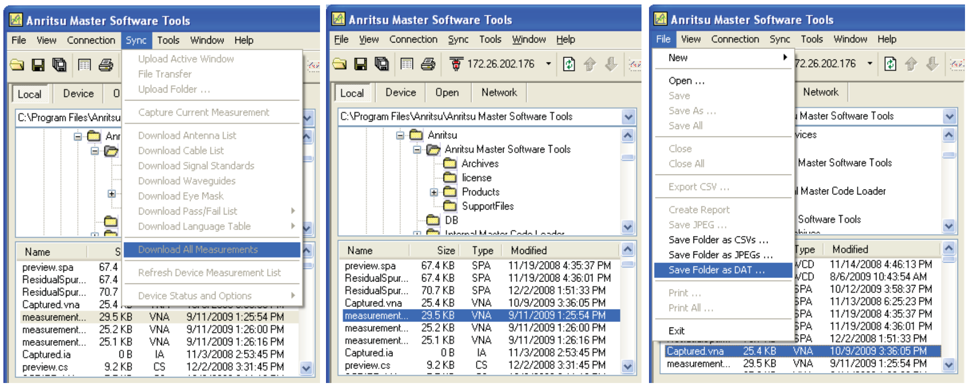


Figure 3-9. MST Dialog

4. Files converted to .DAT file format can be opened in HHST.

Group Edit

The Group Edit feature allows markers and limit lines to be copied from one trace to all of the traces in a folder. In addition, the title and subtitle can be quickly renamed for all of the traces in a folder. For example, to add a cell site number on the title.

To change the title to be the cell site number for all traces in a folder:

1. Select Tools | Group Edit.
2. Set the application type to VNA.
3. Select the location of the folder.
4. Enter the cell site number and check Plot Title.
5. Click Apply to rename all of the plot titles in the selected folder.

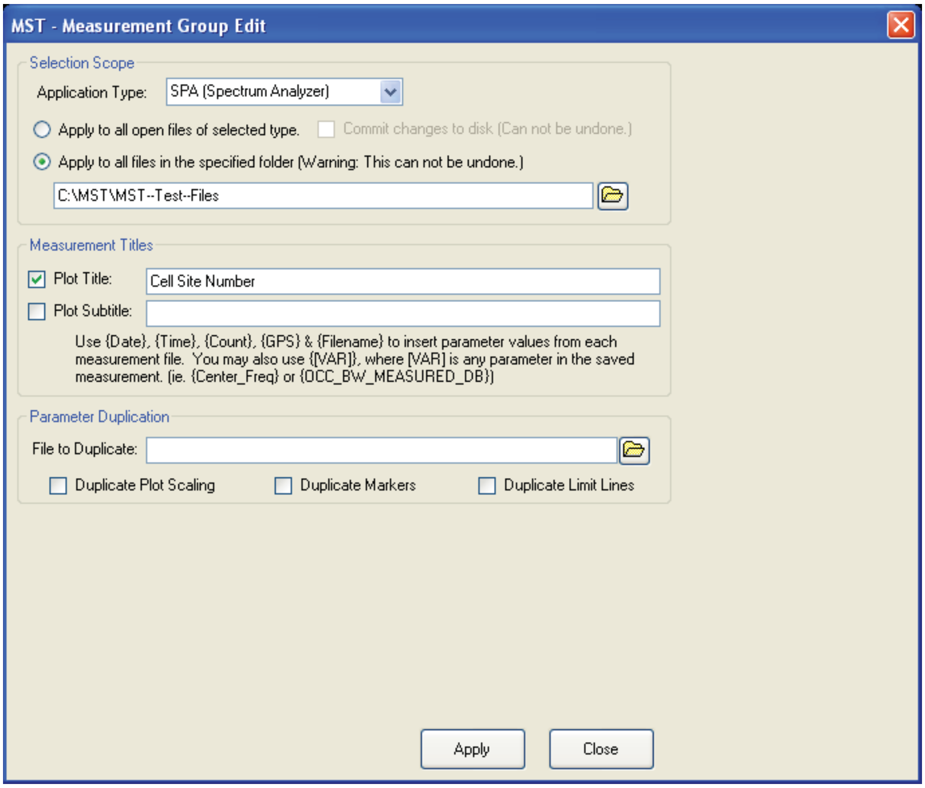


Figure 3-10. MST Measurement Group Edit Dialog

Print All to PDF

If Adobe Acrobat is installed on the computer with MST, traces can be converted to PDF using Print All and selecting Print to PDF. This creates a compact and portable PDF report of all of the traces in a folder with just one click.

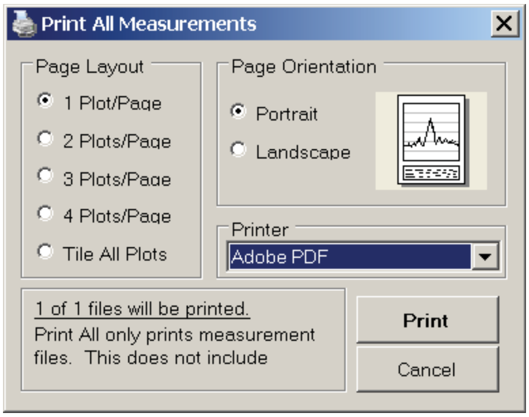


Figure 3-11. MST Print All Measurements Dialog

Chapter 4 — File Management

4-1 Introduction

This chapter will review the file management features of the Site Master and detail the **File** menu. The submenus under this menu allow the user to save, recall, copy, and delete files in internal memory or an external USB flash drive.

4-2 Managing Files

Press the **Shift** key then the **File** (7) key on the numeric keypad to list the **File** menu. Follow the additional steps below.

Note	When navigating through the **File** menu, pressing the **Esc** key will return to the previous menu.

Save Files

Set the Save Location

Press Save then the Change Save Location submenu keys and select the location to save files. You can save files to the internal memory or to an external USB flash drive. You can also create new folders. If an external USB flash drive is connected or disconnected, press Refresh Directories to update the location tree. Press the Set Location key to store the save location.

Save Measurement As

The Save Measurement As key is used to quickly save measurements with a specific file name. The Site Master saves the measurement with the latest file name that was used to save a measurement and with a number that is automatically incremented and appended to the end of the file name. For instance, if the last measurement was saved with the name System Return Loss, Save Measurement As saves the next measurement as System Return Loss_#1, System Return Loss_#2 etc. The file name used can be changed using the Save dialog box (Figure 4-1).

Save a Measurement

Press the Save Measurement key and enter the name for the measurement file. The measurement file can be stored as .DAT or as .VNA. Select the .DAT file type to edit traces in Handheld Software Tools. Select the .VNA file type to edit traces with Master Software Tools. Note that .DAT files do not support 1102 and 2204 data points. Also, measurements saved as .DAT can not be recalled and viewed in the instrument.

Save a Setup

Press the Save submenu key, type a name for the setup file, confirm that the file type is Setup using the Change Type key or the touchscreen and press **Enter** to save.

Create a Menu Shortcut for a Setup File

Press the Recall submenu key to display saved setup files. Locate the setup file to shortcut and then press and hold on the file name for a few seconds. Select a location in the shortcut grid to save the setup file.

Save a Measurement Screen as JPEG

Press the Save submenu key, type a name for the JPEG file, confirm that the file type is Jpeg, and press **Enter** to save.

Save Dialog Box

The save dialog box (Figure 4-1) is used to store files on the internal memory or an external flash drive. The file type, file name, and save location are set starting with this display. See "Save Menu" on page 4-9 and "Save Location Menu" on page 4-10 for details.

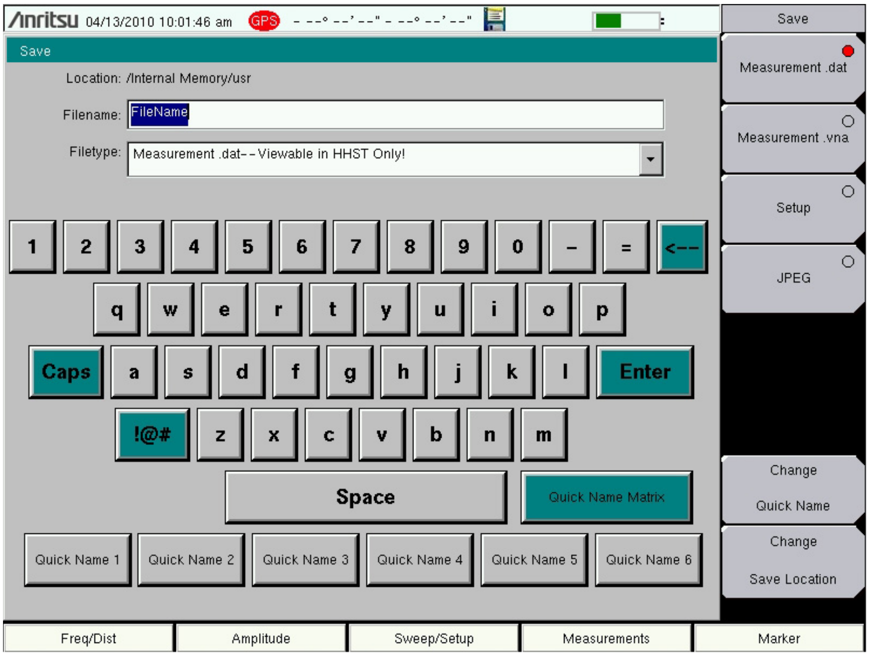


Figure 4-1. Save Dialog Box

Quick Name Keys

Quick Name keys below the keyboard in Figure 4-1 allow users to enter quick names for frequently used file measurement names. To edit the keys, press the **Shift** key, then the **File** (7) key. Press Save then the Change Quick Name key, select one of the Quick Names for editing, press **Enter** and enter the new name for the key. Press **Enter** again and the new name will be displayed on the key.

Quick Name Matrix

The Quick Name Matrix button displays in the Cable and Antenna Analyzer measurement mode. The Quick Name Matrix button allows contractors and field personnel to save time entering files names when they are making measurements. Using the touchscreen, press the Quick Name Matrix key shown in Figure 4-1 to open the Quick Name Matrix shown in Figure 4-2.

Often carriers require file names to be reported in special conventions including site number, sector information, color coding, measurement type, termination device, and frequency information. Setup the buttons in this matrix to quickly enter the required file name.

1. Press and hold any Matrix key in the first column to edit the label. Use this column to enter the first set of variables required in the file naming convention.
2. Continue with additional columns as necessary.

After the keys have been labeled they can be used to quickly create filenames with the required file naming conventions. Select the type of file and press Enter to save the file.

The Keyboard key returns to the Save Dialog Box (Figure 4-1).

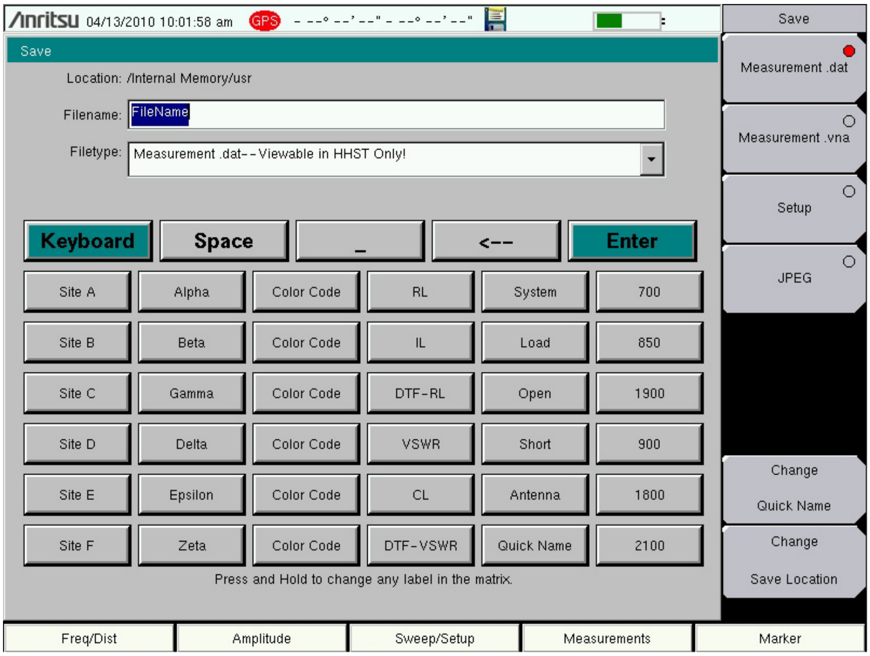


Figure 4-2. Quick Name Matrix

Recall Files

The recall menu enables you to view all the Measurement and Setup files in the internal memory and external USB flash drive.

You can sort the recall menu by name, date, or type. You can also select to view only measurement files or setup files by pressing File Type on the Recall dialog box and selecting the file type you want to view.

Recall a Measurement

From the **File** menu, press the Recall Measurement submenu key, select the measurement with the touchscreen, rotary knob or the **Up/Down** arrow keys and press **Enter**.

Recall a Setup

Press the Recall submenu key. Confirm that the file type is Setup or All. Select the setup file (.stp) with the touchscreen, rotary knob or the **Up/Down** arrow keys and press **Enter**.

Recall Dialog Box

The Recall dialog box (Figure 4-3) will open previously saved measurements and setups. See the “Recall Menu” on page 4-12 for additional information.

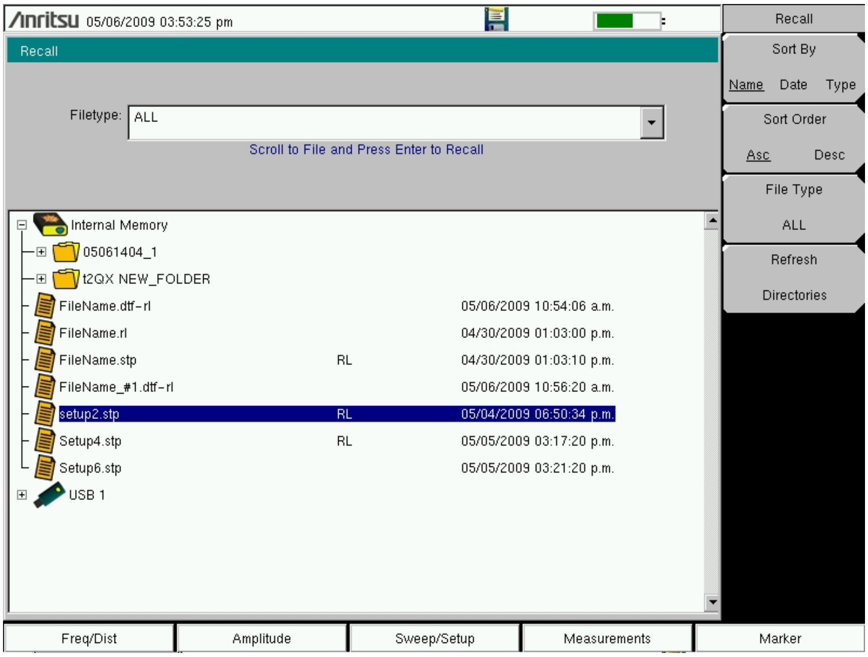


Figure 4-3. Recall Dialog Box

Copying Files

The steps below detail copying a file from internal memory to an external flash drive. Select the files to copy in the top window and the location for the files to be copied to in the bottom window (Figure 4-4). Refer to the "Copy Menu" on page 4-13 for additional information.

3. Insert a USB drive into either USB Type A port of the Site Master.
4. From the **File** main menu, press the Copy submenu key. The Copy submenu and Copy dialog box are displayed.
5. Select the file(s) to copy. To select multiple files, highlight the first then press the Select or De-Select key to keep the file selected. The file will be outlined in blue. Repeat with all the files to copy. To display files in a folder, select the folder and press the **Enter** key.
6. Press the Scroll key and highlight the USB drive in the lower window using the touch screen or the **Up/Down** arrow keys. The Scroll submenu key toggles between Src (top window) and Dst (bottom window).
7. Press the Copy key to copy the files to the flash drive.

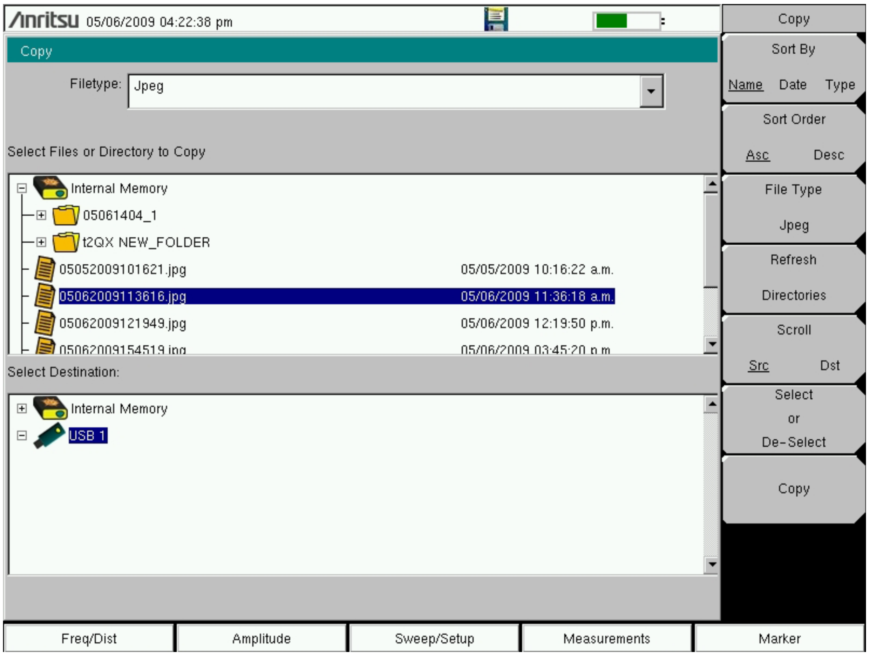


Figure 4-4. Copy Dialog Box

Deleting Files

Delete a Selected File or Files

Press the Delete submenu key. Highlight the file to be deleted with the touchscreen or the **Up/Down** arrow keys. Press the Select or De-Select key. The file will be outlined in blue when selected. Press the Delete key and **Enter** to delete the selected file.

Delete Dialog Box

Press the Delete submenu key to open the Delete dialog box (Figure 4-5). The submenus allow sorting by file type, name and saved date. See the "Delete Menu" on page 4-14 for additional information.

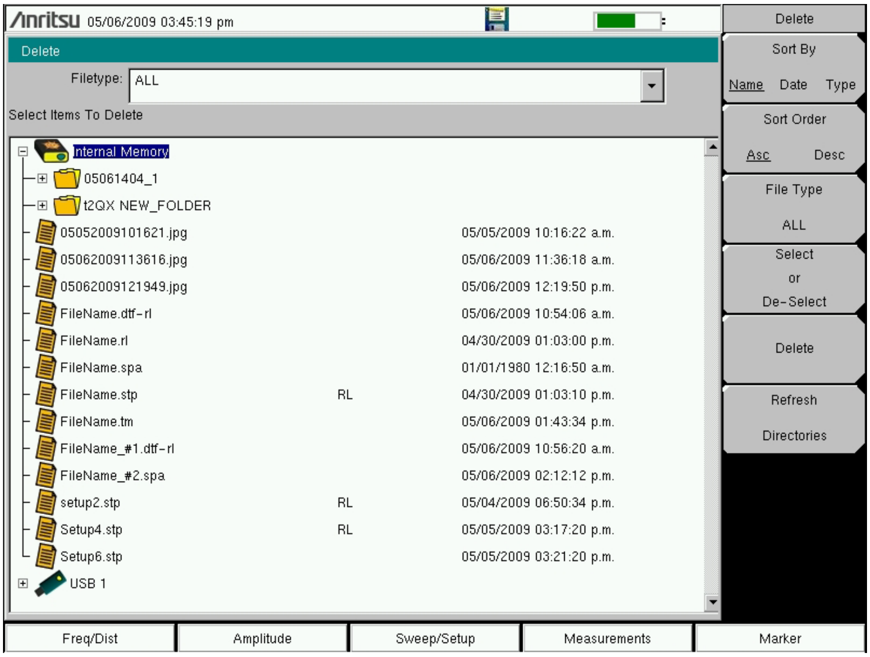


Figure 4-5. Delete Dialog Box

4-3 File Menu Overview

Open this menu by pressing the **Shift** key, then the **File** (7) key.

