

INSTRUCTION MANUAL

MATCHBOX

MODEL MB500



HELPER INSTRUMENTS COMPANY

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FRONT PANEL FUNCTIONS	ii
SPECIFICATIONS	1
CAUTION	2
INTRODUCTION	2
OPERATION.....	2
GENERAL OPERATING INSTRUCTIONS.....	3
SPECIAL INSTRUCTIONS FOR UHF RADIO INSTALLERS	4
SPECIAL INSTRUCTIONS FOR HF AND VHF LOW-BAND RADIO INSTALLERS	5
GENERAL INSTRUCTIONS TO INSTALLERS.....	12
MATCH EFFICIENCY VERSUS SWR.....	12
MAIN SCHEMATIC DIAGRAM.....	6
MAIN SCHEMATIC DIAGRAM.....	7
BRIDGE SCHEMATIC DIAGRAM	8
DISPLAY SCHEMATIC DIAGRAM	9
PANELS SCHEMATIC DIAGRAM	10
MAINBOARD PLACEMENT DIAGRAM	11
ABOUT ACCURACY	13
ABOUT BATTERY LIFE.....	14
MBACC5 NICAD BATTERY ACCESSORY.....	14
LIMITED FREQUENCY RANGE	14

SPECIFICATIONS

Model:

Helper Instrument Company MATCHBOX, MB500

Frequency Range:

2 to 550 MHz

Metering:

Analog meter for SWR/Match Efficiency, Digital Meter for Frequency

SWR (VSWR) Indication Range:

1.0: 1 to 5.0:1

Match Efficiency Indication Range:

100% to 55%

Connectors:

Connectors:
Universal Panel Connector with adapters for TNC, BNC, N, and MiniUHF.
Others available*.

Power:

Internal battery supply of 6 "C" cells or optional factory installed NICAD battery with wall plug charger. (MBACC5)

Size:

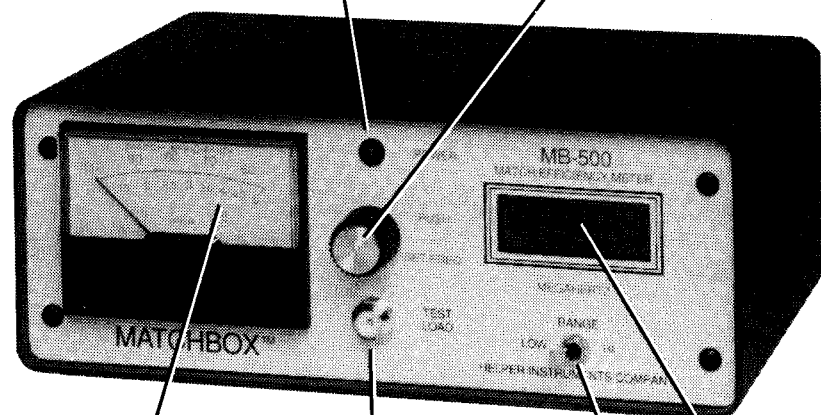
3.4" H x 8.8" W x 6.8" D including controls. 8.6cm H x 22.4cm W x 17.3cm D.

Weight:

4.1 lbs. (1.8kg)

Green LED lights when SET FREQ knob is pushed in. Replace batteries if LED does not light. (If MBACC5 is installed, switch on back panel will leave unit on and if green LED does not light, recharge NICAD battery.)

Push in to turn instrument on.
Rotate to set desired frequency.



Frequency Counter

Range Switch
Selects Low or Hi
Range of Frequencies.

Universal Flange
Install Appropriate Connector
To Mate With Antenna
Load Connector.

