ZM-30 Digital Antenna Analyzer

Owner's Manual

Firmware Level: Version 6.0

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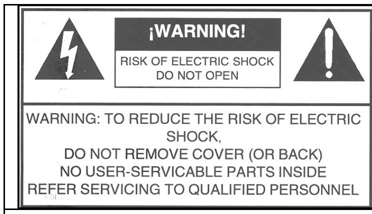
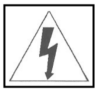
Important Safeguards



WARNING: TO PREVENT FIRE OR ELECTRICAL SHOCK DO NOT EXPOSE TO RAIN OR MOISTURE

An appliance and cart combination should be moved with care. Quick stops, excessive force and uneven surfaces may cause the appliance and cart combination to overturn.



The lightning flash with arrow head symbol, within an equilateral triangle, is intended to alert the user to the presence of uninsulated "dangerous voltage" within the product's enclosure that may be of sufficient magnitude to constitute a risk of electric shock to persons.

The exclamation point within an equilateral triangle is intended to alert the user to the presence of important operating and maintenance (servicing) instructions in the literature accompanying the appliance.

1. Read Instructions—All the safety and operating instructions should be read before the appliance is operated.

2. Retain Instructions—The safety and operating instructions should be retained for future reference.

3. Heed Warnings—All warnings on the appliance should be adhered to.

4. Follow Instructions—All operating and use instructions should be followed.

5. Cleaning—Unplug this appliance from the wall outlet before cleaning. Do not use liquid cleaners or aerosol cleaners. Use a damp cloth for cleaning.

6. Do Not Use Attachments—Do not use attachments not recommended by the manufacturer as they may cause hazards.

7. Water and Moisture—Do not use this product near water—for example, near a bathtub, wash bowl, kitchen sink, laundry tub, in a wet basement, or near a swimming pool—and the like.

8. Accessories—Do not place this product on an unstable cart, stand, tripod, bracket, or table. The product may fall, causing serious injury to a child or adult, and serious damage to the appliance.

9. Ventilation—This product should never be placed near or over a radiator or heat register. This product should not be placed in a built-in installation such as a bookcase or rack unless proper ventilation is provided or the manufacturer's instructions have been adhered to. Any slots or openings in the cabinet are provided for ventilation. To ensure reliable operation of the video product and to protect it from overheating, these openings must not be blocked or covered. The openings should never be blocked by placing the product on a bed, sofa, rug, or other similar surface.

10. Grounding or Polarization—this product is equipped with a 3-wire line cord receptacle. It is intended for use with a 3-wire properly grounded power socket. Do not defeat the safety purpose of the supplied line cord and plug.

11. Power Sources—This product should be operated only from the type of power source indicated on the marketing label. If you are not sure of the type of power supplied to your home, consult your appliance dealer or local power company.

12. Power-cord Protection—Power-supply cords should be routed so they are not likely to be walked on or pinched by items placed upon or against them. Pay particular attention to cords at plugs, convenience receptacles, and the point where they exit.

13. Lightning—For added protection for this product during a lightning storm, or when it is left unattended and unused for long periods of time, unplug it from the wall outlet.

14. Power Lines—An outside antenna system should not be located in the vicinity of overhead power lines, other electric light or power circuits, where it can fall into such power lines or circuits. When installing an outside antenna system, extreme care should be taken to keep from touching such power lines or circuits as contact with them may be fatal.

15. Overloading—Do not overload wall outlets and extension cords as this can result in a risk of fire or electric shock.

16. Object and Liquid Entry—Never push objects of any kind into this product through openings as they may touch dangerous voltage points or short-out parts that could result in a fire or electric shock. Never spill liquid of any kind on the product.

17. Servicing—Do not attempt to service this product yourself as opening or removing covers may expose you to dangerous voltage or other hazards. Refer all servicing to qualified service personnel.

18. Damage Requiring Service—Unplug this product from the wall outlet and refer servicing to qualified service personnel under the following conditions:

a. When the power-supply cord or plug is damaged.

b. If liquid has been spilled, or objects have fallen into the product.

c. If the product has been exposed to rain or water.

d. If the product does not operate normally by following the operating instructions. Adjust only those controls that are covered by the operating instructions. An improper adjustment may result in damage and will often require extensive work by a qualified technician to restore the product to its normal operation.

e. If the product has been dropped or the cabinet has been damaged.

f. When the product exhibits a distinct change in performance—this indicates a need for service.

19. Replacement Parts—when replacement parts are required, be sure the service technician has used replacement parts specified by the manufacturer or have the same characteristics as the original parts. Unauthorized substitutes may result in fire, electric shock or other hazards.

20. Safety Checks—Upon completion of any service or repairs to this product, ask the service technician to perform safety checks to determine that the product is in proper operating condition.

21. Outdoor Antenna Grounding—Before attempting to install this product, be sure the antenna or cable system is grounded so as to provide some protection against voltage surges and built-up static charges.

a. Use No.10 AWG copper, No.8AWG aluminum, No.17AWB copper-clad steel or bronze wire or larger, as ground wire.

b. Secure antenna lead-in and ground wires to house with stand-off insulators spaced from 4 feet to 6 feet apart.

c. Mount antenna discharge unit as close as possible to where lead-in enters house.

d. A driven rod may be used as the grounding electrode where other types of electrode systems do not exist. Refer to the National Electric Code, ANSI/NFPA 70-1990 for information.

e. Use jumper wire not smaller than No.6 AWG copper or equivalent, when a separate antenna grounding electrode is used.

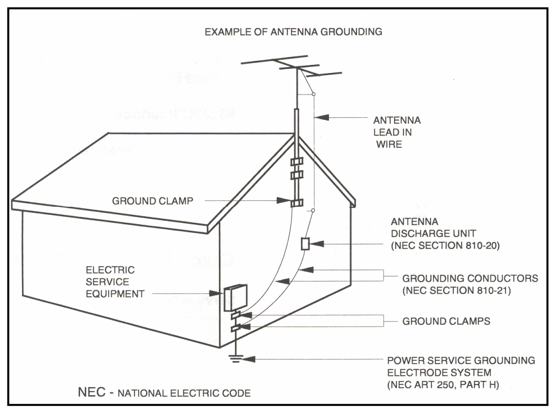


Table of Contents

Thank you for purchasing a Palstar ZM-30 Antenna Analyzer. This antenna analyzer has been designed and manufactured to high quality standards, and will provide reliable operation for many years.

Please carefully read the Owner's Manual in order to take advantage of the many interesting features that will provide years of enjoyable amateur radio operation.

General Description

The ZM-30 “Digital Antenna Z Bridge” is a quality measurement instrument that determines antenna system performance across the amateur bands through use of automatically collected SWR and complex impedance readings. It was designed to be easily operated on the bench as well as in-hand while portable. The analyzer is comprised of a single printed circuit board containing all components, connectors, controls and a 2 row by 16 character liquid crystal display (LCD). The enclosure holds an 8-cell AA battery back enabling convenient field use.

The antenna analyzer utilizes a powerful 8-bit microcontroller to instruct a Direct Digital Synthesis (DDS) integrated circuit to generate RF signals from 1 MHz to 30 MHz. The DDS generates extremely precise and accurate signals that give the ZM-30 the ability to also serve as a stable RF signal source for testing and basic network analysis. The low-current 68HC908AB32 microcontroller also handles the user interface of an LCD, pushbuttons and rotary encoder to allow full control of the instrument. The “field-programmable” feature allows the user to download new or updated software from the ZM-30 website and load it into the antenna analyzer.

A very low power transmitter is automatically swept across selected frequencies by a microcontroller. The transmitter's signal is delivered to the antenna system through a reflectometer consisting of an absorptive SWR bridge using diode detectors and compensated buffer amplifiers. The data provided by the reflectometer are digitized and used by the microcontroller to compute SWR and impedance values for each frequency sampled. The microcontroller retains the frequency and corresponding results throughout the measurement period, and at the end of the scan the microcontroller statically displays the SWR and impedance at the resonant frequencies.

Thus, with a press of a button the antenna analyzer is able to quickly and automatically determine the frequencies for which the antenna system is best matched, and display the associated complex impedance values at those frequencies.

Manual operation allows the user to control the frequency of operation while selecting among four operational modes: Impedance, Inductance, Capacitance and VFO. Impedance is the most common-used mode, useful in measuring antenna performance in terms of SWR, Resistance and Reactance. Inductance mode allows measurement of inductors within the reactance range of the instrument, as does Capacitance mode provide for measuring capacitors. The VFO mode allows the ZM-30 to serve as a precise and stable frequency source, useful for troubleshooting RF equipment or serving as an outboard local oscillator. An audio tone may be configured to sound relative to the magnitude of the SWR, providing for eyes-free operation of the instrument when needed.

The ZM-30 is designed to be field-usable and operator friendly. The handheld instrument can be battery operated and the enclosure conveniently holds eight AA cells, facilitating convenient operation while away from the bench. The RF connector is located at the top of the instrument to provide easy connection to the antenna system being measured. The jacks for external power and serial port connection to the PC are all located at the top end of the instrument, and the power pushbutton is located on the front panel.

A convenient and power control feature prolongs battery life by automatically powering the unit down after a user-settable period of inactivity. Similarly, the LCD backlight automatically turns off after a preset time interval in order to conserve battery life.

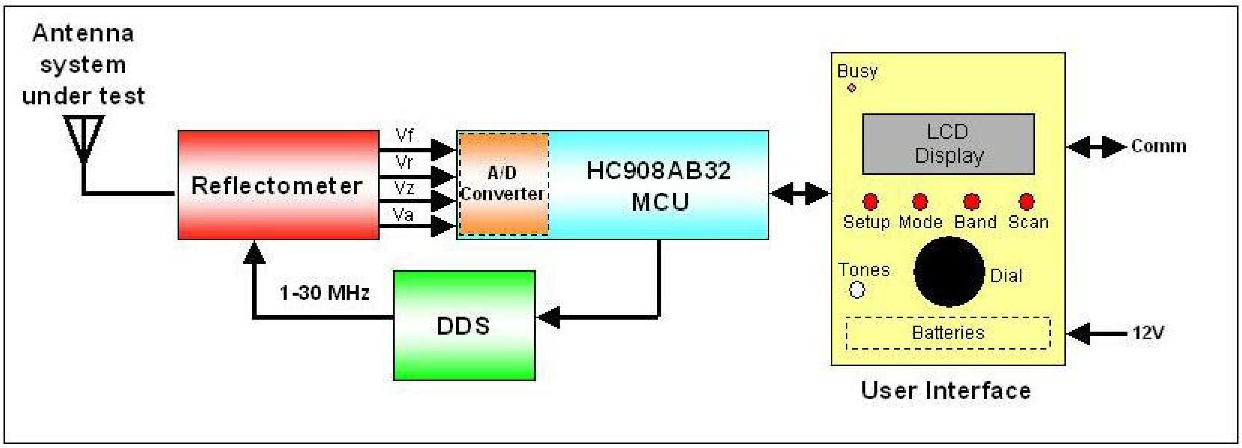


Figure 1 – Block Diagram of the ZM30 Digital Antenna Z Bridge

Features

- Manual and automated antenna analysis based on SWR and complex impedance measurements
- Operating modes provide for measurement of network impedance, and components (inductors and capacitors)
- VFO operating mode provides RF signal source at output, serving as VFO and test signal
- Powerful 8-bit microcontroller controls all aspects of the operation
- High-precision, low power DDS signal generator is used as rock-solid signal source
- Internal reflectometer measures forward, reflected and impedance signals
- Automatic scanning results displayed as frequencies with lowest SWR
- Configurable frequency scanning limits and step sizes
- Manual control option displays SWR and complex impedance at selected frequencies
- Audible tone indicates resonance – lower tone indicates lower SWR (May be enabled/disabled.)
- Serial port connects to PC for field-upgradable software
- Battery-operated for convenient field use, or can use external 9-16V for bench operation
- Other uses of the ZM30:
  - Measure antenna bandwidth
  - Measure feedpoint impedance
  - Measure ground loss
  - Measure coaxial cable Loss
  - Adjust antenna tuners and determine loss
  - Measure coax transmission line (SWR, length, velocity factor, approximate Q and loss, resonant frequency, and impedance)
  - Measure and determine optimum settings for tuning stubs: SWR, approximate Q, resonant frequency, bandwidth, impedance
  - Determine characteristic impedance of transmission line.
  - Determine length of ¼ and ½ wave phasing lines.
  - Measure inductor Q
  - Measure magnetic loop resonance and SWR.

Connections and Controls

FRONT PANEL

BUSY Light
Turns on when scanning and when saving user settings.

SETUP
Provides menu of user-configurable settings and functions:
- Custom Scan settings
- Audio tone
- Software Load
- Calibrate
- Debug Mode
- Power-Off time
- Backlight control
- View Settings

MODE
User can change the ZM-30 to any of the 4 available operating modes:
- Impedance (default)
- Capacitance
- Inductance
- VFO

LCD Display
2 lines x 16 characters

SCAN
Pressing this control initiates a scan of the frequencies selected in the BAND function. Scan exits to Impedance mode showing the resonant point in the antenna system.