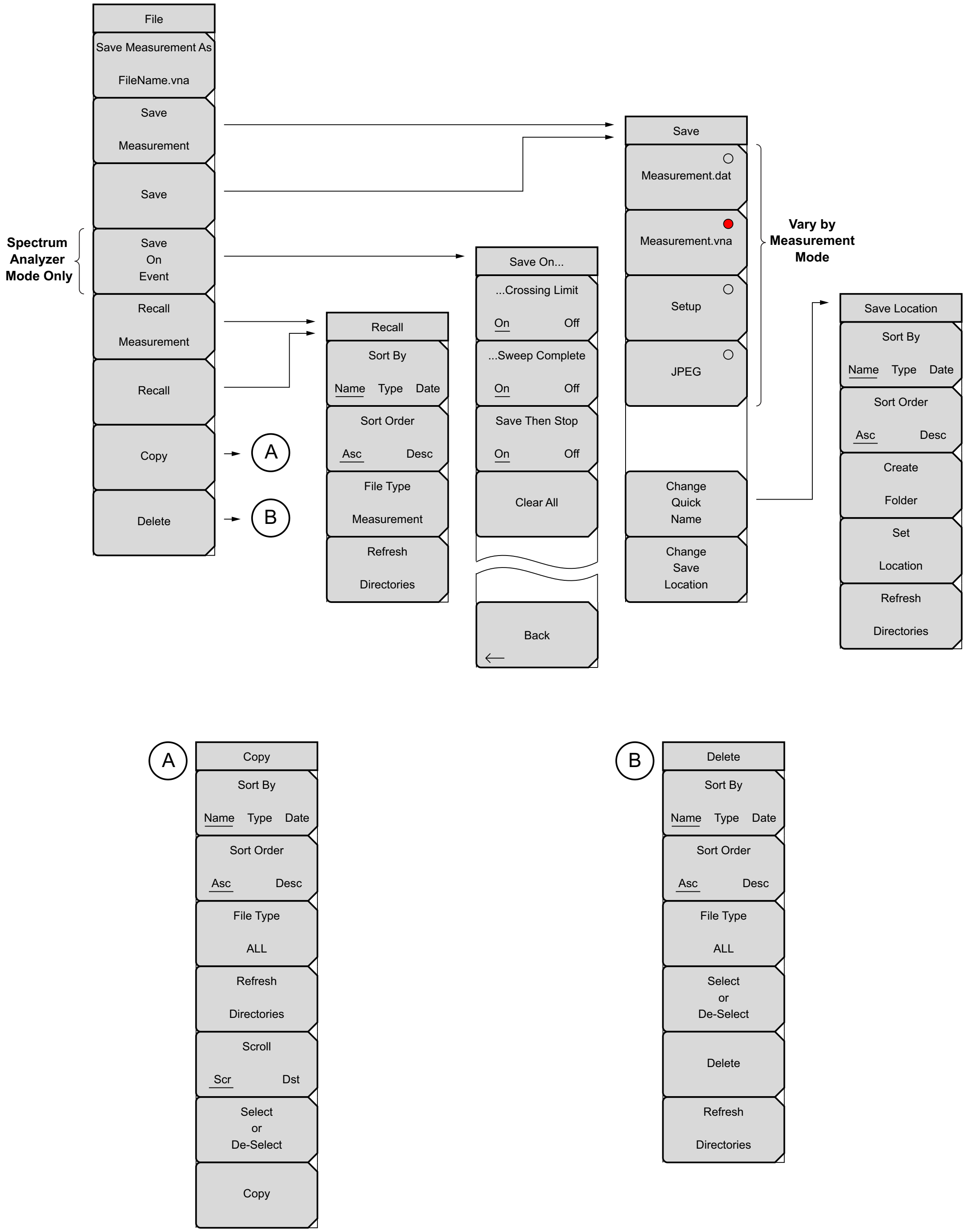
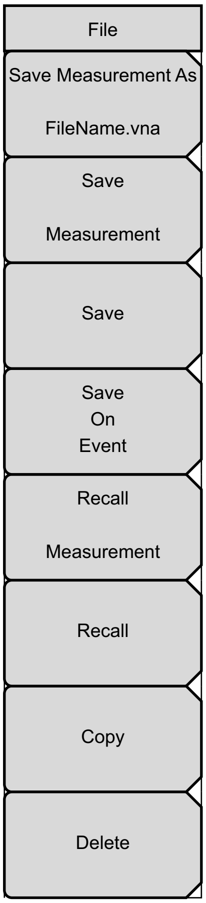


Figure 4-6. File Menu

4-4 File Menu

Key Sequence: **File**



Save Measurement As: This key will save the current setup with a user defined file name. The default file name is changed using the Save submenu. To change the default file name, type in a new file with the touch screen keyboard and press **Enter**. After a few seconds the screen with return to File menu. Press the Save Measurement As key again and the new file name will be used. Measurement files names have a .vna or .spa extension.

Save Measurement: Press this submenu key to display the "Save Menu" on page 4-9 and the touch screen keyboard. Measurements can be saved to internal memory or to a USB flash drive. The saved measurement can be named by using touch screen keyboard. By default, measurements are saved in a directory named /user to internal memory. The save destination is set with the "Save Location Menu" on page 4-10.

Save: Press this submenu key to display the "Save Menu" on page 4-9 and the touch screen keyboard. Measurements can be saved to internal memory or to a USB flash drive. The saved setup, measurement or JPEG file can be named by using touch screen keyboard. By default, measurements are saved in a directory named /user to internal memory. The save destination is set with the "Save Location Menu" on page 4-10.

Save on Event (Spectrum Analyzer mode only)**:** Press this submenu key to display the "Save On Event Menu" on page 4-11.

Recall Measurement: Press this submenu key to display the "Recall Menu" on page 4-12. This menu is for recalling measurements from internal memory or a USB flash drive.

Recall: Press this submenu key to display the "Recall Menu" on page 4-12. This menu is for recalling measurement or setup data from internal memory or a USB flash drive.

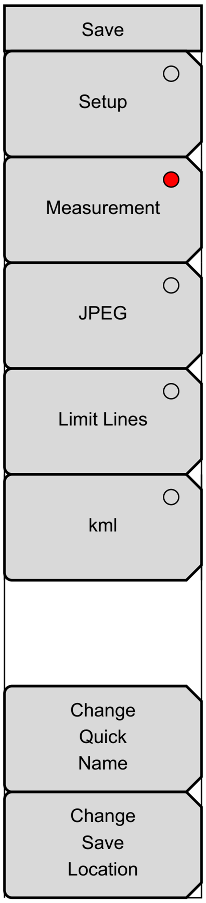
Copy: Press this submenu key to display the "Copy Menu" on page 4-13. This submenu is for copying files or folders from internal memory or a USB flash drive.

Delete: Press this submenu key to display the "Delete Menu" on page 4-14 and a selection box that shows the setup and measurement names, the type and the date and time that the information was saved. Use the rotary knob or the **Up/Down** arrow keys to highlight the file that is to be deleted and press the Delete submenu key, then **Enter**. Press the **Esc** key to cancel the operation. Note that deleted files can not be recovered.

Figure 4-7. File Menu

Save Menu

Key Sequence: **File** > Save



The top keys in the Save menu will display the available save options based on the current measurement mode. Options include:

> **Setup:** Setup files contain basic instrument information, measurement mode setup details, measurement marker data, and limit data. File extension: .stp
>
> **Measurement:** Contains the measurement data and opens up with Master Software Tools. File extension: Varies based on measurement.
>
> **Jpeg:** Jpeg files contain a screen capture of the display. File extension: .jpg
>
> **Limit Lines:** Contains limit line data details. File extension: .lim
>
> **kml:** Saves measurement and location data that can be viewed in Google Earth. File extension: .kml
>
> **Measurement .dat:** Contains the measurement data and opens up with Handheld Software Tools. Available in Cable and Antenna measurement mode. File extension: .dat

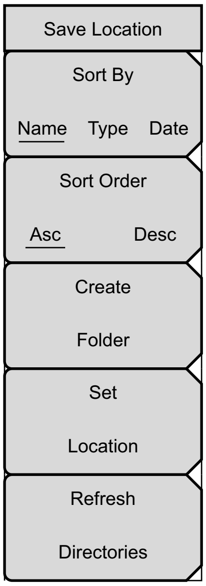
Change Quick Name: Press this submenu key to change the Quick Names at the bottom of the touch screen keyboard (Figure 4-1). Select the Quick Name to edit and press **Enter**. Type the new Quick Name and press **Enter** again. The new Quick Name will display on the button below the keyboard.

Change Save Location: Press this submenu key to open the "Save Location Menu".

Figure 4-8. Save Menu

Save Location Menu

Key Sequence: **File** > Save > Change Save Location



This menu and dialog box is used to create folders and select where the Site Master will save the current file. Select folders or drives with the **Up/Down** keys, the rotary knob or the touch screen.

Note: Only folders (not files) are visible in the Save Location dialog box. To view files, use the "Recall Menu" on page 4-12.

Sort By: Press this submenu key to sort the folders by Name, Type, or Date.

Sort Order: Displays the folder names in ascending or descending order .

Create Folder: This key will create a new folder in the highlighted location or folder. The create directory dialog box will display for naming the folder.

Set Location: This key will set the current location for saving files and return to the "Save Menu" on page 4-9.

Refresh Directories: Press this key to update the display.

Figure 4-9. Save Location Menu

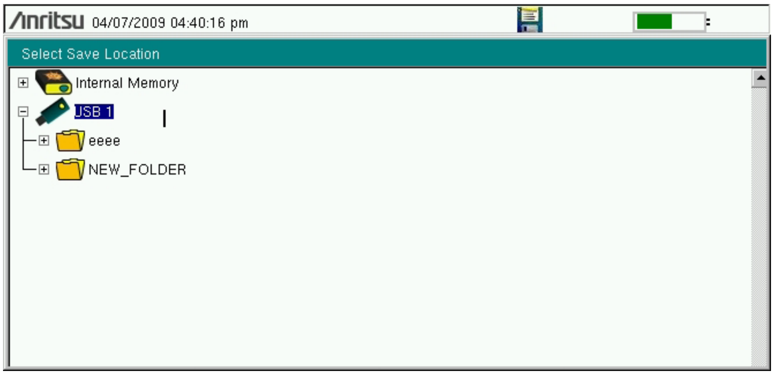
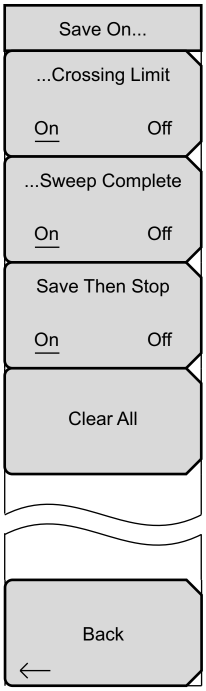


Figure 4-10. Select Save Location Dialog Box

Save On Event Menu

Key Sequence: **File** > Save On Event



In Spectrum Analyzer mode, this menu is used to auto save measurements to internal memory after:

...Crossing Limit: Toggling this submenu key to On will save the measurement to internal memory when the measurement has crossed a defined limit line created with the **Limit** menu.

...Sweep Complete: Toggling this submenu key to On will save the measurement to internal memory after the current sweep is complete. If Save Then Stop is toggled Off, a measurement will be saved after every sweep.

Save Then Stop: Set this key to On to stop the sweep after a measurement is saved. With this key Off and Sweep Complete On a measurement is saved after every sweep.

Clear All: Pressing this key will turn Off the three save on event keys:

Crossing Limit

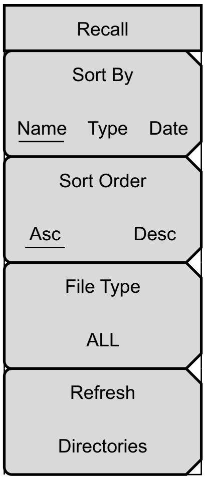
Sweep Complete

Save Then Stop

Figure 4-11. Save On Menu

Recall Menu

Key Sequence: **File** > Recall



This menu and dialog box is used to create folders and select where the Site Master will save the current file. Select folders or drives with the **Up/Down** keys, the rotary knob or the touch screen.

Sort By: Press this submenu key to sort file and folders by the file name, by the type of file, or by the date that the file or folder was saved.

Sort Order: Displays the folder or file in ascending or descending order based on the selection in the Sort By key.

File Type: Press this submenu key to select what type of file is viewed. The options are the ALL, Measurement, or Setup. The file type can be changed with the **Up/Down** keys, the rotary knob, or the touch screen. Press **Enter** to make the selection.

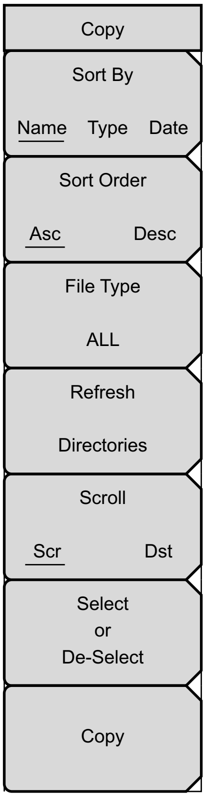
> **Setup:** Setup files contain basic instrument information, measurement mode setup details, measurement marker data, and limit data.
>
> **Measurement:** Measurement files contain all of the information in the setup files and the measurement data.
>
> **Limit Lines (.lim):** The Limit line file contains limit line data details.
>
> **ALL:** Displays all file types.

Refresh Directories: Press this key to update the display.

Figure 4-12. Recall Menu

Copy Menu

Key Sequence: **File** > Copy



This menu and dialog box is used to copy folders and files. Select folders or files with the **Up/Down** keys, the rotary knob or the touch screen. Figure 4-4 on page 4-5 shows the Copy dialog box with two Jpeg images and one folder (including the folder's contents) selected and ready to be copied to the USB flash drive. Highlight a folder and press **Enter** to view the contents.

Sort By: Press this submenu key to sort file and folder lists by name, by type of file, or by the date that the file was saved.

Sort Order: Displays the folder or file in ascending or descending order based on the selection in the Sort By key.

File Type: Press this submenu key to select what type of file to view for copying. The options are: ALL, Measurement, Setup, or Jpeg. The file type can be changed with the **Up/Down** keys, the rotary knob, or the touch screen. Press **Enter** to make the selection.

Refresh Directories: Press this key to update the display.

Scroll Scr Dst: Press this submenu key to use the scroll function in the Source Folder (Scr - top panel) or Destination Folder (Dst - bottom panel). See Figure 4-4.

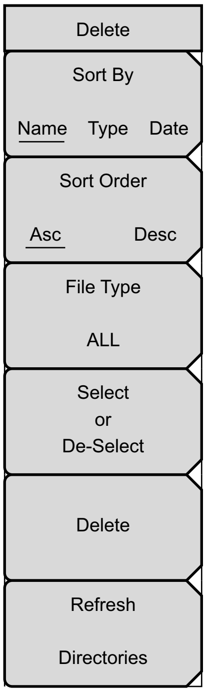
Select or De-Select: Use this key to select or deselect the file(s) or folder(s) to be copied. When selected, a file or folder will be outlined in blue, see Figure 4-4.

Copy: Copies the files or folders selected in the top window to the destination selected in the bottom window. A dialog box will display showing when the copying is complete. If a file with the same name exists in the destination folder a warning box will display to allow file overwrite or to cancel.

Figure 4-13. Copy Menu

Delete Menu

Key Sequence: **File** > Delete



This menu and dialog box is used to delete folders and files. Select folders or files with the **Up/Down** keys, the rotary knob or the touch screen.

Sort By: Press this submenu key to sort files and folders by name, by the type of file, or by the date that the file or folder was saved.

Sort: Displays the folder or file in ascending or descending order based on the selection in the Sort By key.

File Type: Press this submenu key to select what type of file view for deleting. The options are the ALL, Measurement, Setup, Limit Lines, or Jpeg. The file type can be changed with the **Up/Down** keys, the rotary knob, or the touch screen. Press **Enter** to make the selection.

Select or De-Select: Use this key to select or deselect the file(s) or folder(s) to be deleted. When selected, a file or folder will be outlined in blue.

Delete: Press this key to open the Delete dialog box. Press **Enter** to delete the selected item or **Esc** to Cancel.

Refresh Directories: Press this key to update the display.

Figure 4-14. Delete Menu

Chapter 5 — System Operations

5-1 Introduction

This chapter will review the Site Master system operations.

- "System Menu Overview" on page 5-2
- "System Menu" on page 5-3
- "Preset Menu" on page 5-8
- "Self Test" on page 5-8
- "Updating the Site Master Firmware" on page 5-9

The other menus (Sweep Measure Trace and Limit) are detailed in the Measurement Guides listed in Appendix A.

5-2 System Menu Overview

To access the functions under the System menu, select the **Shift** key, then the **System** (8) key.

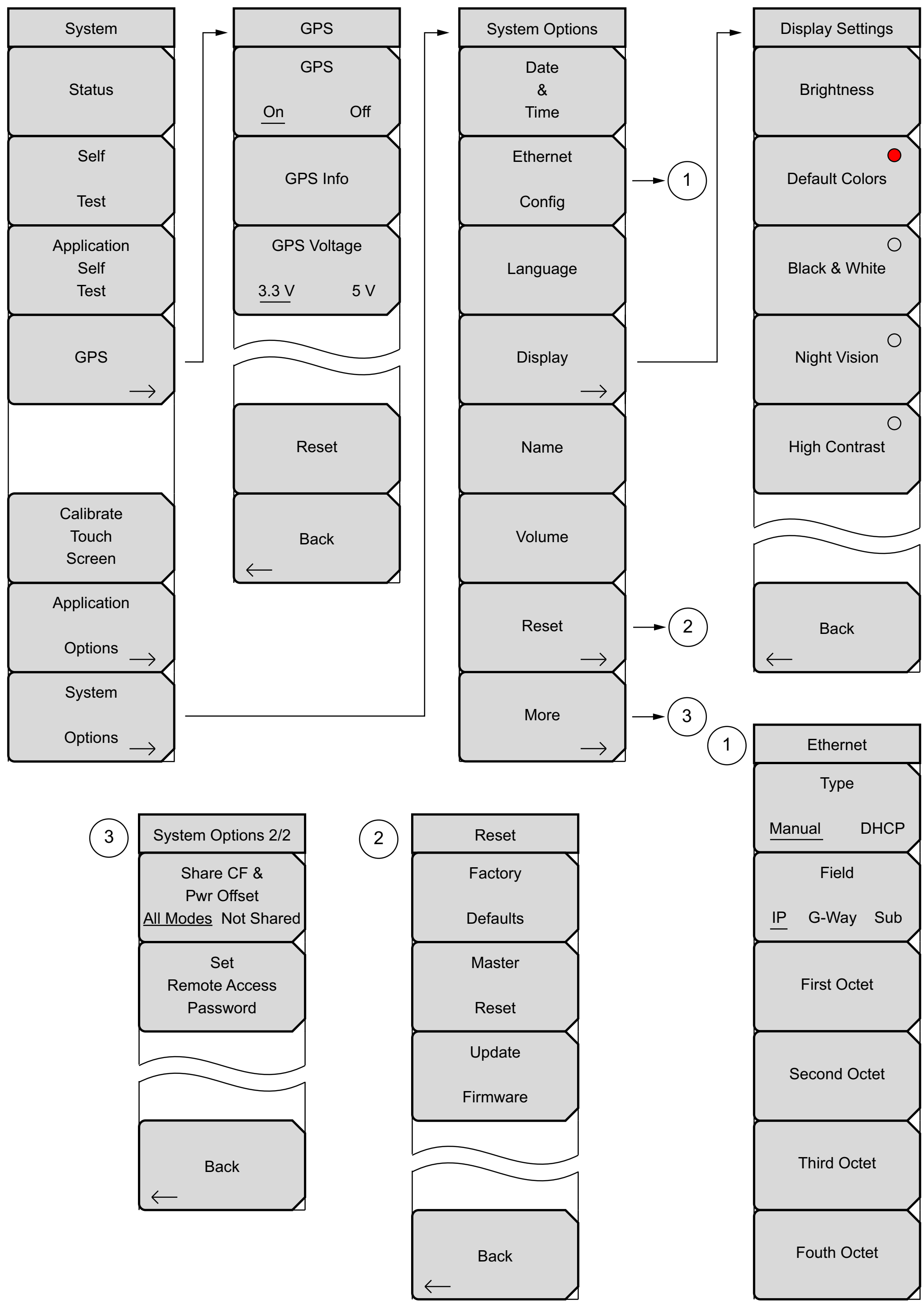
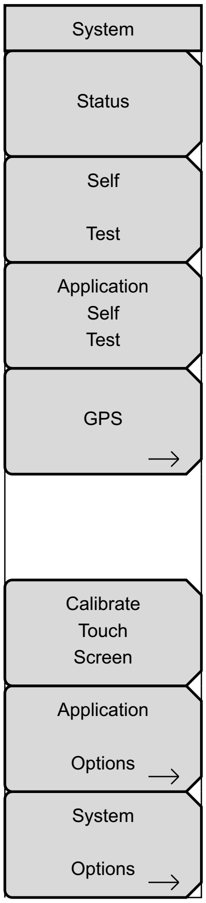


Figure 5-1. System Menu

5-3 System Menu

Key Sequence: **Shift**, **System** (8)



Status: Pressing this submenu key displays the current system status, including the operating system and firmware versions, temperatures and other details such as current battery information. Press **Esc** or **Enter** to return to normal operation.