Indicates /
Match Efficiency
and SWR

**The panel connector mates with Greenpar™ and Unidapt™ connectors. The types supplied with the instrument are available from Helper Instruments. Other types can be obtained from Unidapt™ or Greenpar™ distributors.*

CAUTION

The RF port of the MB500 contains sensitive (and expensive!) semiconductors and other components. Do not connect the MB500 to the output of transmitters. If the MB500 is to be used for checking base station antennas, particularly those sharing towers with other stations, a test should be conducted to assure that no more than 1 milliwatt of power is present at the coax end.

INTRODUCTION

Satisfactory performance of a mobile radio transceiver or radio telephone is dependent upon the proper installation and performance of the antenna.

Because of this, radio installers usually test the antenna for Standing Wave Ratio to assure themselves that the antenna has been installed properly and is in working order.

The most common test is to use a directional wattmeter in conjunction with the transmitter output of the installed radio/telephone. From the forward and reflected power measurements, the SWR can be calculated, or read from a chart. Unfortunately, this test only determines the SWR at the mobile transmit frequency. The performance at the mobile receive frequency remains unknown, because no source of adequate power at the mobile receive frequency is available to the installer.

Using a directional wattmeter for checking the antenna system of a trunked mobile is especially awkward. The repeater may order a change in transmit frequency of the mobile unit while the test is in progress. Further, the transmitter must come up on the channel dictated by the repeater and the measurement is only valid for that (and nearby) channels.

The MATCHBOX was developed to enable installers to make quick, and complete measurements of mobile antennas in the 2 to 550 MHz band. Essentially, it is a directional wattmeter with its own source of signal, so no transmitter is needed. The signal source can be set to any frequency in the band, so mobile antennas can be checked over the entire transmit and receive bands.

OPERATION

Operation of the MATCHBOX is simple: Just connect the antenna lead to the front panel connector. Pushing the frequency control knob all the way in turns the instrument on. Rotate the frequency control knob to set the right hand display to the desired frequency. The MATCHBOX then calculates the SWR and presents it to you on the left hand meter.

In addition to the SWR calibration on the left hand meter, the MATCHBOX is also calibrated in Match Efficiency. Match Efficiency is an easier way of judging just how good (or bad) the situation is. An SWR of 1.5 to 1 isn't very meaningful unless you have been working with SWR for some time. An SWR of 1.5 corresponds to a Match Efficiency of 96%. That tells you right away that 96% of the power sent to the antenna stays there and only 4% is reflected.

GENERAL OPERATING INSTRUCTIONS

Four coaxial adapters are supplied with the MATCHBOX. Find the one that fits the connector at the end of the antenna lead, and install it on the universal connector located on the front panel of the MATCHBOX. Do not force the adapter into place. A finger tight fit is good enough.

Connect the antenna lead to the adapter. Again, finger tight is sufficient.

You can now check the antenna Match Efficiency (SWR) at any frequency in the 2 to 550 MHz band. Push in the SET FREQUENCY knob (center of front panel) and adjust it to obtain the desired frequency on the right-hand meter. The left-hand meter will then read Match Efficiency (SWR) of the antenna system at that frequency.

The MB500 has a frequency range switch that selects either a high or low frequency range. The low range can operate from 2 to 90 MHz and the high range from 80 to 550 MHz. Both ranges may be limited to specific portions of the range by internal adjustments by the user.

Pushing in on the SET FREQUENCY knob turns the instrument on, and releasing the knob turns it off. This assures long battery life. When the SET FREQUENCY knob is pushed in, the green panel lamp will light. If the panel lamp does not light, it is time to replace the batteries. (Also see section on the MBACC5 operation.)

Battery replacement: Remove the top and bottom outside covers of the instrument by removing the eight screws holding them in place. Then remove the inner shield covers. The battery holder is located on an inner shield cover. Six type "C" cells are required. Alkaline type cells result in the best battery economy. (Also see MBACC5 NICAD battery and charger.)

Avoid making measurements if there are operating transmitters in the vicinity.

If you want to test an antenna over a band of frequencies, hold the SET FREQUENCY knob in while rotating it to cover the desired band of frequencies displayed on the digital frequency counter, and observe the Match Efficiency readings of the left-hand meter.

