MDC

MICROWAVE DOWNCONVERTER FOR THE

OSCOR™
OMNI SPECTRAL CORRELATOR

MDC-900
MDC-2100

OWNER'S GUIDE

VER 3.0

RESEARCH ELECTRONICS INTERNATIONAL LLC

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Introduction

The OSCOR Microwave Downconverter option (MDC-2100) expands the OSCOR's frequency range limit to 21GHz. The MDC-900 extends the OSCOR's range to only 9 GHz. **NOTE:** Throughout this manual, whenever the MDC-2100 is discussed please remember that the MDC-900 only covers Band 1, or 3-9 GHz.

Microwave signals tend to be directional, therefore the MDC-2100 features an array of high gain directional antennas. The MDC is compatible with the OPC interface and the OTL locator options. It can function in the sweep, analyze and correlation modes and includes a tripod, which provides the stability needed to securely point the Downconverter antennas and a swivel neck for easy positioning.

Figure 1 MDC-2100 MICROWAVE DOWNCONVERTER

Since the range of frequencies at this level is so broad, it would take an excessive amount of time to view the entire spectrum, therefore, a special folding process is implemented to increase the scanning speed. This process folds the spectrum from 3-21GHz into a 1.5GHz window. While this process may seem confusing, it greatly facilitates the ability to cover a broad frequency range in a timely process and maintain the ability to accurately determine the frequency of the transmitted signal. **Figure 2** below illustrates the down-conversion process.

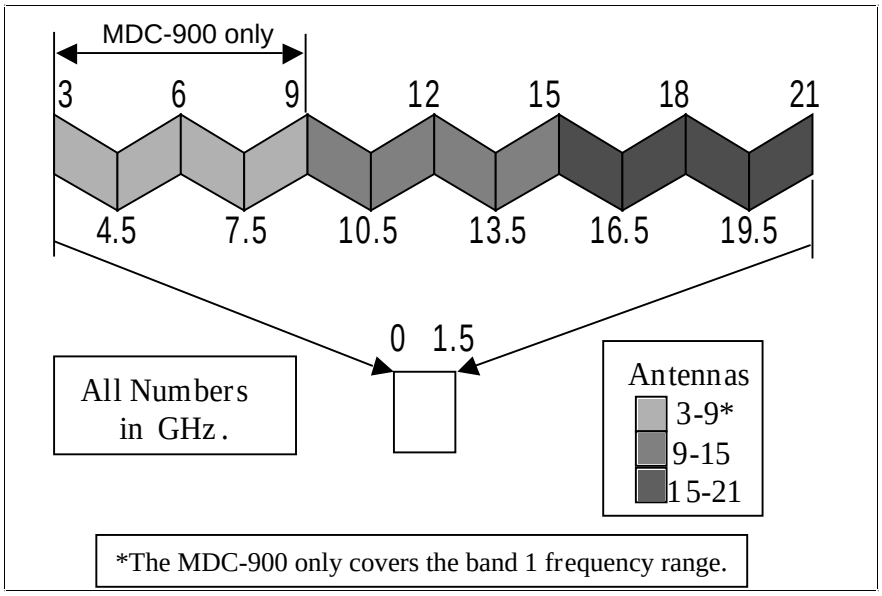

Figure 2 ILLUSTRATION OF THE MDC-2100 DOWNCONVERSION PROCESS

The range between 3-21GHz displays all twelve 1.5GHz windows simultaneously, or the spectrum may be separated into the three antenna frequency bands: 3-9GHz, 9-15GHz, or 15-21GHz with each antenna displaying four 1.5GHz MHz windows simultaneously. Note: the MDC-900 only has a single antenna and covers the band from 3 to 9 GHz. Furthermore, built-in microwave filters can reduce the display even further. These filters are referred to as Filter A and Filter B. The Identify feature allows for the final determination of a single frequency. Below is a chart representing the display of the frequencies in response to the selected antenna and microwave filter. Understanding **Figure 3** is critical to understanding the OSCOR operations using the MDC-2100 and MDC-900.