BAND
User can select one of 14 pre-set bands, or enter specific parameters for a custom-set band to use for the scan operation:
- 1-10 MHz
- 10-20 MHz
- 20-30 MHz
- 1-30 MHz
- 160m
- 80m
- 60m
- 40m
- 30m
- 20m
- 18m
- 15m
- 12m
- 10m
- Custom Band

Audible Tones
When enabled, tones indicate value of SWR.

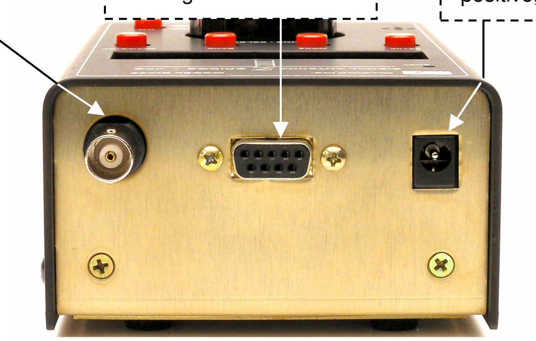
Dial
Main part of user interface, used to select menu items and frequency settings.

Power Control
Push-hold to turn unit on or off.

RF Output Jack
BNC

RS-232 Serial Port
Connect to PC when loading new software.

External Power Jack
2.1mm jack, center positive, 9-16V DC



TOP END VIEW

1) Power Control

The ZM-30 utilizes a unique power circuit that is controlled by the momentary contact On/Off pushbutton located on the front panel. Power is turned on to the unit by pressing-and-holding the On/Off pushbutton until the version of software is displayed, and then the pushbutton can be released. Turning off the ZM-30 is equally simple – just press-and-hold the On/Off pushbutton until "Stopped" is displayed on the LCD. This press-and-hold feature for power control prevents the unit from inadvertently being turned on or off by bumping the pushbutton during use or while in transit.

Press-Hold the On/Off button – To turn the instrument on, the On/Off button must be pressed and held for a short period of time during which the unit sequences through two displays before automatically entering the Impedance more.

The first information that appears on the LCD indicates the approximate battery (or supply) voltage, and it is displayed for about ½ second. This is a useful feature that indicates the relative state of the instrument's power source.

Battery: 9.04V

The next information that is automatically displayed is the version number of the software loaded in the instrument:

ZM-30 v6.0

Release the On/Off pushbutton – Upon release of the On/Off pushbutton, the instrument enters the Impedance mode, which is the most common use of the analyzer, indicating a screen such as that shown below. The initial frequency that is generated and displayed is 10.00000 MHz; and with no antenna or load connected to the RF output jack, the open circuit SWR and impedance will likely indicate as shown below. (See "Impedance Mode" for detailed description of this display and mode operation.)

SWR 10,000.00
>10 Z>1K

2) User Interface Pushbuttons

The user interface consists of four pushbuttons, one for each instrument function as described in the next section, and a rotary dial that is used to select various options presented in a menu-like manner. You use the function pushbuttons and the dial to operate the ZM-30 – just press a function button and rotate the dial and the various menu options for that function are sequentially displayed on the LCD. Once you have dialed up the desired option or operation on the LCD, you may select it by pressing the dial pushbutton.

At any time during the instrument's operation, you have the option of pressing any of the function pushbuttons to perform the corresponding operation, as described below.

BAND

Pressing BAND pushbutton will present the band choices: 1-10 MHz, 10-20 MHz, 20-30 MHz, 1-30 MHz, 160m, 80m, 60m, 40m, 30m, 20m, 15m, 10m, and "Custom Band". Once you have dialed in the range that you wish to automatically scan, press the dial pushbutton to select it. You will then exit back to the Impedance display with the frequency dial set to the bottom end of the selected band.
(When Custom Band is selected, you will be prompted to enter a start frequency, stop frequency, and step size. Just dial-in the desired start or end frequency using the same techniques as used when setting the main frequency, and then dial-in the desired step size when prompted. These settings

allow you to prepare for a special scan and they will be in effect when you exit from the Band function.)

SCAN

Pressing the SCAN pushbutton will automatically sweep the antenna analyzer test signal across the band range previously selected, incrementing from the lower frequency limit to the upper frequency limit, in steps of 100 Hz, 1 kHz, 10 kHz, or 100 kHz, as preset in the Setup menu. The red BUSY LED is turned on during the scan and the following message is displayed:

~~Scanning~~
(please wait)

The reflectometer signals are sampled after each step change and are used to compute the SWR and complex impedance at each frequency step. Each SWR value is compared to previous value in order to determine if a minima, or a "dip", has occurred at this point in the scan. If so, that data point is stored for later display. The Scan takes approximately 6 seconds at the 1 kHz step rate. At the end of the scan, the Impedance mode is automatically entered and the SWR and impedance data at the frequency of resonance is displayed.

MODE

Pressing the MODE pushbutton presents sub-displays representing the four modes available in the instrument: Impedance, Capacitance, Inductance and VFO. To enter a specific mode, press the dial pushbutton when that mode name is displayed.

Impedance Mode

This is the main operational mode for the antenna analyzer. Impedance mode is entered automatically during the power-on sequence, and can be re-entered from any other mode by pressing the dial pushbutton when Impedance is displayed. Upon entry to the Impedance mode, you will see the following typical display:

SWR 10,345.00
2.1 49 + j 23

- The top line indicates the frequency.
- The first number on the second line is the SWR. In this case it indicates 2.1:1
- The middle value is Resistance, the real part of Impedance. In this case it is 49 ohms.
- The rightmost value is the Reactance, or the reactive part of Impedance. In this case it is 23-ohms inductance. (Capacitive reactance would be indicated as a negative number.)

Adjusting the Frequency

In the Impedance mode, you have the ability to manually adjust the frequency and see the SWR, resistance and reactance values at whatever frequency is dialed up.

Frequency is changed by adjusting a single digit indicated at the point in the display where the cursor (_) is. Upon power-up of the instrument, the 10 kHz digit is the adjustment point, as shown by the digit with the cursor in the display above.

To move the cursor to a different digit to be adjusted, press the dial pushbutton while simultaneously turning the dial. The cursor will move to any of the seven available digits, allowing subsequent up/down adjustment of that digit with the dial pushbutton is released.

Rotating the dial clockwise will increase the digit value and, correspondingly, the signal generated by the unit. Counter-clockwise rotation will decrease the digit and the generated signal.

When the digit is incremented past 9, or when it is decremented past 0, the digits above the selected adjustment point are rolled up or down, respectively.

Using this frequency adjustment scheme, the user can conveniently pick an "increment" digit and manually scan frequencies with the desired granularity. Rough scans can manually be done by positioning the cursor under the 100 kHz digit or the 1 MHz digit, giving a wide and course scan of the frequencies with a quick twist of the dial. The signal frequency can then be set to the area of interest and the cursor set to a lower granular digit (e.g., 10 kHz or 1 kHz) in order to manually perform a detailed scan while watching displayed results for SWR, impedance and reactance.

An **audio tone** may be configured to sound when turning the dial in Impedance mode. When you approach a resonance (i.e., an SWR "dip"), the tone lowers according to the SWR. Thus the operator will have an audible indication of when minimum SWR is found. The tones may be enabled or disabled in the Setup menu, and the setting is saved in nonvolatile EEPROM so the selection stays in the unit when power is turned off.

NOTE: The practical lower limit of the ZM-30 is about 400 kHz due to the coupling capacitors used in the internal circuitry. Signal levels will drop to an unusable level with frequency settings below this level, so the instrument prohibits adjustment lower than this frequency. The upper limit of the instrument is restricted to 30 MHz, as this is the highest quality signal safely obtainable from a DDS clocked at 100 MHz.

Capacitance Mode

Capacitance mode may be entered at any time by pressing the dial pushbutton when Capacitance is displayed. Upon entry to the Capacitance mode, you will see the following typical display for about ½ second:

Capacitance (pF)

Then, the capacitance display screen is shown, as illustrated below when a 120 pF capacitor is connected to the RF output jack.

10,000.00
C = 126.4 pF

The top line indicates the frequency.

The second line is the computed value for the load connected to the output jack.

Capacitance values that may be displayed must fall within the measurement range of the instrument. Keeping in mind the 1K-ohm maximum impedance specification for the analyzer, the display will only indicate a numeric value for the capacitance when its reactance is less than that 1K-ohm spec. The equation used to compute the capacitance is:

XC = 1/ (2 * pi * F * C)

When the frequency and/or capacitance is beyond the instrument's capabilities, producing a value for XC greater than 1,000 ohms, the display will indicate as shown below.

10,000.00
C = (Z>1K)

Inductance Mode

Inductance mode may be entered at any time by pressing the dial pushbutton when Inductance is displayed. Upon entry to the Inductance mode, you will see the following typical display for about ½ second:

Inductance (uH)

Then, the inductance display screen is shown, as illustrated below when a 2.2 uH capacitor is connected to the RF output jack.

10,000.00
L = 2.2 uH

The top line indicates the frequency

The second line is the computed value for the load connected to the output jack.

Inductance values that may be displayed must fall within the measurement range of the instrument. Keeping in mind the 1,000-ohm maximum resistance or reactance specification for the antenna analyzer, the display will only indicate a numeric value for the inductance when its reactance is less than that 1,000-ohm spec. The equation used to compute the inductance is:

XL = 2 * pi * F * L

When the frequency and/or inductance is beyond the instrument's capabilities, producing a value for XL greater than 600 ohms, the display will indicate as shown below.

10,000.00
L = (Z>1K)

VFO Mode

The VFO mode may be entered at any time by pressing the dial pushbutton when VFO is displayed. Upon entry to the VFO mode, you will see the following typical display:

10,000.00
VFO

The top line indicates the frequency of the continuous signal available on the output connector.

The feature that makes the VFO mode valuable is the constant signal being generated the selected frequency. The impedance mode uses a technique of frequency shifting at ½-second intervals in order to determine the sign of the reactance component. This frequency shifting makes the signal unusable for purposes other than impedance measurement. When the signal is to be used as an external VFO, local oscillator or test signal, it is desirable to have a steady and constant-frequency signal, and the VFO mode provides just this.

SETUP

Pressing the SETUP pushbutton presents a menu of functions to allow setting of configurable options in the instrument. Rotate the dial to display the desired function, then press the dial to select that function.

Set Scan Step Size

This function allows the user to select the step size to be used for the Scan operation. Available step sizes are 100 kHz, 10 kHz, 1 kHz (default), and 100 Hz.

Enable Tones

This function provides an audible tone whose pitch corresponds to the SWR being measured when in Impedance mode. This feature is useful in eyes-free conditions or by the visually-impaired. Tone varies with changes in SWR again, even when the dial is not being moved. (Facilitates changing antenna while listening to lower SWR.)

Disable Tones

This function disables the audible tone. (Default setting.)

Turn Lite On

This function turns on the display backlight. After a user-settable amount of instrument inactivity, the backlight will turn off. When the user touches any of the controls again, the display backlight will again turn on.

Turn Lite Off

This function turns off the display backlight. (Default setting.)

Lite Off Time

This function prompts the user to enter the number of minutes of inactivity before the display backlight is automatically turned off. (Default value is 10 minutes)

Power Off Time

This function prompts the user to enter the number of minutes of inactivity before the entire instrument is automatically turned off. When the user touches any of the controls again, the timeout counter is reset to this user-entered value. (Default value is 10 minutes.)

Battery Voltage

Select this function to display the approximate voltage of the battery.

Default Settings

This function restore the default settings of all data stored in nonvolatile EEPROM memory.

View Settings

This function sequences through a display of all settings stored in nonvolatile EEPROM memory when the dial is turned.

Debug Mode
Enabling the Debug mode sends raw measurment data out the serial port which, when the instrument is connected to the the serial port of a PC, can provide diagnostic information about the ZM-30 operation in the field. (Default setting is OFF.)

Calibrate Reflectometer
Entering this function instructs the operator to follows a sequence of steps that result in new calibration data being stored on the unit. This is a useful function to be performed in the field when a new software program is loaded, necessitating a recalibration. (For additional detail on Instrument Calibration, please refer to Appendix E.)

Calibrate Frequency
This feature allows you to adjust the internal DDS reference clock. When properly calibrated, the frequency dial will indicate very accurately the frequency being generated by the ZM-30. The unit's frequency is set to 10,000.00 kHz and the dial is used to vary an internal calibration factor that moves the actual frequency up/down in 1-Hz increments. Thus when the signal being generated by the ZM-30 is read by a high-quality frequency counter, or when the signal is zero-beat against WWV (for example), you can adjust the generated signal to be as accurate as possible compared to the reference. Once the best setting is achieved, pressing the Dial will save the frequency correction factor to nonvolatile memory and the ZM-30 frequency display will forevermore reflect that same accuracy throughout its operational range.

Update Software
This function is used when upgrading the ZM-30 software in the field. Whenever newer or improved capability software is available, the user may download the binary file from the PalStar website to his local PC. (For additional detail on upgrading ZM-30 software programs in the field, see Appendix D.)

3) Additional Features

Save Settings (Press-Hold Dial)
This is a way for you to save all customizable settings to nonvolatile memory such that the unit comes on next time with everything set the exact way it was before power-off, including the last-used frequency on the dial. Here's how it works: At any time in the normal impedance display of frequency (SWR, R and X) if you press-and-hold the Dial pushbutton steady for about 5 seconds without moving it, a message will pop up saying "Saving Settings" and the LED will come on. When it turns off, the unit returns to normal operation. At subsequent power-ups, the unit will have the same settings previously in use for: dial frequency and cursor position, tone, band, mode, backlight, backlight timer, power-down timer and data mode.