You can find the resonant frequency of an antenna by sweeping across the band while watching for maximum Match Efficiency (minimum SWR).

Some broad band antennas have multiple resonances across the band,

while others have a single, rather deep resonance approximately in the middle of the operating band.

Most tunable antennas can be easily adjusted by tuning to make the deepest resonance point occur halfway between the lowest and highest frequency of interest (i.e. halfway between the lowest transmit frequency and the highest receive frequency). After tuning the antenna in this manner, check the results at the highest and the lowest to be sure both are OK.

Be suspicious of the cable if you measure a very high Match Efficiency which remains high across the entire frequency range of the MATCHBOX. Only very specialized antennas will show flatness over this wide range. An extremely lousy cable (possibly with moisture distributed along its length) can cause this. If in doubt, disconnect the cable at the antenna end or arrange a short at the antenna end. With the cable lengths used in mobile installations, the Match Efficiency meter should peg to the right (55% Match Efficiency).

SPECIAL INSTRUCTIONS FOR UHF RADIO INSTALLERS

Most UHF Transceiver manufacturers specify that the antenna used with their product should show an SWR no worse than 1.5: 1 over the operating band.

Typical test conditions in the United States are as follows:

The UHF frequency band from 450 to 470 MHz usually operates with repeaters. The repeater will typically have the transmitter and receiver frequencies spaced 5 MHz apart. To check your antenna, set to a frequency halfway between the transmit and receive frequency and measure the Match Efficiency. It should be over 96%. Then, vary the frequency to either side of the center frequency and observe the Match Efficiency meter. Again the meter should read better than 96% Match Efficiency for the transmitter and receiver frequencies.

UHF radio users share a band of frequencies with the Television Broadcast Industry. In this band you may experience difficulty using the MATCHBOX due to the signal levels from the TV transmitters. In most areas this should not be a problem. Should you experience this, check your local broadcast listings to determine the signal frequency. Note also that TV signals use much larger bandwidths than two-way radios and due to the modulation, these signals may vary a large amount when you observe them. The repeaters in this shared UHF frequency band operate from 470 to 512 MHz. The repeater will typically have a lower power transmitter and the transmitter and receiver frequencies spaced 3 MHz. To check your antenna, set to a frequency halfway between the transmit and receive frequency and measure the Match Efficiency. It should be over 96%. Then, vary the frequency to either side of the center frequency and observe the Match Efficiency meter. Again the meter should read better than 96% Match Efficiency for the transmitter and receiver frequencies.

You should make sure you test over the appropriate bands, sweeping the

frequency dial across the band while watching the Match Efficiency (SWR) reading. The Match Efficiency should not drop below 96% over the band (SWR should not rise over 1.5).

SPECIAL INSTRUCTIONS FOR HF AND VHF LOW-BAND RADIO INSTALLERS

As compared to UHF antennas, HF and VHF antennas are relatively narrow band devices. Depending on the element lengths, these may have high "Q" matching coils built into them as well as complex matching circuits that limit the usable bandwidth to a few tenths of a Megahertz. It then becomes extremely critical to either cut the radiator (element) to the correct length or adjust the tuning controls to the precise tuning points for optimum performance. By following the antenna manufacturer's procedures with the MATCHBOX you will be able to reduce your antenna installation time and obtain optimum performance.

The MATCHBOX will allow you to sweep the frequencies the antenna is to operate over and quickly tune the antenna. Where you typically use a directional wattmeter to tune an antenna for a multichannel transceiver you may have difficulty finding the best setup for the antenna. Worse yet, if you have to trim the antenna element you may cut it too short (Oops!), in which case you will need a new element.