Self Test: This key initiates a series of diagnostic tests that check the components of the instrument. A display will list the individual tests with a pass or fail indication. Press **Esc** or **Enter** to return to normal operation.

Application Self Test: This key initiates a series of diagnostic tests related to the performance of the instrument for specific applications. A display will list the individual tests with a pass or fail indication. Press **Esc** or **Enter** to return to normal operation.

GPS : Opens the "GPS Menu" on page 6-4.

Calibrate Touch Screen: Start the touch screen calibration. Run the calibration procedure when instrument is not responding to your screen taps as expected.

Application Options: This submenu key presents a menu to select application options. This will vary depending upon the measurement mode.

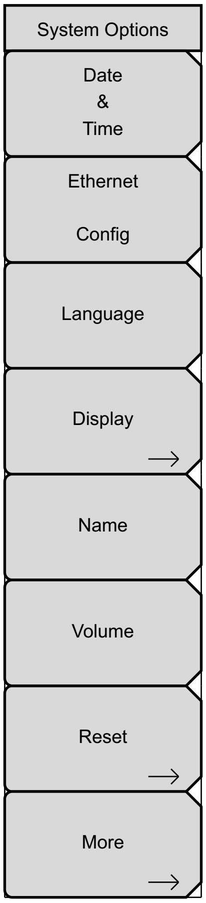
System Options: This key opens the "System Options Menu" on page 5-4.

Figure 5-2. System Menu

Note	**Calibrate Touch Screen Shortcut** Press **Shift** then **0** to open the Calibrate Touch Screen display. Press **Enter** to start the calibration or **Esc** to cancel.

System Options Menu

Key Sequence: **Shift**, **System** (8) > System Options



Date and Time: This key brings up a dialog box for setting the current date and time. Use the submenu keys or the **Left/Right** arrow keys to select the field to be modified. Use the keypad, the **Up/Down** arrow keys or the rotary knob to select the date and time. Press **Enter** to accept the changes, or press the **Esc** key to return to normal operation without changing anything.

Ethernet Config: Press this submenu key to display the Ethernet submenu and to open the Ethernet Editor dialog box to set the IP address of the instrument. For details refer to Chapter 7, "Ethernet Connectivity (Option 411)".

Language: This submenu key brings up a selection box allowing selection from a list of built-in languages for the Spectrum Master displays. The languages currently available are English, French, German, Spanish, Japanese, Chinese, Korean, and Italian. In addition, up to two custom languages may be loaded into the instrument if they have been defined using the Master Software Tools. If a mode does not have language translations available, English is the default language. Press **Enter** to accept the change, or press the **Esc** key to return to normal operation without changing the setting.

Display: The Display submenu key opens the "Display Settings Menu" on page 5-6 allowing brightness control and the selection of the default color display, black & white display, night vision display, or a high contrast display.

Name: Opens a dialog box to name the instrument. The unit can be named using the keypad to select numbers and the touch screen keys to select letter groups. Use the **Shift** key to select an upper case letter. Use the **Left/Right** directional arrows to move the cursor position. The Back Space key will remove the last character entered. Press **Enter** to save the name.

Volume: The current volume setting is displayed on the screen. Use the keypad, the **Up/Down** arrow keys or the rotary knob to change the volume and press the **Enter** key to accept the change.

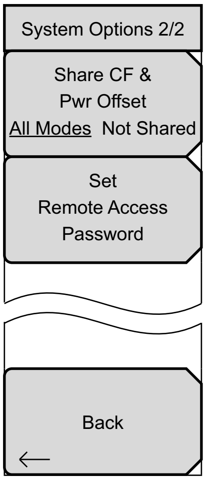
Reset: Press this submenu key to open the "Reset Menu" on page 5-7.

More: Press this submenu key to open the "System Options 2/2 Menu" on page 5-5.

Figure 5-3. System Options Menu

System Options 2/2 Menu

Key Sequence: **Shift**, **System** (8) > System Options > More



Center Freq Share: Select All Modes to have the current center frequency setting carried over when changing measurement modes. This feature is not applicable to measurements which do not have a center frequency setting or to measurements in which the current center frequency setting is outside the range of the new measurement.

Set Remote Access Password: Press this submenu key to open the Password text box (Figure 5-5) and Text Entry menu. Type in the desired password. Upper case and lower case letters and the symbols **-** **_** **+** **.** are the allowed password characters. Press **Enter** to save or **Esc** to cancel.

Back: Press this submenu key to return to the "System Options Menu" on page 5-4.

Figure 5-4. System Options Menu

Remote Access Password

Warning	Do not use SCPI commands with this feature.

This function is valid only with Master Software Tools (MST) v2.21.1 or later. After setting the password, reboot the instrument (normal power **OFF** then **ON**) to provide remote access security. Only one user then has access at any one time.

The password is first set into the instrument, then used in MST. When prompted in MST, enter the password into the password text box. The password text box shown in Figure 5-5 may differ from the text box that is displayed on your instrument.

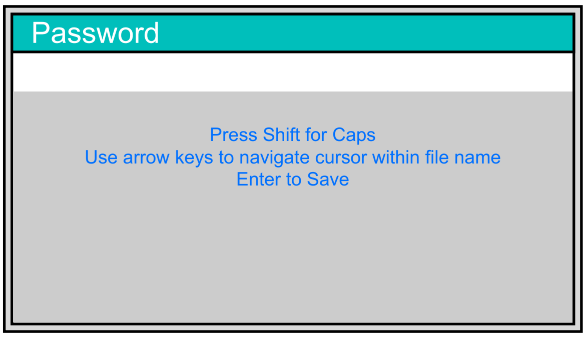
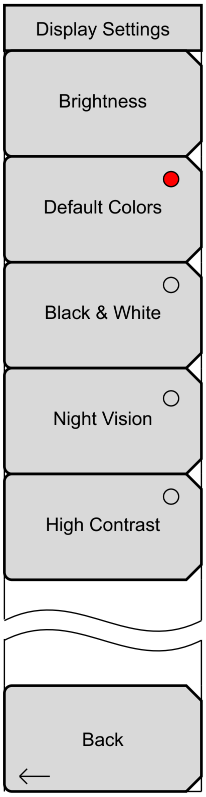


Figure 5-5. Remote Access Password Text Box

The password can be removed or reset by a Master Reset, by a Factory Default reset, or by a firmware update (which includes a restart).

Display Settings Menu

Key Sequence: **Shift**, **System** (8) > System Options > Display



Brightness: The brightness of the display can be adjusted to optimize viewing under a wide variety of lighting conditions. Use the keypad, the **Up/Down** arrow keys or the rotary knob to select a brightness level from 1 to 9, with 9 being the brightest. Press **Enter** to accept the change.

Default Colors: Sets the display colors to their factory default condition. Used for normal viewing.

Black & White: Sets the display colors to black and white. Used for printing and viewing in broad daylight conditions.

Night Vision: Sets the display to a red-tinted color. Optimized for night-time viewing.

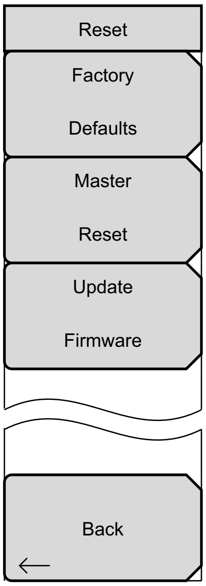
High Contrast: Increases the contrast of the default display colors. Used for other challenging viewing conditions.

Back: Press this submenu key to return to the "System Options Menu" on page 5-4.

Figure 5-6. Display Settings Menu

Reset Menu

Key Sequence: **Shift**, **System** (8) > System Options > Reset



Factory Defaults: Restores the instrument to the factory default values, including Ethernet (Option 411), language, volume, brightness setting, and user created shortcut icons on the Menu screen. Press the **Enter** key to initiate the reset, and power-cycle the instrument.

Master Reset: In addition to the functions described in Factory Defaults above, all user files in the internal memory are deleted, and the original language and antenna files are restored. Press the **Enter** key to initiate the Master Reset and power-cycle the instrument. Press **Esc** to return to normal operation without resetting.

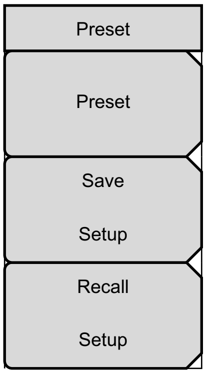
Update Firmware: Press this submenu key to update the instrument operating system with a USB memory device. Press **Enter** and follow the onscreen instructions to update the firmware or press **Esc** to return to normal operation without updating. Refer to "Updating the Site Master Firmware" on page 5-9 for additional information on firmware update.

Back: Press this submenu key to return to the "System Options Menu" on page 5-4.

Figure 5-7. Reset Menu

5-4 Preset Menu

Key Sequence: **Shift, Preset** (1)



Preset: This key resets the instrument to the default starting conditions.

Save Setup: Opens the Save dialog box (Figure 4-1) to name and save the current operating settings, allowing them to be recalled later to return the instrument to the state it was in at the time the setup was saved.

The saved setup can be named using the touch screen keyboard. Use the Caps key to select an upper case letter. Use the **Left/Right** directional arrows to move the cursor position. Press **Enter** to save the setup.

Note: Set the File type as Setup. See "Save Menu" on page 4-9 for details.

Recall Setup: This key allows the selection and recall of a previously stored instrument setup using the "Recall Menu" on page 4-12. Use the rotary knob, the **Up/Down** arrow keys, or the touchscreen to highlight the saved setup, and press **Enter**. All current instrument settings are replaced by the stored setup information.

Figure 5-8. Preset Menu

5-5 Self Test

At power on, the Site Master runs through a series of quick checks to ensure that the system is functioning properly. The System self test runs a series of tests that are related to the instrument. The Application Self Test runs a series of tests that are related to the current operating mode of the instrument.

If the Site Master is within the specified operating range with a charged battery, and the self test fails, then contact your Anritsu Service Center (http://www.anritsu.com/Contact.asp).

To start a self test when the system is already powered up:

1. Press the **Shift** key and then the **System** (8) key.
2. Press the Self Test submenu key. The Self Test results are displayed.
3. Press **Esc** to continue.

5-6 Updating the Site Master Firmware

The Site Master is updated using a USB memory stick. Updated product information can be found on the Anritsu web site:

http://www.anritsu.com/

Search for the product model number. The firmware updates are on the product page under the Library tab in the "Drivers, Software Downloads" section.

Note	The "Release History" link provides a summary of the firmware changes.

1. Click on the "Firmware Update for the Site Master S3xxE" link.
2. Click the "Download" button and then "Run". After the download is complete, press "Run" again and follow the onscreen instructions. Press "Help (?)" for additional information.
3. After the firmware update is saved on the USB memory stick, eject the memory stick from the computer.
4. Turn the Site Master off and insert the USB memory stick into the Site Master.
5. Connect the AC adapter and turn the Site Master On.
6. The instrument should update automatically. Follow the instrument prompts.
7. If the automatic update did not start, complete the following steps:
    a. On the instrument press the **Shift** key and then the **System** (8) key.
    b. Press the following key sequence: System Options > Reset > Update Firmware. The Load Firmware menu opens.
    c. Press the **Load Firmware** main menu key (located at the bottom-left corner of the instrument screen).
    d. Press the Update Application Firmware submenu key.
    e. From the choices presented, select the desired "Save" mode.
    f. Press the **Enter** key to begin the firmware update.
    g. Press the **Enter** key one more time to confirm that you want to upgrade the instrument firmware.
8. After the update is compete, the Site Master will restart.

Note	Do not turn off the instrument during the firmware update to avoid potential permanent damage to the instrument.

Chapter 6 — GPS (Option 31)

6-1 Introduction

The Site Master is available with a built-in GPS receiver feature (Option 31) that can provide latitude, longitude, altitude, and UTC timing information. This option also enhances the frequency reference oscillator accuracy in the spectrum analyzer mode (S332E/S362E). The accuracy of the CW generator (Option 28) is also improved with the GPS option. Within three minutes of satellite acquisition, the reference oscillator will have an accuracy of better than 50 ppb (parts per billion).

In order to acquire data from the GPS satellites, the user must have line-of-sight to the satellites or the antenna must be placed outside without any obstructions. An Anritsu GPS antenna is required.

Note	The Site Master Technical Data Sheet provides a list of options and the measurements that require GPS (Option 31).

6-2 Chapter Overview

6-3 Activating the GPS Feature

Install the Anritsu GPS antenna onto the GPS Antenna connector on the Site Master.

1. Press the **Shift** key, then the **System** (8) key.
2. Press the GPS submenu key.
3. Press the GPS On/Off submenu key to toggle the GPS feature on or off. When GPS is first turned on, a RED GPS icon will be appear at the top of the display.

Figure 6-1. GPS Icon, Red

4. When the GPS receiver has tracked at least three satellites, the GPS icon will change to GREEN. Latitude and Longitude information is displayed in the white bar on top of the display. Acquiring satellites may take as long as three minutes.

Figure 6-2. GPS Icon, Green

5. Press the GPS Info submenu key to view information about:

- Tracked Satellites
- Latitude and Longitude
- Altitude
- UTC
- Fix Available
- Almanac Complete
- Antenna and Receiver Status
- GPS Antenna Voltage and Current

See Section 6-5 “GPS Menu” on page 6-4 for details about the GPS Info dialog box.

6. Press the Reset submenu key to reset the GPS.
7. The GREEN GPS icon with a RED CROSS through it, as shown below, appears when GPS satellite tracking is lost (after actively tracking 3 or more satellites). The GPS longitude and latitude are saved in the instrument memory until the Site Master is turned off or until GPS is turned off by using the GPS On/Off key.

Figure 6-3. GPS Icon, Tracking Lost

6-4 Saving and Recalling Traces with GPS Information

Saving Traces with GPS Information

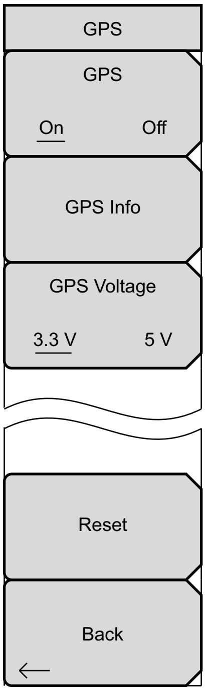
The GPS coordinates of a location can be saved along with a measurement trace. Refer to the "Save Menu" on page 4-9 for more information. The current GPS coordinates will be saved with the measurement traces whenever GPS is on and actively tracking satellites.

Recalling GPS Information

If the GPS coordinates were saved with a measurement, then when the measurement is recalled, the coordinates that were saved are recalled as well. Refer to the "Recall Menu" on page 4-12 for more information about recalling a saved trace.

6-5 GPS Menu

Key Sequence: **Shift**, **System** (8) > GPS



GPS: Press this submenu key to turn GPS on or off.

GPS Info: Press this submenu key to display the current GPS information.

Tracked Satellites: Shows the number of tracked satellites (three are required to retrieve latitude and longitude, four are required to resolve altitude). Generally, the larger number of satellites tracked, the more accurate the information.

Latitude and Longitude: Shows location in degrees, minutes, and seconds.

Altitude: Shows altitude information in meters.

UTC: Universal Coordinated Time.

Fix Available: The cold start search sets are established to ensure that at least three satellites are acquired within the first couple of minutes. When three satellites are found, the receiver will compute an initial fix (typically in less than two minutes). **Fix Not Available** means that the initial position has not been established.

Almanac Complete: The system Almanac contains information about the satellites in the constellation, ionospheric data, and special system messages. In a cold start, the GPS receiver does not have any navigation data so the receiver does not have a current almanac. A complete system almanac is not required to achieve a first position fix. The availability of the almanac, however, can significantly reduce the time to first fix.

Antenna Status:
OK: Antenna is connected properly and antenna is working properly

Short/Open: A short or open exists between the antenna and the connection. If this message is displayed, then remove and replace the GPS antenna. If the message persists, then try another Anritsu GPS antenna (part number 2000–1528-R). If the message persists, then contact your nearest Anritsu Service Center.

Receiver Status: Current status of the receiver.

GPS Antenna Voltage and Current: Shows voltage and current.

GPS Voltage: Press this submenu key to set the source voltage to be either 3.3 V or 5 V depending on the GPS receiver being used. GPS antenna voltage is set to 3.3 V by default in order to prevent accidental damage to lower-voltage GPS antennas.

Reset: The Reset key sets the tracked number of satellites to 0 and erases any almanac data, along with saved coordinates. The process of searching for and reacquiring satellites will begin again.

Back: Press this submenu key to return to the “System Menu” on page 5-3.

Figure 6-4. GPS Menu

Chapter 7 — Ethernet Connectivity (Option 411)

7-1 Introduction

This chapter describes how to connect to a network or directly to a PC using Option 411 Ethernet Connectivity. It also describes the RJ-45 connector, DHCP, and connection tests for the Site Master.

7-2 Ethernet Connection

Network Connection

Note	DHCP is the default Ethernet type. If the Anritsu handheld has been set to Manual, change to DHCP from the **System** main menu (**Shift**+8) > System Options > Ethernet.

Use the following procedure if you can connect to a network that offers DHCP.

1. Connect the handheld instrument and the computer running MST to the Ethernet network.
2. Turn on the Anritsu handheld and confirm the network connection from the **System** main menu (Shift+8) > Status submenu key. The IP address on the handheld is displayed in the STATUS window.
3. In Master Software Tools, press the Network tab then the Query Network for Instruments button. Double-click on the handheld instrument to complete the connection. The instrument model and IP address along with a green connection icon will be displayed at the top of the MST window.

Ethernet Direct Connection

Use the following procedure if you can not connect to a network running DHCP.