The ZM-30 antenna analyzer is an extremely useful instrument to have around the ham shack or homebrewer's workbench. This section describes the basic uses, as well as some advanced techniques for which you can use the analyzer to get intermediate measurements in order to compute the desired result.

Antenna Measurements

The antenna is simply connected to the analyzer antenna terminal and the analyzer is set to the desired frequency. The readout gives the resultant SWR, impedance, reactance and resistance. If the frequency is tuned across a ham band, the minimum SWR point (resonance) can be found as well as the SWR end points (usually 2:1) yielding the bandwidth of the antenna system. *See Figure 7.*

Measure Feed Point Impedance

Connecting the analyzer directly at the antenna terminals or remotely through a half-wavelength of transmission line allows direct measurement of the antenna terminal impedance. This is often useful with vertical antennas.

A matching network can be connected to the antenna and then adjusted for best SWR on the analyzer.

Measure Ground Loss

With short vertical antennas, measuring the impedance directly at the feedpoint allows estimation of ground loss or loading coil loss. For example a ¼ wave vertical will have a resistance of about 36 ohms at resonance. Any higher reading indicates ground loss. Similarly shorter antennas (when resonated) will have lower resistance values. Reading a good SWR may mean excess loss and measuring the actual impedance allows gauging just how much loss.

Adjust Antenna Tuners

The analyzer can be used to adjust an antenna tuner for a perfect match without the need to transmit a strong signal from the station rig. The analyzer uses only milliwatts of power lessening the possibility of causing interference. *See Figure 5.*

Capacitor Measurement

There are several ways to measure capacitance with the ZM-30. The simplest is to connect the capacitor across the RF output connector and select Capacitance from the Mode pushbutton menu. You can accurately measure capacitance values as long as the reactance at the measurement frequency is within the impedance measurement specifications of the analyzer (about 10-to-1000 ohms).

Another way to measure capacitance with the ZM-30 is to measure it in a series resonant circuit. *(See as Figs 1 and 6).* You will need an inductor of known value and a 51-ohm carbon composition or film resistor. It is recommended that a small 5% tolerance choke with an inductance of between 1 and 10 uH be used. Common RF chokes are fine and can be obtained from most full-service mail order component suppliers.

To measure capacitance by the second method, connect the components as shown in Figure 1. Then adjust the operating frequency for lowest SWR and record the frequency. Now you can calculate the capacitance using the formula:

$$C = 25330/(F*F*L)$$

where C is the capacitance in picofarads, F is the frequency in MHz and L is the inductance in microhenries.

Inductor Measurement

There are several ways to measure inductance with the ZM-30. The simplest way is to connect the inductor across the RF output connector J3 and select Inductance from the

Mode pushbutton menu. You can accurately measure inductor values as long as the reactance at the measurement frequency is within the impedance measurement specifications of the analyzer (about 10-to-1000 ohms).

Yet another method is to do the measurement in a series resonant circuit as shown below in Figure 1.

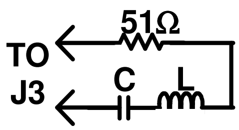


Figure 1

This requires a capacitor of known value in addition to a 51-ohm carbon composition or film resistor. The capacitor should have a tolerance no wider than 10% and have a low loss dielectric composition such as NP0 ceramic or mica. A capacitance value of about 100 pf is appropriate for many RF measurements.

You can make your own precision capacitor from a piece of coaxial cable. Common RG-58 type 50 ohm coax has a capacitance of about 29 to 30 pf (detailed data is available at http://thewireman.com/coaxdata.pdf). For example RG58/U is specified at 28.8 pf per foot so a length of about 3.5 ft – including a 1" pigtail for attachment will serve as a fairly accurate 100 pf capacitor.

To measure inductance by the second method, connect the components as shown in as Figure 1. *See also Figure 6.* Adjust the operating frequency for lowest SWR and record the frequency. Now you can calculate the capacitance using the formula:

$$L = 25330/(F*F*C)$$

where L is the inductance in microhenries, F is the frequency in MHz and C is the capacitance in picofarads.

Measure Inductor Q

The Q of an RF inductor can be measured with a very simple setup.

First measure the inductive reactance XL of the inductor and record this value. Now connect it to the Analyzer as shown below in Figure 3.

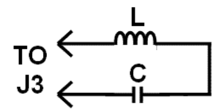


Figure 3

Capacitor C must be chosen to resonate with L at the frequency where you want to measure the inductor's Q. The Inductor and Capacitor Measurement section of this manual shows how this capacitor value can be determined.

Now tune the Analyzer for the lowest R (resistance) value with a reading of zero X (reactance). If R is above 10 ohms you can now calculate inductor Q using the formula:

$$Q = \frac{XL}{R}$$

If R is less than 10 ohms a slightly different method needs to be used. In this case use the test setup shown in Figure 1. Adding the non-inductive (carbon composition or film) ¼ or ½ watt 51ohm resistor allows more accurate measurement of the series resistance of the inductor.

Again tune the analyzer for lowest R (resistance) value with a reading of zero X (reactance). Record this resistance value. Now connect the 51-ohm resistor directly across the analyzer's RF output connector and measure its exact value at the resonance frequency and record it. Next subtract the exact 51-ohm resistor value from the measured R value and use this new resistance in the above formula to calculate the Q value.

Transmission Line Characteristic Impedance

The characteristic impedance of coaxial, twisted pair, open wire or ribbon type feedlines can be estimated using the ZM-30.

Practical measurements are best done in the mid-tuning range of the instrument where accuracy is optimum and feedline lengths are reasonable; so this procedure will be performed between 7 and 21 MHz.

The measurements need to be done with a transmission line over frequencies where the feedline is at about 1/8 wavelength at the low frequency end and something over ¼ wavelength at the high frequency end, so it is recommended that a length of about 16 feet is used.

Connect the near end of the feedline to the ZM-30. Connect a 1000-ohm carbon or Cermet potentiometer to the far end with leads no longer than an inch or so. Initially set the pot to its highest value. *See Figure 8.*

Ensure that the transmission line is supported for its entire length in a fairly straight line and kept several inches from any conductive surface or material. This is important to minimize any detuning effects. Ideally the line should be dressed along to top of a wooden fence or supported by fiber rope or string.

Now tune the ZM-30 over the range of 7-to-21 MHz while noting the resistive (R) and reactive (X) values. More than likely they will vary widely over the tuning range. Now readjust the potentiometer to a slightly lower value and do another sweep while observing the variation of R and X values. At some potentiometer setting the R value will vary very little over the tuning range while the X value will remain near zero. This is the estimated characteristic resistance.

Transmission Line Loss

Transmission line loss for 50-ohm feedlines can be easily measured using the analyzer. The basic operating principle is that loss in transmission lines attenuates RF sent through them. When the line is connected to the analyzer and the far end is short or open-circuited there is a theoretically infinite SWR. If the feedline had zero loss this would be the case. However since any real line has some loss both the forward and reflected power are attenuated and a finite SWR is measured.

For most good quality new coaxial feedlines the loss at HF frequencies will not exceed several dB per hundred feet; however as they age the dielectric becomes lossy to it is a good idea to periodically check the loss.

Measurement is simple. All you have to do it is to remove the load, short-circuit the far end of the feedline, and then connect the near end to the analyzer's RF output connector. Measure the SWR and refer to Table 1 for the approximate corresponding loss. If the measured SWR is above 9:1 that's good news since the SWR then is less than 1 dB. If you vary the analyzer frequency you will see that SWR decreases with frequency indicating that loss increases at higher frequencies.

Table 1 – SWR vs line loss (infinite load SWR)

Approx Loss	**Measured SWR**
1 dB	9:1
2 dB	4.5:1
3 dB	3:1
4 dB	2.3:1
5 dB	2:1
6 dB	1.7:1
7 dB	1.6:1
8 dB	1.5:1
9 dB	1.4:1
10 dB	1.3:1

Transmission Line Stub Lengths

Measurement of quarter and half wave transmission line stubs can be performed regardless of the transmission line characteristic impedance. The method relies on the fact that an open-circuited quarter wavelength line or a short-circuited line acts like a precise short circuit at the chosen frequency of operation.

With either type of feedline first cut it about 10% longer than the desired length, taking the appropriate velocity factor into account. The velocity factor of common feedlines is available from manufacturer's literature or references such as the ARRL Antenna Book. If you cannot find the value or if you are using a custom type of feedline, the "Velocity Factor Measurement" section in this manual provides a way to determine this value.

The following formulas can be used to estimate the length of transmission line required.

For a **half-wavelength** stub the length is:

$$L = \frac{5904 * VF}{F}$$

Where L is the length in inches, VF is the velocity factor and F is the operating frequency in MHz for the stub.

Similarly for a **quarter-wave** stub use the formula:

$$L = \frac{2952 * VF}{F}$$

To determine the length of a **half wave stub**, connect the near end of the transmission line through a 51-ohm resistor as shown in Figure 4 to the analyzer's RF output connector. Short circuit the two leads at the far end of the half wave stub.

Ensure that the transmission line is supported for its entire length in a fairly straight line and kept several inches from any conductive surface or material. This is important to minimize any detuning effects. Ideally the line should be dressed along to top of a wooden fence or supported by fiber rope or string.

Now tune the ZM-30 for minimum SWR and note the frequency. This is the frequency where the transmission line is exactly a half wavelength long. If the initial length was chosen properly it should be below the desired frequency. If so, cut off a short length making sure the far end is still short-circuited, and repeat until resonance is achieved at the desired frequency.

For a **quarter wave stub**, the above procedure can be used except, of course that the length is different and that the far end needs to be open-circuited.

Transmission Line Velocity Factor

Velocity factor of a transmission line can be measured using techniques similar to the ones used for measuring quarter and half wave stubs.

The procedure can be performed at any frequency that the ZM-30 tunes but it is most practical in the vicinity of 10 MHz where line lengths are reasonable and instrument accuracy is optimum.

Either a quarter wave or half wave length can be used; but using the shorter length consumes less feedline if it will be discarded after the measurement.

Begin by cutting a quarter wavelength of feedline using the formula:

$$L = \frac{2952 * VF}{F}$$

for a frequency of 10 MHz and assuming a VF (Velocity Factor) of 1.

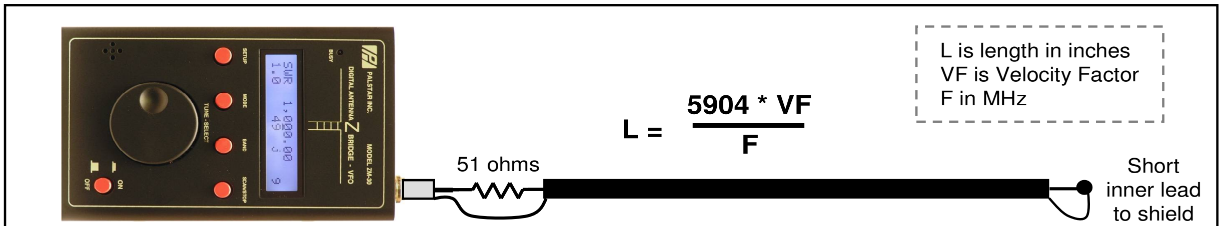
Now connect the near end of the feedline to a 51-ohm resistor as shown in Figure 9 then to the analyzer's RF output connector. The far end must be open circuited.

Ensure that the transmission line is supported for its entire length in a fairly straight line and kept several inches from any conductive surface or material. This is important to minimize any detuning effects. Ideally the line should be dressed along to top of a wooden fence or supported by fiber rope or string.

Now tune the ZM-30 for lowest SWR and note the frequency. VF can now be calculated using the formula:

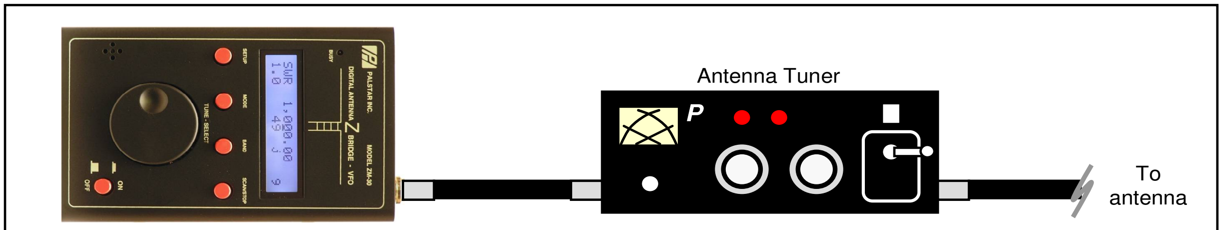
$$VF = 10/F$$

where F is the measured frequency in MHz.