In an example of a 30 MHz base loaded coil antenna, the manufacturer's adjustment procedure calls for the whip element to be cut 29 inches long for 30 MHz. The transceiver operates on 30.78, 30.88, 30.98, and 31.18 MHz. Upon cutting and installing the element, you find the transceiver only works on the lowest frequency. Using the MATCHBOX, you can see as you sweep through the frequencies (Figure 1) that the Match Efficiency falls off at the higher frequency.

As indicated by the dashed lines representing the maximum and minimum transceiver frequency, the Match Efficiency is only 92% at 31.18 MHz, but it appears that close to 100% Match Efficiency could be obtained between 29.8 to 30.2 MHz. Rechecking the antenna element cutting chart it appears we should cut the element to 28.5 inches for 30.93 MHz (center frequency) for the optimum match. After reinstalling the element in the antenna base and measuring the performance with the MATCHBOX, you will see a response similar to that shown below (Figure

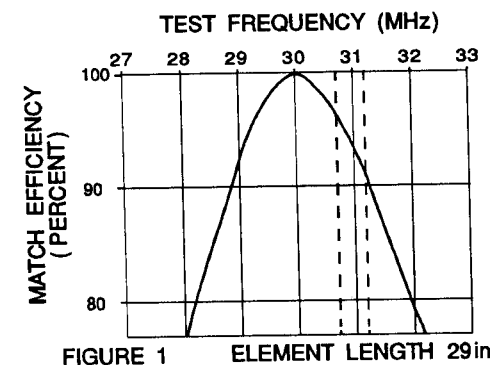
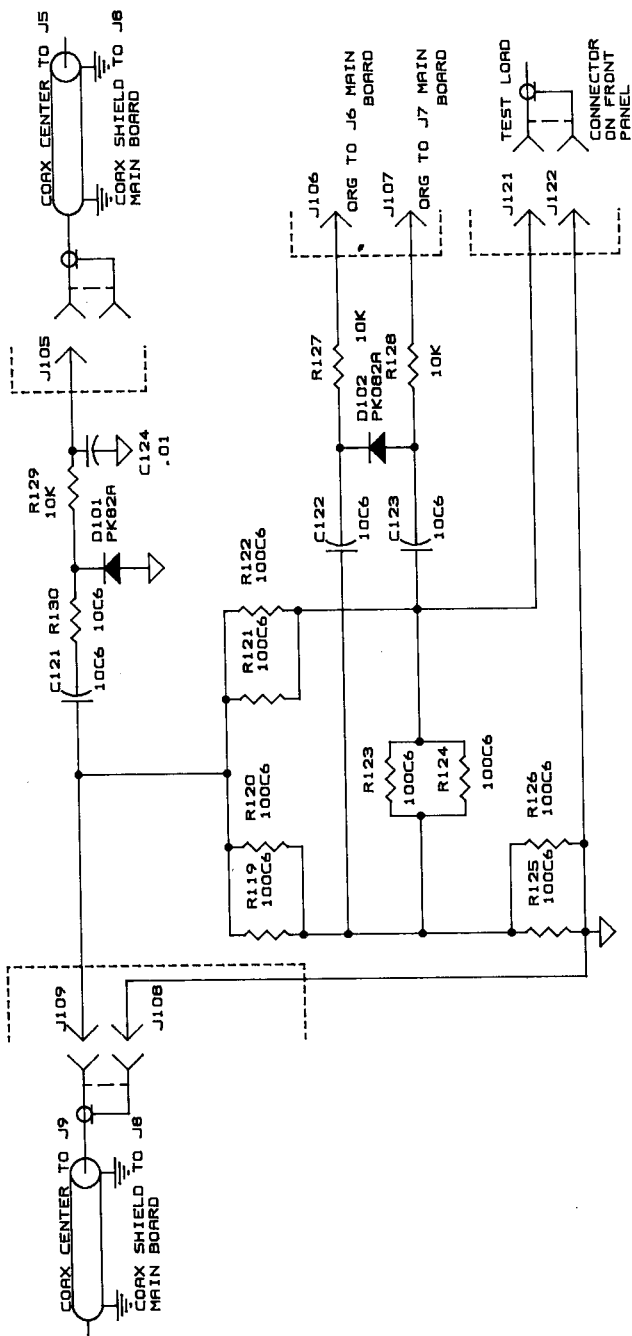


FIGURE 1 ELEMENT LENGTH 29in



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Title

MB500 BRIDGE CIRCUIT BOARD

Size Document Number

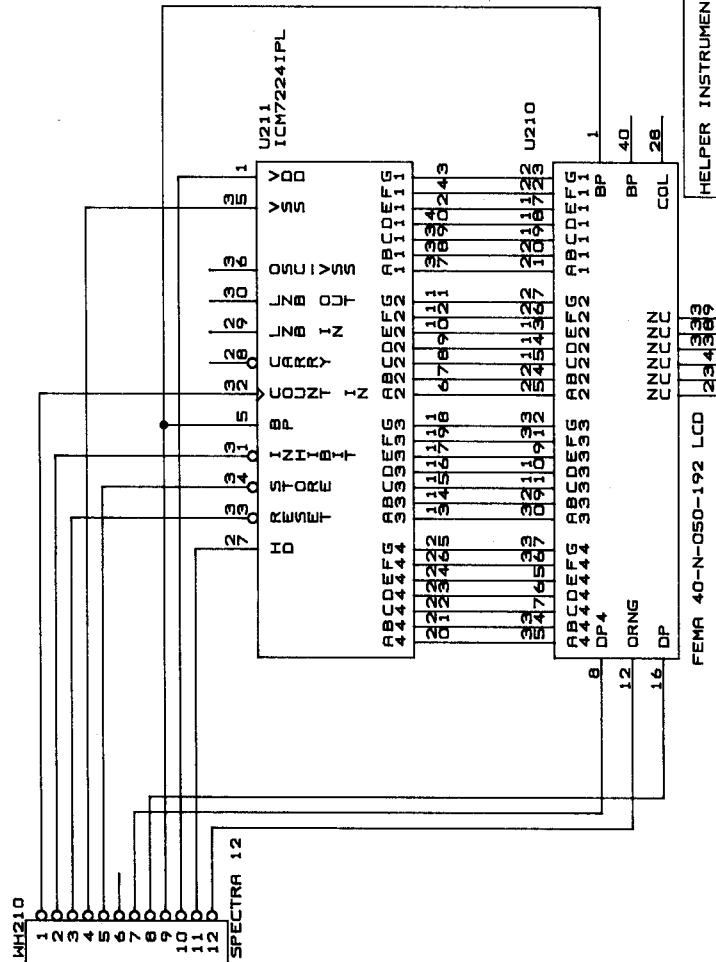
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Date! November 6, 1991 Sheet 1 of 1

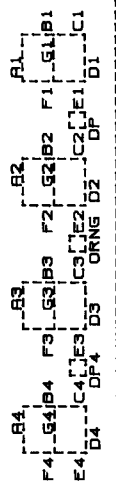
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LCD DISP 4 DIGITS