Note: The OSCOR display always shows the various 1.5GHz windows super-imposed on each other.

ANTENNA BAND	Filter A	Filter B	Filter A & B	
3 – 9 GHz	4.5 - 6 6 - 7.5	3 - 4.5 7.5 - 9	4.5 - 6 6 - 7.5	3 - 4.5 7.5 - 9
9 – 15 GHz **(MDC-2100 only)**	10.5 - 12 12 - 13.5	9 - 10.5 13.5 - 15	10.5 - 12 12 - 13.5	9 - 10.5 13.5 - 15
15 – 21 GHz **(MDC-2100 only)**	16.5 - 18 18 - 19.5	15 - 16.5 19.5 - 21	16.5 - 18 18 - 19.5	15 - 16.5 19.5 - 21

Figure 3 OPERATIONAL FREQUENCY BANDS

Installing the MDC-2100/MDC-900

In order to use the MDC-2100 with the OSCOR, a special connector (the OEP-2100) must be installed in the connector tray of the OSCOR. This connector should be installed permanently into the connector tray and provides for easy connection of the MDC-2100 while not affecting the OSCOR normal operation. Note the step numbers on the figure below to assist in the installation.

To install the OEP-2100 connector for use with the MDC:

1. *Remove the OEP connector from the MDC packaging and insert the male mini-din connector into the expansion port of the OSCOR as shown in the figure. (It may be necessary to unplug the two tape recorder cables labeled REMOTE OUT RECORDER).*
2. *Insert the black metal support into the connector tray. (The cables that provide connection to the tape recorder controls must be placed under the black metal support.)*
3. *Use the provided hex wrench (Alan wrench) to tighten the two hex screws into place. (This is what holds the OEP into position.)*
4. *Unplug the UF/UHF BNC connector and plug it into the OEP at the properly labeled jack.*
5. *Plug the OEP BNC cable into the OSCOR HF/UHF input.*

To install the MDC-2100 and MDC-900:

1. *Plug the MDC BNC connector into OEP BNC jack.*
2. *Plug MDC mini-din connector into the jack labeled MDC POWER/CTRL.*
3. *Utilize the OSCOR keypad for function control of the MDC-2100.*

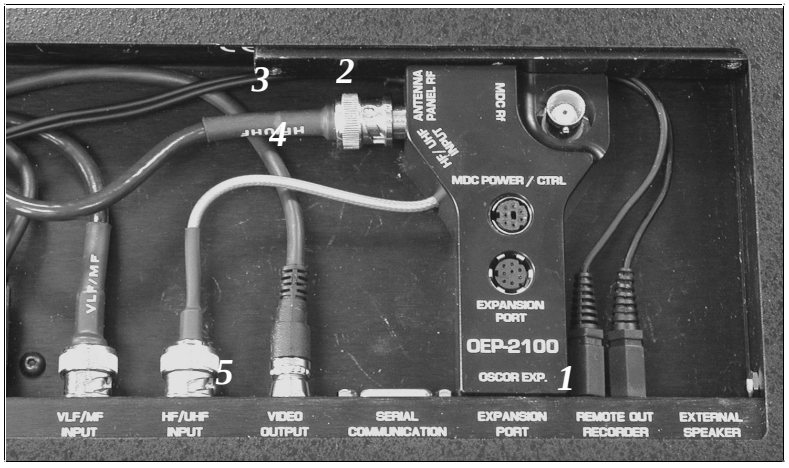

Figure 4 INSTALLATION OF THE OEP

The MDC-2100 can be used in a stationary position sitting on the provided tripod or it can be moved around the environment to provide a thorough sweep of the area. For proper operation, the MDC-2100 should be located at least three feet away from the OSCOR.