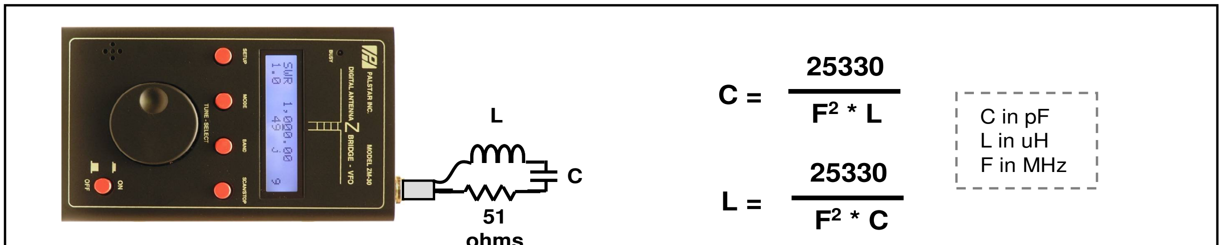
Tune for minimum SWR.
Freq where SWR is min is ½-wavelength

Figure 4: Determining Length of Halfwave Stub



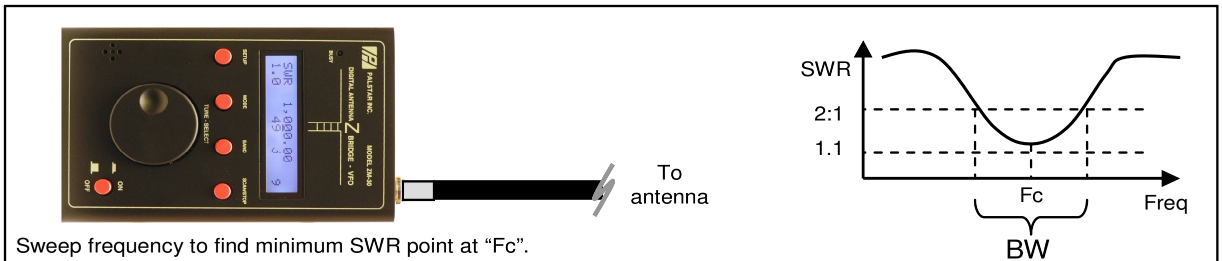
Use VFO mode to dial in the desired operating frequency.
Then disconnect ZM-30, connect Xcvr and operate!

Figure 5: Adjust Antenna Tuners



Adjust freq "F" for lowest SWR

Figure 6: Capacitor or Inductor Measurement



Sweep frequency to find minimum SWR point at "Fc".
Then find freqs where SWR=2:1 below and above

Figure 7: Antenna Bandwidth

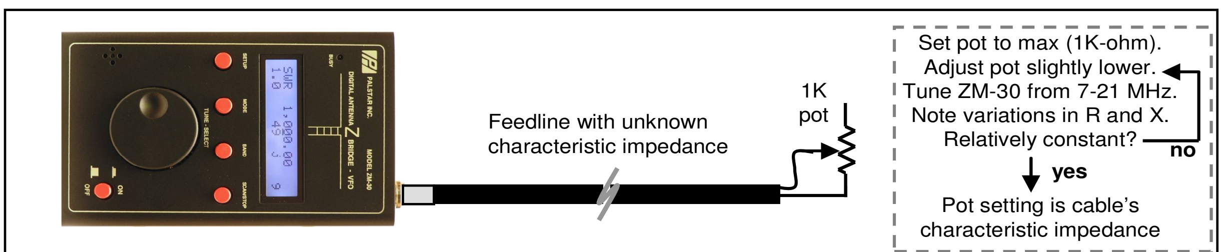


Figure 8: Determining Feedline Characteristic Impedance

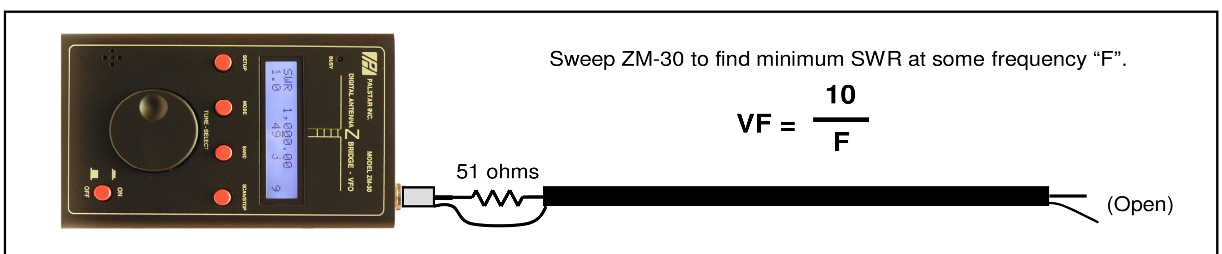


Figure 9: Determining Feedline Velocity Factor

SPECIFICATIONS

- **Frequency Generation & Control:**
  - 1 - 30 MHz
  - Source Impedance: 50-Ohms
  - Stability: +/- 50 ppm
  - Spectral Purity: Harmonics down >-35 dB beyond 30 MHz
  - Step Size: User configurable increments of 10 Hz, 100 Hz, 1 kHz, 10 kHz, and 100 kHz
- **Usable Measurement Range:**
  - SWR: 1.0 to 9.9
  - Impedance: approx. 5 to 1,000 ohms
- **RF Output:**
  - 2 Volts p-p (typical)
- **Power Supply:**
  - External: 9-to-16.0 Volts DC
  - Internal: Eight AA-cells, alkaline or NiMH
  - Current Requirements: 200 ma (typical)
- **User Interface:**
  - Pushbuttons (5): “Mode”, “Band”, “Scan”, “Setup”, “On/Off”
  - Rotary Encoder: “Tuning”, 24-position/rotation, smooth operation
  - LED: “Busy”
  - 2-line x 16-character LCD display, with optional backlight under software control, configured in Setup menus. Backlight may be configured to turn off after user-set period of inactivity. If enabled, backlight turns on again with any of the controls are touched.
- **Power Control:**
  - Power applied by press-and-hold of On/Off momentary contact pushbutton
  - Instrument turns itself off after preset period of inactivity, configured in SETUP menus
- **Connectors:**
  - External Power: 2.1mm coaxial power plug (center pin positive)
  - RF Out: BNC
  - Serial Port: RS232 (DB9F)
- **Environmental**
  - Temperature: 0-70C
  - Humidity: 0-100% RH

Loading New Software into the ZM-30

This appendix overviews a way you can load an updated software program into the ZM-30, as provided on the Palstar website.

BACKGROUND

Increasingly today, microcontrolled projects have an ability to be "field updated" with new capabilities and software updates made available by the designer. So instead of needing to send your instrument back for re-programming to get these new features, you can now simply download the program update from the Palstar website and send it to the ZM-30, and the instrument will automatically update its internal memory with the new program. What a great way to keep your project completely up to date with the latest features!

PC REQUIREMENTS

- Computer (at least 33 MHz Intel 486)
- Windows 95, 98, 2000, or XP. (Windows Vista may work.)
- RS-232 serial port. USB-to-Serial converters are not supported as the timing requirements for loading new ZM-30 firmware demand a genuine RS-232 serial port.
- Terminal emulator program. You can freely download TeraTerm at http://hp.vector.co.jp/authors/VA002416/teraterm.html. It's easy to install the program. We will assume this terminal program is being used in the following discussion on usage.

USAGE

1. Download the latest ZM-30 software from the Palstar website located at www.palstar.com/zm30. Save the S19 file to a known location on your PC (like in your desktop folder.) The S19 file is the file with the ".s19" extension to its filename. This is a text representation of the binary image to be loaded onto the ZM-30.
2. Connect your ZM-30 to the PC using a standard, straight-through male-female DB9-type serial cable. Do not use a null modem cable that swaps pins 2 and 3 from end-to-end.
3. Start up the TeraTerm program on your PC. If not already set up, configure the communications as 9600 8N1, no flow control (in the Setup ➔ Serial Port menu).
   Very important: ***You must have the line delay set to at least "40ms/line".***
   Make sure that you have TeraTerm configured to be using the active serial port in your PC. Be certain that no other program has control of the serial port – e.g., if your Palm HotSync program is running, as evidenced by its icon in the system tray in the lower right of the screen, you must quit that program by right-clicking the icon and select "exit".)
4. Issue the **Update Software** command on the ZM-30, located as an option under the SETUP menu. The program called "HCmon" will display its sign-on message on the PC screen.
5. Type **C** to clear out memory on the ZM-30. See the C character echoed to the screen and the HCmon> prompt displayed again.
6. Type **L** to load new program. See message "…waiting …"
7. Pull down **the File ➔ Send File** menu.
8. Navigate to where you saved the *.s19 file.

9. Once in the folder that contains **zm30v2-2.s19** file, select that file and click the Open button. ***Very Important:* Be careful to only load S19 files!** If you mistakenly select any other file extension, it is very likely that you'll mess up the bootstrap loader program.)
10. See line after line of ASCII data displayed in short one-second bursts. This will continue for about 2 minutes until the entire program has been sent to the ZM-30 and has been flashed into its memory. **DO NOT INTERRUPT THIS PROCESS!!** When it is complete, the **HCmon >** command prompt will be displayed again.
11. Type **X** to exit the HCmon program and the ZM-30 will power down. Disconnect the serial cable and power the ZM-30 on again with the On/Off pushbutton to start the newly-loaded program. You will see the new version number presented in the LCD sign-on message.
12. ***Very Important:*** The first thing you must do after loading new software is to go into the SETUP menu and select the Default Settings item. This will synchronize the internal nonvolatile EEPROM memory in your ZM-30 with the new software you just loaded. (If this step is omitted, strange things are likely to happen, like the beeper sounding when it shouldn't, or some unusual impedance results being shown.)
13. Lastly, be sure to calibrate your instrument after loading new software. The ZM-30 retains the calibration parameters in a special nonvolatile section of EEPROM memory that is not cleared when Default Settings is invoked, but these parameters also must be synchronized with the newly-loaded software and it's good to ensure you are calibrated with the software currently loaded on your instrument.

IN CASE OF SOFTWARE LOADING PROBLEMS

The normal indication of new software being successfully sent to the ZM-30 is seeing line-after-line of nicely-formatted text data being displayed to the PC terminal screen, as indicated in Step #10 above.

However if this process is interrupted for some reason (such as your computer accessing the Internet in the background, or you task switching over to another program), the PC data link to the ZM-30 can get out of sync, resulting in either a complete stopping of the scrolling data lines, or unusual and unformatted data continually being displayed to the screen. Neither of these conditions will end in a successful display of the HCmon prompt and the software memory of the ZM-30 will be left blank … brain dead.

But all is not lost! There is an alternate way to load new software into your ZM-30.

ALTERNATE LOADING METHOD

1. Remove power from the ZM-30 by pulling the power plug (if the unit is externally powered), or by opening the battery compartment and removing one of the batteries (if the unit is battery powered).
2. Open the ZM-30 case by removing the four screws on the sides of the instrument.
3. Locate the two 2-position pinheaders in the lower left portion of the pc board – one is just above the round piezo speaker device, and the other is about 0.5" to the right of the speaker.
4. Place the two supplied shunts (small black jumpers) onto these two pinheaders, ensuring that each of the two pinheader pins is shorted by its respective shunt.