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Title

LCD DISPLAY BOARD MB500 MBDISBDN.SCH

Size Document Number

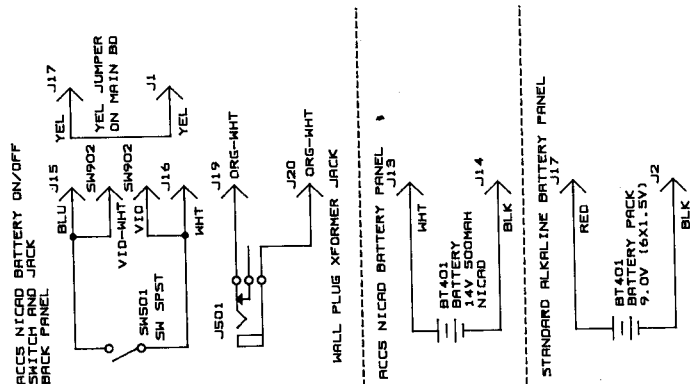
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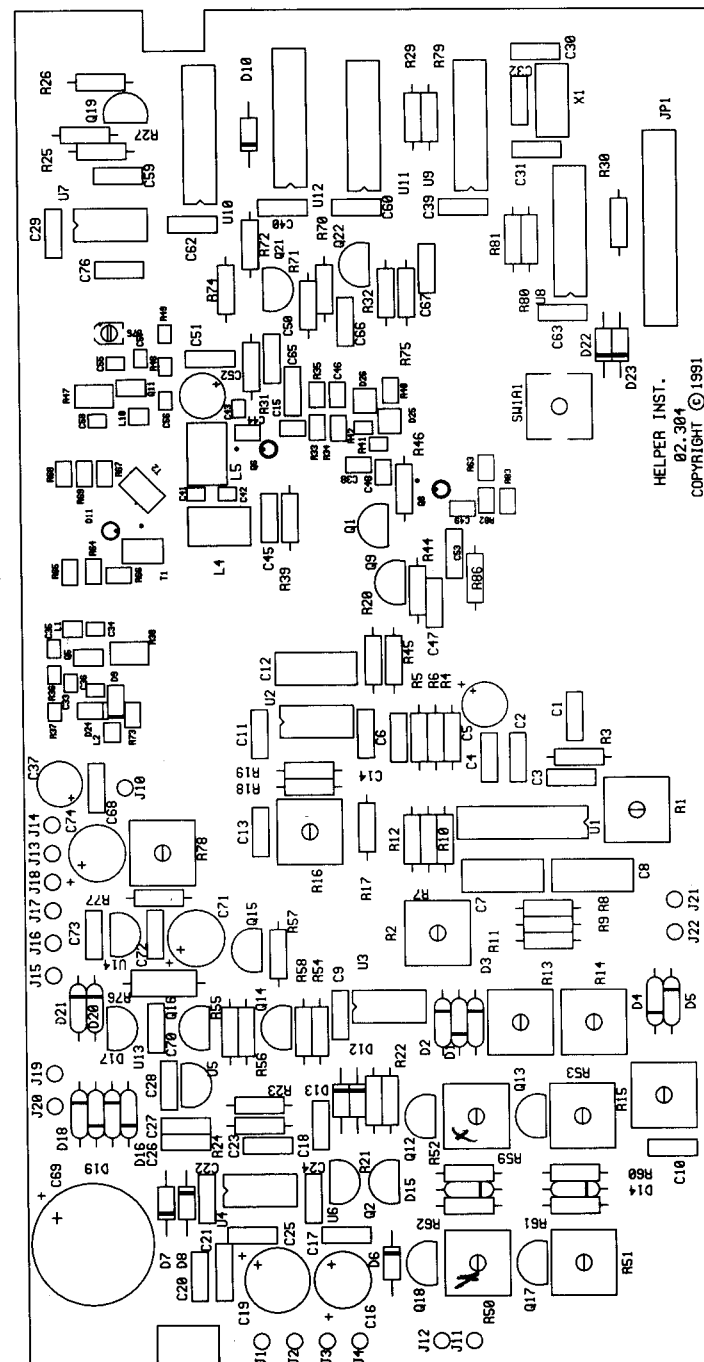
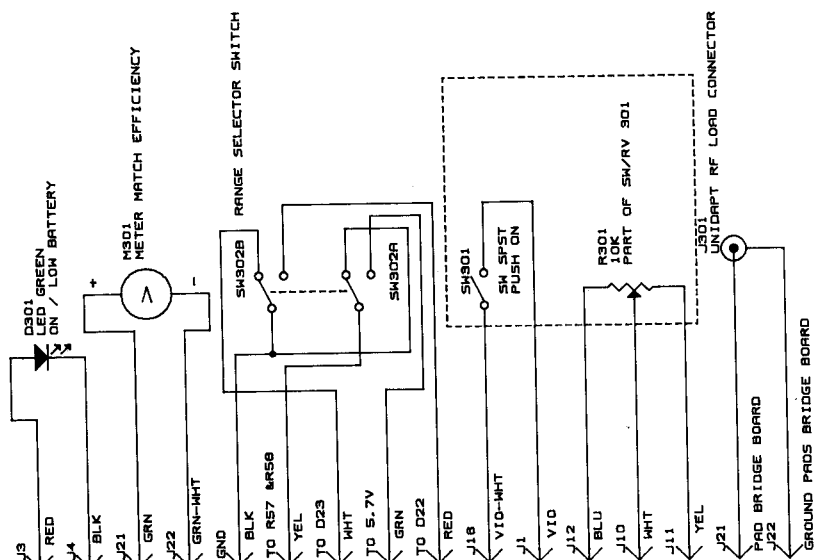