OSCOR Operational Control of the MDC-2100/MDC-900

Operational control of the MDC-2100 is provided by the OSCOR keypad using the normal OSCOR functional control. For example, in the OSCOR SWEEP or ANALYZE modes, pressing the **F1** button will toggle through all of the OSCOR inputs including the MDC-2100 frequency bands. Furthermore, in the SWEEP mode, pressing the **RECALL** button will display the OSCOR available inputs including the MDC inputs. Some of the other normal OSCOR functions that are impacted by the MDC-2100 are described below.

- *F1, "Input", press and repeat until "3-9GHz" is displayed in the lower left.*
- *Press "Shift" (Data Functions) and "Expand" (Control) for a full span.*
- *F1, "Show All", press once to select "Show All". Use the Control wheel to move the arrow to any signal you wish to analyze.*
- *Press "Narrow" (Control) 2 or 3 times.*
- *Press "Sweep/Analyze" (Control) to select "Analyze".*
- *Reposition arrow over signal and press "Narrow" to center the signal.*
- *F4, "MDC Anlz", press once.*
- *F2, "3-9GHz", press to select 3-9GHz, 9-15GHz or 15-21GHz. Select the band with your signal.*
- *F3,"Fltr A & B", press to select Filter A or Filter B. Select the Filter with your signal.*
- *F4, "Identify", press once to identify the frequency. Note which way your signal moved. The two possible frequencies are displayed at top left. Press F4 a second time to return to the previous menu.*
- *MENU returns to the normal menu for the SWEEP and ANALYZE modes.*

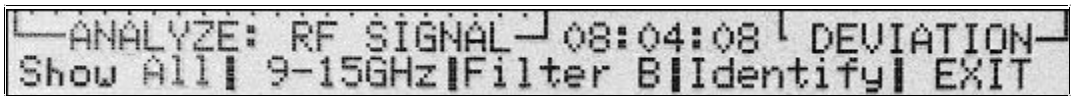

Figure 5 ANALYZING AN MDC SIGNAL

OSCOR Sweep and Analyze Modes with the MDC-2100/MDC-900

In the Sweep mode, the cursor frequency is no longer representative of a single frequency because of the folding principle described in the introduction of this manual. Therefore, when the entire frequency spectrum is displayed from 3 to 21 GHz (MDC-2100) or 3 to 9 GHz (MDC-900), only the local frequency is displayed for the cursor frequency. In this display, it is important to note that the OSCOR is in the MDC mode and not confuse this display with the normal RF/WhipH frequency display. Furthermore, when selecting a single antenna band as described by **Figure 3**, the cursor frequency represents 4 different possible frequencies, and when a specific filter is selected (A or B) then the cursor frequency represents 2 different possible frequencies. From the sweep mode, it is impossible to tell the exact frequency of the transmitted signal. Follow the sequence described in the previous paragraph to determine the exact transmitted frequency.

Furthermore, when rolling the cursor rotary dial back and forth, half of the numbers representing potential signal frequencies will be increasing while others will be decreasing. This again is due to the down-conversion process. Furthermore, often signals will have an odd shape due to the downconversion. In **Figure 6**, a signal is selected using the OSCOR NARROW button and the OSCOR rotary dial. This signal has a rather strange shape because of the folding process of the down-conversion, but it provides an excellent indicator for the proper signal downconversion. Hence, by pressing the F4 button to further analyze the signal, it is possible to analyze which antenna and filter that is actually receiving the signal. **Figure 7** shows the proper antenna selected and the proper filter selected which corrects the signal shape. Furthermore, the unusual signal shape of **Figure 6** indicates that this signal should be a Filter B signal.

In looking at the frequency span limits, these limits are always between 0 and 3GHz. This is because the OSCOR is a spectrum analyzer that covers the frequency range up to 3GHz, but the input frequencies of the down-converter cover 3 to 21 GHz (MDC-2100) or 3 to 9 GHz (MDC-900). Therefore, the cursor frequencies provide the possible signal frequencies while the span numbers (indicated at the top right and left of the display) provide the frequency span the OSCOR is actually viewing after the down-conversion process.