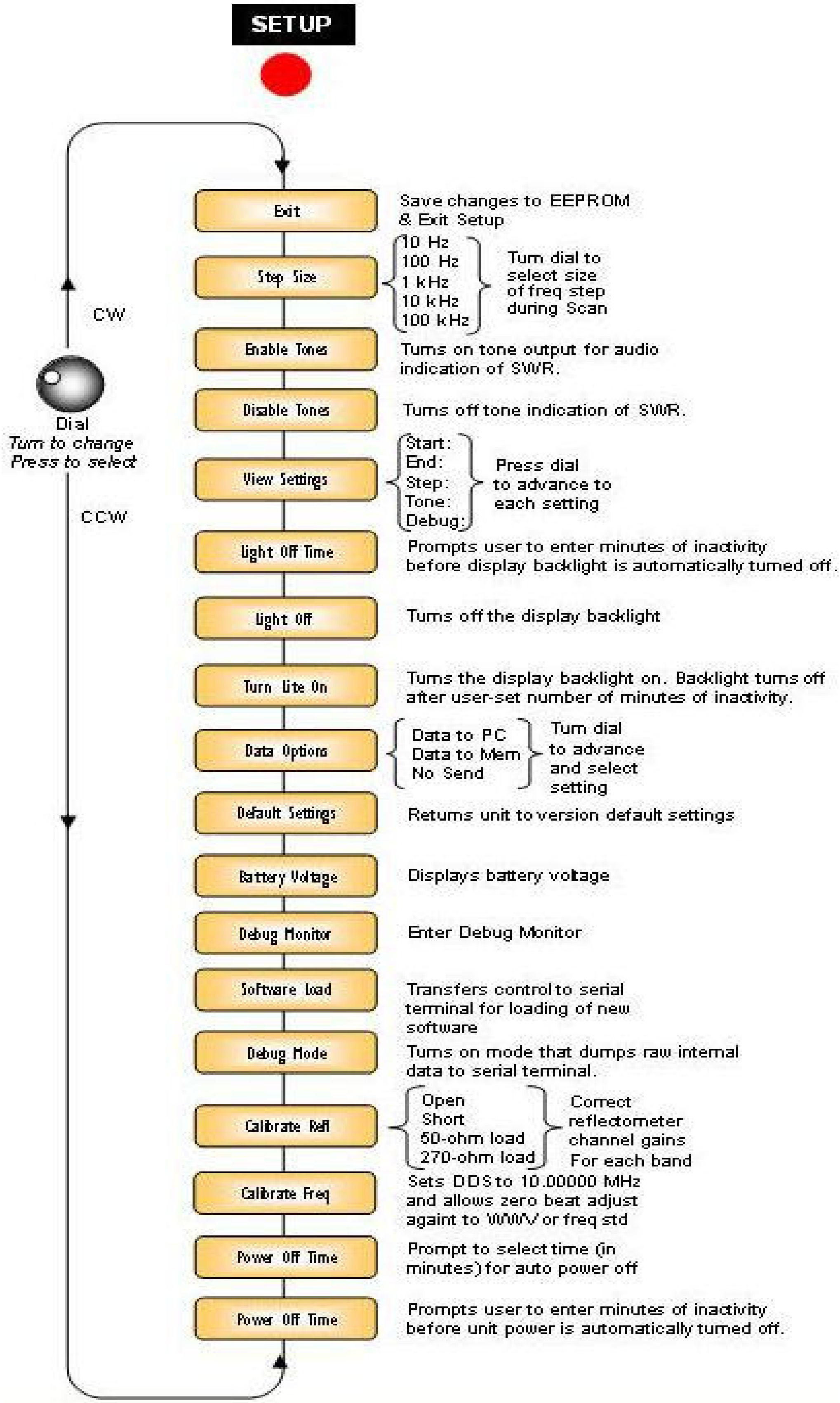
5. Connect your ZM-30 to the PC using a standard, straight-through male-female DB9-type serial cable. Do not use a null modem cable that swaps pins 2 and 3 from end-to-end.
6. If not already running, make sure that TeraTerm (or some other terminal program) is running on your PC.
7. Power-up the ZM-30 again by plugging in the external power cable, or by inserting the battery that was previously removed.
8. You should immediately see the HCmon program display its sign-on message to the PC screen.
9. Proceed as before in steps 5-11 above, copied below for easy reference …
    a. Type **C** to clear out memory. See the C character echoed to the screen and the HCmon> prompt displayed again.
    b. Type **L** to load new program. See message "…waiting …"
    c. Pull down **the File → Send File** menu.
    d. Navigate to where you saved the *.s19 file
    e. Once in the folder that contains **zm30vXXX.s19** file, select that file and click the Open button. (Be careful to only load S19 files! If you mistakenly select any other file extension, it is very likely that you'll mess up the bootstrap loader program.)
    f. See line after line of ASCII data displayed in short one-second bursts. This will continue for about 2 minutes until the entire program has been sent to the ZM-30 and has been flashed into its memory. DO NOT INTERRUPT THIS PROCESS!! When it is complete, the **HCmon >** command prompt will be displayed again.
    g. Type **X** to exit the HCmon program and the ZM-30 will power down.
10. Disconnect the serial cable.
11. Remove the two jumpers.
12. Re-install the case.
13. Power the ZM-30 on again with the On/Off pushbutton to start the newly-loaded program. You will see the new version number presented in the LCD sign-on message.

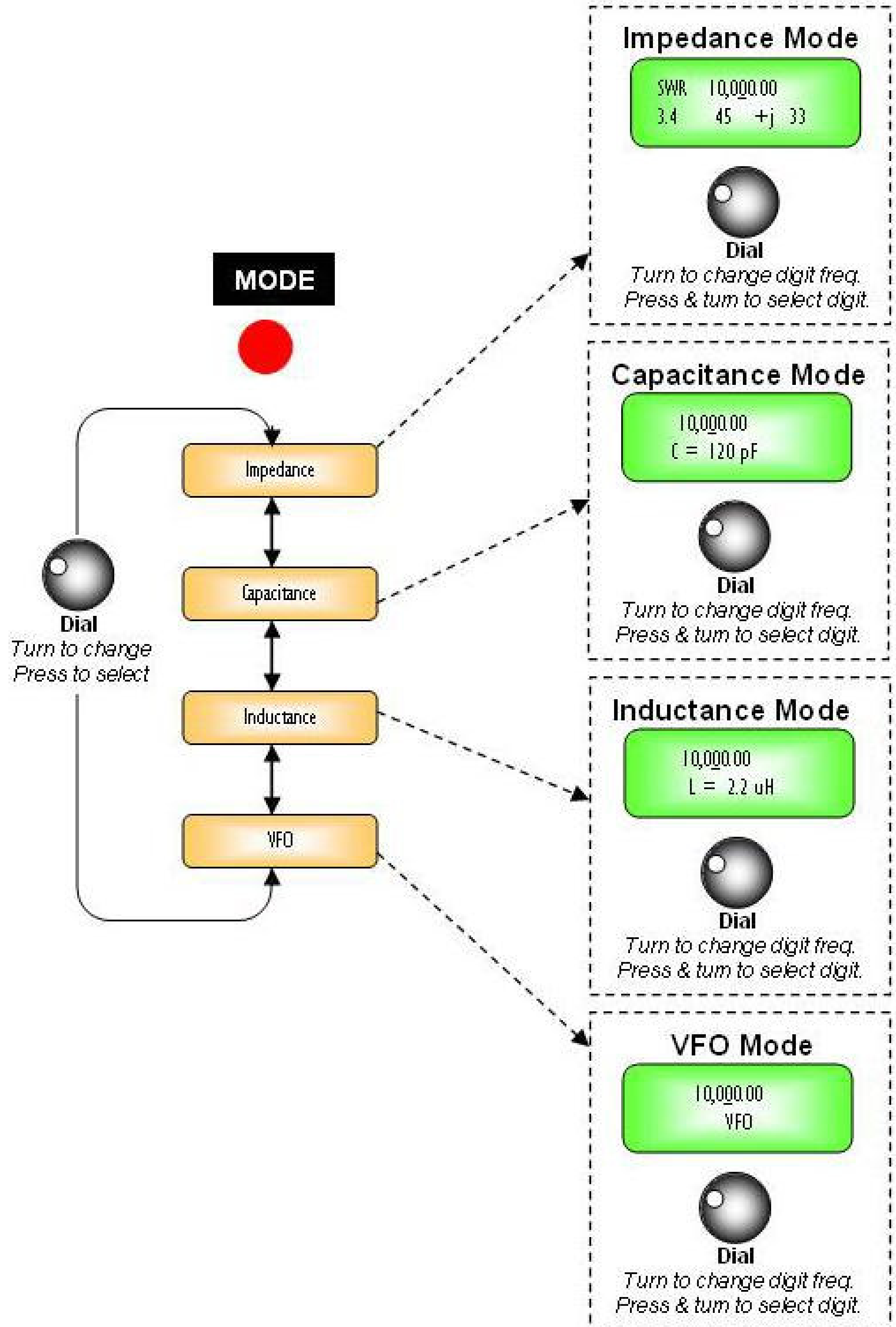
Calibration

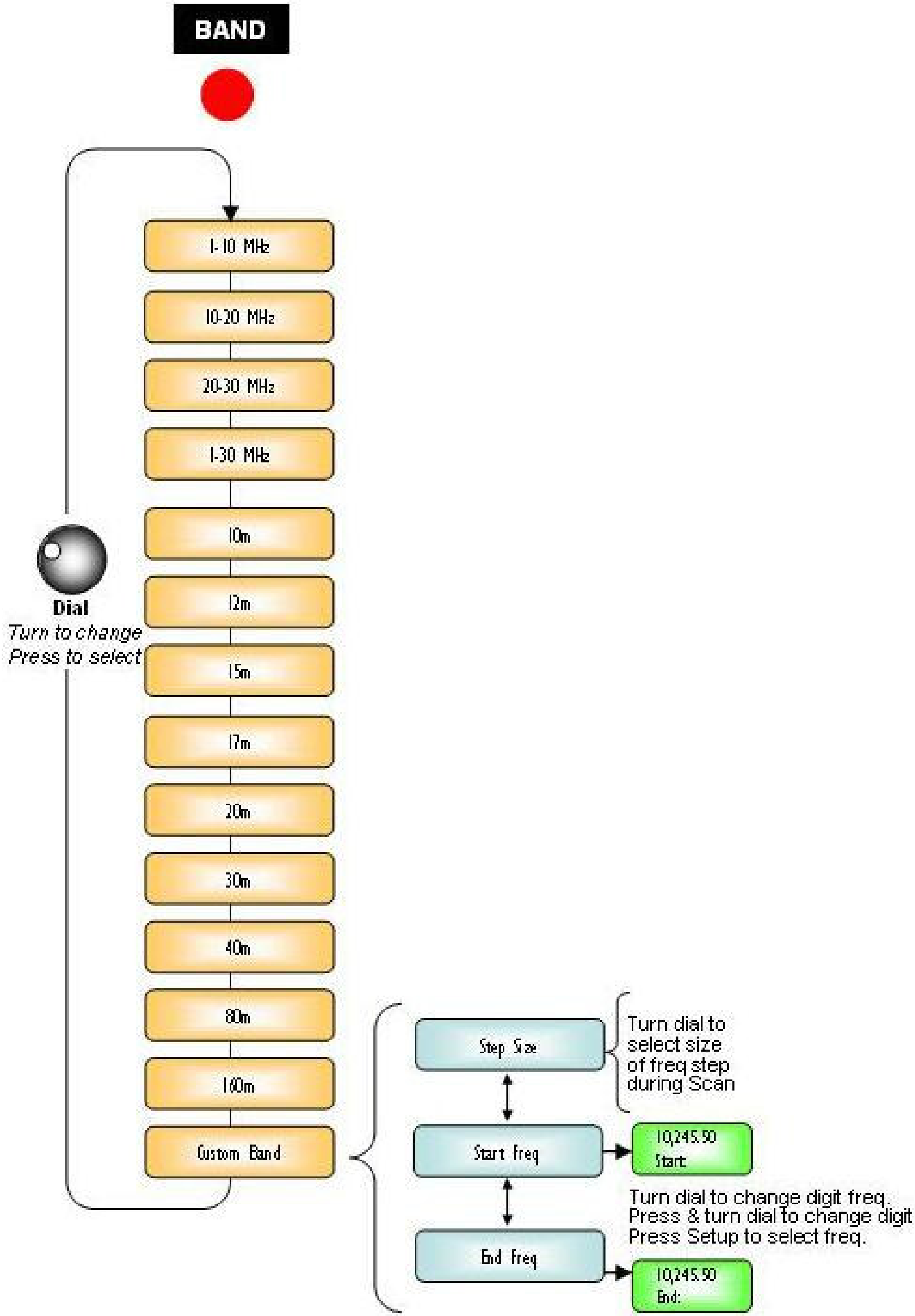
The ZM-30 is delivered pre-calibrated from the factory. However you may occasionally find the need to recalibrate the ZM-30 instrument, such as when new software updates are available that change the way in which calibration data are used, or when the characteristics of the DDS signal source change in any regard. In these cases, the instrument may be quickly and easily recalibrated by following a short sequence of operations located in the "Calibrate" function, located beneath the CONFIG pushbutton.