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MB500 PANELS-FRONT-BACK-BATTERY MB500PNL.SCH

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Date: November 6, 1991 Sheet 1 of 1



2). The Match Efficiency is 98% at the transceiver's highest and lowest frequencies.

If your antenna requires element cutting, remember that the longer the element the lower the frequency. If you cut an element too short the operating frequency will be higher than the desired frequency of operation and a new element will be required for your application. It is wise to cut your elements a little long until you become familiar with a particular brand of antenna.

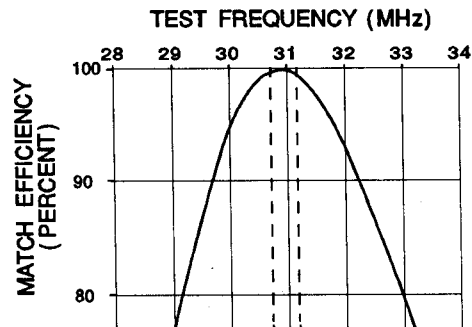


FIGURE 2 ELEMENT LENGTH 28.5 in

Some transceiver equipment is designed with high "Q" output circuits that may interact with high "Q" antennas in a way that causes the antenna tuning to vary from the supplied data. Although this is rare, occasions may occur where this interaction will cause the transceiver not to load properly into the antenna when it is adjusted into a 50 ohm source such as the MATCHBOX. Consult the antenna and transceiver manufacturer for special cutting charts or adjustment procedures if this occurs.

GENERAL INSTRUCTIONS TO INSTALLERS

In most installation shops, you will be installing several of the same brand and model of antenna. Be alert for variations from one to another. An antenna that measures "different", but still within specs, should be inspected carefully.

Remember the purpose of these tests. Simply making a radio call to check out your installation is not sufficient. Your shop may be favorably located with respect to a base station and the call could come through even with a very poor antenna. However, when your customer gets on the road to use his radio telephone, he may miss calls and have noisy reception. A few minutes of checking with the MATCHBOX gives you assurance that the antenna is in good shape.

MATCH EFFICIENCY VERSUS SWR

Match Efficiency and SWR are two different ways of stating how well the antenna matches to standard 50 ohm output of transceivers. Either one can be used. We suggest that technicians start using the Match Efficiency method. A Match Efficiency of 75% tells you that 75% of the power from the transmitter is being utilized and that 25% is being returned and wasted. 75% Match Efficiency happens to be the same as an SWR of 3, but the SWR number isn't as meaningful in telling you how good (or bad) the match is.

We suggest you get acquainted with using Match Efficiency instead of SWR.

ABOUT ACCURACY

Match Efficiency readings between 90% and 100% are accurate to 2%. For Match Efficiency readings between 90% and 55% the accuracy decreases from 2% to 5% in a linear manner. The best accuracy is obtained at a 100% Match Efficiency. This represents a 50 ohm load, and for most antennas, the desired load the radios should be matched to.