1. Connect the handheld instrument and the computer running MST with an Ethernet crossover cable or a standard Ethernet cable with a crossover adapter.
2. Turn on the Anritsu handheld and set the Ethernet connection to Manual. **System** main menu > System Options > Ethernet.
3. Use the Field and Octet submenu keys to setup the following:

   IP: 10.0.0.2
   Gateway: 10.0.0.2
   Subnet: 255.255.255.0

   Press **Enter** to save the changes.

Note The following steps may disable network and/or internet access.

4. Configure the computer for direct Ethernet connection:

   a. On the computer running MST, double-click on the local area connection associated with Ethernet crossover cable connection (Start menu > Settings > Network Connections > Local Area Connection *x*).

   b. Click on the Properties button, then double-click on Internet Protocol (TCP/IP).

   c. Select Use the following IP address (or Alternate Configuration) and enter the following information:

      IP: 10.0.0.1
      Gateway: 10.0.0.1
      Subnet: 255.255.255.0

   d. Close all the open windows and restart the computer and the Anritsu handheld.

5. Open Master Software Tools, press the Network tab then the Query Network for Instruments button. Double-click on the instrument to complete the connection. The instrument model and IP address (10.0.0.2) along with a green connection icon will be displayed at the top of the MST window.

7-3 Ethernet Configuration on the Site Master

LAN Connection

The RJ-45 connector is used to connect the Site Master to a local area network. Integrated into this connector are two LEDs. The amber LED shows the status of the Ethernet Link: Link Up (On) or Link Down (Off). The green LED flashes to show that LAN traffic is present. The instrument IP address is set by pressing the **Shift** key, then the **System** (8) key followed by the System Options soft key and the Ethernet Config soft key. The instrument Ethernet address can be set automatically using DHCP, or manually by entering the desired IP address, gateway address, and subnet mask.

Note	An active Ethernet cable must be connected to the instrument before it is turned ON in order to enable the Ethernet port for DHCP or for a static IP address. Depending upon local conditions, the port may remain enabled when changing from DHCP to static IP address, when changing from static IP address to DHCP, or when temporarily disconnecting the Ethernet cable. If the port becomes disabled, ensure that an active Ethernet cable is attached to the instrument before cycling the power OFF and back ON.

Dynamic Host Configuration Protocol (DHCP) is an Internet protocol that automates the process of setting IP addresses for devices that use TCP/IP, and is the most common method of configuring a device for network use. To determine if a network is set up for DHCP, connect the MT8222B to the network and select DHCP protocol in the Ethernet Config menu.

Turn the Site Master off, and then on. If the network is set up for DHCP, the assigned IP address should be displayed briefly after the power up sequence.

To display the IP address with the instrument on, press the **Shift** key, then the **System** (8) key, then the System Options soft key and the Ethernet Config soft key. The IP address will be displayed as shown in Figure 7-1. The image on the display panel of your Site Master may differ from the image shown here.

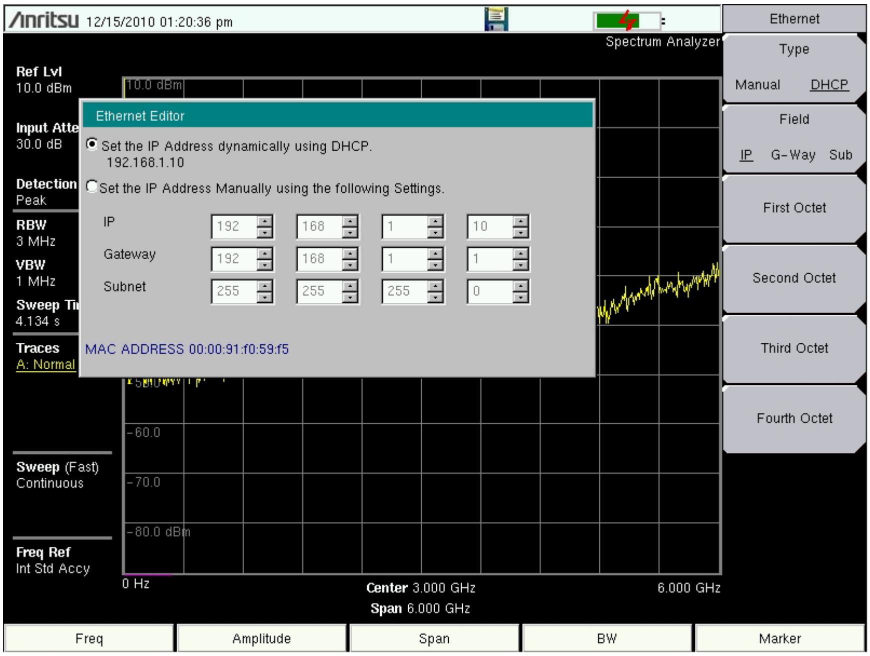


Figure 7-1. IP Address Assigned Using DHCP

Ethernet Config

Press this submenu key to display the Ethernet submenu and to open the Ethernet Editor dialog box in order to set the IP address of the instrument.

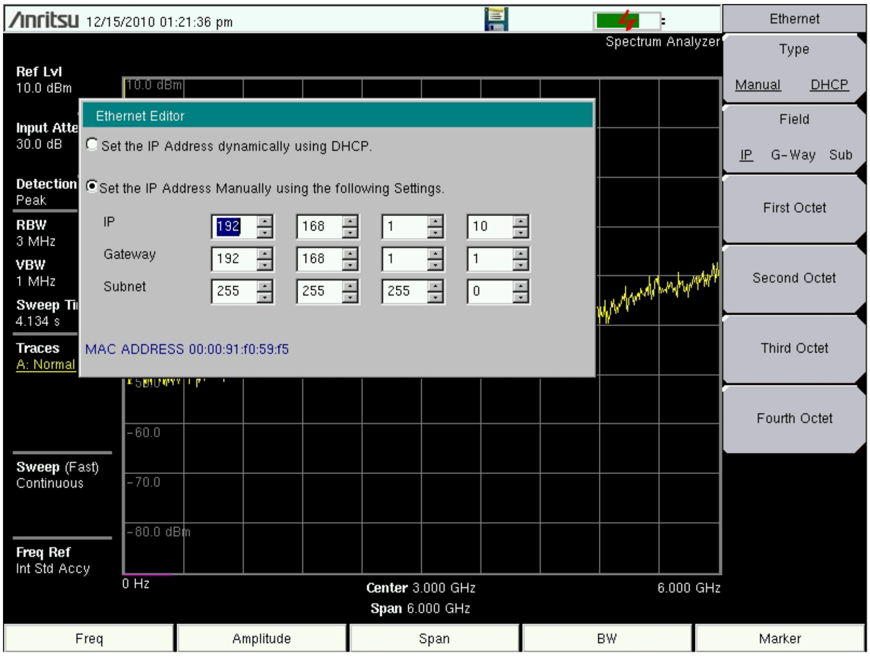
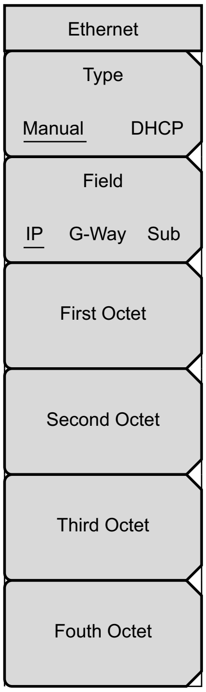


Figure 7-2. Setting IP Address Manually

Ethernet Menu

Key Sequence: **Shift**, **System** (8) > System Options > Ethernet Config



Type
Manual DHCP: Press this submenu key to select whether the address will be entered manually, or will be supplied automatically by a network DHCP server. If Manual is selected, then use the submenu keys or the **Left/Right** arrow keys to select the field that is to be modified. Use the keypad, the **Up/Down** arrow keys, or the rotary knob to enter the input. Press **Enter** to accept the changes, or press the **Esc** key to return to normal operation without changing anything.

Field
IP G-Way Sub: Press this submenu key to select the desired Internet Protocol Property to be edited.

First Octet: Moves the cursor to the left most column of the selected IP properties field.

Second Octet: Moves the cursor to the second column from the left of the selected IP properties field.

Third Octet: Moves the cursor to the third column from the left of the selected IP properties field.

Fourth Octet: Moves the cursor to the forth column from the left of the selected IP properties field.

Figure 7-3. Ethernet Menu

7-4 DHCP

DHCP stands for Dynamic Host Configuration Protocol. It is a protocol that allows a server to dynamically assign IP addresses to devices that are connected to the network. Most networks include a DHCP server to manage IP addresses. When a DHCP server is available on the network, DHCP is the preferred IP address assignment mode.

When using DHCP, no setup is required to lease and use a dynamic IP address. In a dynamic IP operation, the IP address in use may change from use to use. The DHCP server hands out IP addresses on a first come, first served basis. As soon as the device is disconnected from the network, the IP address that it was using becomes available to lease to the next unit that requests an IP address. Normally, some amount of lag time is present on the DHCP server end, so if the device is connected again reasonably soon, then it may end up with the same address.

Note	The instrument must be connected to the network before it is turned on in order for DHCP to function. Key elements of the DHCP lease are performed only during the instrument startup operations, or when switching from manual to DHCP

When a DHCP server is not available, a Static IP address can be used. A Static IP address is a fixed address. After being set, it will always remain the same, and care must be taken to not conflict with other equipment on the network.

When using a static IP address on an established network, always request the Static IP address from the network administrator. Randomly choosing a Static IP address on an established network may result in duplicate IP addresses or other conflicts.

Three parameters must be set prior to using a Static IP address:

IP Address

This is the Static IP address on the network.

Default Gateway

Often when a static IP address is assigned, a default gateway is also identified. If the default gateway is unknown, then type in the Static IP address so that the Static IP address and Default Gateway are the same number.

Subnet Mask

This parameter is usually extracted from the Static IP address based on the class of the address and determines the destination of any broadcast messages that might be sent from the instrument. It can be customized if necessary. The subnet mask may also be provided with the Static IP address.

Example 1

In this example, a Static IP address has been chosen because no network DHCP service is available. The instrument is connected to the network port on the PC with a crossover Ethernet cable (not included). This is also referred to as Direct Connect:

```
IP Address: 10.0.0.2
Default Gateway: 10.0.0.1
Subnet Mask: 255.255.0.0
```

Example 2

In this example, the Static IP address has been assigned with an associated gateway and subnet mask:

```
IP Address: 153.56.100.42
Default Gateway: 153.56.100.1
Subnet Mask: 255.255.252.0
```

7-5 ipconfig Tool

A few tools that are built into the Microsoft Windows operating system can assist in making some determinations about the network to which the PC is connected. Typing ipconfig at a command prompt produces a display of information about the in-use parameters of the PC and its network connection. Following is an example of the typical results expected:

Note	The ipconfig display does not report whether the information is from a DHCP server or from a Static IP setup.

```
Y:\>ipconfig
Windows 2000 IP Configuration
Ethernet adapter Local Area Connection:
Connection-specific DNS Suffix. : us.anritsu.com
IP Address. . . . . . . . . . . . : 172.26.202.172
Subnet Mask . . . . . . . . . . . : 255.255.252.0
Default Gateway . . . . . . . . . : 172.26.200.1
```

7-6 Ping Tool

Another tool that can find out if a selected IP address is already on the network is ping. Ping is a harmless way to determine if an address is found on the network, and (if it is found) to receive a reply. Basically, the ping function sends out a request to a specific address to determine if a computing device is connected to the network at that address. If a valid connection is found, then a copy of the signal (that was sent) is returned. If a connection is not found, then the response is "request timed out", which means that no reply was received from that IP address.

```
Y:\>ping 172.26.202.172

Pinging 172.26.202.172 with 32 bytes of data:

Reply from 172.26.202.172: bytes=32 time<10ms TTL=128

Reply from 172.26.202.172: bytes=32 time<10ms TTL=128

Reply from 172.26.202.172: bytes=32 time<10ms TTL=128

Reply from 172.26.202.172: bytes=32 time<10ms TTL=128

Ping statistics for 172.26.202.172:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milliseconds:

Minimum = 0 ms, Maximum = 0 ms, Average = 0 ms
```

Chapter 8 — Bias Tee (Option 10)

8-1 Overview

Option 10 provides a bias tee that is installed inside the instrument. The bias arm is connected to a 12 VDC to 32 VDC power source that can be turned on as needed to place the voltage on the center conductor of the instrument's RF In port. This supply of bias implies it is mostly useful when conducting two-port transmission measurements. This voltage can be used to provide power to block down-converters in satellite receivers and can also be used to power some tower-mounted amplifiers.

The bias can be turned on only when the instrument is in transmission measurement, return loss, cable loss, VSWR, DTF, or spectrum analyzer mode. When bias is turned on, the bias voltage and current are displayed in the lower left corner of the display. The 12 VDC to 32 VDC power supply is designed to continuously deliver a maximum of 6 watts.

The bias tee menu can be accessed from the applications options menu and in transmission measurement, it can also be accessed from the **Measure** main menu.

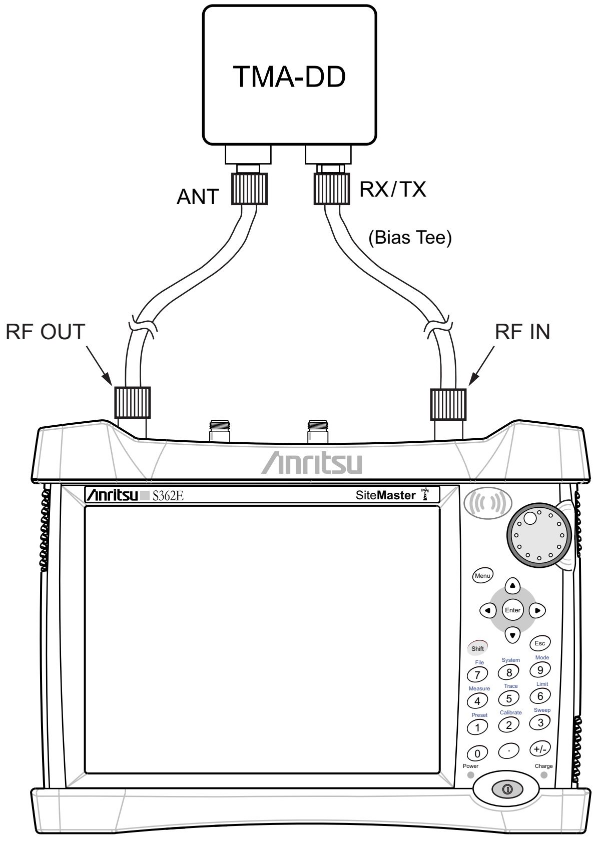


Figure 8-1. Variable Bias Tee

Chapter 9 — Anritsu Tool Box and Line Sweep Tools

9-1 Introduction

This chapter provides a brief overview of the Anritsu Tool Box and the Line Sweep Tools program. For detailed information about Line Sweep Tools, refer to the program Help.

9-2 Anritsu Tool Box with Line Sweep Tools

The Anritsu Tool Box is a central location to open an Anritsu measurement, visit the Anritsu web site, or launch an Anritsu application (Figure 9-1). To open the Anritsu Tool Box, either click on the shortcut icon on the desktop or click Start and navigate through the Programs folder to the Anritsu folder. Then click on the Anritsu Tool Box shortcut to open the Anritsu Tool Box. Once the Tool Box is open, move the mouse pointer over any of the application icons to view a short description of the application.

Figure 9-1. Anritsu Tool Box

9-3 Install the Software

Place the Installation DVD in your computer and follow the on-screen instructions (Figure 9-2).

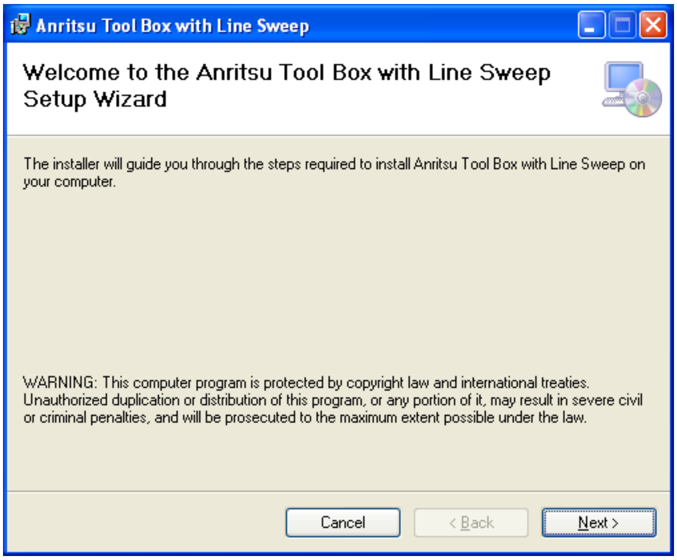


Figure 9-2. Installing Anritsu Tool Box with Line Sweep Tools

If the installer does not autostart, navigate to the DVD and run setup.exe (Figure 9-3).

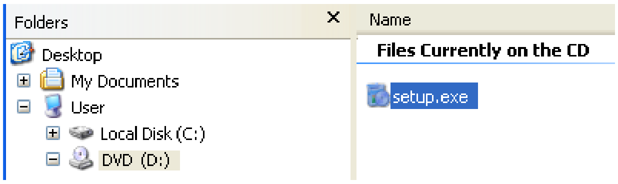


Figure 9-3. setup.exe on the Anritsu Tool Box DVD

The installation will start. Follow the on-screen instructions. The software is also available free of charge from the Anritsu web site (http://www.anritsu.com).

9-4 Other Software

The Anritsu Tool Box may also contain the Anritsu Master Software Tools software and the Anritsu Map Master software. If this software had already been installed on your computer, the Tool Box will link to it. If not, clicking on the icons will bring you to the Anritsu web site, where you will be able to download the software free of charge.

9-5 Why use Line Sweep Tools?

Line Sweep Tools is a program designed to increase productivity for people who work with dozens of Cable traces, Antenna traces, and Passive Intermodulation (PIM) traces every day. Line Sweep Tools will:

- Collect sweeps from Anritsu PIM and Line Sweep gear.
- Help verify that those sweeps are done properly and that the Cable, Antenna and PIM sweeps meet specifications.
- Help create reports of the findings quickly and to a professional standard.

Line Sweep Tools Features

The Line Sweep Tools user interface is familiar to users of Hand Held Software Tools, the current industry standard line sweep post-capture trace processing software. This leads to a short learning curve and easy trace collection, validation, and reporting.

Anritsu’s Line Sweep Tools program includes:

- Presets for markers and limit lines take hours off the report preparation time for a user with dozens of traces to verify.
- The Report Generator which makes generating PDF reports for multiple traces, with logos, quick and easy.
- Dual Trace viewing mode ensures compatibility with the E series line sweep instruments.
- A naming grid makes renaming files, titles, and subtitles much quicker and error free.
- Line Sweep Tools can open DAT or VNA files from a wide range of current and supported Anritsu hand-held instruments.
- Line Sweep Tools can open the PIM files generated by Passive Inter-Modulation measurements.

9-6 Using Line Sweep Tools

Like its predecessor, Hand Held Software Tools (HHST), Line Sweep Tools is intuitive for most users. However, unlike HHST, Line Sweep Tools has the capability to work rapidly with a large number of traces.

Figure 9-4. Line Sweep Tools Window

Line Sweep Tools can open DAT files from HHST; or VNA/DAT files from Anritsu's E-series instruments. It also can open PIM files. Either way, the file once opened, can be inspected and modified in many different ways. Line Sweep Tools saves files as a new type of DAT file, and can export traces as VNA, text, JPG, BMP, or PNG. Line Sweep Tools does not produce files that can be opened by HHST.

Markers and Limit Lines

The easiest way to manage markers is to turn one on and use the mouse to drag it to the desired position. The marker tool bar is shown in Figure 9-5. Marker number 1 is On in the figure below. Markers can be set to an exact value by pressing the "**e**" button, which displays detailed marker controls, numeric value entry, peak find, and valley find.

Figure 9-5. Limit Toolbar and Marker Toolbar

The dark button on the left turns on the limit line. Once on, it can be dragged to the desired place, or put on an exact y-axis value by entering a number.

Marker Presets

The fastest way to manage markers on multiple traces is to use the preset function. The marker and limit line preset toolbar allows users to quickly set all markers and the limit line to pre-defined values on similar traces (Figure 9-6).

Figure 9-6. Preset Toolbar

First set the markers and limit lines on a typical trace to the desired values. Then, press the red "**e**" or edit button on the Preset toolbar. This puts the preset buttons into "learn" mode. Now, press a preset button (1 to 7). This programs the preset button where to put the markers and limit lines. Finally, press the red "**e**" button again to exit the learn mode.

The programmed button is now enabled. Line Sweep Tools can program up to 7 buttons with preset markers and limit line.

To use the preset, just press it and the markers and limit line will display at the programmed locations even when switching to a new trace. The two arrow keys make going to the next, or previous, trace simple. Using presets, a dozen similar traces can be reliably validated in seconds.

Renaming Grid

The renaming grid, much like the naming grid in the E series instruments, allows users to quickly and consistently rename filenames, trace titles, and trace subtitles. The grid can be set up with custom phrases to make the renaming process simpler.

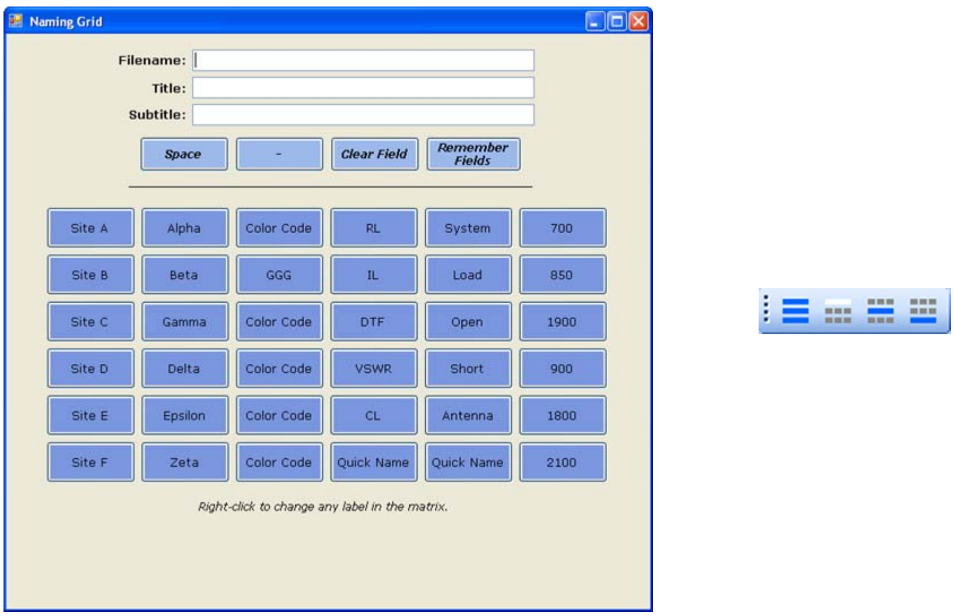


Figure 9-7. Renaming Grid and Renaming Toolbar

To use the renaming grid:

1. Click on the left icon of the Renaming toolbar.
2. Select the filename, title, or subtitle box. Right-clicking on a box will allow you to change the text on the button.
3. Press buttons and type until the desired name is shown.
4. Press Remember Fields to copy the new name for later use.
5. On the toolbar, press the button that corresponds to the field to be renamed.
6. If desired, use the arrow keys on the Marker toolbar to go to the next trace.

Report Generator

To use the report generator in Line Sweep Tools, go to File menu and select Report Setup to tell Line Sweep Tools how you want the report to appear. In this case, the report will have the name of the contractor that did the work (Company field), the contractor logo, and will be generated in PDF format (Figure 9-8).

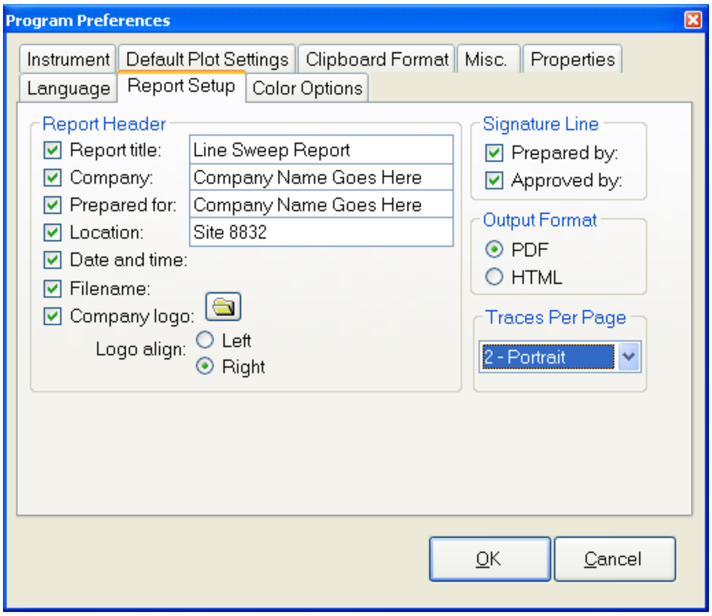


Figure 9-8. Report Setup Tab

Once the report generator is setup, File > Generate Report, will create the PDF. The report will include all traces that were open at the time the report was made (Figure 9-9).

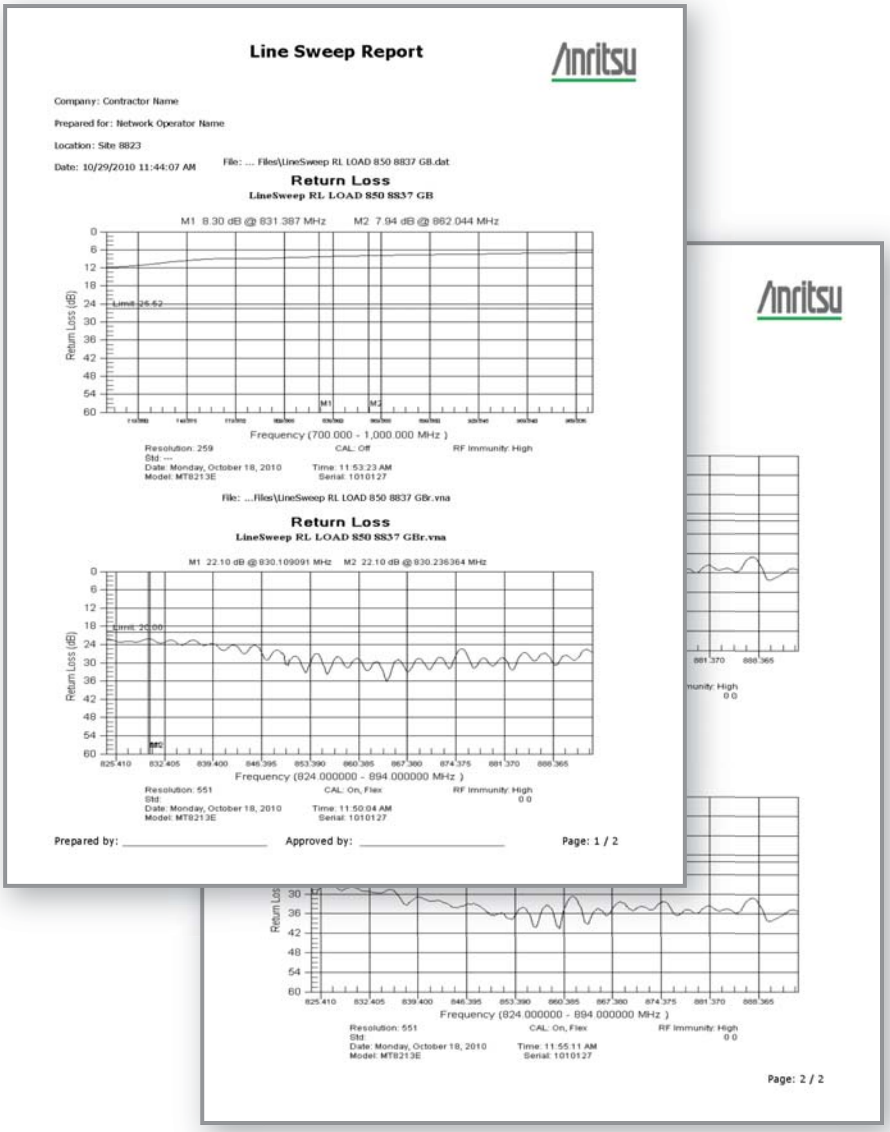


Figure 9-9. Generated Report

Chapter 10 — Master Software Tools

10-1 Introduction

This chapter provides a brief overview of Master Software Tools (MST). For detailed information, refer to the MST Manual.

10-2 MST Overview

Anritsu Master Software Tools is a Windows 2000 and later compatible program for transferring and editing saved measurements, markers, and limit lines to a PC. Master Software Tools will not function on earlier versions of the Microsoft Windows operating system.

10-3 Feature Overview

Capturing or Retrieving Traces

MST includes a feature to capture the current screen and associated data from the test instrument to the Master Software Tools Graphic Display Editor window. Saved files on the test instrument can also be retrieved and displayed or edited with Master Software Tools.

Editing Graphs

MST can be used to change the scale, limit lines, and markers in a measurement through the Edit Graph button in the workspace toolbar, or through the Context Menus.

Context Menus

Context Menus are accessed by right-clicking the mouse on an active measurement screen in the Graphic Display Editor Window. Context Menu functions may include commands that are also available on the pull down menus and toolbar buttons, or functions, commands, and options specific to the active measurement window.

Overlaying Traces

Trace Math and Overlays allow for comparing multiple traces.

Folder Spectrogram

Folder Spectrogram provides a simulated three dimensional view of a large amount of data in one set of graphs.

10-4 Installing MST

MST is provided on the CD-ROM included with the instrument. Insert the CD-ROM into a PC to run the installer. Follow the onscreen instruction.

10-5 Connecting to the Instrument

Use the USB cable supplied with the test instrument to make the connection.

1. Connect the USB cable to the USB-A port on the computer and to the USB-min B port on the test instrument.
2. Turn on the test instrument. Run the Master Software Tools program.
3. Pull down the **Connection** menu and click on Connect – USB. This establishes communication to the test instrument.

For Ethernet connection refer to Chapter 7, “Ethernet Connectivity (Option 411)”.

10-6 Updating Site Master Firmware

Refer to “Updating the Site Master Firmware” on page 5-9.

Appendix A — Measurement Guides

A-1 Introduction

This appendix provides a list of supplemental documentation for Site Master features and options. These measurement guides are available on the documentation disc and the Anritsu website.

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Table A-1. Analyzers and Analyzer Options

Site Master Feature (Required Option)	Related Document (Part Number)
Cable and Antenna Analyzer	Cable and Antenna Analyzer Measurement Guide (10580-00241)
Spectrum Analyzer Interference Analyzer (0025) Channel Scanner (0027) C/W Signal Generator (0028) Gated Sweep (0090) Coverage Mapping (0431) AM/FM/PM Analyzer (0509)	Spectrum Analyzer Measurement Guide (10580-00231) for *Firmware V1.11 and BEFORE* Spectrum Analyzer Measurement Guide (10580-00244) for *Firmware AFTER V1.11*
Bias-Tee (0010) 2-Port Transmission Measurement (0021)	2-Port Transmission Measurement Guide (10580-00242)
High-Accuracy Power Meter (0019) Power Meter (0029)	Power Meter Measurement Guide (10580-00240)
PIM Analyzer (0419)	PIM Master User Guide (10580-00280)
Performance Specifications	Site Master Technical Data Sheet (11410-00484)
SCPI Programming Manual	Site Master Programming Manual (10580-00256)
Maintenance Manual	Site Master Maintenance Manual (10580-00253)
Documentation	Handheld Instruments Documentation Disc (10920-00060)
Computer Software Applications	Master Software Tools CD-ROM (2300-498) or Download Anritsu Tool Box with Line Sweep Tools DVD (2300-530) or Download

Index

Anritsu

10580-00252 F

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MANUAL MMANA-GAL

por Sergio Zuniga
XQ2CG

junio 2014

Contenidos

CAPITULO 1. INTRODUCCIÓN: UN VISTAZO RÁPIDO

MMANA-GAL es una programa para diseñar y analizar antenas. Es gratuito y fue escrito por Alexandr Schewelev DL1PBD, Igor Goncharenko DL2KQ y Makoto Mori JE3HHT. La versión pro es el programa GAL-ANA. El nombre MMANA-GAL viene de abreviaciones del nombre de sus tres programadores: MM por Makoto Mori, G por Goncharenko, y AL por Alexandr.

Este manual recoge algo del material existente en internet, a pesar de que en su mayor parte ha sido desarrollado por el autor.

Existe un grupo discusión de MMANA-GAL de YAHOO (en inglés), en que se puede suscribir gratis, y allí en el que se encuentra mucho material interesante: http://groups.yahoo.com/group/MMANA-GAL

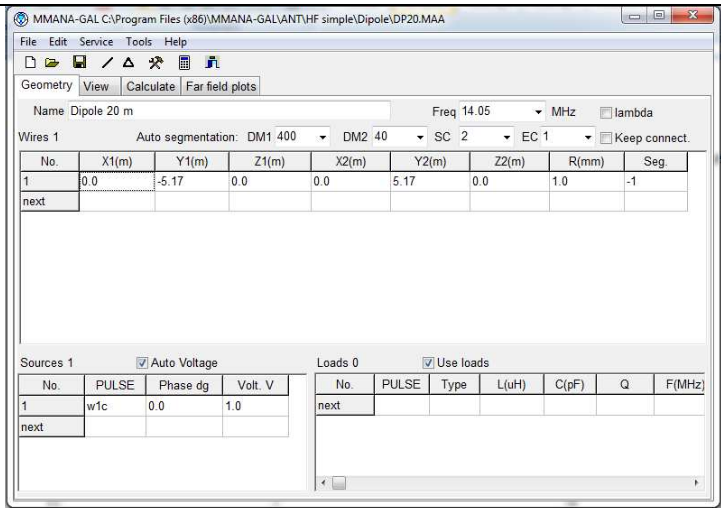
Una vez descargado, instalado y ejecutado, desarrollemos un ejercicio muy simple para comprender lo básico del programa. File --> Open (*.maa), buscar en la carpeta ANT/HF simple/Dipole, y allí seleccionar "DP20.maa". Se trata de un dipolo para la banda de 20 metros. El archivo se guardó originalmente con una frecuencia predeterminada de 14.050 MHz.

Paso 1.- Pestaña Geometry. Se utiliza para introducir las definiciones de la antena (cables o tubos).

En el ejemplo se trata de un dipolo completamente horizontal, con dos brazos iguales, alimentada en el centro.

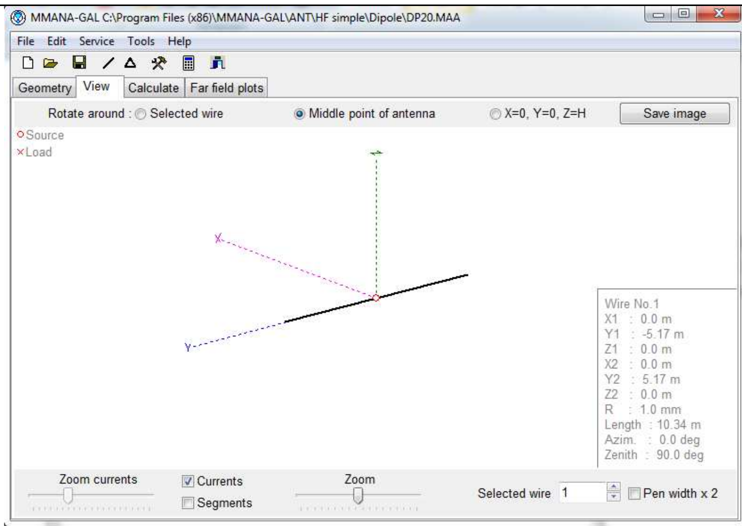
Como es perfectamente horizontal, en un plano tridimensional X-Y-Z, usa una sola dimensión (1 elemento) para dibujarla, por ejemplo el eje Y.

En el programa podemos notar que:
Y1(m)=-5,17 y Y2(m)=5,17, lo que significa que la antena tiene largo de 2x5,17 metros. Son dos brazos a partir del centro, cada uno de 5,17 metros de largo, uno a la izquierda (negativo) y otro a la derecha (positivo).
X1(m)=0 y X2(m)=0, lo que significa que la antena no tiene ancho.
Z1(m)=0 y Z2(m)=0, lo que significa que la antena no tiene altura.



Paso 2.- Pestaña View: Podemos visualizar la antena y verificar las medidas en la pestaña View. El dipolo se distribuye a lo largo del eje Y. Con el botón derecho del mouse se puede rotar la antena.

Abajo a la izquierda puede seleccionarse cada parte de la antena y ver sus características (largo).



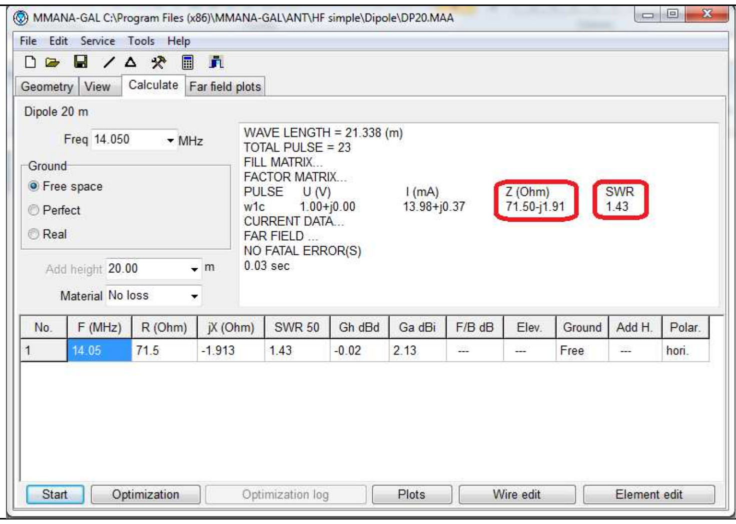
Paso 3. Pestaña Calculate. En esta pestaña el programa hace los cálculos para estimar la impedancia y ROE para la frecuencia predeterminada, y unas condiciones de tierra y altura de la antena que uno defina.

En este caso, en la frecuencia 14.050 Khz, flotando en el espacio libre, y la impedancia es Z=71.5R - j1.913.

La ROE (respecto a 50 ohms) es de 1.43:1.

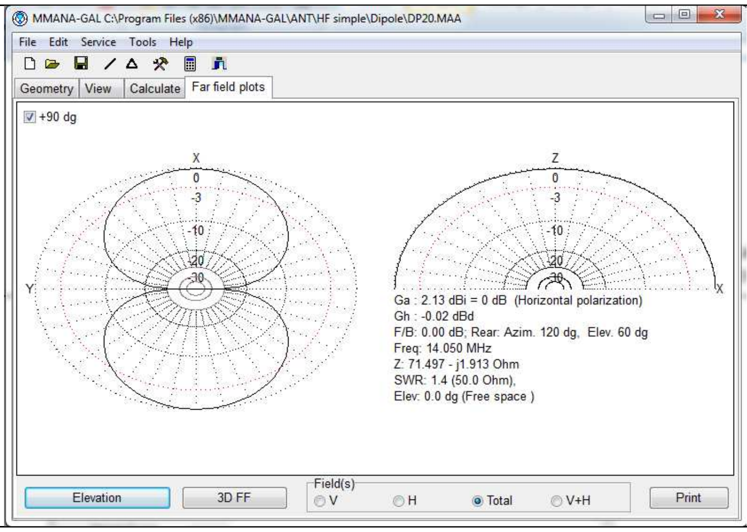
La ganancia es -0.02dBd (respecto a un dipolo), y 2.13dBi (respecto a una antena isótropa teórica).

Podemos cambiar la frecuencia, por ejemplo a 14.150 kHz, y presionando START vemos que nuevos valores son: Z=73.1 + j8.60 y SWR(50) =1,5:1



Paso 4. "Far Field Plots" permite ver el patrón de campo lejano, los gráficos de radiación azimut y de elevación.

Todo esto se explica más adelante.



CAPITULO 2. CONFIGURACION INICIAL

La configuración inicial del programa se define en Menu-->Setup. Las opciones son las siguientes:

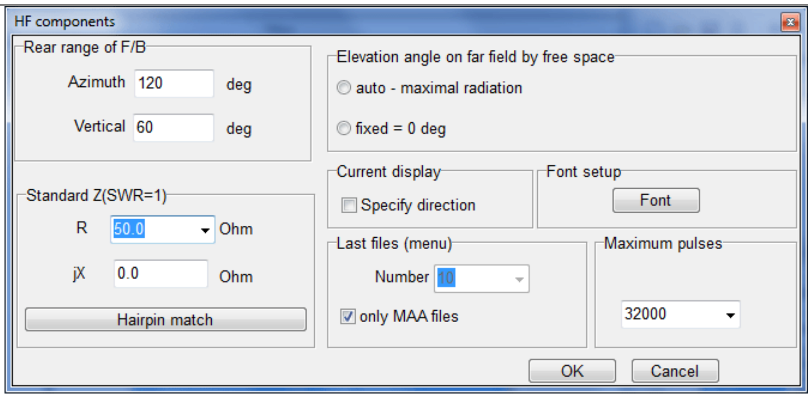
Rear range of the F/B ratio: El rango del ángulo trasero para el cálculo de la relación F/B (front/back).

Standard Z for SWR calculation: La impedancia para calcular la ROE. Pulse hairpin match y Z objetivo para calcular jX del hairpin match. Para adaptación capacitiva, +jX plus. Z objetivo debe ser mayor que R de referencia.

Current display - Specify direction: Muestra la dirección de la corriente en la pestaña antenna view.

Last files (menu): Número de archivos mostrados en File drop down menu.

Maximum pulses
Depende de la memoria RAM. Para calcular 8192 pulsos se requieren 512MB RAM libres.



CAPITULO 3. EJEMPLO: CREACIÓN DE UN DIPOLO EXTENDIDO PARA 40 METROS

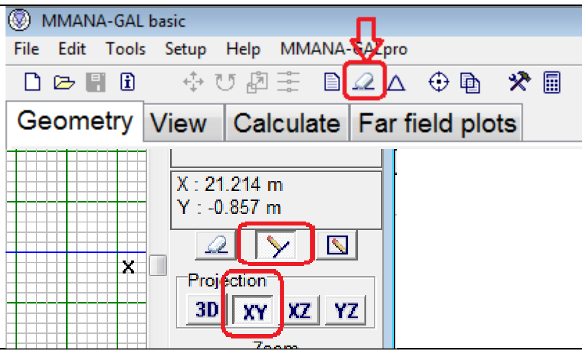
Existen varias formas de definir una antena. La manera más fácil es "dibujar" la antena con el mouse, y luego hacer correcciones al largo, modificando las coordenadas de la antena en la primera tabla en "Geometry", y definiendo la dimensión del cable, fuentes y cargas.

Lo primero es asegurarse que el programa no tenga información previa de una antena anterior. Para esto Menu-->File-->New

En Menu-->Edit-->Wire edit (o directamente en el ícono con forma de goma de borrar) vamos a ir a la pizarra de diseño.

Abajo a la derecha elegimos la proyección más útil. En nuestro caso la proyección XY.

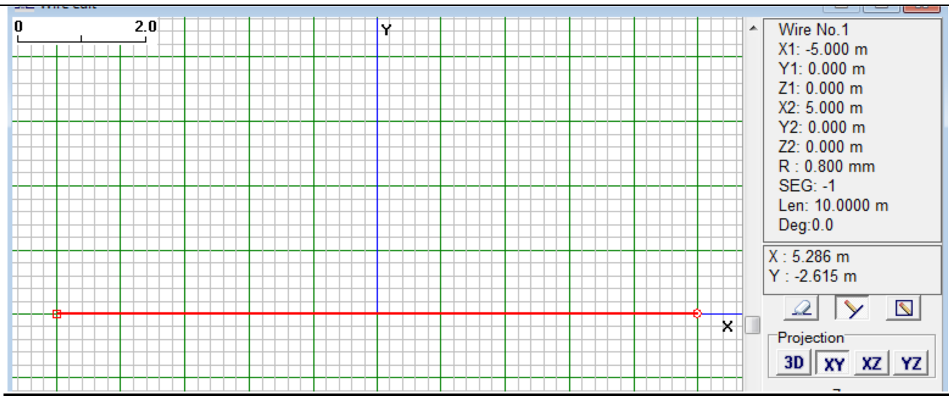
Elegimos el ícono del lápiz para dibujar un cable horizontal con el mouse, atravesando el eje vertical Y.



Supongamos que deseamos que este cable mida 10 metros. Como atraviesa el eje central, significa que tiene dos segmentos de 5 metros cada uno.

Si el cable quedó más corto o largo, lo editamos haciendo click en el icono "edit wire" (al lado del icono del lápiz), y con el mouse seleccionar una punta del cable para acortarlo o alargarlo.

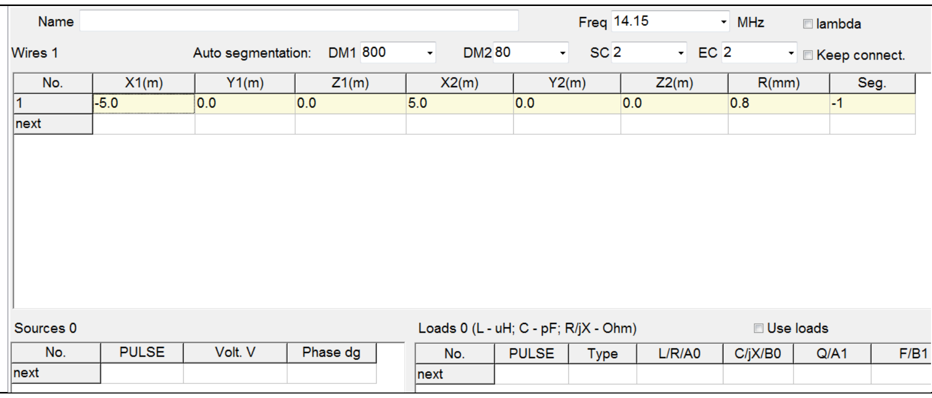
Podemos cambiar la escala de visualización con el Zoom.



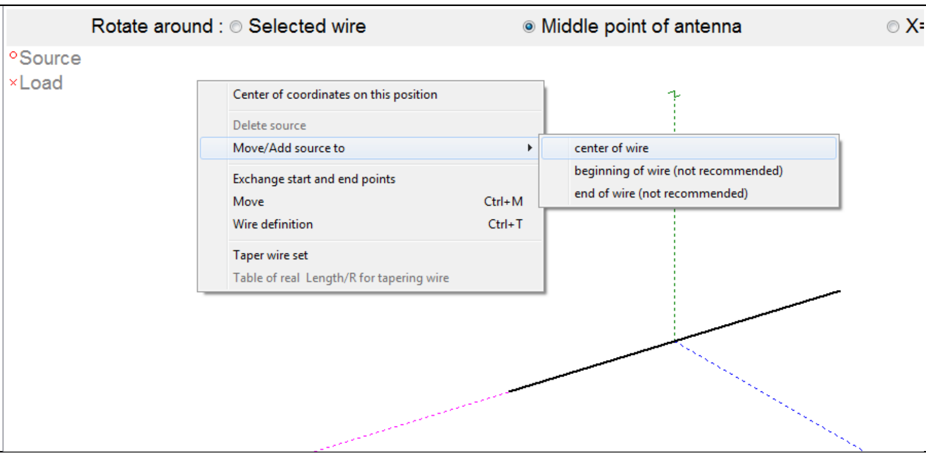
Cuando tenga la longitud deseada, cerramos con OK.

Para verificar el número de elementos y las longitudes resultantes vamos a la pestaña Geometry. Aquí también podemos editar los elementos de la antena.

Para ver el dipolo resultante vamos la pestaña View. Allí podemos rotar para ver el dipolo desde diferentes ángulos.



Para definir la posición de la alimentación de la antena, en View, presionamos el botón derecho del mouse, y seleccionamos que la alimentación se encontrará en el centro del cable, convirtiéndolo así en un dipolo alimentado en el centro.



Nótese que con lo anterior, en la tabla Geometry en "Sources" aparece en el cable 1 el pulso **w1c**. Esto se explica más adelante.

Con esto se tiene un dipolo para 40 metros ya definido.

Sources 1

No.	PULSE	Volt. V	Phase dg
1	w1c	1.0	0.0
next			

CAPITULO 4. LAS PESTAÑAS DEL PROGRAMA

PESTAÑA 1: GEOMETRY

La pestaña Geometry contiene básicamente tres tablas para definir completamente una antena.

La casilla Name: Puede escribirse una descripción de la antena.
La casilla Freq: La frecuencia en Mhz en la que se desea operar.
La casilla 'Lambda': Cuando se activa, todas las dimensiones se proporcionan con respecto a la longitud de onda, y no en metros.
La casilla 'Keep Connected': Cuando se activa, todos los elementos conectados al elemento que se modifica son re-escalados, sin perder la conexión con el elemento de destino.
Auto segmentación: Se recomienda el uso de Seg.=-1, que significa "Tapering", ya que mejora la precisión del cálculo, porque divide la sección del elemento las curvas en pequeños segmentos, pero divide las los tramos rectos en grandes segmentos. Los siguientes parámetros controlan la precisión de los cálculos que hace el programa:

M1	El intervalo de inicio para el tapering (= lambda / DM1xEC)
DM2	El intervalo de término para el tapering (= lambda / (SCxDM2))
SC	La tasa a la cual cambia el tapering, 1 < SC < 3.
EC	El número de segmentos DM1 hasta el final del tapering.

Los cálculos aumentan su precisión cuando se usan valores pequeños de DM1 y DM2 (siempre DM1 debe ser mayor que DM2), aumenta SC y EC. En antenas simples aumentar la precisión no tiene efecto significativo en los resultados.

La Tabla WIRES (Cables)

Hay tres ejes: X, Y y Z, y por convención se asigna como se indica en la siguiente tabla:

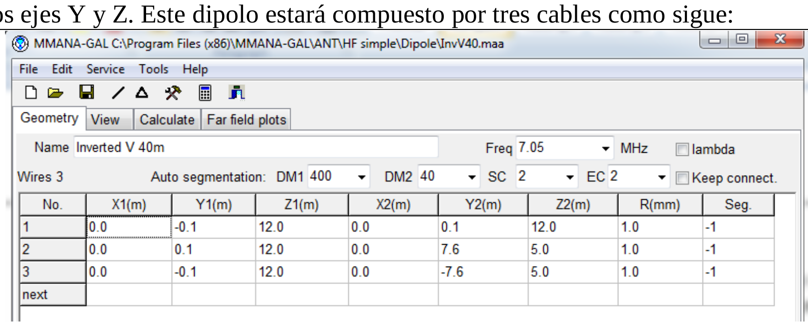
Eje	Vista
X	Profundidad en metros
Y	Ancho en metros
Z	Alto en metros

Ejemplo: Queremos modelar un dipolo en V invertida (archivo InvV40.maa). Un dipolo no tiene profundidad, solo alto y ancho: eje X será siempre cero, y tendremos valores solamente en los ejes Y y Z. Este dipolo estará compuesto por tres cables como sigue:

Cable No1: Segmento horizontal que une los brazos del dipolo. Mide 20 cm de largo, y está localizado horizontalmente a 12 metros de altura.
Y(1)=-0.1; un extremo a -0.1 metros del centro.
Y(2)=0.1; el otro extremo a +0.1 metros.
Z(1)=12; en Z un extremo a 12 m de altura
Z(2)=12; en Z el otro extremo a 12 m de altura

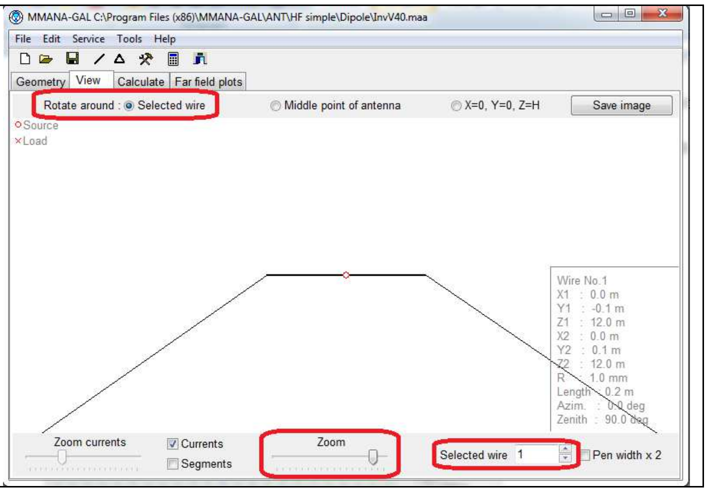
Cable No2: Brazo derecho del dipolo.
Y(1)=0.1 el extremo izquierdo
Y(2)=7.6; el otro extremo derecho
Z(1)=12; el extremo superior
Z(2)=5; el extremo inferior

Cable No3: Brazo izquierdo del dipolo.
Y(1)=-0.1 el extremo derecho
Y(2)=-7.6; el otro extremo izquierdo
Z(1)=12; el extremo superior
Z(2)=5; el extremo inferior



R(mm) Radio del elemento: En el caso del ejemplo, usamos un cable de 1mm de radio, es decir 2mm de diámetro.
Si R = 0, se aísla el elemento de los demás.
Si R<0, se modela un elemento cónico de dos o más elementos con diferentes radios.

Segmentación: El programa divide un elemento en segmentos y calcula el flujo de corriente de cada segmento. Esto es más importante cuando un elemento es curvo (por ejemplo, una antena loop).
Se recomienda el uso de Seg.=-1 (automático).

<table>
<tr>
<td>El gráfico anterior puede verse en "View", seleccionando el cable 1, haciendo zoom y rotando la imagen para obtener el ángulo deseado.</td>
<td>
</td>
</tr>
</table>

La Tabla SOURCES (Fuentes)

Indica donde se alimenta la antena (Feeding point), es decir donde se conectará la línea de alimentación (por ejemplo el coaxial).

En esta tabla hay que definir tres cosas:

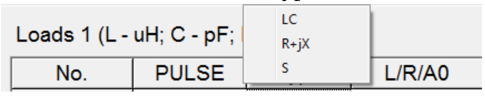
<table>
<tr>
<td>a) Pulso=Cuales cables y en qué posición del cable se encuentra una fuente.
Ejemplos:
W1C = Centro del cable 1 (ejemplo son los dipolos simples)
W3C2 = 2 puntos más allá del centro del cable 3
W2B = Al comienzo del cable 2
W5E3 = 3 puntos más allá del final del cable 5.</td>
<td>c) Volt.= Voltaje de la alimentación. El Voltaje sólo afecta la amplitud de la corriente en los gráficos (Pestaña View). Por defecto se usa 1.0
Sources 1<table><tr><th>No.</th><th>PULSE</th><th>Volt. V</th><th>Phase dg</th></tr><tr><td>1</td><td>w1c</td><td>1.0</td><td>0.0</td></tr><tr><td>next</td><td></td><td></td><td></td></tr></table></td>
<td>b) Phase deg = Fase de la alimentación, en grados.
Phase=0 para una antena con una sola fuente.
Para antenas enfasadas (phased) con más de una fuente de alimentación, debe indicarse la fase de cada fuente.</td>
</tr>
</table>

La Tabla LOADS (Cargas)

En esta tabla se pueden definir las cargas, es decir las bobinas y condensadores que se usarán para adaptar impedancias. En los dipolos simples, G5RV, Windom y similares no se usan cargas. Sin embargo sí se usan en el caso de los dipolos multibanda.

Loads 0 (L - uH; C - pF; R/jX - Ohm) ☑ Use loads

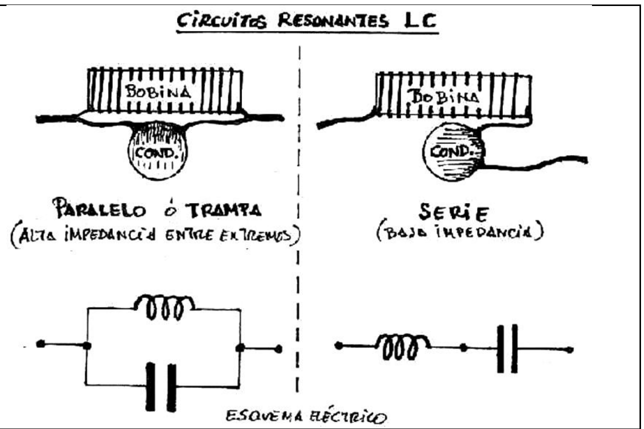
No.	PULSE	Type	L/R/A0	C/jX/B0	Q/A1	F/B1
next						

<u>Pulse: Pulsos con distribución constante (lumped-constant)</u>: Aquí se indica la posición donde se ubicará la carga. Se usa el mismo criterio que con las fuentes, es decir: W3C2, representa 2 puntos más allá del centro del cable 3. Si un cable con un pulso se conecta a otro cable, el pulso es asignado al final de ese punto de conexión. Si un cable tiene un cero en su eje Z (altura), se asigna el pulso en ese punto (típicamente en las antenas verticales).	**<u>Type:</u>** Se puede elegir tres alternativas de cargas: LC, R+jX y S. Las unidades de medida son: L(uH), C(pF), y Q es el factor de calidad. Con el botón izquierdo del mouse sobre la celda del elemento de la columna "Type" mostrará:  **<u>a) Carga LC</u>**: La carga más usada. La comentamos más abajo. **<u>b) Carga R+jX</u>**: Para resistencias puras, o con reactancia. Si se elige R+jX, las opciones son R(OHM), jX(OHM). **<u>c) Carga S</u>**: Para cargas complejas. Raramente usado.	**<u>Opciones</u>**: Las columnas siguientes a la derecha indican las opciones: L/R/A0: Con LC, la opción es L. Con R+jX, la opción es R Con S, la opción es A0 C/jX/B0: Con LC, la opción es C. Con R+jX, la opción es jX Con S, la opción es B0 Q/A1: Con LC, la opción es Q. Con R+jX, la opción es A1 F/B1: Con LC, la opción es F. Con R+jX, la opción es B1

<u>Cargas LC</u>: Circuito LC o circuito resonante es un circuito formado por una bobina L y un condensador eléctrico C. En el circuito LC hay una frecuencia de resonancia, para la cual la reactancia inductiva (parte imaginaria de la impedancia de la bobina) es igual a la reactancia capacitiva (parte imaginaria de la impedancia del condensador) (X_C = X_L), y la impedancia será igual a la resistencia real.

La frecuencia de resonancia es: $f_0 = \frac{\omega_0}{2\pi} = \frac{1}{2\pi\sqrt{LC}}$

Según como se disponga una bobina o un capacitor se tendrá como resultado un circuito que trabajará de un modo muy diferente:

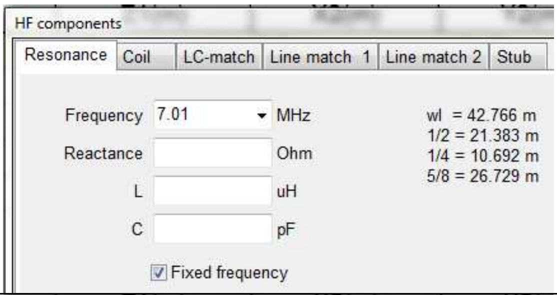
En el caso de un circuito en paralelo, la impedancia total del circuito es la diferencia entre la reactancia del condensador (X_L) y la reactancia de la bobina (X_C), es decir $X_{total} = X_L - X_C$. En cambio en el caso del circuito en serie, la impedancia total del circuito es el siguiente ratio: $X_{total} = \frac{-X_L \times X_C}{X_L - X_C}$. Para una explicación detallada del origen de estas fórmulas, véase páginas 4.39 y 4.40 del ARRL Handbook 2009.	

- Q/A1: Por defecto Q=0. Un Q alto normalmente indica una situación de baja pérdida de C o L. Para trabajar eficientemente, una trampa debe tener un alto Q, pero un alto Q tendrá un ancho de banda estrecho para la antena.

Ejemplo: La antena T2FD.maa con sólo una resistencia pura de 650 ohms.

Loads 1 (L - uH; C - pF; R/jX - Ohm) ☑ Use loads

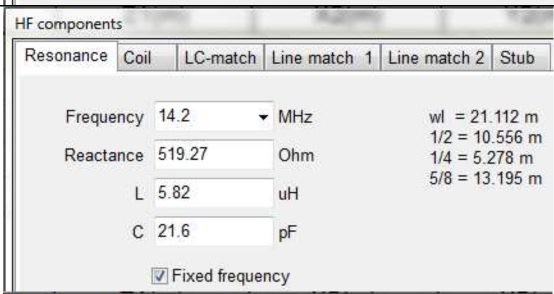
No.	PULSE	Type	L/R/A0	C/jX/B0	Q/A1	F/B1
1	w3c	R+jX	650	0		
next						

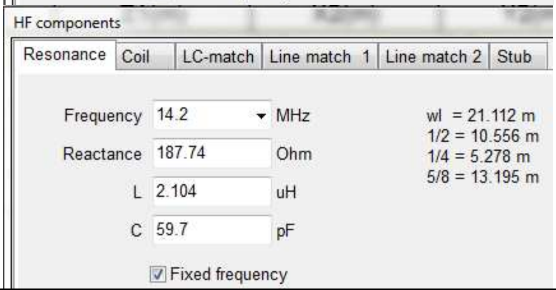


Ejemplo, La antena vertical 7-14LC1.maa:
- Para definir una bobina, especifique L, y C=(0).
- Para definir un capacitor, especifique C, y L=(0)
- Si L=0 ó C=0 se detiene la resonancia automática.

Loads 2 (L - uH; C - pF; R/jX - Ohm) ☑ Use loads

No.	PULSE	Type	L/R/A0	C/jX/B0	Q/A1
1	w1b	LC	5.82	0	300.0
2	w1b	LC	0	59.7	0.0
next					

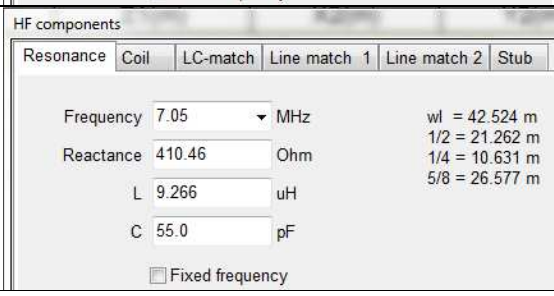




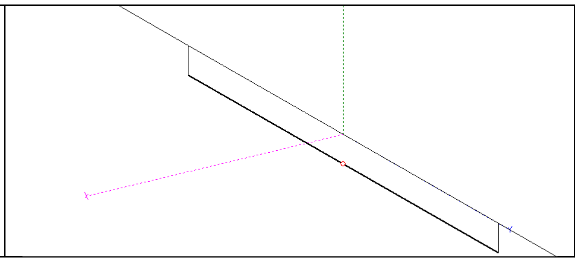
Ejemplo: El dipolo rígido con trampas W3DZZm.maa:
- Para crear una trampa paralela sintonizada, ingresar valores en L y C, y se calculará automáticamente el faltante entre f (Frequency), L o C.

Loads 2 (L - uH; C - pF; R/jX - Ohm) ☑ Use loads

No.	PULSE	Type	L/R/A0	C/jX/B0	Q/A1	F/B1
1	w2b	LC	9.266	55	300.0	7.05
2	w3b	LC	9.266	55	300.0	7.05
next						

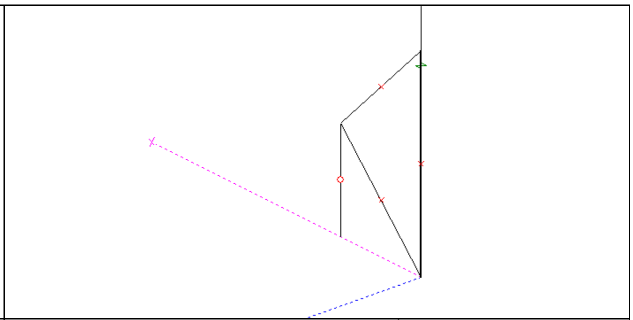


No todos los tipos de sistemas de adaptación requieren definir componentes en la tabla anterior.
Por ejemplo para una antena Yagi-Uda (T-match Yagi.maa), el T-match en el elemento excitado se puede definir combinando cables, como se muestra en este gráfico:

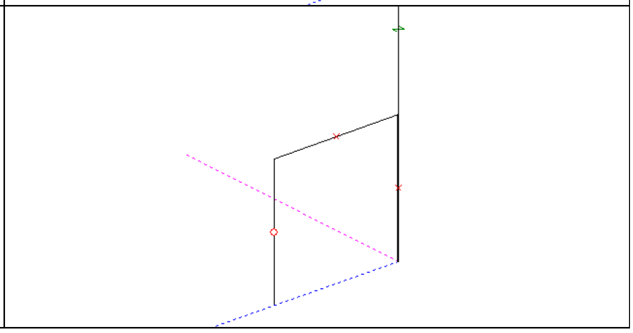


Ejemplo: Vert0.6L+ LC.maa
También es interesante ver que una antena vertical con dos bobinas y un condensador en la base de la antena, y puede ser definida como se muestra a la derecha.

La antena es compuesta por 5 cables. Uno es el irradiante propiamente tal, en dos cables van las bobinas, en otro va el condensador, y en el último cable va la alimentación de la antena.



Ejemplo: VERT58.MAA
En el caso de las antenas verticales de 5/8, el sistema de adaptación más usado es con una bobina y un condensador en la base de la antena. En el ejemplo se definen 4 cables, el irradiante, uno para el condensador, otro para la bobina y el último para la alimentación.



PESTAÑA 2: ANTENNA VIEW

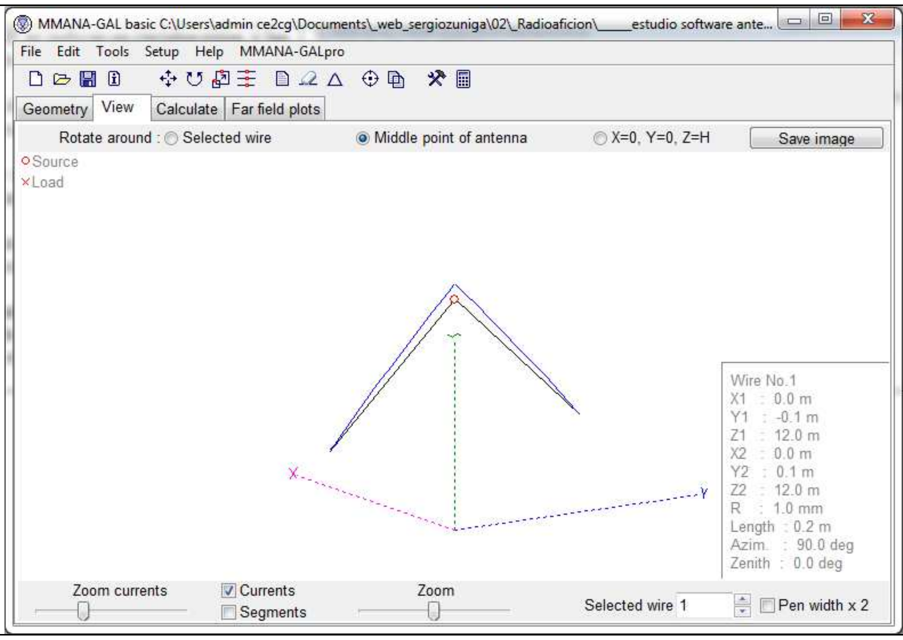
Las fuentes de RF se indican en círculos rojos (o), y las cargas, si las hubiera, en cruces rojas (x).

La distribución de la corriente se calcula y se superpone a la imagen.

Las corrientes verticales se muestran en rojo y las horizontales en azul.

Es necesario para llevar a cabo al menos un cálculo (Calculate) para mostrar las corrientes.

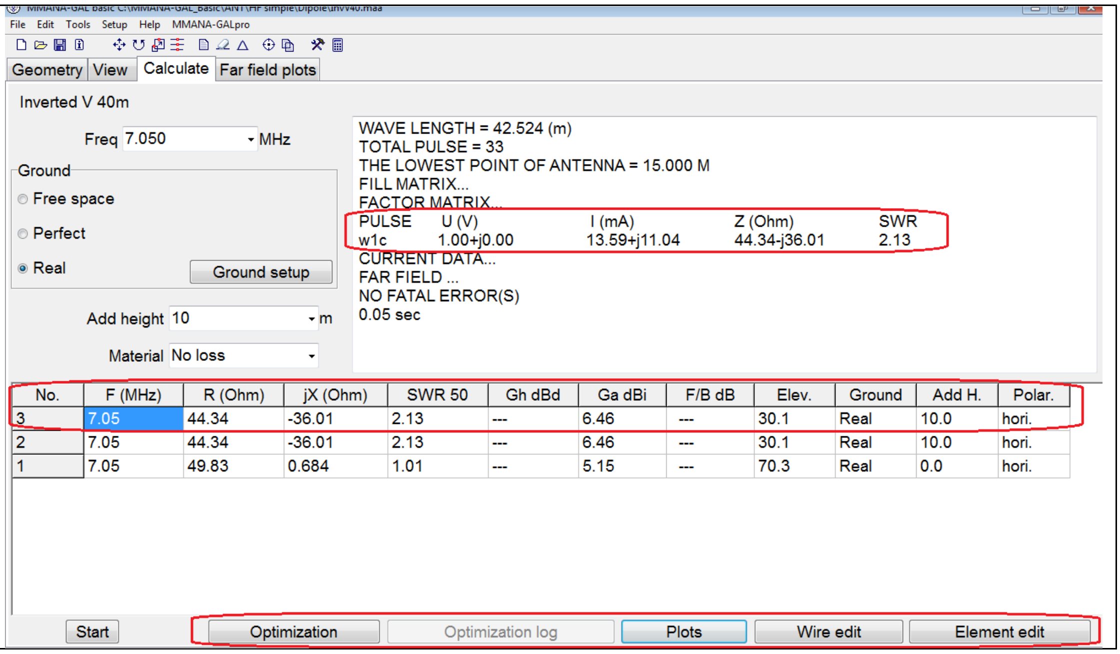
Es útil esta pestaña para verificar de un modo rápido el largo de los elementos de la antena, en "Selected wire" eligiendo el elemento que se desea verificar.



PESTAÑA 3: CALCULATE

Para una frecuencia determinada, un tipo de terreno, y una altura sobre el suelo, el programa entrega el cálculo de la impedancia (Z), y del ROE (SWR) en primer lugar. Luego entrega las ganancias en Db, ganancia F/B, elevación y polarización.

- En primer hay que definir la frecuencia en que se desea hacer la simulación.



Ground (Tipo de Terreno)

La antena puede ser ubicada flotando en el espacio infinito (Free Space), en una tierra perfecta, o en una tierra real. Con tierra real hay varias opciones (Ground Setup): Por defecto, el programa usa Dielect: 13.0 y Conduct (mS/m): 5.0.

Terreno	Constante dielectrica (k)	Conductividad (mS/m, Siemens por metro)
Agua de mar	81	4000
Agua pura	80	Nd
Terreno húmedo	5-15	1-10
Bosque seco (promedio)	13	5
Terreno arenoso	12	2
Terreno árido	2-6	0.1
Vacío o aire seco	1	Nd

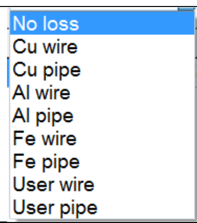
Height (Altura)

La altura final del extremo de un cable por sobre el terreno es la suma de su coordenada Z en la pestaña GEOMETRY, y la altura agregada en la pestaña "CALCULATE". Si se quiere conectar un extremo de un cable a la tierra, entonces la suma de su coordenada Z en GEOMETRY, más la altura agregada en CALCULATE debe ser cero.

Si la antena es horizontal, es recomendable localizar el centro de la antena en Z=0. La altura de la antena por sobre el terreno se controla después en la ventana CALCULATE.

Si la antena es vertical ubicada a nivel del suelo, es recomendable ubicar la fuente en Z=0, y hay que asegurase que en Ground de CALCULATE la altura también sea cero.

Material: Existen varias opciones de material para construir la antena, los tienen diferentes grados de pérdida. Pueden ser cables (wire) o tubos (pipe).



Optimizacion

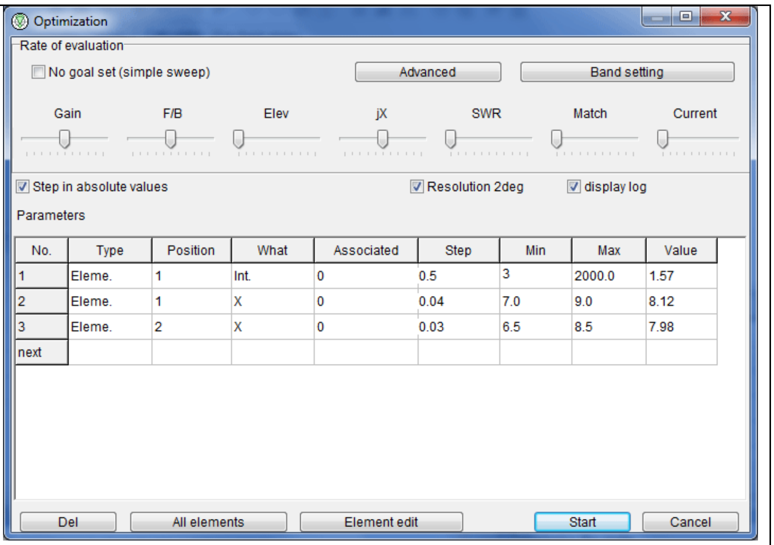
Existen varias cosas que se pueden optimizar, aunque generalmente mejorar una implica perjudicar las demás. Las opciones son:

- Minimize the jX (get the antenna resonant)
- Minimize the SWR
- Maximize the gain
- Maximize the F/B ration
- Minimize the elevation of the beam
- Matching circuit
- Maximize or minimize the current

Al mover la barra deslizante hacia la derecha ese objetivo es priorizado.

Elegir varios elementos es útil cuando se trabaja con antenas multibanda.

El hairpin match es -jX (capacitivo)
El capacitivo match es + jX (inductivo).



La optimización es un aspecto muy interesante del programa, pero requiere de un tratamiento aparte, que se posterga para ser analizada más adelante.

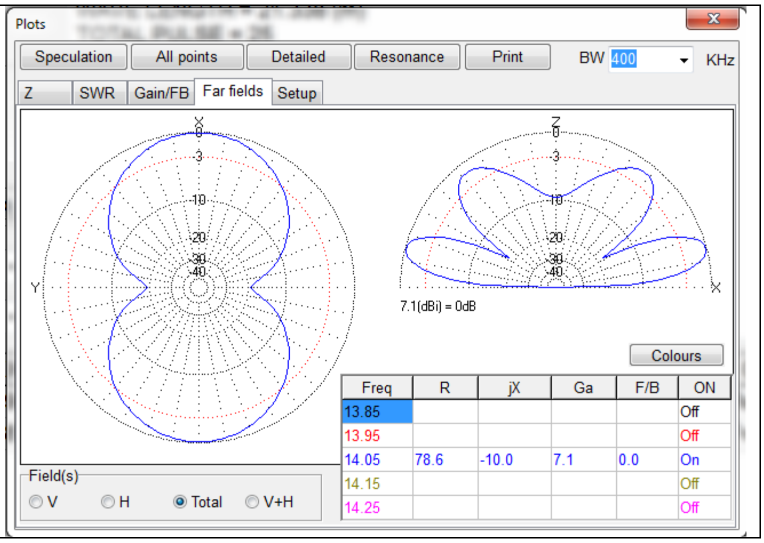
Plots

En esta pestaña se pueden ver los gráficos de campo lejano.

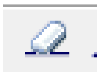
Tambien se pueden hacer una serie de acciones de optimización o mejoramiento de la antena:

a) Para ver la Resonancia: SWR-->Resonance

b) Para comparar, superponiendo dos gráficos de campo lejano, se puede grabar un gráfico inicial en:
File-->Save Far fields plots-->ingresar nombre.mab
Luego optimizar la antena, generando una nueva.
Entonces, en Tools--> compare-->Load *.mab file.



Wire edit

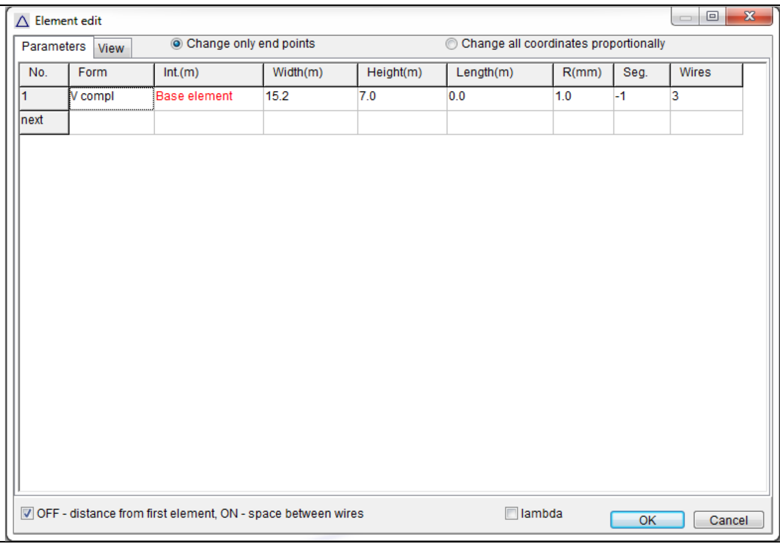
Es equivalente al ícono:  del menú. Esto se analizó previamente.

Element edit

Es equivalente al icono  del menú.

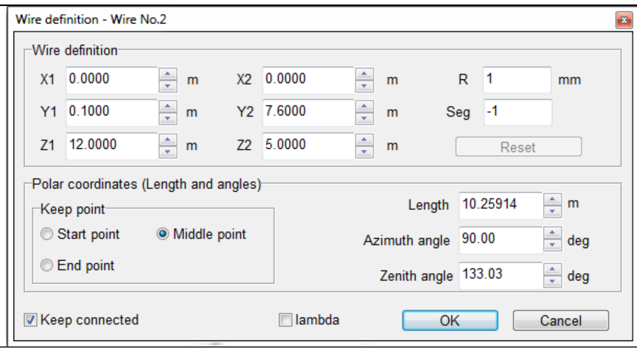
Esta es la mejor forma de definir antenas complejas, ya que definir antenas en la pestaña GEOMETRY es un poco engorroso.

Sin embargo, es más simple crear dipolos horizontales y V invertidas en el menú "Wire Edit".



Para editar elementos, también es útil la herramienta "Wire Edit".

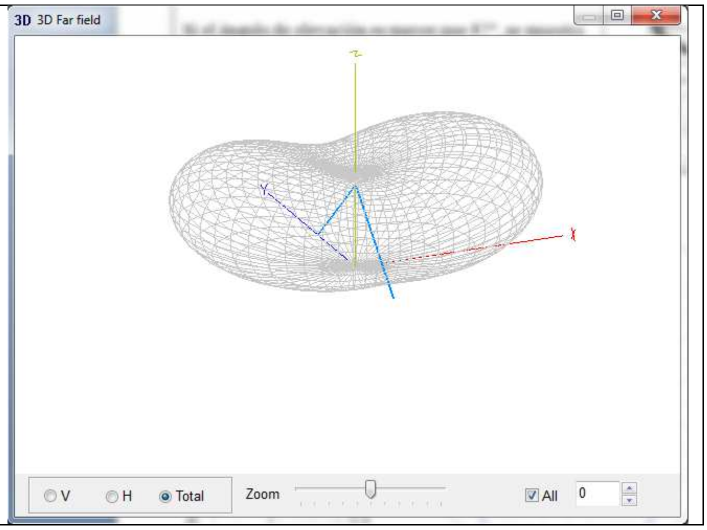
Para esto, en VIEW seleccionar con el mouse el cable a editar, y hacer doble click.



PESTAÑA 4: FAR FIELDS PLOTS

La energía irradiada por una antena en función de la dirección se puede apreciar en los gráficos de campos lejanos. Existen varias formas de observar el patrón de radiación de una antena, pero nos interesan dos:
- El patrón horizontal, haciendo un corte horizontal, y observando desde arriba.
- El patrón vertical, haciendo un corte vertical, y observando lateralmente.

El gráfico de la derecha se ha obtenido para un dipolo (InvV40.maa), en "Far Field Plots" y allí en "3D FF".



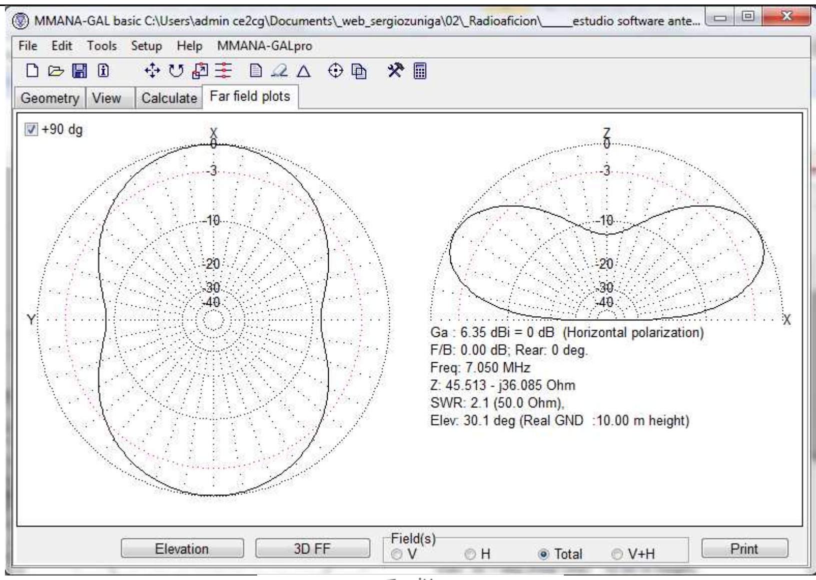
Haciendo los cortes horizontal y vertical se obtienen los siguientes dos gráficos:

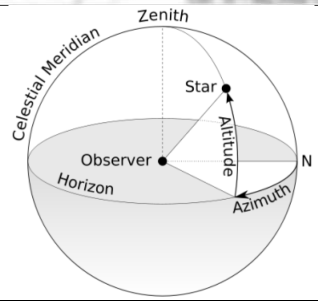
- Ga ganancia absoluta, es decir respecto a un radiador isotrópico (en dBi).
- Gh ganancia respecto aun dipolo: dBd = 2.15dBi. Gh se muestra sólo cuando se elije Free Space.
En el ejemplo, la máxima ganancia es de 6,35dBi, y ocurre a la elevación de 30,1 grados.

F/B= es la relación de ganancia, en dB, que compara front-to-back la dirección (azimuth) de maxima ganancia, respecto de la ganancia en dirección 180°.

Por ejemplo, si Ga=16.0dBi. Si en 180 grados Ga=-3.5dBi, entonces
F/B=16.0-(-3.5)=19.5dB.

Elev=Es el ángulo de elevación al cual se obtiene la máxima ganancia. Si el ángulo de elevación es mayor que 87°, el patrón horizontal se muestra a 45° de elevación.





Nota: En antenas para 1.2 GHz o frecuencias superiores la resolución de Mmana-gal puede no ser suficiente para mostrar los gráficos con la precisión deseada.

CAPITULO 5. ADAPTACION DE IMPEDANCIAS

MMANA-GAL ofrece excelentes ayudas para diseñar componentes y sistemas de adaptación de impedancia de una antena.

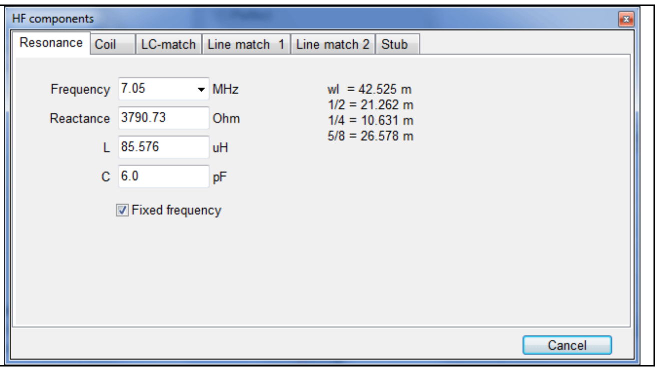
Se pueden encontrar en Menu-->Tools-->HF Components, o también directamente en el icono 

Pestaña: Resonance

En la frecuencia de resonancia existe una relación entre L(uH) y C(pF). La fórmula es:

$$f = \frac{1}{2\cdot\pi\cdot\sqrt{L\cdot C}}$$

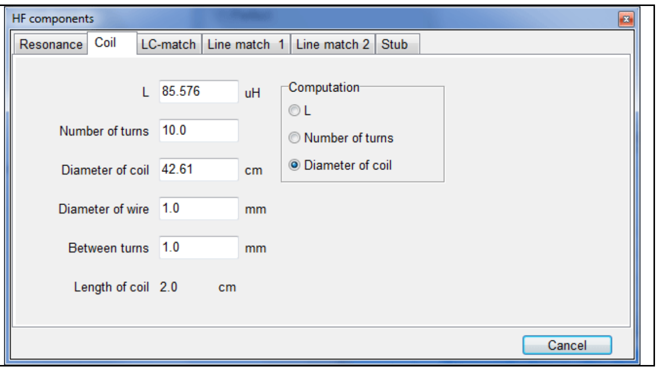
Por ejemplo, para L=28; C=18, la Frecuencia (HZ)=7,089Mhz (40 mts). El programa indica que la reactancia es 1247,22Ohms.



Pestaña: Diseñar una bobina (Coil Inductor)

El programa hace los cálculos para construir una bobina de una sola capa, con una determinada inductancia (la de resonancia).

Si las dimensiones resultantes no son apropiadas, por ejemplo si el diámetro del alambre es muy delgado para la potencia de trabajo, el programa permite fijar el parámetro y recalcular los restantes.

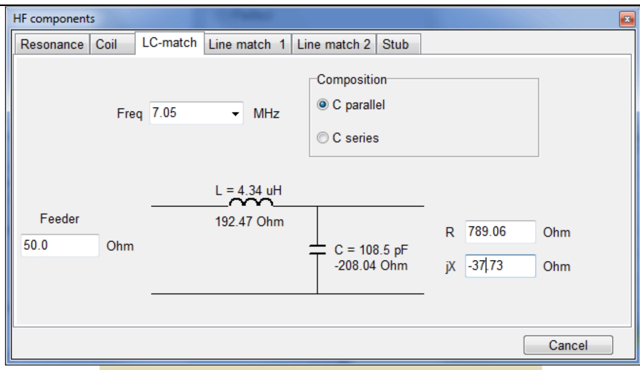


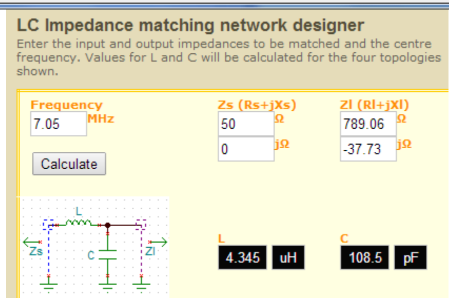
Pestaña: Adaptación LC (LC matching network)

Se usa frecuentemente para adaptar antenas cortas de cable, y por los sintonizadores de antenas automáticos, haciendo combinar L & C para que la ROE sea mínima.

Para maximizar eficiencia (en dB) L debe ser bajo comparado con C.

Ejemplo: Una antena móvil HF para 40 mts instalada arroja una impedancia de Z=789,06-37,73j (reactancia capacitiva). Para adaptar a 50 Ohms, se requiere un condensador de 108,5pF en paralelo a una bobina de 4,34mH.



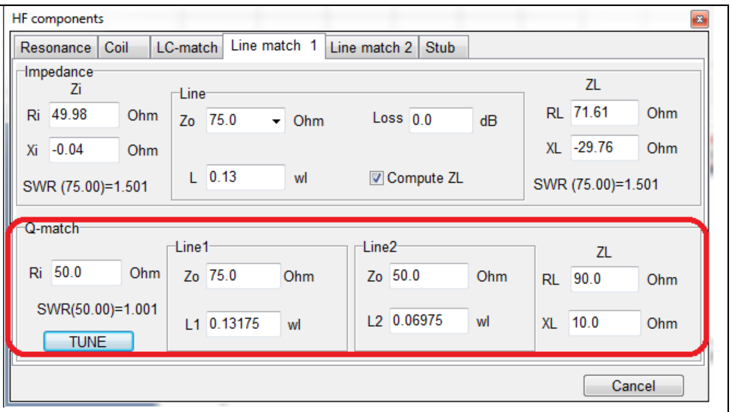


Line match 1: series-section transformers

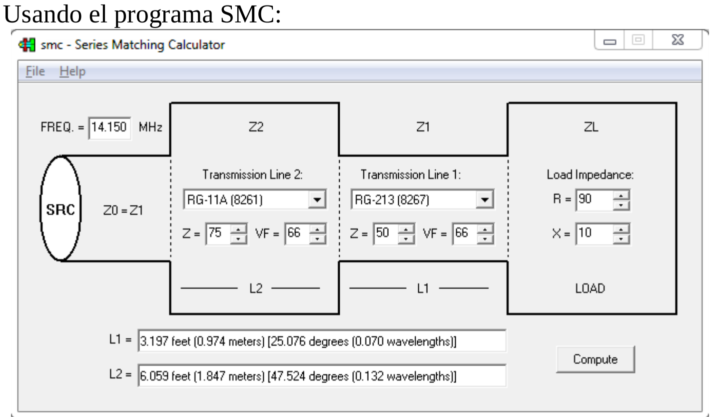
La ventana del programa aquí tiene dos partes distintas:
a) En la parte superior calcula la impedancia en la entrada de la línea (Impedance).
Ejemplo: Se tiene un equipo de radio que trabaja con 75 ohms. La antena medida directamente en su entrada tiene una impedancia de ZL=109-17.88j, de modo que ROE(75ohms)=1.525. Se tiene una línea de transmisión perfecta (Loss=0.0dB) de Zo=70 ohms, y con un largo de 0.22 veces el largo de onda (79,2°). Entonces la impedancia de entrada hacia el equipo de radio será de Z=49.2-0.16j, con una ROE(75ohms)=1.525

b) En la parte inferior calcula el largo de dos segmentos de adaptación (Q-match).
Ejemplo: Se tiene un equipo de radio que trabaja con 50 ohms. La antena tiene una impedancia ZL=90+10j.
Para lograr un ajuste a 50 ohms se requieren dos segmentos en línea:
Segm. 1: 50 ohms, y largo 0.070λ (en 14.150Mhz, 0,97m app)
Segm. 2: 75 ohms, y largo 0.132λ (en 14.150Mhz, 1,85m app)

La velocidad afecta el largo final (en metros) de los cables, pero no su largo en grados o número de longitudes de onda.



Usando el programa SMC:

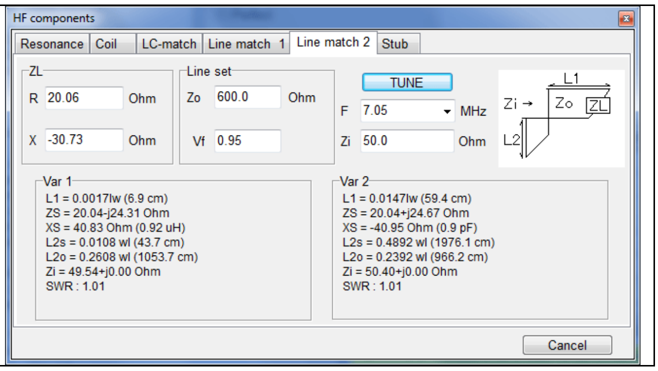


Line match 2

Se trata de un stub corteado y un open-stub conectado en paralelo al punto de alimentación para adaptar Zi.

El programa asume una línea de transmisión sin pérdidas.

Se ofrecen a lo más 2 soluciones, aunque puede no encontrarse una solución.
- L1 – Distancia desde la carga al stub.
- ZS – Impedancia del stub.
- XS – Reactancia del Stub.
- L2s – Largo del Stub (short)
- L2o – Largo del Stub (open).

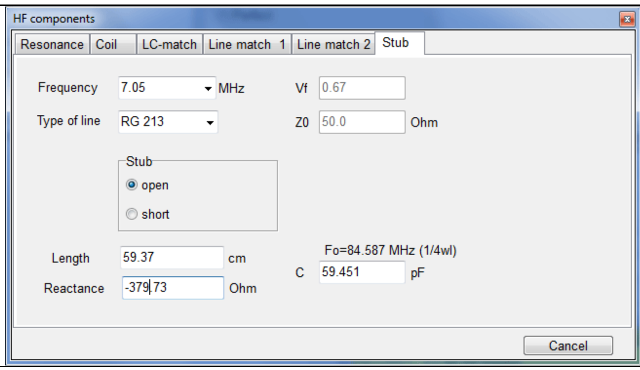


Stub (cabo) Match

Un stub shorted se comporta como un inductor.
Un stub open-end se comporta como un capacitor.

El ejemplo muestra la linea de RG-213 mostrando Vf=0.67, y una impedancia característica Z0=50 Ohms.

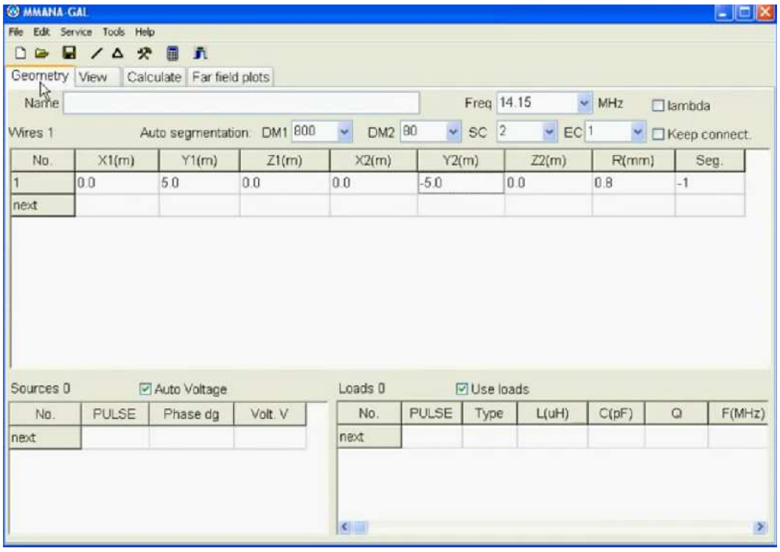
En el ejemplo 59.37cm es 1/4 de onda en 84.587MHz.

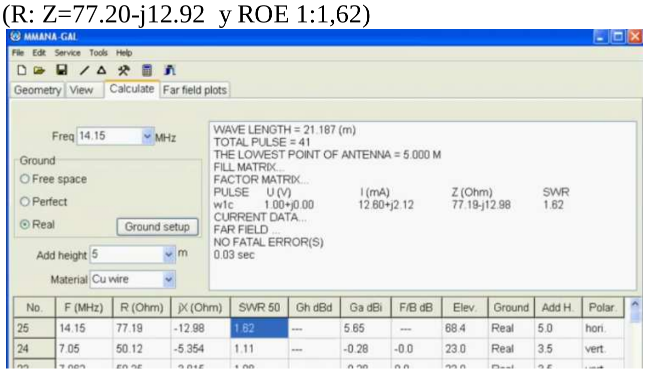
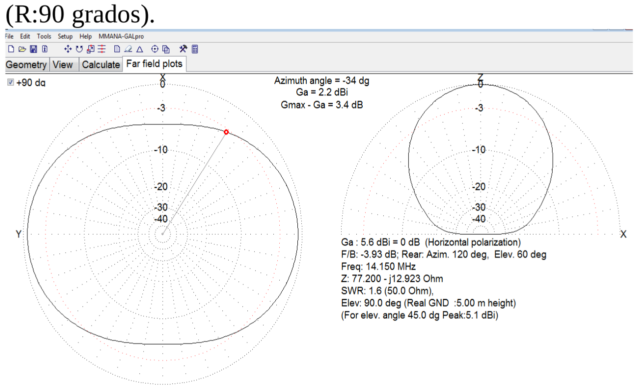


CAPITULO 6. EJEMPLOS

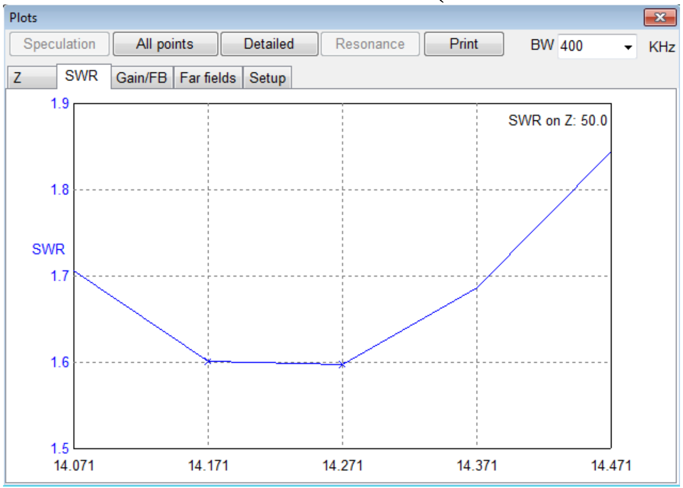
Ejemplo 1

1.- Crear un dipolo extendido para 20 metros, de 10 metros de largo total, con cable de cobre 0,8mm de radio, a 5 metros de altura de una tierra real.



2.- Calcular la impedancia y ROE en la frecuencia de 15.150Mhz (R: Z=77.20-j12.92 y ROE 1:1,62)	3.- Analice los gráficos de campo de esta antena, y su elevación (R:90 grados).
	

4.- Encontrar su frecuencia de resonancia (Plots--> SWR-->Resonance).



5.- Grabe esta antena en un archivo con nombre x.mab (File-->Far fields plots-->ingresar nombre).

6.-¿Cómo cambia el desempeño de la antena si la altura de la misma es de 10 metros? Para responder esto, compare los gráficos de campo de esta antena en ambas alturas. (Tools--> compare-->Load *.mab file).