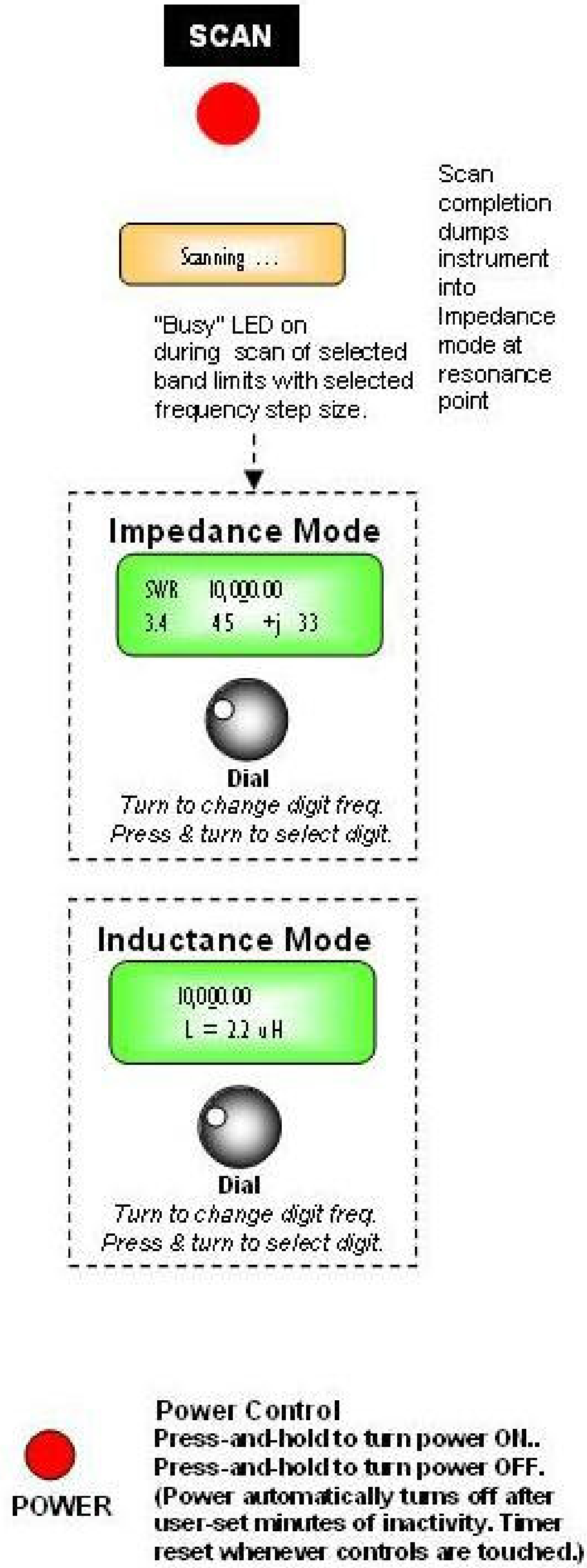
1. Select the Calibrate function, located within SETUP.
2. See "Calibrate now?" displayed in the LCD. Confirm by selecting "yes" with the dial. (Press the dial when "yes" is displayed.)
3. See "Open load" displayed on the LCD. Ensure that nothing is connected to the RF output jack, then confirm by selecting "yes" with the dial.
4. See a display of numbers representing the reflectometer channel voltages for Vf, Vr, Vz and Va. Ensure that the first three hex numbers are "high" in the range of C0 and C8, and that the last channel (Va) should be very low, somewhere between 00 and 09. A little higher is okay, but certainly no higher than 10. If the channels are showing in the acceptable range as explained above, press the Dial to continue.
5. However, if you do not see the first three channels "high" and the Va channel "low", or if any channel is grossly out of the acceptable range, then some internal adjustment is needed. Remove the cover and use a non-metallic tool to carefully adjust the small trimpot located on the circuit board between the Band and Scan/Stop buttons (3rd and 4th buttons in the row.) As you adjust this pot, the numbers will change and you will find a setting that meets the requirements of first three numbers being between C0 and C8, and last number being between 00 and 09. If you are not able to achieve these channel settings, then you ought not proceed with calibration and you should contact Support.
6. See "Shorted load?" displayed on the LCD. Place a short circuit on the RF output jack and select "yes" with the dial. The display will automatically cycle through each band and collect calibration data for the shorted load condition.
7. See "50-ohm load on?" displayed on the LCD. Place a 50-ohm load on the RF output connector and confirm by selecting "yes" with the dial. The display will automatically cycle through each band and collect calibration data for the 50-ohm load condition.
8. See "274-ohm load on?" displayed on the LCD. Place the supplied 274-ohm resistive load on the RF output connector and confirm by selecting "yes". The display will automatically cycle through each band and collect calibration data for the 274-ohm load condition.
9. When the instrument has completed its automatic data gathering for this last load condition, it will display "Calibration done! Saving data" and the red BUSY LED will turn on for several seconds.
10. When BUSY turns off, "Exit" will be displayed. Confirm this action by pressing the dial and control will again be placed in the Impedance mode, with measurements being made using the newly-created calibration data.

ZM30 Menus


SETUP
Exit
Save changes to EEPROM & Exit Setup
Step Size
10 Hz
100 Hz
1 kHz
10 kHz
100 kHz
Turn dial to select size of freq step during Scan
Enable Tones
Turns on tone output for audio indication of SWR.
Disable Tones
Turns off tone indication of SWR.
View Settings
Start:
End:
Step:
Tone:
Debug:
Press dial to advance to each setting
Light Off Time
Prompts user to enter minutes of inactivity before display backlight is automatically turned off.
Light Off
Turns off the display backlight
Turn Lite On
Turns the display backlight on. Backlight turns off after user-set number of minutes of inactivity.
Data Options
Data to PC
Data to Mem
No Send
Turn dial to advance and select setting
Default Settings
Returns unit to version default settings
Battery Voltage
Displays battery voltage
Debug Monitor
Enter Debug Monitor
Software Load
Transfers control to serial terminal for loading of new software
Debug Mode
Turns on mode that dumps raw internal data to serial terminal.
Calibrate Refl
Open
Short
50-ohm load
270-ohm load
Correct reflectometer channel gains For each band
Calibrate Freq
Sets DDS to 10.00000 MHz and allows zero beat adjust againt to WWV or freq std
Power Off Time
Prompt to select time (in minutes) for auto power off
Power Off Time
Prompts user to enter minutes of inactivity before unit power is automatically turned off.
CW
Dial
Turn to change
Press to select
CCW

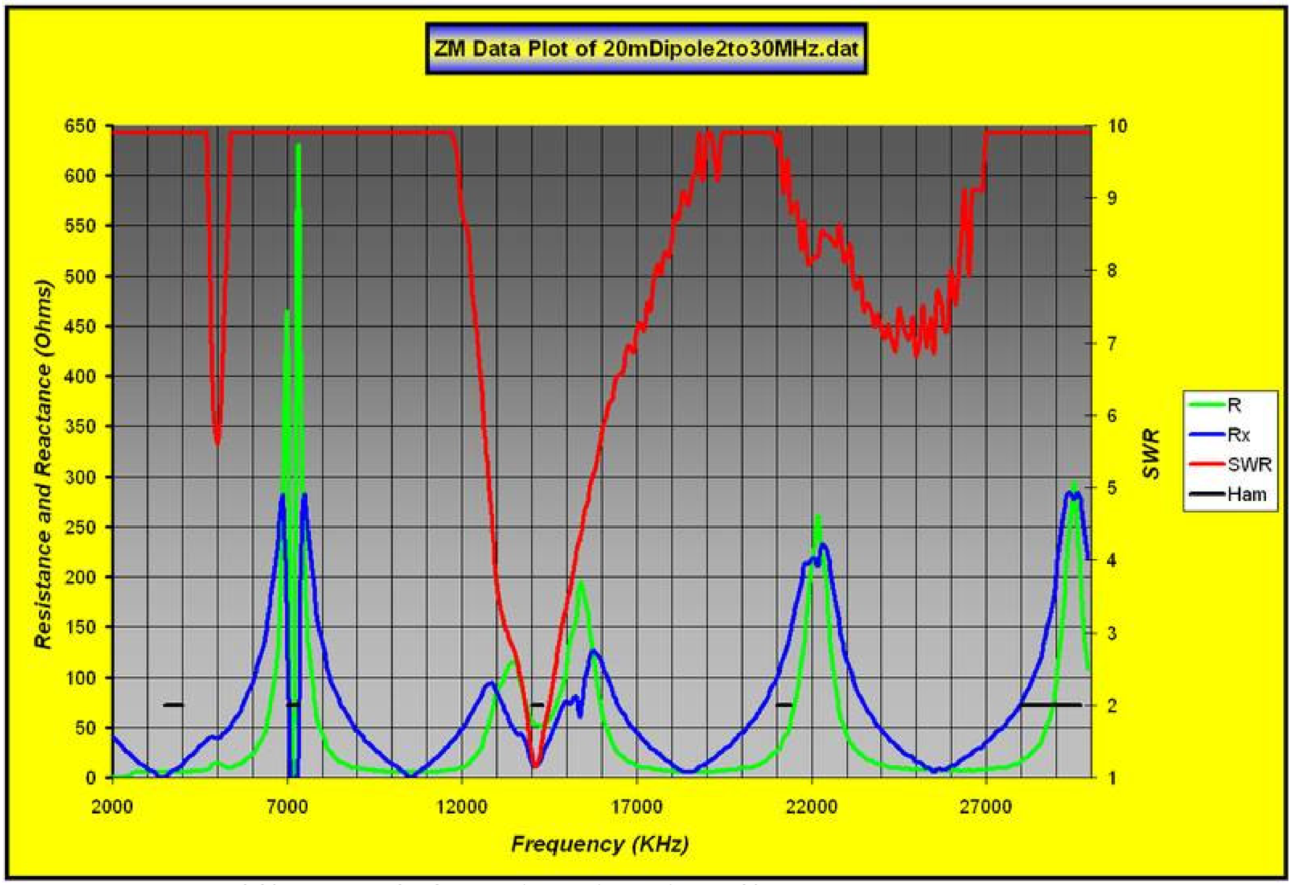

MODE
Impedance
Capacitance
Inductance
VFO
Dial
Turn to change
Press to select
Impedance Mode
SWR 10,000.00
3.4 45 +j 33
Dial
Turn to change digit freq.
Press & turn to select digit.
Capacitance Mode
10,000.00
C = 120 pF
Dial
Turn to change digit freq.
Press & turn to select digit.
Inductance Mode
10,000.00
L = 2.2 uH
Dial
Turn to change digit freq.
Press & turn to select digit.
VFO Mode
10,000.00
VFO
Dial
Turn to change digit freq.
Press & turn to select digit.


BAND
1-10 MHz
10-20 MHz
20-30 MHz
1-30 MHz
10m
12m
15m
17m
20m
30m
40m
80m
160m
Custom Band
Dial
Turn to change
Press to select
Step Size
Turn dial to select size of freq step during Scan
Start Freq
10,245.50
Start
Turn dial to change digit freq.
Press & turn dial to change digit
Press Setup to select freq.
End Freq
10,245.50
End:


SCAN
Scanning ...
"Busy" LED on during scan of selected band limits with selected frequency step size.
Scan completion dumps instrument into Impedance mode at resonance point
Impedance Mode
SWR 10,000.00
3.4 45 +j 33
Dial
Turn to change digit freq.
Press & turn to select digit.
Inductance Mode
10,000.00
L = 2.2 uH
Dial
Turn to change digit freq.
Press & turn to select digit.
POWER
Power Control
Press-and-hold to turn power ON..
Press-and-hold to turn power OFF.
(Power automatically turns off after user-set minutes of inactivity. Timer reset whenever controls are touched.)

Appendix E

ZM Plotter



2-30 MHz scan of K7SBK multi-band dipole using ZM-30 and the ZMPlot program.
Note all the useful data shown in the plot: major resonance at 14 MHz, interesting minor resonance points at the SWR dips at 5 and 24 MHz, interesting behavior of resistance and reactance at various frequencies, and especially on either side of the resonance points.

OVERVIEW

Here is a wonderfully useful Excel macro program that allows you to collect and plot ZM-30 antenna analyzer scan data on a PC display. With just a simple keystroke and a click on the uploaded data file, ZMPlot automatically generates a colorful scaled representation of antenna measurements for SWR, resistance and reactance – just like the sample above showing the performance of a multi-band dipole. Options can be set to show data points of interest on the SWR curve, as well as indications of the ham band segments along the frequency axis. Further, you can hover the mouse cursor over a data point along the curve and a small window will show the frequency and SWR for that point.

ZMPlot can also remotely control your instrument over a serial cable to start and automatically collect/display the results. Options are available to compare two plots on the same display, and determine network impedance matching data points for your antenna transmission line!

ZMPlot is an Excel workbook containing a macro that imports the data files generated during the ZM-30 scan function. It then plots a graph of the data and leaves you inside Excel to do what you want with the graph and data.

Along the way, a vastly useful worksheet is created listing the scan settings, all the data points, and the polar representation of the impedance with reactance sign!

Multiple data sets can be handled on separate Excel sheets and then the whole thing can be saved as a workbook containing the graphs and datasets.

ZMPlot is a great technical analysis companion to your ZM-30 antenna analyzer!

ZMPlot is available for download at the Palstar website … http://www.palstar.com/zm30.php

INSTALLATION

The preferred location to install ZMPlot is in a folder called "ZMDataFiles" on your hard drive. This will be the default location for the data files you scan on the instrument or import to your PC.

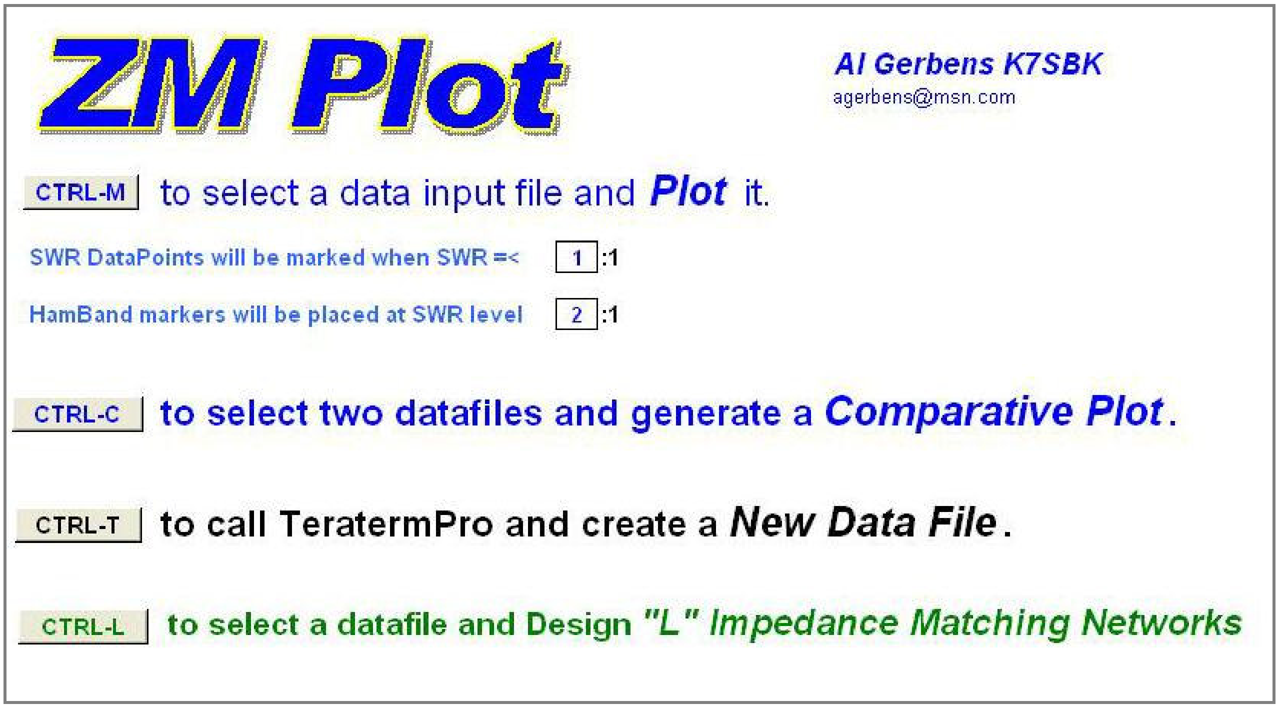
Create a folder at the root of your C: drive with this name and unzip the ZMPlot.zip file to that folder.