To check the load accuracy of the MATCHBOX you should use a calibrated 50 ohm load. You may use a 50 ohm load or a 20 dB attenuator for a general check of the MATCHBOX's operating accuracy. (Be sure the loads you use are intended for use up to 1000 MHz.) With such a load or pad connected to the antenna port, the Match Efficiency should read 98% to 100% on the MATCHBOX at all tuning frequencies.

For MATCHBOX calibration at loads other than 50 ohms, check with the factory for a complete calibration kit that is available for sale as an accessory to the MATCHBOX line of antenna testers (MBACC2).

Frequency is indicated by a digital meter that is controlled by a frequency counter. Frequency errors will not exceed plus or minus one count of the right-hand digit displayed.

Do not attempt to confirm the frequency accuracy by connecting a counter to the antenna port of the MATCHBOX. The signal at this port is chopped and the counter will read approximately 1/2 of the actual value of the test signal. Also, some counters may respond erratically to the chopped signal.

If you wish to confirm the accuracy of the test signal counter, you can open the MATCHBOX 500 and connect an external frequency counter. For high range frequencies, connect your frequency counter to pin 5 of U7 (UPB572). The frequency you will measure at this point is 1/20th of the test signal frequency. Get your calculator out. Multiply the frequency on your external counter by 20 and compare the product with the reading on the MATCHBOX counter. The reading should be within plus or minus one count of the least significant digit of the frequency counted. For low range frequencies, connect your counter to pin 5 of U11A (74F74). The frequency you will measure at this point is directly displayed on the MB500 LCD display. Use a high impedance input to your counter or it could load the internal circuits of your MB500 and cause the display to blank.

ABOUT BATTERY LIFE

The MATCHBOX Line uses six Alkaline "C" cells to power the circuits. Combined with the Push ON/FREQUENCY control which connects the batteries only when the instrument is testing antennas, MATCHBOX will provide many months of service in normal shop environments. When the battery voltage falls below 8.6 VDC, the LED lamp on the front panel will no longer light and it is time to replace the batteries. It is wise to replace the batteries on a yearly basis if your usage of the instrument is light.

For MATCHBOX users who have heavy usage, check with the factory for rechargeable battery packs and wall plug power supply accessories (MBACC5).

MBACC5 12V NICAD BATTERY ACCESSORY

The MBACC5 for the MB500 is a factory installed only accessory. The accessory replaces the "C" cells with a NICAD battery pack and adds a charging circuit for a wall plug transformer to both power the unit and charge the battery. Also included is a switch on the back panel that turns the unit on or off, eliminating the need to push the frequency set control to operate the unit. MBACC5 is a factory installed accessory and should be ordered when the MB500 is ordered.

LIMITED FREQUENCY RANGE

The user may decide to use a smaller range of frequencies than the MB500 is provided with. The low range 2 to 90 MHz is factory set to 10 to 90MHz. You may limit the range from 30 to 50 MHz by adjusting the range end set controls. For the low range R52 adjusts the highest frequency and R50 adjusts the lowest frequency. Since the controls interact, the readjusting of these two controls will be necessary until the desired range is achieved. The high range is factory adjusted from 80 to 550 MHz. To limit the high range adjust R53 for the highest frequency in the range you desire and R51 for the lowest frequency in the range you desire. Since the controls are interactive multiple readjustments will be necessary.



WARRANTY

Helper Instruments Company warrants this test instrument to be free of defects in materials and workmanship for a period of one year from the date of purchase.

Helper Instruments will repair or replace, at their option, any defective instrument which is returned freight prepaid, unless the defect has been caused by obvious abuse, or misuse of the instrument.

In no event shall Helper Instruments Company's liability under this warranty exceed the cost of repairing or replacing such defective instrument, and under no circumstances shall Helper Instruments Company be liable for consequential damages.

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