Technical Note: It is possible to have a very slight shift in frequency in the down-conversion process. In the example below, the signal shifted by about 50KHz. This a minimal shift considering the signal is at 10GHz.

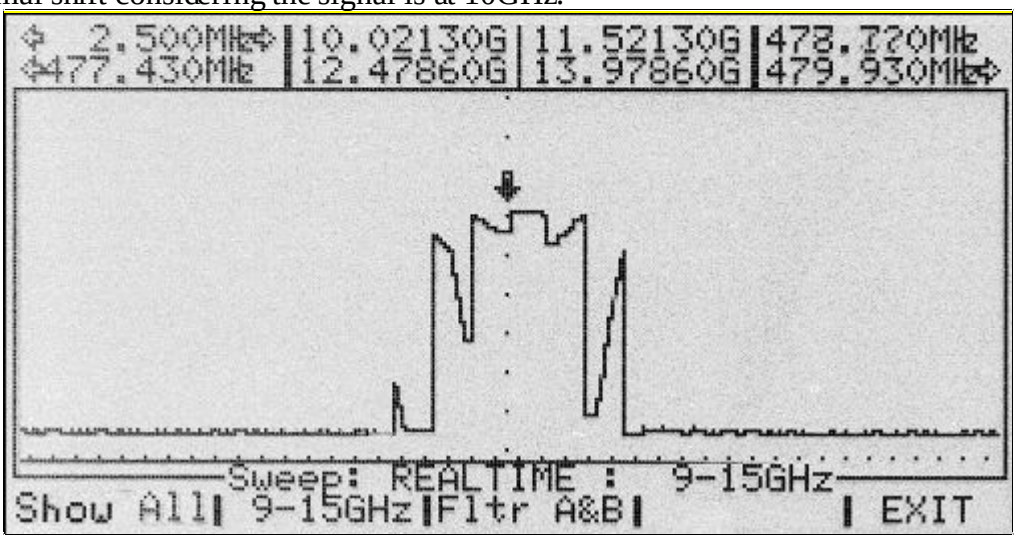

Figure 6 SELECTING A SIGNAL WITH THE MDC

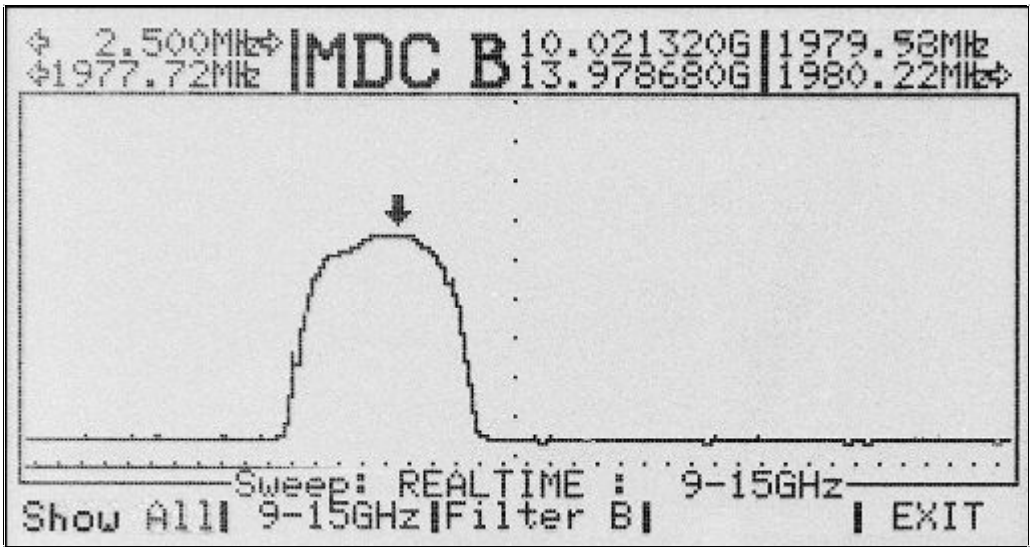

Figure 7 SELECTING THE PROPER MDC BAND AND FILTER

Special Considerations for Storing a Sweep Span with the MDC

Since the MDC down-conversion process displays multiple frequency bands at once, the easiest way to quickly view a specific frequency span is to type in a desired center frequency span and then use the EXPAND and NARROW keys to adjust the frequency span.

To store a specific frequency span:

1. *Ensure that the OSCOR is in the SWEEP mode and the MDC is connected.*
2. *Type in the desired center frequency between 3 and 21 GHz (or 3 and 9 GHz for the MDC-900).*
3. *Adjust the frequency span using the EXPAND and NARROW keys. (The span is noted by the number in the top left corner of the OSCOR display.)*
4. *Press the **STORE** button.*
5. *To review the stored spans, simply press the **RECALL** button from the SWEEP mode.*

There are some important aspects of storing spans that should be understood:

- If you store a specific frequency band in the MDC range (for example 5.6 to 5.8 GHz), the MDC will also simultaneously search a parallel frequency band (in the example it will also search from 6.2 to 6.4 GHz).
- You cannot store frequency spans that cross the 1.5 GHz cross-over points. See **Figures 2** and **3** for the 1.5GHz bands. Therefore, to search specifically from 4 to 6 GHz as an example, you may choose to search the 3 to 9 GHz antenna band with the Group A filter to cover the range from 4.5 to 6 GHz (See **Figure 3**). And then, store a range centered at 4.25 GHz with a 500 MHz span to cover from 4 to 4.5 GHz. However, the fastest and simplest method would be to simply cover the entire span from 3 to 9 GHz with both Group A & B filters selected.

- When storing a span in memory, the actual frequency limits are not displayed in the frequency span list. However, pressing the RECALL button will recall the span showing the stored frequency span.
- To summarize these effects:
  If you desire to cover a frequency span that is greater than 1.5GHz or crosses the antenna bands, the best approach is always to cover the entire antenna band that includes the desired frequency span. The table below provides some examples and recommended search span for speed and accuracy.

Example of a Desired Frequency Span	Recommended Implementation:
4 – 6 GHz	3 – 9 GHz
6 – 8 GHz	3 – 9 GHz
5.7 – 5.9 GHz	5.7 – 5.9 GHz
8 – 10 GHz	3 – 21 GHz
13 – 16 GHz	3 – 21 GHz

Figure 8 EXAMPLES OF STORING SPANS

Storing a Signal in the MDC Frequency Range

When a signal is stored in the OSCOR signal database, only the signal frequency is stored in OSCOR memory. However, when the OSCOR tunes to a specific signal in the MDC frequency band (3-21GHz) then the OSCOR automatically directs the MDC to the proper antenna band and filter group to maximize the signal to noise ratio and maximize the system performance. An example signal is shown below Figure 9.

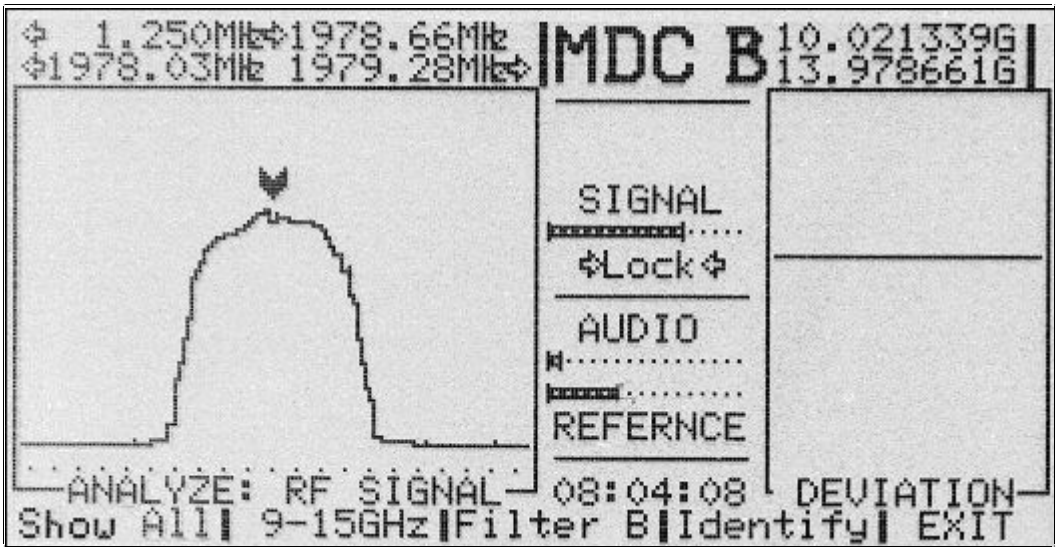

Figure 9 ANALYZE MODE USING THE MDC

Microwave Transmission Considerations for the MDC-2100/MDC-900

There are important principles and considerations to understand when dealing with very high frequency radiators.

- As the frequency increases, the penetration of the RF signal through building materials decreases rapidly. Therefore, most high frequency microwave signals are often considered to be a line-of-sight communication link. If you locate a microwave surveillance device, the receiving station will be in the direction of the transmission antenna.
- Also, as frequency increases, the size of the antenna used for transmission also decreases. Therefore, in order to penetrate through building materials and to transmit long distances, microwave transmissions are usually done using high-gain directional antennas.
- Reflections from metal structures in a building can greatly complicate the location and detection process. Furthermore, these reflections tend to de-polarize the transmitted signals rather quickly. The MDC antennas are linearly polarized, and some customers have had concerns that the polarization effect of the MDC antennas could cause the user to overlook a transmitter due to an incorrect polarization effect. However, our experience and testing indicate that this is not a problem because of the reflective nature of the metal structures in a normal building environment.

Because of the principles above, it is important to understand that to properly use the MDC, it is necessary to point the MDC-2100 in all directions of possible concern. It is advisable to move the MDC to different locations in the room. It has been suggested that because of the microwave reflections, it may be possible to completely cover a room by pointing the MDC directly at the ceiling. The concept is that due to the metal in most ceiling structures, there would be enough reflective effect to detect a transmitter from any location in the room. This method has some merits, but it is impossible to predict how reliable that it would be in all situations. Therefore, this method should only be used when it is absolutely necessary in order to save time. A good rule of thumb is to assume that the MDC has an antenna pattern that is about 100 degrees wide. In other words, it is necessary to point the MDC in at least 4 different directions around the room to cover the perimeter. Also, the MDC should be pointed up and possibly moved around the room to cover the ceiling, and down to cover the floor. Furthermore, if you expect a very sophisticated threat, it is recommended to point the MDC into duct work, above ceiling tiles, and in any enclosed spaces in which it would be possible to place a transmitter with a high gain antenna. At each position that the MDC is placed, it is necessary to allow the OSCOR time to sweep the entire frequency spectrum from 3 to 21GHz. For this case, it is highly recommended that the "Show All" mode of operation for the MDC-2100 be utilized. When a signal is detected, the user can then manually select the different antenna bands and filters to further investigate the signal. Or, the user can simply go to the analyze mode and allow the MDC to determine the operational frequency of the transmitter. Also, it is not recommended to use the MDC with the OSCOR automatic mode unless the MDC directional characteristics are taken into consideration. Also when running the OSCOR and MDC in the automatic mode, it is recommended to search the entire frequency span with both A&B filter selected as previously described.

Using the MTU-2100 Microwave Test Unit

The MTU-2100 is designed to provide a simple test to verify that the MDC is working properly. When the button is pressed on the MTU, low power signals are generated at about 6, 12, and 18 GHz for 3 minutes. Each transmitted signal contains a modulated tone between 900Hz and 1KHz to verify that the signal is radiating from the MTU-2100. It is important to note that the frequency transmissions from the MTU may drift slightly. It should also be noted that the MTU test transmitter and the MDC down-converter both have polarized antennas. When using the MDC in a room environment, the polarization is often not of great concern because of the depolarizing effect that occurs from reflections from the room structure. However, when verifying proper operation of the MDC using the MTU at a close proximity, the polarization of the antennas is important. To achieve the proper polarization with the high gain antennas of the MDC, the following positioning should be utilized.

1. 3 – 9 GHz band: MTU and MDC should be both horizontally oriented.
2. 9 – 15 GHz band: MTU and MDC should be perpendicularly oriented.
3. 15 –21 GHz band: MTU and MDC should be perpendicularly oriented.

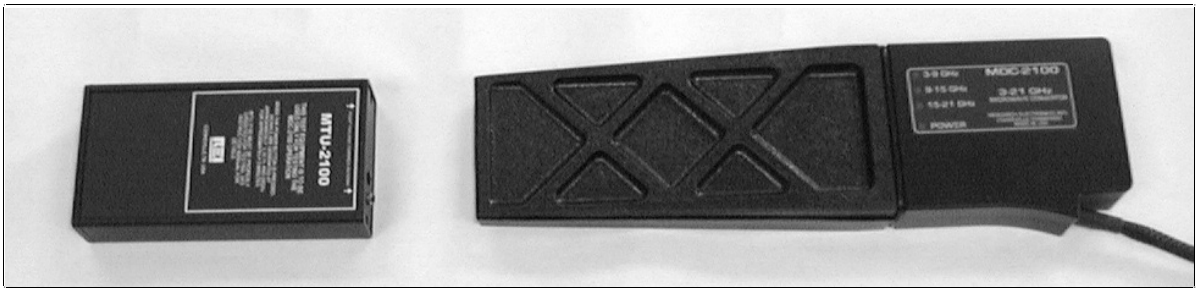

Figure 10 PROPER MTU ORIENTATION FOR TESTING BAND 1 (3-9GHZ) AND MDC-900

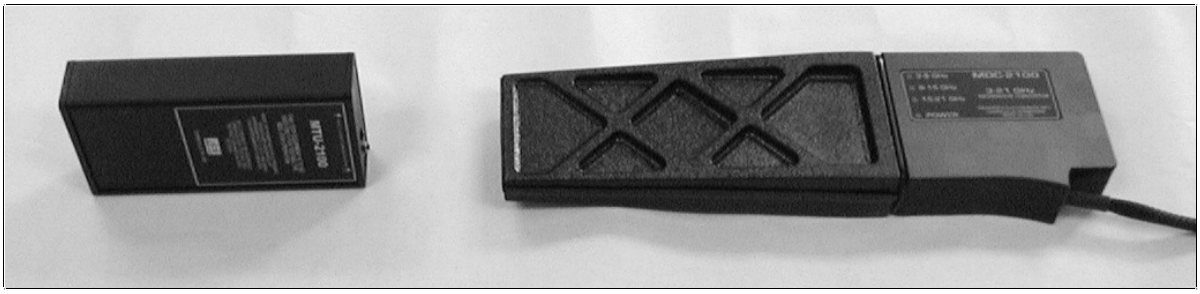

Figure 11 PROPER MTU ORIENTATION FOR TESTING BAND 2&3 (9-21GHZ) FOR MDC-2100 ONLY

Since the MDC is a very sensitive receiving device, it is very possible for the MDC to detect sub-harmonics from the MTU. In other words, when using the MTU, additional signals may appear at frequencies other than the main signals of 6, 12, and 18 GHz. The best way to determine if a signal is being radiated from the MTU is to move the MTU away from the MDC and see if the signal disappears or go the analyze mode in the OSCOR and listen for the modulated tone from the MTU. All signals from the MTU will contain the modulated tone.

MDC-2100/MDC-900 SPECIFICATIONS

Specifications	MDC-2100	MDC-900
Frequency Range:	3-21GHz	3-9 GHz
Conversion output:	5MHz to 3005MHz	5MHz to 3005MHz
Frequency Bands of Operation:	Band 1: 3-9GHz Band 2: 9-15GHz Band 3: 15-21GHz Show All: 3-21GHz	Band 1: 3-9GHz
Antenna Gain:	Band 1: 10 dB Band 2: 9 dB Band 3: 9 dB	Band 1: 10 dB
MDS - Minimum Detectable Signal including receiver sensitivity, antenna gain, and filtering losses:	Band 1: -110 dBm Band 2: -110 dBm Band 3: -110 dBm	Band 1: -110 dBm
Input Power:	300 milliamps at 12 volts	150 milliamps at 12 volts

All models

Weight:	1.4 lb	.635 Kg
Dim:	11.4 x 3.1 x 1.4in	29 x 8 x 3.5 cm
Tripod:		
Weight:	.77 lb	.35 Kg
Dim:	8.75 x 2.5 x 1.5 in	22.2 x 6.4 x 3.8 cm
Usage Height:	5.5 in	14 cm
Case Dimensions:		
Size (HxWxD):	6.25 x 18.5 x 14.5 in	47 x 36.8 x 15.9 cm

RESEARCH ELECTRONICS INTERNATIONAL

Technical Bulletin

24 April 2002
For the MDC-900 and MDC-2100

This bulletin describes a calibration process to ensure the maximum technical performance for the MDC unit.

Technical Background:
Most Down-converter products contain a local oscillator (LO) reference signal that is utilized in the down-conversion process. While this LO frequency is vital to the down-conversion process, it also creates a blind spot in the frequency spectrum that cannot be analyzed. However, the MDC and OSCOR design addresses this technical problem. In order to ensure that there is not a blind spot at the LO frequency or any of it's harmonics (6GHz, 12GHz, 18GHz), the OSCOR automatically shifts the LO frequency as it is sweeping through the frequency range near the LO frequency. The ability to automatically shift the MDC LO frequency as commanded by the OSCOR is one of the primary reasons that the MDC units were designed only be used with the OSCOR. Other spectrum analyzers do not contain the intelligent functions to control this function and remove blind spots created by the LO. In order for this shifting process to be optimized, it is necessary to calibrate the OSCOR shift command with the physical characteristics of the MDC frequency shifting process. However, even if the calibration process is not performed, the probability for a random signal of 200KHz bandwidth to actually be located in a blind spot assuming a uniform random signal distribution is only 0.000167.

Calibration Process:
Follow these steps to calibrate the MDC unit to the particular OSCOR that it is being used with.

To calibrate an OSCOR to a specific MDC unit (The MDC does not need to be connected to the OSCOR):

1. Press SHIFT and the numbers 786.
2. Enter the number _____. (This number is unique to each MDC unit and must be obtained from REI.) This calibration number is to be used with MDC-900/MDC-2100 Serial Number _____. This calibrates the OSCOR for 6GHz. Enter _____ to calibrate for 12GHZ. Enter _____ to calibrate for 18GHz.
3. Press Shift and the numbers 788 to permanently store the calibration data in the OSCOR.

Note: This calibration data is permanently stored in the OSCOR Kernel. It will never need to be repeated even if the OSCOR program key is replaced. But, the calibration process can be repeated as often as desired. Also, if the MDC is used with another OSCOR, the calibration process must be repeated to ensure that the MDC and OSCOR are calibrated together.