Microsoft Excel must be loaded on your computer for ZMPlot to work.

OPERATION

The screen below is displayed upon launching the ZMPlot.xls program.

(You may need to click "Accept" button if your computer displays a window asking permission to run an Excel macro.)



CTRL-M Plot Data File

You can start the main function of ZMPlot by either pressing **ctrl-M** or by clicking on the **ctrl-M** button on the menu display.

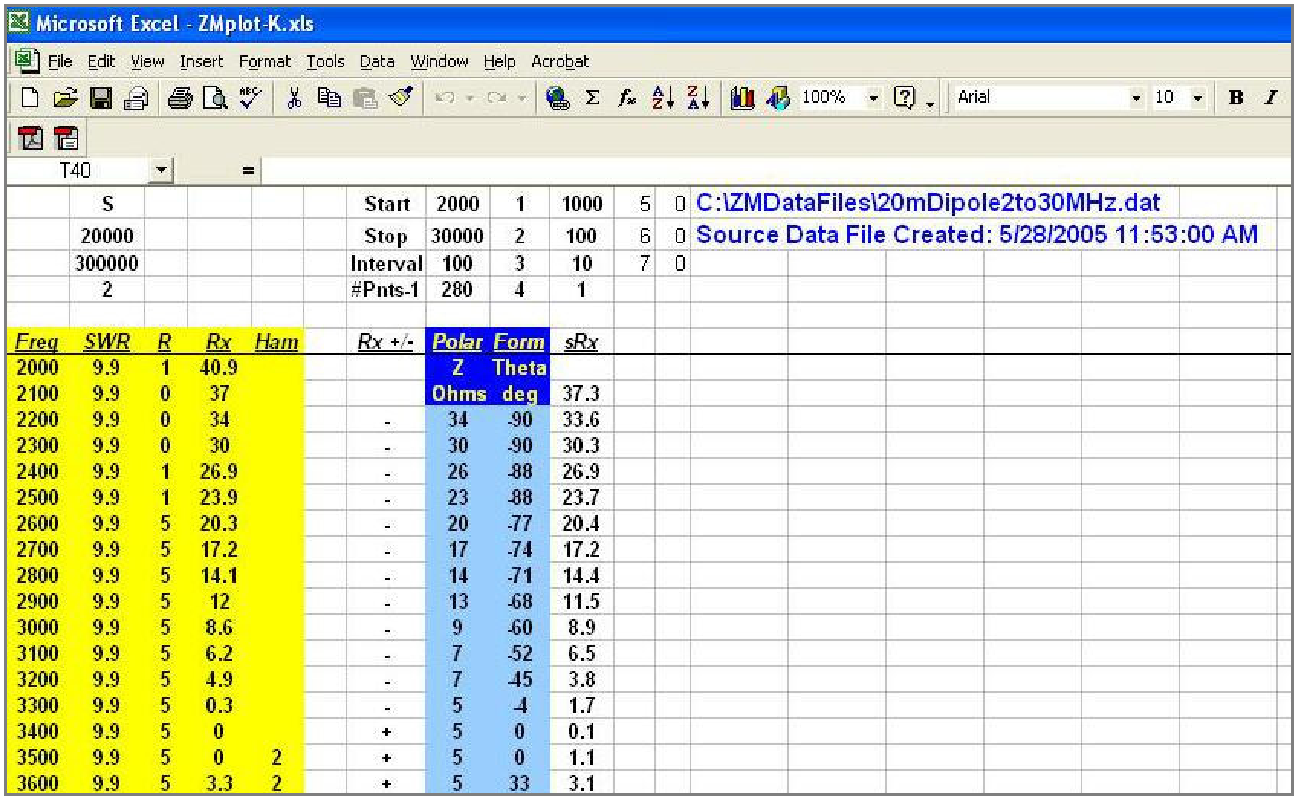
- A window will be displayed showing the contents of the ZMDataFiles and from there you can select one of the data files to plot. The data files are text and sometimes have a .dat or .txt extension on the filename, but it is not necessary. The distribution zip file has several sample data files you can select and try out before getting your own files into that folder. (If the files you are intending to plot are not located in this folder, you can navigate to the correct location for them.)
- Once you select the desired data file, the program will import the data to a worksheet of the same name (see the tabs at the bottom of the Excel program window) and in just a moment display new worksheet containing the plot. (It may take up to a minute to import and display a large data file.)
- You can print the chart using the standard Excel menus, or save it as a unique filename like the name of your antenna or date of the scan.
- You can also display additional data plots … just click on the worksheet tab for Sheet3, click on **ctrl-M** again and select the next file to plot.

SWR Data Points may be enabled by placing a number 'n' into the upper box, indicating a n:1 SWR threshold for displaying white circles on the SWR plot. Below this SWR level each SWR data point will be marked with a small white circle on the red SWR line in the plot. This indicates where the SWR curve falls below a reference level and shows the position of each data point in this area. Hovering the mouse cursor over each white circle produces a display of the frequency and SWR for that data point. The default setting is 1:1 which is the same as turning this feature off.

Ham Band Indicators may be specified in the lower box. This step results in a reference SWR level being plotted as a thick black line indicating where the Ham frequencies are located. Note that this line is continuous at frequencies where data points exist with Ham bands. That's not exactly the same as absolute ham band edge indicators but the differences are generally very small in this system. This feature provides dual information – ham frequency location on this plot and the SWR reference level of my choice. The default SWR level is 2:1. Both SWR level features can be used at the same time.

Getting Data Files from the ZM-30 – Most ZM-30 owners are familiar with the procedure for setting up their instruments to generate the data and importing it to the PC. This is specified in the ZM-30 manual as well as in a ZM-30 Application Note. For a refresher on the technique, see the Appendix in this document.

Formatted Data File – After the data file is plotted, the worksheet containing the data is named with the filename you originally specified. The imported data points are displayed with column headings, and the polar representation of Z is displayed in the worksheet. The scan settings are displayed at the top of the worksheet, forming a great numerical/text record of the antenna being analyzed. (See the example shown below.)



	S					Start	2000	1	1000	5	0	C:\ZMDataFiles\20mDipole2to30MHz.dat
	20000					Stop	30000	2	100	6	0	Source Data File Created: 5/28/2005 11:53:00 AM
	300000					Interval	100	3	10	7	0	
	2					#Pnts-1	280	4	1			
Freq	SWR	R	Rx	Ham		Rx +/-	Polar	Form	sRx			
2000	9.9	1	40.9				Z	Theta				
2100	9.9	0	37				Ohms	deg	37.3			
2200	9.9	0	34			-	34	-90	33.6			
2300	9.9	0	30			-	30	-90	30.3			
2400	9.9	1	26.9			-	26	-88	26.9			
2500	9.9	1	23.9			-	23	-88	23.7			
2600	9.9	5	20.3			-	20	-77	20.4			
2700	9.9	5	17.2			-	17	-74	17.2			
2800	9.9	5	14.1			-	14	-71	14.4			
2900	9.9	5	12			-	13	-68	11.5			
3000	9.9	5	8.6			-	9	-60	8.9			
3100	9.9	5	6.2			-	7	-52	6.5			
3200	9.9	5	4.9			-	7	-45	3.8			
3300	9.9	5	0.3			-	5	-4	1.7			
3400	9.9	5	0			+	5	0	0.1			
3500	9.9	5	0	2		+	5	0	1.1			
3600	9.9	5	3.3	2		+	5	33	3.1			

CTRL-T Remote-Control Scan & Data Import

The **ctrl-T** command uses the TeraTerm terminal program to remotely command the ZM-30 to perform a scan. The data collected from the scan is placed into a data file in the ZMDataFiles folder on the PC, and control is returned to the ZMPlot main menu. From there, you can select the **ctrl-M** Plot command to display the plot of your newly-collected data file.

The ZM-30 must be connected to the PC with the serial cable. The ZM-30 must also be turned on and have the setting of "Send during scan" set in the Data item of the Setup menu on the instrument.

You must also have the TeraTerm dumb terminal program installed on your PC. All ZM-30 owners have this program and have it installed for software upgrade purposes as well as in using other Data features of the instrument. (When you installed TeraTerm, the application was very probably placed in a folder with path name "C:\Program Files\TTERMPRO". This is where ZMPlot looks for the application and if not there will ask you where its located. If TeraTerm is not at this location it is probably a good idea to install it there, or change the macro to look in a different location.)

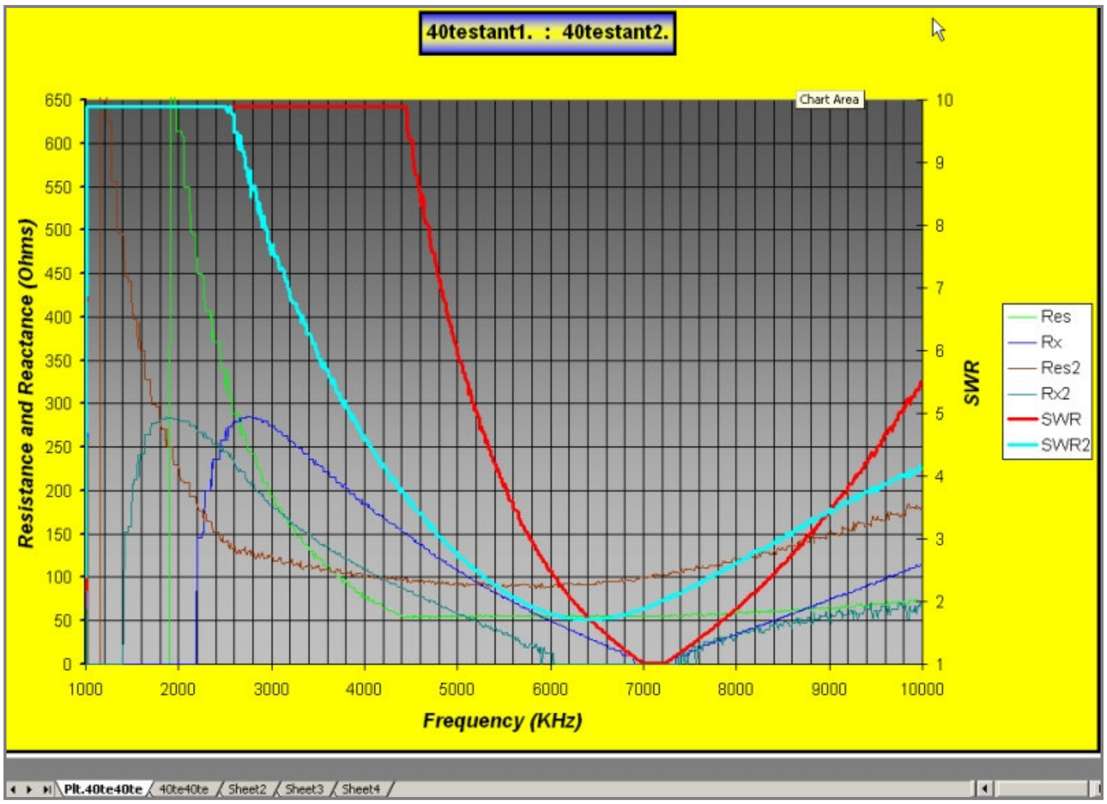
CTRL-C Generate Comparative Plot

The **ctrl-C** command generates a comparative. Operation is simple, just enter the location of the two data files when prompted, and both plots get displayed on a single graph.

These graphs are basically XY scatter plots and so it is possible to arrange them such that all six parameters are plotted against frequency (X axis). The program uses the minimum frequency of the two data sets as the minimum and the maximum frequency of the two data sets as the maximum in determining the frequency range of the graph. So if you plot two 40 meter datasets they'll look pretty good in comparison. If you plot a 160 meter dataset and a 10 meter dataset, you're not going to be too happy with the result, although it is not too likely that you would want to do that anyway).
Because there is so much going on with 6 parameters being plotted on the same graph, the hamband indicator and SWR data point marker options were eliminated.

The SWR and SWR2 curves are wide lines for emphasis and the Res, Res2, Rx and Rx2 lines are very thin to help the observer maintain sanity.

As you're looking at any of the graphs, remember that all of Excel's functions are available to you to tinker with. For example if you would like to remove a plotted line, use your mouse to select that line, right click on the mouse and edit that series to eliminate the line, change its color, change its width, add data point markers, etc. When you've got it looking right, just save the workbook with your own unique filename.



Above is a comparative plot using a test antenna circuit consisting of RLC mounted on a BNC connector. The circuit is held firmly between thumb and forefinger when generating the second dataset. You can clearly see the downward shift in resonant frequency and the reduction in circuit Q. Evaluating the effect of antenna modifications using before and after AA908 data scans and overlaying them using the **ctrl-C** macro should be very interesting.

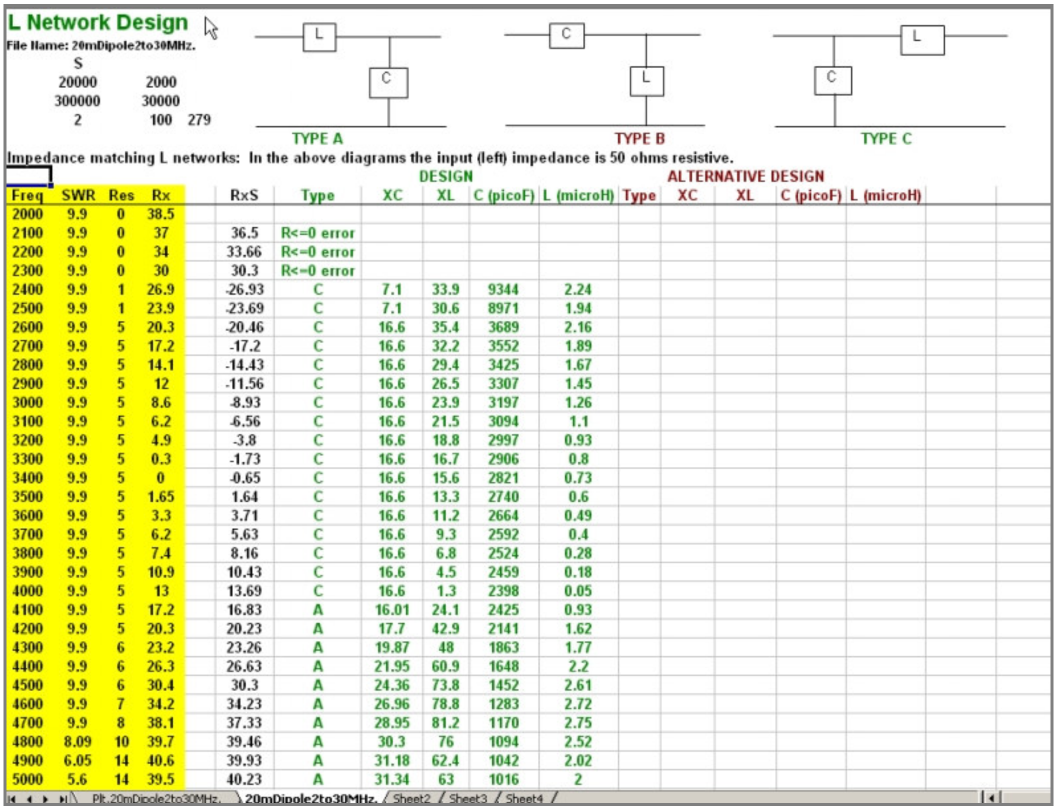
CTRL-L Determine Network Impedance Matching Data Points

The **ctrl-L** command determines network impedance matching data points for your antenna transmission line. This function designs an impedance-matching L network for each data point in the data file you select. The input to the L network is 50 ohms resistive and the other end of the network is the complex impedance of individual data points.

There are 8 possible L configurations. Most matching problems can be solved with 2 of the 8 and the two most desirable are the so called 'low pass' configuration. These are the two primary solutions given by LNET a third alternative (TYPE B) is also calculated and presented whenever it'll work. A single L network configuration cannot solve all matching problems.

Determining the sign of the reactance turned out to be a source of error. Some of the limitations result from not being able to sample the reactance outside of the data set range, an occasional 'weird' data point (s) and the method itself. This program attempts to smooth the data and remove 'outliers' but could never get all of them.

There are a lot of reactance vs. frequency inflection points in many observed data sets.



L Network Design

File Name: 20mDipole2to30MHz.

S

20000 2000

300000 30000

2 100 279

Impedance matching L networks: In the above diagrams the input (left) impedance is 50 ohms resistive.

						DESIGN				ALTERNATIVE DESIGN				
Freq	SWR	Res	Rx	RxS	Type	XC	XL	C (picoF)	L (microH)	Type	XC	XL	C (picoF)	L (microH)
2000	9.9	0	38.5											
2100	9.9	0	37	36.5	R<=0 error									
2200	9.9	0	34	33.66	R<=0 error									
2300	9.9	0	30	30.3	R<=0 error									
2400	9.9	1	26.9	-26.93	C	7.1	33.9	9344	2.24					
2500	9.9	1	23.9	-23.69	C	7.1	30.6	8971	1.94					
2600	9.9	5	20.3	-20.46	C	16.6	35.4	3689	2.16					
2700	9.9	5	17.2	-17.2	C	16.6	32.2	3552	1.89					
2800	9.9	5	14.1	-14.43	C	16.6	29.4	3425	1.67					
2900	9.9	5	12	-11.56	C	16.6	26.5	3307	1.45					
3000	9.9	5	8.6	-8.93	C	16.6	23.9	3197	1.26					
3100	9.9	5	6.2	-6.56	C	16.6	21.5	3094	1.1					
3200	9.9	5	4.9	-3.8	C	16.6	18.8	2997	0.93					
3300	9.9	5	0.3	-1.73	C	16.6	16.7	2906	0.8					
3400	9.9	5	0	-0.65	C	16.6	15.6	2821	0.73					
3500	9.9	5	1.65	1.64	C	16.6	13.3	2740	0.6					
3600	9.9	5	3.3	3.71	C	16.6	11.2	2664	0.49					
3700	9.9	5	6.2	5.63	C	16.6	9.3	2592	0.4					
3800	9.9	5	7.4	8.16	C	16.6	6.8	2524	0.28					
3900	9.9	5	10.9	10.43	C	16.6	4.5	2459	0.18					
4000	9.9	5	13	13.69	C	16.6	1.3	2398	0.05					
4100	9.9	5	17.2	16.83	A	16.01	24.1	2425	0.93					
4200	9.9	5	20.3	20.23	A	17.7	42.9	2141	1.62					
4300	9.9	6	23.2	23.26	A	19.87	48	1863	1.77					
4400	9.9	6	26.3	26.63	A	21.95	60.9	1648	2.2					
4500	9.9	6	30.4	30.3	A	24.36	73.8	1452	2.61					
4600	9.9	7	34.2	34.23	A	26.96	78.8	1283	2.72					
4700	9.9	8	38.1	37.33	A	28.95	81.2	1170	2.75					
4800	8.09	10	39.7	39.46	A	30.3	76	1094	2.52					
4900	6.05	14	40.6	39.93	A	31.18	62.4	1042	2.02					
5000	5.6	14	39.5	40.23	A	31.34	63	1016	2					

Plt.20mDipole2to30MHz. 20mDipole2to30MHz. Sheet2 Sheet3 Sheet4

A screen capture of the LNET worksheet is shown above. The three network configurations are diagrammed at the top of the page with the 50-ohm input (coax) indicated leftmost. The TYPE column indicates the configuration, and the C and L columns contain the capacitance (in pF) and inductance (in uH) required to build a network matching 50 ohm coax to the complex impedance in your data set Res +/- Rx. (If R is less than zero, no design is reported.)

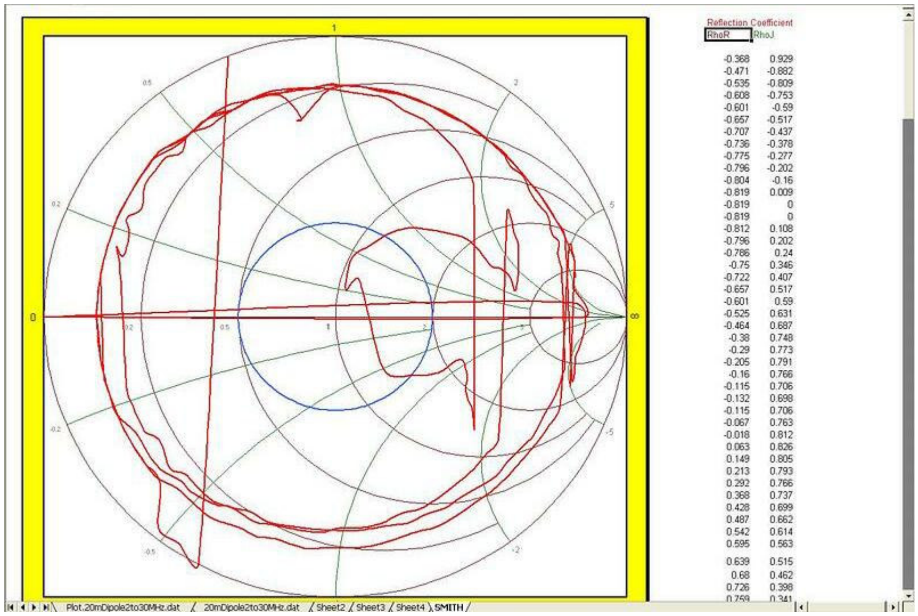
Depending on your dataset you'll find an occasional point or small region of points that don't make a lot of sense and in most cases looking at the data set it will be obvious why, generally they'll be connected to a bump in the data that produces a reactance sign transition that possibly is not real or may not be significant to your application.

If you want, for example, to operate your 20m dipole on 17m you should be able to derive a workable impedance matching network using the designs from this program. Just scan your dipole (including 18 MHz) with feedline, generate the data file, execute LNET and select a matching configuration in the 17 meter region of the spreadsheet.

There are several good L network impedance matching tools on the Internet and in HamCalc (by VE3ERP), but I thought it would be interesting to see the designs vary by frequency in a spreadsheet format – something none of them can provide. Looking at the design C and design L variation with frequency can be helpful in selecting components you may already have, etc. It turned out that the spreadsheet format provides a good overall view of the context for the design of each data point and can allow for construction of a workable L matching network for your application.

CTRL-E Select European Data Format

The **ctrl-E** command instructs Excel to use the "," (comma) as the "decimal point" in the data file instead of the "." (period) as is customary for computers in the US and UK. Otherwise, in computers with non-US language pack settings, the data file is not interpreted correctly.



Smith Chart

The Excel Data Plotter program plots a Smith chart when using the first option of the opening menu. It's not visible but I reworked the 'smoothing' code to eliminate a lot of sign changes that were not real and the degree of smoothing (used only to determine the sign of X) can be varied by changing the value of a constant called DOS (Degree Of Smoothing) at the beginning of the main macro. It's set at '12' now and seems to be working pretty well. If interested it is documented in the main macro. What's actually plotted is real, unsmoothed data. I used smoothed data only to determine sign of X.

Main features:

1) Option provided for charting two datasets on the same Smith Chart

2) The first data point in each dataset is identified on the Smith Chart, as is the frequency of the first data point.

A couple of notes on the Smith Chart feature:

1) The Smith Chart is plotted each time the CTRL-M (PLOT) function is selected on an opening page.

2) On the Smith Chart (a tab selection) there is a cell with a yellow frame around it containing the number "1". To add a second plot to the SMITH chart, change the number in the yellow framed box to "2" and run another CTRL-M (PLOT) function from an opening page. The number (1 or 2) can be changed as desired for subsequent PLOTS. Plot1 traces will always be RED and plot2 traces will always be green. The file name(s) is provided on the Smith chart sheet for reference.

3) The first data point in each plot on the smith chart is identified with a colored diamond symbol and the frequency represented by the diamond is supplied on the SMITH chart sheet.

Technical Support

If you experience any problems with the ZM-30, or if you have any questions relative to its operation or specifications, please contact Palstar at (937) 773-6255. Be sure to visit the ZM-30 product website at www.palstar.com to check for product updates and other technical information.

Limited Warranty

Palstar Inc. warrants products manufactured by it to be free from defects in material and workmanship under normal use and service **for a period of three (3) years for the AT-AUTO, AT5K, AT4K, BT1500A, R30, and ZM30** and **all other products for one (1) year from the date of delivery to the first buyer** (the “Warranty Period”). Palstar Inc’s obligation under this warranty is limited to repair or replacement of the product at it’s option at the Palstar factory in Piqua, OH.

Effective only when the product is returned to the factory with all transportation charges prepaid and examination of the product discloses in Palstar’s judgment, to have been defective during the Warranty Period.

The Warranty Period shall not extend beyond its original term with respect to interim in-warranty repairs by Palstar. This Warranty Period shall not apply to any product which has been repaired or altered by anyone other than Palstar without prior written authorization. Warranty does not extend to any products which have been subject to damage from improper installation, application or maintenance in accordance with the operating specification.

Palstar neither assumes nor authorizes any person to assume for it any obligation or liability other than herein stated.

Repair Policy

When sending in a product for service, please “double” box it carefully and ship it insured for your protection. Please include a note clearly describing the problem, how you wish the item returned and how you wish to pay for the service. Package your radio properly. Palstar, Inc. is not responsible for merchandise damaged in shipment. Our service rate is $30 per hour (1/2 hr. minimum).

Return Policy

All returns must receive prior authorization from Palstar. Returned items must be received in original—AS SHIPPED–condition including the original box, manuals, accessories, and copy of sales receipt. Returns must be within 14 days of purchase. Returned items are subject to a 25% restocking fee. Shipping is not refundable.

Notes:

Notes: