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Technical Manual

FM Modminder

Modulation Monitor

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Dear ModMinder Customer,

Congratulations! You have just purchased a ModMinder – the UNProcessor. Using the ModMinder to measure your modulation, you will:

- Enjoy phenomenal measurement accuracy with digital technology
- Increase modulation by 1 to 4 dB
- Use less processing
- Operate from conventional remote control
- Connect to a personal computer for extended functions

But before you do... take a moment to fill out the product registration card. Without it, we cannot let you know when new firmware is available, so you can take advantage of new features as they are made available.

If you have questions which this manual does not answer, please give us a call at our toll free number (800-826-2603).

We hope ModMinder does good things for your station.

FIRST THINGS

HERE IS YOUR MODULATION SCIENCES FM ModMinder. PLEASE FOLLOW THE UNPACKING INSTRUCTIONS BELOW.

- UNPACK THE UNIT AND SAVE ALL PACKAGING MATERIALS. YOU MAY NEED THEM LATER TO SHIP OR MOVE THE ModMinder.
- INSPECT THE UNIT(S) FOR ANY SIGN OF DAMAGE.
- IF YOU FIND ANY DAMAGE, REPORT IT IMMEDIATELY TO BOTH THE CARRIER AND TO MODULATION SCIENCES.
- IF THE ModMinder IS UNDAMAGED, FILL OUT THE REGISTRATION CARD YOU WILL FIND INSIDE THE FRONT COVER OF THIS MANUAL AND RETURN IT TO MODULATION SCIENCES.

FM ModMinder DeMod Board

Quick Set up Instructions

Before installing the ModMinder, first plug in its AC power cord and let it warm up for at least 15 minutes. Connect a 50-ohm coaxial cable from a sample port on your transmitter or antenna feedline to the RF input on the ModMinder rear panel. The signal should be greater than 10 milliwatts and less than 1 watt.

Unplug the ModMinder power cord for at least 3 seconds, then reconnect it. While the front panel LEDs flash, (the ModMinder is performing self-tests) press the THRESHOLD button.

The ModMinder displays should show HI 1. When you see this display, press the UP button three times. The ModMinder will perform more self-tests. When the right display reaches 12, press the THRESHOLD button. When test 13 has completed, press THRESHOLD repeatedly until 98 appears in the left display and 10 appears in the right display, indication 98.1 MHz.

Use the UP and DOWN buttons to set the demodulation to your carrier frequency. When you are done, press THRESHOLD to check the RF level. Indications are as follows:

rf LO	:RF level is too low to operate ModMinder.
rf 1	:RF level is marginal, it must be increased by at least 3dB
rf 2	:RF level is correct. (20 to 800 milliwatts)
rf 3	:RF level is marginally high, it should be reduced at least 1 dB, to less than 800 milliwatts.
rf HI	:RF level is too high. Disconnect the RF input immediately to avoid damaging the ModMinder.

When the display shows rf 2, press the THRESHOLD button to begin normal operation of the ModMinder.

Introduction

What is ModMinder?

ModMinder is an advanced and highly accurate digital device for measuring and displaying peak FM deviation. Using ModMinder's new techniques, most FM stations can increase modulation, reduce signal processing, or do some of both. ModMinder processes modulation information digitally using an 80C88 microprocessor.

What does it do?

ModMinder provides a comprehensive front panel display of modulation information, as well as extensive remote control capability. Interface to a conventional broadcast remote control is provided by relay contacts and slowly varying DC signals. In addition, expanded capability and a completely new type of remote control is provided by ModMinder's serial data circuit.

Personal Computer Interface

The power of a personal computer to analyze information can be added to the ModMinder's impressive data collecting ability to let you create a statistical picture to see your station's modulation in a new way.

ModMinder can be connected locally or, using an inexpensive 1200 baud modem, over phone lines to a computer. All functions of the ModMinder can be remoted to any location – the studio, the home, office, even across the country.

Information about modulation never before available, except in a laboratory, is now available operationally. Peak modulation data is provided every 20 milliseconds over a serial data circuit. A full description of the data format is given later in this manual so anyone can write software to analyze modulation. In addition, a program is provided free with the ModMinder to display and analyze modulation on any IBM compatible computer. Additional programs are available to further extend the analysis capability of ModMinder.

How well does it work?

ModMinder is highly accurate. Typical monitors have an accuracy of ±5.0%. Their Resolution is no better than an operator's ability to read a moving pointer meter. ModMinder delivers an accuracy of ±1.0%, and a digital resolution of 0.5%.

But is it legal?

In a word, yes.

ModMinder is probably the first modulation monitor to take advantage of the deregulation of monitors that took place in 1983. ModMinder delivers technical improvements that the FCC hoped for. The FCC Report and Order that explained the deregulation took pains to say that a major reason for deregulating monitors was to encourage "…new and better measurement methods."

ModMinder provides a slightly less than one millisecond peak flasher response time which complies with 47 CFR 73.332 (d)(4)(i) and (ii) as of October 1982, the most recent objective statement from the FCC on modulation monitor performance. A ModMinder operating with this response time is said to be in "FCC Mode."

ModMinder allows for user selection of peak response time, either faster or slower than 1 millisecond. Any time faster than one millisecond would clearly fall under the rules, however response times longer than a millisecond should be approached with caution until more data is available.

"FCC Mode" Response Time

Conventional modulation monitors respond to peaks of less than 200 microseconds. But ModMinder waits almost 1000 microseconds (1 millisecond) before registering a peak. This delayed response means the ModMinder ignores brief overshoots that contain very little power. The more rapid response of ordinary monitors means these brief excursions are counted as modulation-robbing peaks. Because ModMinder ignores them, either the average modulation may be raised or the amount of processing greatly reduced. Often, doing some of each is most desirable. Typical improvements in modulation will range from 1 to 4 dB, depending on the amount and type of processing employed.

Serial Data

A bi-directional RS-232C port allows complete remote operation of the ModMinder as well as processing of modulation data by a computer.

Diagnostics

Whenever the ModMinder is powered up it automatically goes through a diagnostic routine, testing all LEDs, indicators, relays and analog outputs before normal operation begins.

Three other diagnostic modes allow more detailed testing. In Mode 1, relays and analog outputs can be exercised; Mode 2 allows any ASCII terminal (such as PC running a communications program) connected to the RS-232C port to control item-by-item diagnostic access; in Mode 3, fourteen diagnostics tests are performed on the analog circuitry and converters.

NIST Traceability

DeMod equipped ModMinders come with a certificate of calibration. This provides you with proof that the ModMinder is calibrated to its stated accuracy of (±1.0%) over the temperature range of 0° to 50° C. Its documented path exists between your instrument and the primary standards maintained by the National Institute of Standards and Technology (formerly known as the National Bureau of Standards), an agency of the United States Government.

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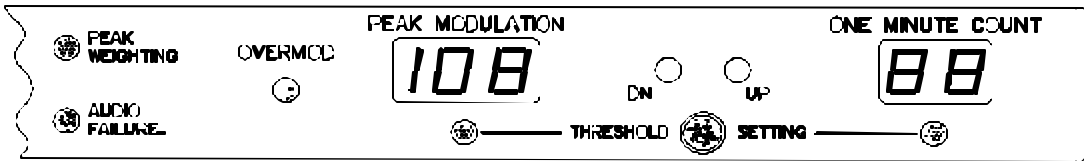
Controls and Displays



ModMinder FRONT PANEL

Front Panel Displays

Peak Modulation: A 3 digit display showing the highest modulation peak attained during the previous second.

This unique display eliminates the constant "tweaking" with the peak flasher control of a conventional monitor to find what the real peak modulation is. The PEAK MODULATION display is updated each second with the highest peak of modulation achieved in the previous second. The display is invaluable in setting up or verifying the performance of an air chain.

Percentage modulation is calculated internally in half percent increments. If the decimal point following the third digit is lit, the actual reading is 0.5% higher than the number in the display.

One Minute Count: The number of occurrences of overmodulation that have taken place in the past 60 seconds.

The count is displayed on a 2 digit numerical readout. If the preset limit for overmod occurrences is exceeded, the display flashes.

The one minute count display is a "rolling minute" counter. At any point, only the number of overmodulation events in the *immediately preceding minute* is shown. The counter works like this: at the moment when an overmod is detected, it is added to the counter, and held there for sixty seconds, after which it is removed from the counter. The counter continuously adds overmods as they occur and subtracts them as they age past one minute.

Overmod: This red LED lights each time the overmodulation limit is exceeded.

The shortest peak which is reported as an overmodulation event is 900 microseconds when in FCC mode. The minimum duration peak is user selectable in the PEAK WEIGHTING mode. Units are presently shipped with this response time set to 3 milliseconds.

Once triggered, the OVERMOD indicator will stay on for 0.25 seconds. An option can be set to hold the light on for 2.0 seconds. See the section on Options for a complete discussion of this.

Audio Failure: If program audio fails, this red LED will come on.

Any total loss of dynamic range will trigger this alarm. This is true whether the failure is silence, steady tone or steady noise.

Peak Weighting: This green LED indicates that the ModMinder is in Peak Weighting mode.

When lit, it indicates that the response time and standoff time parameters are in user-selected mode rather than using the factory setting of the pre-1983 FCC values (FCC mode).

Threshold Setting: These yellow LED's indicate that limits, rather than data, are being displayed.

The LED's are located under the PEAK MODULATION and ONE MINUTE COUNT displays. During Threshold Setting, they light to show that the present limit for that function is displayed, and may be changed.

Front Panel Controls

Threshold Setting: A multifunction control that:

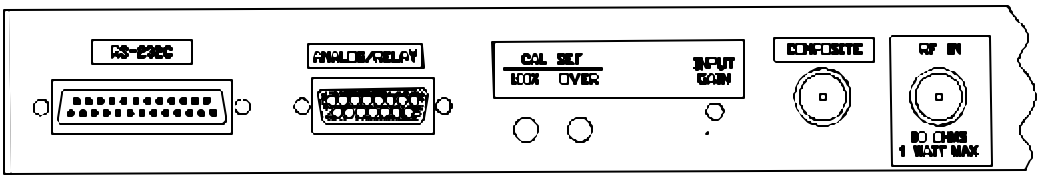
- Toggles each of the displays between showing parameter values and preset limits. When the preset limits are displayed, the yellow LED beneath the display is on. Viewing the ONE-MINUTE COUNT threshold automatically clears the one-minute counter.

- Allows setting the present threshold limits for peak modulation and the allowable overmodulation occurrences in a rolling minute.

- Puts the unit into Mode 2 or 3 diagnostics, when pressed during the self-test routine that starts on power up.

UP and DN: Push buttons recessed behind the front panel.

They are used in conjunction with the THRESHOLD SETTING mode, to set the preset limits for overmodulation and maximum counts per minute. In the diagnostic mode these buttons select various options, including RF carrier frequency.



ModMinder REAR PANEL

Rear Panel Displays

100% Indicator: Red and Green LED's located on the rear panel near the INPUT LEVEL adjustment.

These LED's are used during calibration to indicate the modulation level. The green LED is on when the PEAK MODULATION display is reading exactly 100%; the red indicator comes on at readings greater than 100%. (In measuring percentage modulation, 100% is 75 kHz deviation.) This allows the precise adjustment of the ModMinder without needing to read the PEAK MOUDLATION display while adjusting the INPUT LEVEL.

During normal operation with program material, the red LED will flash whenever 100% deviation is exceeded.

Rear Panel Controls

Input Level: A 20-turn trimmer potentiometer that sets the input sensitivity of the ModMinder. On units which include a DeMod board, this control is covered by a calibration seal.

During calibration of units without a DeMod board, it is used with the 100% INDICATOR to calibrate the unit.

Peak Weighting (ON/OFF): An option, selected from the front panel, selects the dynamic characteristics of the peak detector and the one-minute counter. With Peak Weighting OFF, the parameters fall within the specifications of 47 CFR 73.332(d)(4) as of October 1982. With this function switched ON, the dynamic parameters are set by user selected components.

Relay Outputs

Peak Flash: Closes for 0.25 or 2.0 seconds (option selectable) whenever the modulation exceeds the preset limit. Follows the action of the OVERMOD indicator on the front panel.

One-Minute Overcount: Closes whenever the one-minute count exceeds its preset limit. Remains closed for as long as the count is above the maximum. The ONE-MINUTE COUNT display flashes when this relay is closed.

Audio Fail: Closes if there is a program audio failure. Any absence of dynamic range, whether silence, steady noise, or steady tone will activate this relay and its associated indicator.

Analog Outputs

Local Meter: A fast DC output for driving a conventional moving pointer meter to provide a continuous indication of peak modulation. Uses a unique, easy to read ballistic. Any good quality one milliamp meter may be used.

One Second Peak Modulation: A DC voltage proportional to the highest peak attained in the previous second. The value is held for one second until it is updated with the new one second peak value.

One-Minute Rolling Count: A DC voltage proportional to the ratio of the number of occurrences of overmodulation to the counts per minute preset limit.

Analog Inputs

Composite Input: This BNC connector accepts a composite stereo signal from a wideband demodulator such as a modulation monitor. This input is not used if the DeMod board is installed.

RF Input: If the DeMod is installed, this BNC connector accepts a RF signal from the transmitter. Input impedance is 50 ohms, and level must be between 10 milliwatts (±10 dBm) and 1 watt (±30 dBm).

Digital Port

Serial Data: An RS-232C input and output port allows for complete remote operation of the ModMinder and analysis of modulation data by a computer.

The output is a data stream carrying real-time modulation information fast enough at 1200 bits/second to accurately drive a moving pointer meter. All other front panel information is embedded in the data stream.

The RS-232C input duplicates the front panel controls of the ModMinder. It is not necessary to use this input. The output can be used as a one-way data stream.

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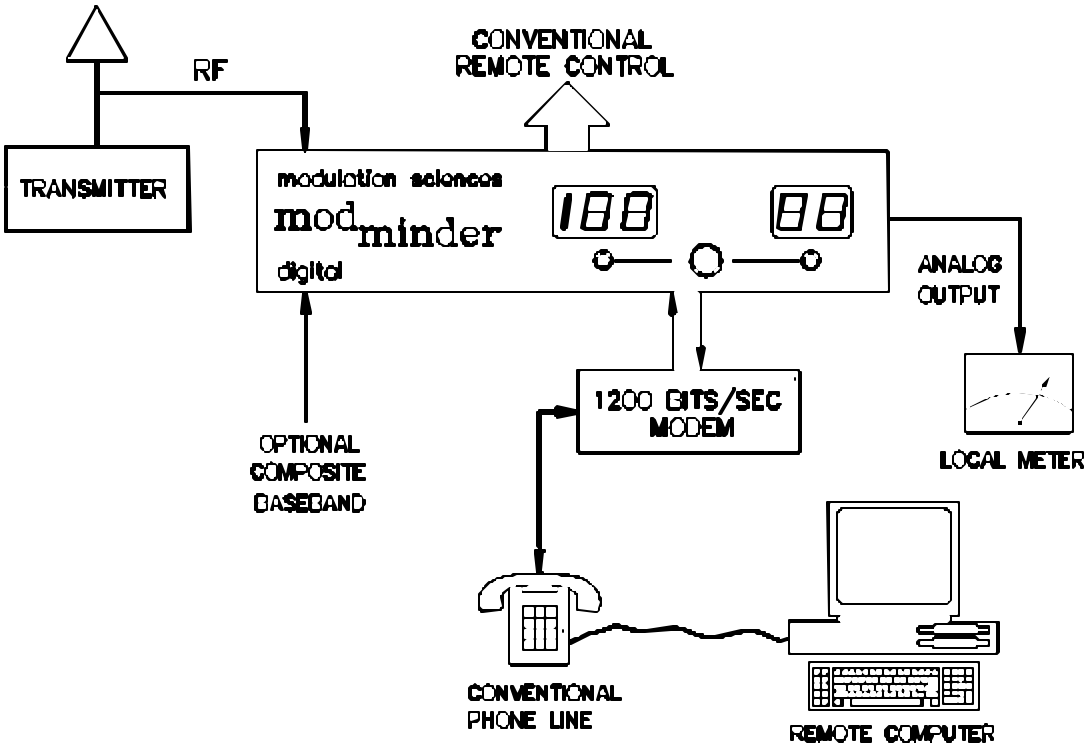
Location

The ModMinder should be located at the transmitter site. Often by doing so, several percent of additional modulation may be gained. This is because ANY multipath present in an off-the-air pickup will increase the apparent peak modulation of the signal, thus causing the modulation to be reduced unnecessarily.

When monitoring a signal off the air, many of the extraneous peaks added by multipath are very brief, less than one millisecond. ModMinder, when in FCC mode, will ignore these short peaks. So, although ModMinder is less accurate off the air than at the transmitter, it is more accurate than a conventional modulation monitor under the same circumstances.



TYPICAL ModMinder INSTALLATION

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Installation and Set-Up

The installation and set-up procedure for the ModMinder are different for units with a DeMod board than those without one.

When a DeMod board is installed, a new connector labeled RF INPUT is installed on the back panel, and the COMPOSITE input is disconnected. Units with a DeMod card are calibrated at the factory, and are shipped with a calibration seal over the INPUT control on the rear panel, and over several top cover screws. Breaking either of these seals voids the calibration certificate which Modulation Sciences supplies with each unit. This certificate shows the calibration to be traceable to NIST (formerly NBS), and is valid for two years.

Since the cover is sealed, all units with a DeMod board, and all units without a DeMod board shipped after March 1991, contain firmware version 1.4. This allows setting all options from the front panel. Frequency setting for all units with DeMod cards is also done from the front panel.

Set-Up of a ModMinder with a DeMod Board

Installing a ModMinder with a DeMod board is simplified by the fact that the calibration is done at the factory.

Before installing the ModMinder, first plug in its AC power cord, and let it warm up for at least 15 minutes. Connect a 50-ohm cable from a sample port on the transmitter or antenna feedline to the RF input on the rear panel.

Unplug the ModMinder power cord for at least 3 seconds then reconnect it. ModMinder will enter self-test mode (indicated by all front panel LED's and displays lighting for 2 seconds and then going out for 2 seconds). While the ModMinder is in self-test mode, press the THRESHOLD button.

When it completes its self-test, them ModMinder displays should show HI 1. When you see this display, press the UP button 3 times. ModMinder will begin execution of Mode 3 diagnostic tests. In this mode, the right display will show the test number, and the left display will show the test result. These tests will execute in sequence until a test fails, or until test 12 is reached.

If a test fails, the AUDIO FAIL indicator will come on, and the test sequence will stop with failing test number displayed on the right. Consult the DIAGNOSTICS section to determine the type of fault. A ModMinder which fails any of these tests must be repaired before use.

If the sequence has stopped at test 12, and the AUDIO FAIL indicator is not on, press the THRESHOLD button to execute test 13. When test 13 has completed, press THRESHOLD again to enter option setting mode.

The displays should show OP 10 or OP 11 (that is, the left display should show "OP" and the right display either "10" or "11"). In the right display, the first digit is the option number, and the second digit is the option setting, either 1 (on) or 0 (off). To change the option setting, press the UP button to turn the option on or the DN button to turn it off. To skip the next option, press the THRESHOLD button. A complete discussion of option setting can be found in the section on DIAGNOSTICS.

When option setting is completed, a unit with a DeMod board will enter frequency setting mode. The first display in frequency setting mode shows the carrier frequency in MHz. As shipped from the factory, frequency is set to 98.1 MHz. Both displays are used to display a single frequency setting. Frequency is changed in 100 kHz steps by pressing the UP or DN buttons. Holding a button down will cause the frequency to scroll up or down until the button is released. When the display show the correct frequency, press the THRESHOLD button to move to the next phase.

The display will next show RF input level, with the "rF" indicator in the left display, and a level indicator in the right window, as follows:

rf LO	RF level is too low to operate ModMinder.
rf 1	RF level is marginal, it must be increased by at least 3dB before ModMinder will operate properly.
rf 2	RF level is correct. (within the range of 20 to 800 milliwatts)
rf 3	RF level is marginally high. It must be reduced at least 1 dB, before ModMinder will operate properly.
rf HI	RF level is too high. Disconnect the RF input immediately, or the input attenuator may be damaged.

When the display shows rF 2, press the THRESHOLD button to start normal operation of the ModMinder. If you press the THRESHOLD button when the display does not show rF 2, the ModMinder will loop back to frequency setting mode. It is not possible to start normal operation of ModMinder until the RF level is correct.

Once the ModMinder enters normal operation, the RF input level must remain within the range of 10 milliwatts to 1 watt. If RF level goes outside of this range, ModMinder will stop operating, and the front panel displays will show either rF LO or rF HI. Normal operation will resume as soon as RF level is within this range.

Set-Up of a ModMinder Without a DeMod Board

To install a ModMinder without a DeMod board, first plug in its AC power cord, and let it warm up for at least fifteen minutes.

Connect the Composite Input of the ModMinder to the composite baseband output of your modulation monitor or other source of composite stereo. The ModMinder has a 10 kOhm input impedance.

The ModMinder will begin to read and display the modulation of the signal immediately. However, before the ModMinder can give you meaningful readings, it is necessary to calibrate the unit to 100% (75 kHz deviation) of your station's modulation.

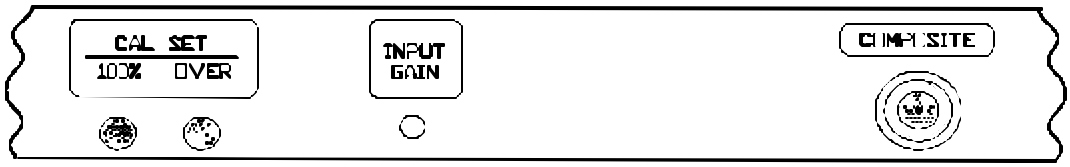
The accuracy of your ModMinder depends completely on how accurately you calibrate it. The inherent accuracy of the ModMinder is ±1.0%, with a resolution of ±0.5%. That is 3 to 5 times better than conventional monitors. However this increased accuracy is only usable if the ModMinder is adjusted to its demodulator with similar accuracy.

A documented, defensible calibration procedure is also important in any discussion of overmodulation with the FCC. If the FCC were to cite you for overmodulation when you were not getting any such indications from ModMinder, chances are the final outcome would hinge on the quality and frequency of calibration.

An accurate calibration is also needed to get the most out of ModMinder. You can not set the modulation any closer to the limit than the accuracy of its calibration permits. For example, if the monitor is calibrated to ±5.0%, then the highest modulation you can show is 95%.

Easy Calibration of ModMinder Without a DeMod Board.

The easiest way to set up ModMinder, assuming that a conventional modulation monitor is being used as the demodulator, is with the modulation monitor's own calibrator. All conventional monitors have some type of built-in calibrator to create a 100% reference. Such built-in calibrators are very convenient to use, but can ***not*** be counted on to be any more accurate than the instrument they are used to verify the calibration of. Typical conventional monitors have an accuracy of between ±3.0% to ±5.0 depending on the make and model. That is significantly worse than the ±1.0% of ModMinder.



ModMinder CALIBRATION CONTROLS

To set up ModMinder using the calibrator built into a modulation monitor, proceed as follows:

1. Connect the ModMinder to the composite output of the modulation monitor.

2. Turn on the monitor's calibrator.

3. Adjust the INPUT LEVEL control on the rear panel until the green LED on the rear panel is on and the red LED off. When the input level is correctly set, the red LED should never come on, and the green LED should either be on continuously or should be flickering rapidly.

4. Turn off the calibrator to return to normal operation. During normal operation with program material, the red LED will flash whenever 100% modulation is exceeded.

Bessell Calibration

For units without a DeMod board or to verify units with a DeMod.

The most accurate method to calibrate the ModMinder (or any other FM monitor) is by using Bessel functions. The theory of this technique has been discussed extensively elsewhere, so it will be described here only briefly. Simply put, at certain modulation indexes, the carrier of a frequency-modulated signal will disappear, leaving all the energy in the sidebands. The modulation indexes at which the carrier disappears are predicted with great precision by Bessel functions.

The modulation index is the deviation of the carrier divided by the modulating frequency. For example, a carrier deviated to 75 kHz sine wave would have modulation index of 15. In order to have calibration points at a variety of modulating frequencies, it may be necessary to pass through several nulls of the carrier as the amplitude of the modulation tone is increased from zero to one hundred percent.

The elegance of the Bessel function method of calibrating an FM modulation monitor is that the carrier is observed with no modulation applied, then as modulation is increased, a deep null (better than 50 dB) occurs at the exact deviation specified.

The accuracy of the Bessel function technique depends on: 1) the spectral purity of the audio oscillator, i.e. its harmonic distortion, 2) the accuracy with which the modulating audio frequency can be set an maintained, and 3) the ability to resolve the nulling of the carrier.

There are several practical problems associated with using the Bessel function technique to calibrate an actual modulation monitor. An RF spectrum analyzer is most frequently specified as the instrument to determine when the carrier is nulled. Few FM stations own an RF spectrum analyzer and not too many even have access to one. Trying to determine a carrier null on the same frequency as an FM station is broadcasting a fully modulated carrier can present problems, especially when the work is being conducted at the transmitter site using the exciter on the alternate main transmitter.

It must be possible to smoothly and continuously vary the amplitude of the audio tone from full off to whatever level will modulate the transmitter 100%. Most broadcast audio oscillators have decade attenuators and even

0 1 dB steps are not fine enough. A related problem is the need to maintain a great enough amplitude into the frequency counter so an accurate frequency measurement is available at all times.

There are straight-forward solutions to these problems. Rather than using a spectrum analyzer to determine a null in the carrier, a conventional receiver will work well. The “S” meter of the receiver is a wide range level indicator – ideal for finding a carrier null. The most important characteristic of the receiver is that it must have a narrow enough bandwidth to separate the carrier from the nearest sidebands. The first set of sidebands appears at the carrier frequency plus and minus the modulating frequency. So if 8136 Hz is the lowest modulation frequency used, a standard single sideband filter bandwidth of 2.4 kHz provides a narrow enough bandwidth.

Several companies make receivers (super scanners) that cover 88 to 108 MHz with a 2.4 kHz bandwidth and an AM detector. An added advantage of several of these receivers is that they also cover the 900 MHz STL band and thus allow modulation of calibration of an STL system. However, before you run out and buy one of these receivers, consider the problems of making measurement on-frequency with a receiver that may not have mil spec shielding. This may not be a problem if all the testing will take place when the station is off the air, but if you want to do a calibration during normal working hours, interference from the modulated signal could be a real problem.

Manufacturer	Model	Frequency Range
Icom	IC-R7000	25 - 1300 mHz
Yaesu	FRG-9600	60 - 905 MHz
Kenwood	RZ-1	(N/A)

Suitable Receivers

One way to avoid interference from signals on-carrier is to derive the carrier from the IF of a monitor or receiver. Virtually all receivers use a 10.7 MHz IF, while most monitors have their last IF in the 1 to 1.5 MHz region. This approach has the advantage of only requiring a communications receiver covering the IF frequency.

The problems of smooth level control and maintaining sufficient signal into a frequency counter are both solved by building a simple external attenuator box. The audio oscillator is run “wide open” into the attenuator.

The frequency counter is connected at this point. A ten turn pot allows attenuating the signal all the way to off with sufficient resolution to make nulling the carrier easy. A simple one-turn pot on the output provides a coarse setting of level so that the maximum resolution of the ten turn pot can be used. Ten turn pots are readily available on the surplus market, just be certain that it is of the carbon element type, not wirewound. A wirewound unit will not be flat across the wide range of frequencies used in the calibration measurements.

% MOD	1 NULL	2 NULLS	3 NULLS	4 NULLS
85%	26,509	11,549	7,367	5,406
90%	28,069	12,228	7,800	5,724
95%	29,628	12,907	8,233	6,042
100%	**31,188**	**13,587**	**8,667**	**6,361**
105%	32,747	14,266	9,100	6,679
110%	34,306	14,945	9,533	6,997
115%	35,866	15,625	9,967	7,315

BESSEL NULLS (in Hz)

The procedure for actually doing a Bessel function calibration is as follows:

1. Select the modulation level you wish to calibrate the monitor for. Of course, 100% is the most important point, but it is a good idea to check calibration at 10% above and below 100%. Enter the table at "% Mod" and note the four frequencies. As is noted in the table, these frequencies correspond to 100% modulation at 4, 3, 2 and 1 null of the carrier. It is suggested that calibration be checked across a wide range of frequencies to be certain the monitor is flat.

2. Adjust the oscillator to exactly what the frequency called for in the table above. It is important that you keep a close check on this adjustment, because the frequency may drift and need adjustment.

3. Connect the output of the attenuator box to the wideband composite input of the exciter. It is important that NO OTHER SIGNALS be modulating the exciter while this test is being conducted. Often, turning off sources such as stereo and SCA generators will not provide sufficient isolation. It is suggested that all signal sources be disconnected from the exciter to insure that there is no leakage.

4. Set the ten turn attenuator for maximum output and adjust the coarse pot for a modulation level somewhat more than 100%, or whatever percentage is being calibrated. This is not a critical adjustment and it is only important and it is only important that the level be somewhat greater than the modulation percentage you want to calibrate.

5. Set the ten turn attenuator to the full off position or disconnect the signal from the exciter. It is important that there be no modulation of the carrier.

6. Center the unmodulated carrier in the passband of the receiver or center it on the spectrum analyzer. If a receiver is being used, it must be set for its narrowest bandwidth, which must be considerably less than the frequency of the modulating signal. If a spectrum analyzer is being used, it must be set to clearly resolve the first sideband pair from the carrier.

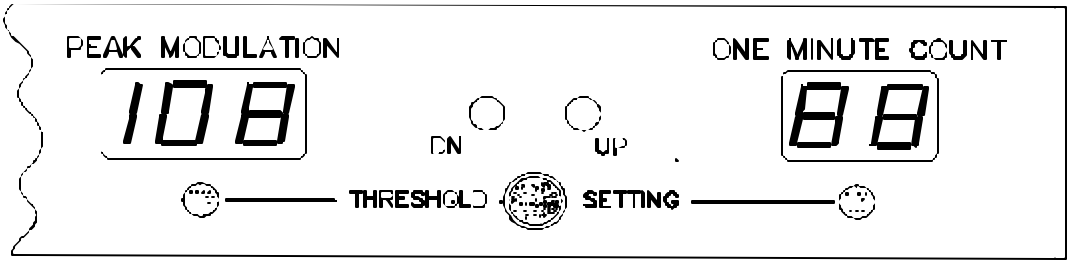
7. Gradually increase the amplitude of the modulating signal by turning up the ten turn pot while carefully observing the amplitude of the carrier. It is suggested that if this is the first time a Bessel function calibration is being done, use the 1 NULL, 100% frequency, 31,188 Hz. As 100% modulation is approached, the amplitude of the carrier will gradually decrease. At exactly 100%, the null will be quite deep, on the order of 50 to 60 dB below the unmodulated carrier. At the deepest point of the null, the modulation is exactly 100%.

   If a lower modulating frequency is chosen, the carrier will go through more than one null before the desired modulation is reached. In this case, it is necessary to carefully count the number of nulls as you increase the modulation.

Operation

Once the appropriate set-up procedure is completed, ModMinder is ready for normal operation.

Units without a DeMod board must have a source of composite signal connected to the Composite Input, and must be calibrated by the user. Units with a DeMod board must have the frequency set, and be connected to a source of RF input. Once this is done, the ModMinder will begin displaying peak modulation and counting overmodulation occurrences.



THRESHOLD SETTING CONTROLS

Pressing the black button labeled “THRESHOLD SETTING” allows adjustment of the peak flash threshold and the count-per-minute limit.

The first press of this button turns on a yellow LED under the PEAK MODULATION display. This indicates that the reading of that display is now the peak flash threshold, or the highest percentage of modulation allowed before an overmodulation event is registered. The peak flash threshold may now be adjusted by using a small screwdriver to press the buttons recessed behind the holes labeled “UP” and “DN”.

Pressing the black button again:

1. Restores the PEAK MODULATION display to its normal function of displaying the highest peak of modulation in the previous second;

2. Turns the yellow LED under the display off; and

3. Turns on another yellow LED under the ONE-MINUTE COUNT display.

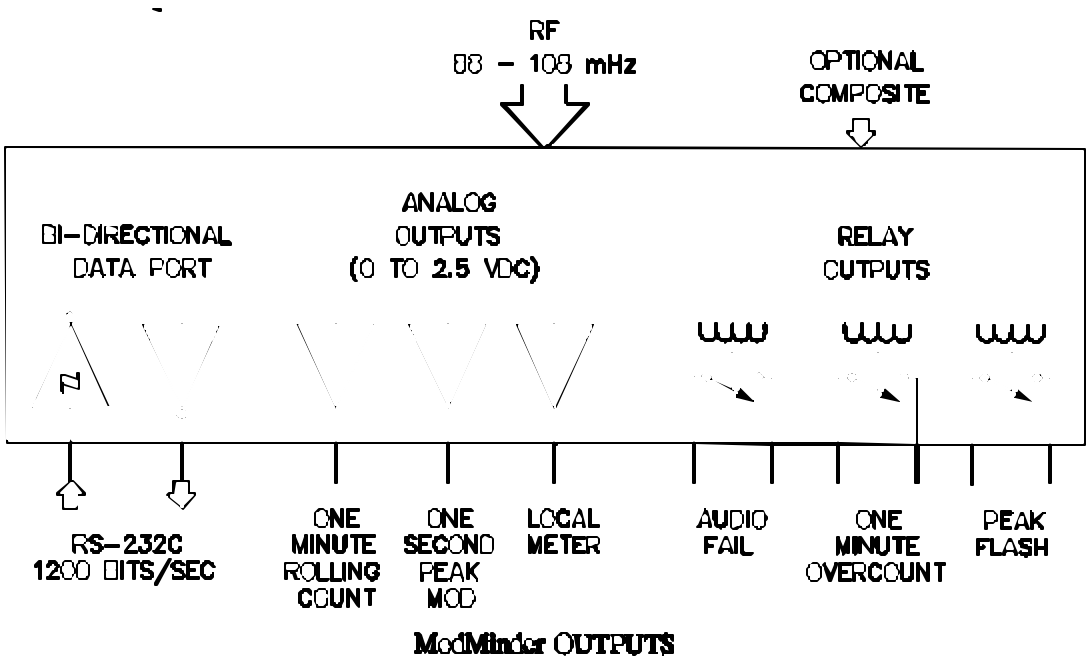
In this mode, the ONE-MINUTE COUNT display indicates the number of overmodulation occurrences that can take place in one rolling minute before an alarm is caused. Again, the “UP” and “DN” recessed buttons are used to set the limit threshold.

It should be noted that by merely observing the count trip threshold, the one-minute counter is reset to zero. In setting up modulation or a processor, it can be very useful to be able to clear the one-minute count easily.

Pressing the black button again restores the ModMinder to normal operation.

Remote Operation

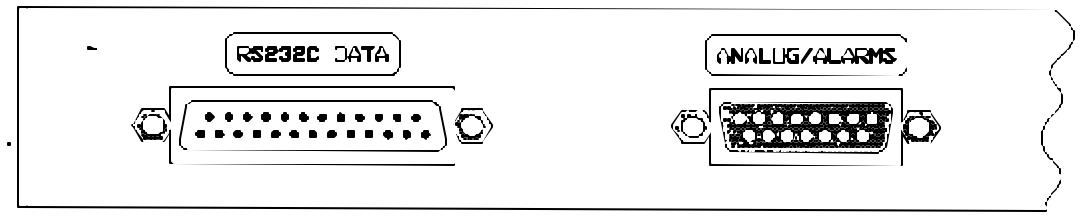
ModMinder has two modes of remote operation to make it easy to locate it at the transmitter and still enjoy full benefits of its unique functionality at the studio.



ModMinder OUTPUTS

First, ModMinder will interface with a conventional broadcast remote control. DC outputs proportional to the One Second Peak and One Minute Rolling Count are provided, as well as relay closures for Peak Flash, One Minute Overcount and Audio Failure. These DC voltages and contact closures may be connected directly to any remote control system. The analog and relay connector is a standard female 15 pin D-subminiature connector, located on the rear panel.

The second interface is a serial RS-232C data circuit. This allows the total remote control and monitoring of the ModMinder on a computer. The connection may be made via a conventional 1200 bits/second modem and a dial telephone circuit or by connecting the serial port of the computer directly to the ModMinder. Using MSI supplied software on an IBM compatible personal computer, all the front indications and controls of ModMinder are available across town or across a continent. The computer can also provide functions not even available on the ModMinder itself, such as statistical analysis of the peak modulation. The serial data connector is a standard male 25 pin D-subminiature connector, located on the rear panel.



ModMinder OUTPUT CONNECTORS

Conventional Remote Operation

Relay Outputs

The ModMinder has 3 relay outputs – PEAK FLASH, ONE MINUTE OVERCOUNT, and AUDIO FAILURE. The contact closes when the indicated event occurs. In most cases, the relay outputs are connected to alarm inputs on the remote control.

The relay contacts are rated to switch loads from logic level (1 milliamp at 5 volts) to 100 milliamps at 48 volts, AC or DC. The voltage from either side of the contact to the ModMinder chassis should not exceed 48 volts. Each contact is connected to 2 pins on the 15 pin "D" connector, so contacts are floating isolated from each other and from ground. For best noise immunity, a separate twisted pair should be used for each output.

The ModMinder RELAY OUTPUTS ARE NOT INTENDED TO BE USED WITH 120 VOLT AC CIRCUITS. Such use will certainly damage the relay, and may also cause internal damage to the ModMinder.

Analog Outputs

The three analog outputs are LOCAL METER, ONE SECOND PEAK MODULATION and ONE MINUTE COUNT.

The LOCAL METER output is not useful with most remote controls, since the sampling rate of the remote control is not fast enough to accurately reproduce the signal. It is intended to drive a moving-pointer meter; the ModMinder uses special digital processing to compensate for meter characteristics and provide an accurate and easy to read modulation indicator.

The ONE SECOND PEAK MODULATION output is intended for use with remote controls. It provides a voltage proportional to the reading of the Peak Modulation display on the front panel. Since the reading changes only once per second, even the slowest remote control can accurately convey the reading to the studio.

The ONE MINUTE ROLLING COUNT output provides a voltage proportional the reading of the One Minute Count display on the front panel. It is updated once each second.

Each analog output provides a voltage, which varies from 0 to +2.5 volts with respect to ground. The voltage will be independent of load provided the load is less than 5 milliamps (load resistance greater than 500 Ohms). The ModMinder outputs are stable with capacitive loads up to 100 nanoFarads, so cable length is not limited by output drive capability. Analog ground is chassis ground.

When connecting the ModMinder's analog outputs to a remote control, you should run a separate twisted pair for each analog signal. The ModMinder output connector has multiple ground pins, so the low side of each pair can be connected to a separate pin. If shielded cable is used, the shield should be grounded only at the remote control end.

PIN#	FUNCTION
8	Local Meter
15	1 Second Peak Modulation
7	1 Minute Rolling Count
6,5,13	Analog Ground
12,11	Peak Flash
10,9	1 Minute Overcount
2,1	Audio Fail

Analog and Relay Output
(15 Pin Female D-Connector)

Calibration

The ModMinder analog outputs are driven by an 8 bit digital-to-analog converter. The digital input to the converter ranges from 0 to 255. We will refer to these numbers as "counts." For the Local Meter and Peak Modulation outputs, each count represents 0.5% modulation. Full scale of these outputs is therefore 127.5%, and 100% equals 200 counts.

The One Minute Count output does not provide a voltage directly proportional to the front panel reading; instead, the voltage represents the ratio of the One Minute Count reading to the One Minute Count threshold. When this ratio is 1, the output will be 200 counts. This allows meter calibrated to read modulation percentage to show the One Minute Count as a percentage of the One Minute Threshold. For example, with the threshold set to 10, a One Minute Count reading of 1 would produce a meter indication of 10%.

Diagnostic Mode 1 provides the ability to set any analog output to either 0 or full scale. To calibrate your meter or remote control to the ModMinder, set each analog output in turn to full scale, and adjust the meter or indicating device for a reading of 127.5%.

Calibration can also be performed at 100% (or at any other level) by using Diagnostic Mode 2. This requires that you connect a computer or terminal to the ModMinder's RS-232C port. See the section on Diagnostics for more information on this.

Once you are in Diagnostic Mode 2, the "ANALOG n vvv" command can be used to set any analog output to any voltage. "n" is the analog output number (1 to 3), and "vvv" is the input to the D/A converter. To set output 1 to 100%, the command would be "ANALOG 1 200". (Remember that each count on the converter input equals 0.5% modulation). Once the output is set to 100%, adjust the meter or indicating device for a reading of 100%.

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RS-232C Remote Operation

Setting up for Remote Operation

Equipment

- A telephone line to connect to the modem.
- A 1200 baud modem capable of auto-answer operation. The modem must provide a Data Carrier Detect signal on pin 8 of its RS-232C connector. Most Hayes compatible modems are acceptable, but many other modems will work. The modem need not support Hayes command mode (or indeed, any command mode) as long as it can auto-answer and provides a Data Carrier Detect signal.
- A cable to connect the modem to the ModMinder. The RS-232C connector on the ModMinder is a male 25 pin "D" connector, and the connector on most modems is a female 25 pin "D" connector. At a minimum, pins 1,2,3,7 and 8 must connect through the cable. A male to female cable with all pins connected "one to one" will work, since the additional pins on the ModMinder are not connected internally. The cable should not exceed 25 feet in length. "D" connectors and pre-assembled cables are easily available through a local electronics, radio or computer store.

Modem Setup

- Auto-Answer must be turned ON.
- The modem must be set to ignore DTR and RTS.
- The Data Carrier Detect (DCD) signal must indicate presence of a carrier from the remote modem. The DCD signal must **not** be forced high.

On some modems, setup is via DIP switches; on others, you must send commands to the modem to change the setup. Setup via DIP switches is preferred, since the modem can be set up without connecting it to a computer. Also, the setting of the DIP switches does not change if power is lost.

If you choose a modem that must be set up via commands, be sure the settings are stored in a non-volatile memory, which is protected against power loss.

If the items listed above cannot be set up using DIP switches, you must connect the modem to you computer (or to a terminal) to change the setup. The modem manual should tell you how to do this.

PIN #	*FUNCTION*
1	Protective Ground
2	ModMinder RXD
3	ModMinder TXD
4	ModMinder RTS
8	Modem DCD
20	ModMinder DTR
7	Signal Ground

SERIAL DATA OUTPUT (25 PIN MALE D-CONNECTOR)

This pinout is correct for direct connection to most modems. ModMinder is configured as a DTE device. DCD (carrier detect) must be controlled by the modem. However, if unconnected, DCD is held asserted. DTR (Data Terminal Ready) and RTS (Request to Send) are always asserted. Both grounds are chassis ground.

Connecting To A Local Computer

To connect the ModMinder directly to a computer, you need a Null Modem cable to allow you to connect the serial port of your computer to the RS-232C port on the ModMinder.

Both connectors on a Null Modem Cable are standard female 25 pin D-subminiature connectors. Either end of the cable may be connected to the

ModMinder. A Null Modem Cable transposes the data and control signals so as to simulate a pair of modems.

D25F	D25F
1	1
2	3
3	2
4	5
5	4
6,8	20
7	7
20	6,8

NULL MODEM CABLE PINOUT
(25 PIN FEMALE D-CONNECTORS)

When ModMinder is not used with a modem, DCD should be left floating. A high impedance pull-up will hold it asserted with no connection.

The serial port on the computer should be set to NO PARTY, 8 BITS, 1 STOP BIT. The "ModMinder Remote" program available from Modulation Sciences can be set to use any serial port (COM1 – COM4).

"ModMinder Remote"

ModMinder Remote is a program written by Modulation Sciences, Inc. to allow you to use your ModMinder with a remote computer. You can read the front panel displays, and perform all threshold setting operations from the remote location. In addition, the program includes a modulation histogram – a summary display of modulation activity.

Two levels of password protection are available on the ModMinder to protect it from unauthorized access. The program itself is not copy protected.

To use the program, you need an IBM-compatible computer with a floppy disk drive, using DOS 2.1 or later. ModMinder Remote will run from a hard drive, if you have one. For remote operation, you will also need a modem for the computer, and a second modem capable of auto-answer operation attached to the ModMinder. This program is shipped with all ModMinders.

A program with expanded data analysis is also available. For information about ModMinder Remote Advance Edition, contact Modulation Sciences or your dealer.

Password Protection

ModMinders with EPROM version 1.3 or higher have password protection. The ModMinder may be set so that the password protects just the threshold settings, or the entire unit. The factory setting is to protect just the threshold settings.

If only the threshold settings are protected, the ModMinder will start to transmit data as soon as it receives a Data Carrier Detect signal. If it receives a command to change a threshold setting, it will prompt the user to enter the password. Once the correct password has been entered, it will allow the threshold to be changed.

If the entire unit is password protected, the ModMinder will not send any data or respond to commands until the proper password has been entered. Receipt of a command to start data transmission will cause the ModMinder to prompt for password entry.

Password protection mode can be changed from the front panel of the ModMinder. See “Option Setting Mode” in the section on Diagnostics, below.

ModMinders are shipped from the factory with threshold protection on and the password set to “MINDER”. The password can be changed by using the ModMinder Remote program supplied by MSI. You must know the current password in order to change it. The following directions for changing the password are excerpted from the manual supplied on disk with the ModMinder Remote program:

> To change the password, follow these steps:
>
> 1. The program must be on the Panel Screen, Showing data transmitted from the ModMinder.
>
> 2. Hit the “End” key. The program will return to the Communications Screen.
>
> 3. Type “Ctrl”-“P”. (Hold down the “Ctrl” key, then press the “P” key.) The ModMinder will respond with “Password:”. Enter the old password.

4. If you have properly entered the old password, you will be prompted to enter the new password. Follow the prompts.

The password is stored in a non-volatile memory (EEPROM) in the ModMinder. If you have lost or forgotten the password, use the following procedure to reset it to the default password, “MINDER”:

Unplug the ModMinder’s power cord, wait at least 3 seconds, then plug it back in. The ModMinder will go into self-test mode. While the ModMinder is in self-test mode, press and hold the UP button. After about 4 seconds, the front panel displays should show “OP 0”. The ModMinder will then commence normal operation. Release the UP button.

In addition to resetting the password, this will set the Peak Modulation Threshold to 100, and the One Minute Count Threshold to 10.

ModMinder Serial Data Format

The ModMinder transmits 100 bytes per second. The frame length is 100 bytes. Byte values in the table are given in hexadecimal.

BYTE	FUNCTION	BYTE	FUNCTION
0	Sync byte 1 (OFFH)	8	Data
1	Meter reading	9	Meter reading
2	Sync byte 2 (OFFH)	.	..
3	Meter reading	.	..
4	Sync byte 3 (OFFH)	96	Data
5	Meter reading	97	Meter reading
6	Data	98	Data
7	Meter reading	99	Meter reading

ModMinder DATA PROTOCOL

The settings on the computer serial port when communicating with the ModMinder should be: NO PARITY, 8 BITS, 1 STOP BIT.

This allows for transmission of 50 meter readings and 47 bytes of data per second. Frame synchronization is provided by the 3 OFFH sync bytes. To allow unambiguous detection of sync, meter readings must never be OFFH, and the 47 bytes of data must never contain three consecutive values of OFFH. Also, byte 98 must never be OFFH.

It is convenient to think of this data stream as 2 interleaved data frames, one containing 3 sync bytes and 47 data bytes, and the other containing 50 meter readings. We will refer to these as the “meter” frame and the “data” frame. Each byte in the “meter” frame represents the peak modulation level in the preceding 20 milliseconds. The functions of the “data” bytes are listed in a table below.

BYTE	FUNCTION	BYTE	FUNCTION
0	Sync byte 1	17	Carrier Hi (DeMod)
1	Sync byte 2	19	Carrier Lo (DeMod)
2	Sync byte 3	21	RF Level (DeMod)
3	Flags	23	Flags
5	Mtr.PeakHold	25	Options
7	Mtr.MinHold	34	Flags
9	RO.Count	35	MtrThresh
11	Mtr.Thresh	39	RO.Thresh
13	Flags	43	Flags
15	RO.Thresh	47	Serial Number

"DATA" FRAME FUNCTIONS

In the "data" frame table, the bytes are numbered 0 through 49. Note that the conditions described above for unambiguous sync detection will be met if the odd numbered bytes in this table always have values of less than 0FFH (with the exception, of course, of byte #1, which is a sync byte and *must* be 0FFH). Even numbered bytes can have any value.

The functions of the bytes in the "data" frame are listed in the table above. Bytes not listed are reserved for future use, and are filled with the byte number.

The items marked (DeMod) are only transmitted if a DeMod card is installed. If it is not, they are filled with the byte number. This means that the presence of a DeMod card can be detected by checking for a valid value of RF level (0..4).

FLAG BITS		OPTION BITS	
0	Overmod	0	Secure Data
1	Over Count	1	Peak Weight
2	Input Cal	2	Long Flash
3	Peak Thresh	3	Count Flash
4	Count Thresh	4	Not used
5	Peak Weight	5	Not used
6	Audio Fail	6	Not used
7	Not used	7	Not used

FLAG and OPTION BITS

Diagnostics

Self-test

Each time the ModMinder is powered up, it goes through a self-test routine. This checks the computer, the RAM and ROM memory, and the front panel displays. If the computer and memory are OK, all of the front panel LED's and all of the segments of the numeric displays will turn on for 2 seconds. The front panel will then go blank for about 2 seconds, and the ModMinder will commence normal operation.

If the ModMinder detects a problem during self-test, it will display one of the following error codes:

DISPLAY	FUNCTION
Er 0	Fatal error. A hardware failure has occurred which prevents normal operation of the computer.
Er 1	The RAM memory is defective. Replace U22.
Er 2	The ROM memory is defective. Replace U19.

SELF-TEST ERROR CODES

Additional Diagnostic Modes

The ModMinder has 3 diagnostic modes in addition to self-test. Mode 1 provides a simple test for analog and relay outputs, and is useful when calibrating a remote control to work with ModMinder's analog outputs. Mode 2 allows control of relays, LED's, and analog outputs via the ModMinder's RS-232C port. Mode 3 is a comprehensive test of ModMinder's analog circuitry.

Mode 1

To enter Mode 1, unplug the ModMinder power cord for at least 3 seconds, then reconnect it. ModMinder will enter self-test mode. If you press the Threshold button anytime during the 4 second self-test period, ModMinder will go into Diagnostic Mode 1 at the end of self-test. Pressing the Threshold button will then step the unit through the following sequence:

DISPLAY	FUNCTION
HI 1	Local Meter output at 2.5 V Peak Flash relay closed
LO 1	All analog outputs at 0 V All relays open
HI 2	1 Second Peak Mod output at 2.5 V 1 Minute Overcount relay closed
LO 2	All analog outputs at 0 V All relays open
HI 3	1 Minute Rolling Count output at 2.5 V Audio Fail relay closed
LO 3	All analog outputs at 0 V All relays open

DIAGNOSTIC MODE 1 TESTS

This sequence will repeat in an endless loop. To return to normal operation, press the DN button, or remove and re-apply power.

Mode 2

To enter Mode 2, press the UP button while the ModMinder is in Mode 1. Mode 2 allows control of all LED's, relays, and analog outputs via the RS-232C serial port. You must have a terminal, or a computer with a communications program, connected to the ModMinder. Set the serial port of the terminal or computer to 1200 baud, 8 bits, no parity. These commands must be entered in upper case only. If you make an error, hit "ENTER" to terminate the misspelled command, and try again.

COMMAND	FUNCTION
ANALOG CLEAR	Sets all analog outputs to 0 V.
ANALOG n vvv	Sets analog output n to vvv, where n is a number from 1 to 3, and vvv is a number from 0 to 255. 0 = 0 volts, 255 = 2.5 volts.
RELAY CLEAR	Sets all relays open.
RELAY n ON	Closes relay n, where n is a number from 1 to 8.
RELAY n OFF	Opens relay n.
LED CLEAR	Turns LEDs off.
LED n ON	Turns on LED n, where n is a number from 1 to 8.
LED n OFF	Turns off LED n.

MODE 2 COMMANDS

Mode 2 is most useful for controlling analog outputs, since it allows an analog output to be set to any output voltage, not just zero or full scale as in Mode 1. The “LED” and “RELAY” control functions are intended mostly for internal troubleshooting of the ModMinder. The following tables show the functions controlled by the “LED” and “RELAY” commands.

RELAY	FUNCTION
1	Overmod Relay
2	Overcount Relay
3	Audio Failure Relay
4	(not used)
5	Cal Set LED – Red
6	Cal Set LED – Green
7	Peak Weighting Mode
8	Self-Test Mode

RELAY CODES FOR MODE 2 COMMANDS

LED	FUNCTION
1	Overmod LED
2	Peak Mod Display – MSD – Segment B
3	Peak Mod Display – MSD – Segment C
4	Peak Threshold LED
5	Count Threshold LED
6	Peak Weighting LED
7	Audio Failure LED
8	Peak Mod Display – MSD – Dec Pnt

LED CODES FOR MODE 2 COMMANDS

Mode 3

To enter Mode 3, press the UP button while the ModMinder is in Mode 2. To go directly from Mode 1 to Mode 3, press the UP button twice while in Mode 1.

Mode 3 includes 14 tests to check the ModMinder's analog circuitry, D/A converter, and A/D converter. The test number is shown on the One Minute Count display, and the test result is shown on the Peak Modulation display. If a test failed, the Audio Failure LED will be lit.

Pressing the Threshold button will step to the next test. Pressing the UP button will cause ModMinder to run all the tests in sequence, stopping only if a test fails, or when it has reached test 12. The tests are:

MODE 3 TESTS

0	DC Offset. The reading should settle to 0.
1	Gain. (This is used as a reference for later frequency response tests.)
2	Symmetry of peak detector.
3	Frequency response at 50 Hz.
4	Frequency response at approximately 30 kHz.
5	Response to moderately dense pulse waveform.
6	Response to sparse pulse waveform.
7	Peak detector fallback time in FCC mode.
8	Peak detector fall back time in Peak Weighting mode.
9	Reference level set for following tone burst tests.
10	10 kHz tone burst at 105% modulation, FCC mode.
11	10 kHz tone burst at 140% modulation, FCC mode.
12	10 kHz tone burst at 105% modulation, Peak Weighting mode.
13	10 kHz tone burst at 140% modulation, Peak Weighting mode.

For the tone burst tests, the number displayed as the test result is the length of the burst (in cycles of 10 kHz) required to just trip the Overmod indicator, with the Peak Modulation Threshold set at 100%.

The response time in Peak Weighting mode can be field-modified by changing an option. Please see the section on Options for instructions. Tests 12 and 13 provide a convenient way to check the response time after a change has been made. These tests will not normally fail, since the test limits are wide enough to include the entire range of possible response times from 2 to 50 cycles. Therefore, the auto test mode will stop when it gets to step 12, so you can decide if the test result is proper. You must push the Threshold button to step through tests 12 and 13.

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Options

When you step past test 13 in Diagnostic Mode 3, the ModMinder will go into Option Setting Mode. The displays should show “OP 10” or “OP11”.

The One Minute Count display shows the option number and setting; the left digit is the option number, and the right digit is the setting, 0 for OFF, and 1 for ON. The setting may be changed by using the UP and DN buttons. To move to the next option, press the THRESHOLD button.

At present there are four options.

Option 1: Password

Option 1 sets the level of password protection for the ModMinder. A setting of 0 means that only the Threshold settings are protected and a setting of 1 means that the entire unit is protected.

Option 2: Peak Response Time

Option 2 sets the peak response time. The ModMinder is shipped with this option OFF, setting the unit to FCC Mode. In this mode, the ModMinder waits just less than 1 millisecond before registering a peak. With this option set ON, the unit is in Peak Weighting Mode, and the response time is controlled by the value of resistor R9.

On units which are not sealed, the resistor R9 can be changed to control attack time in Peak Weighting mode. Attack time is measured using bursts of 10 kHz sine waves with repetition rate no faster than 5 bursts per second. (For practical calculations, 1 cycle of 10 kHz equals 0.1 milliseconds.) Diagnostic Mode can be used to measure the actual response time for any value of R9. The following table shows nominal attack time for various values of R9:

R9 (ohms)	ATTACK TIME (cycles of 10 kHz)
562	2
1500	5
3320	9
5620	15
7500	20
11500	30
18200	45

ATTACK TIMES FOR R9 VALUES

ModMinders are shipped with R9 set to 11500 Ohms. To change the resistor, cut the leads on the factory resistor, and solder the new resistor to the top of the circuit board in its place. Oversized pads have been provided to make this installation easier. The circuit board does not need to be removed from the unit during this operation.

Option 3: Peak Flash Duration

Option 3 sets the duration of the Peak Flash indicator light. The unit is shipped with the Peak Flash set OFF, for a duration of 0.25 seconds. In some applications, it may be more useful to have the Peak Flash light stay on for a longer period of time. Setting Option 3 to ON will cause the Peak Flash light to stay on for 2.0 seconds whenever modulation exceeds the preset limit. Additional overmodulation events are ignored by the Peak Flash indicator light during the 2 seconds while the indicator is triggered.

Option 4: Counter Control

This option controls the counting method used by the One Minute Counter. The unit is shipped with this option OFF and the counter set to include every overmodulation event detected. Note that multiple overmodulation peaks are considered to be single “Overmod Occurrence” if they are sufficiently close together. In FCC mode, an “Overmod Occurrence” can be up to 5 milliseconds long; in Peak Weighting mode it can be up to 30 milliseconds long.

With this option set ON, the One Minute Counter will count Peak Flashes and the counting method will mimic the operation of the Peak Flash indicator light. Overmod events occurring during the time-out while the light is on will be ignored by the counter.

When option setting is completed, press the Threshold button. ModMinder will store the option settings in its non-volatile memory. Units without a DeMod board will then go through its self-test and start normal operation.

Units with a DeMod board will first go into frequency setting mode before starting normal operation. The frequency must be set, and there must be an RF input level within the range of 20 milliwatts to 800 milliwatts before the ModMinder will begin normal operations.

Frequency Setting and RF Level Check

The first display in frequency setting mode shows the carrier frequency in MHz. As shipped from the factory, frequency is set to 98.1 MHz. Both displays are used to display a single frequency setting. Frequency is changed in 100 kHz steps by pressing the UP or DN buttons. Holding a button down will cause the frequency to scroll up or down until the button is released. When the display shows the correct frequency, press the THRESHOLD button to move to the next phase.

The display will next show RF input level, with the “rF” indicator in the left display, and a level indicator in the right window, as follows:

rf LO	RF Level is too low to operate ModMinder.
rF 1	RF level is marginal. It must be increased by at least 3 dB before ModMinder will operate properly.
rF 2	RF level is correct (with the range of 20 to 800 milliwatts).
rF 3	RF level is marginally high. It must be reduced by at least 1 dB before ModMinder will operate properly.
rF HI	RF level is too high. Disconnect the RF input immediately, or the input attenuator may be damaged.

When the display shows rF 2, press the THRESHOLD button to start normal operation of the ModMinder. If you press the THRESHOLD button when the display does not show rF 2, the ModMinder will loop back to frequency setting mode. It is not possible to start normal operation of ModMinder until the RF level is correct.

Once the ModMinder enters normal operation, the RF input level must remain within the range of 10 milliwatts to 1 watt. If RF level goes outside of this range, ModMinder will stop operating, and the front panel displays will show either rF LO or rF HI. Normal operation will resume as soon as RF level is within this range.

	SPECIFICATIONS
DIMENSIONS:	1.75”H x 19.0”W x 10.0”D 22.5mm H x 483mm W x 254mm D
POWER:	50/60 Hz AC 100-130 VAC, fused for 3/16 A 200-260 VAC, fused for 1/10 A Voltage selector on rear panel.
OPERATING TEMPERATURE:	0 to 50 Celsius
OVERALL ACCURACY:	±1.0 percent at 100% modulation for any frequency from 50 Hz to 100 kHz.
ACCURACY:	Less than 0.4% linearity error.
FREQUENCY RESPONSE:	± 0.5% (+/-0.043 dB) at 100% modulation, from 50 Hz to 100 kHz.
PEAK FLASH RESPONSE TIME:	
FCC Mode:	0.9 milliseconds
Peak Weighted Mode:	If selected, response time is controlled by a user-selectable resistor. Response time is factory set to 3 milliseconds.
ONE MINUTE COUNTER STANDOFF DELAY:	Option selectable to count peak flasher occurrences.
FCC Mode:	5 milliseconds
Peak Weighted Mode:	30 milliseconds
COMPOSITE INPUT	
Input Sensitivity:	0.8 to 5 volts peak for 75 kHz = 100% modulation.
Input Impedance:	10 kOhms
RF INPUT	
Input Sensitivity:	10 milliwatts (+10 dBm) to 1 watt (+30 dBm)
Input Impedance:	50 Ohms
VSWR:	1.05 max

CONNECTORS	
Composite Input:	BNC
RF Input:	BNC
RS-232C:	25 pin “D” connector.
Remote Control:	15 pin “D” connector.
DC VOLTAGES	
Relay Contacts:	100 mA, 48 volts resistive load.
Metering Signals:	0 to 2.5 volts, 5 mA maximum, negative common to ground.
SOURCE IMPEDANCE:	0 ohms at DC.
RF PROTECTION:	All inputs and outputs RF suppressed.

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WARRANTY

We warrant the equipment sold shall be free from defects in materials and workmanship under normal use and service for a period of three (3) years from the date of deliver when properly installed. Our sole obligation under this warranty shall be limited to repair or replacement at Our option or any such part or parts of the product which Our examination shall disclose to Our satisfaction to be defective.

If you wish to have warranty services performed at Our facilities, You shall obtain from Us, in advance, permission to return the equipment and shall ship it properly packed with transportation and insurance prepaid. Service performed at Our facilities under this warranty shall include parts plus labor and normal return shipping. It is expressly agreed that Our obligation to repair and replace defective parts is Your sole and exclusive remedy.

THE WARRANTY TO REPAIR OR REPLACE DEFECTIVE PARTS ARE EXPRESSLY IN LIEU OF AND HEREBY IN DISCLAIMER OF ALL OTHER EXPRESS WARRANTIES, AND ARE IN LIEU OF AND IN DISCLAIMER AND EXCLUSION OF ANY IMPLIED WARRANTIES OR MERCHANTABLITY, FITNESS FOR PARTICULAR PURPOSE, AS WELL AS ALL OTHER IMPLIED WARRANTIES, IN LAW OR IN EQUITY, AND OF ALL OBLIGATIONS OR LIABILITY ON OUR PART. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DECRIPTION HEREOF.

Our liability does not include any labor charges for replacement of parts, adjustments, repairs or any work done outside our factory, unless such work is authorized in writing by Us. Our obligation to repair or replace shall not apply to any equipment which shall have been repaired or altered outside Our factory in any way, subject to negligence, misuse, unauthorized alteration or abuse, or damaged in transit.

OUR LIABILITY HEREUNDER SHALL NOT INCLUDE LOSSES OF ANTICIPATED PROFITS OR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES.

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Parts List

MSI Part Number	Qty	Description	Reference Designators	Manufacturer	Manufacturer Part Number
VO1-FMMC					
A00-TRACECUT	1	ECO FOR BOARD MODIFICATION	BOTTOM, U26P1		
A02-M204FS001	1	2K 20-T TRIMPOT	RV1	BOURNS	3006P1-202
A02-S106FT001	1	100K 1T FLAT TRIMPOT	RV2	BOURNS	3386P1-104
A04-1002JMEG1	1	CAP 10PF MC 10%	C29	AVX	SR151A100K
A04-1004HMEG1	4	1000 PF 50 V 5% MC	C16,C18,C20,C22	PANASONIC	ECU-S1J102JCB
A04-1006HMCH1	19	.1 UF 50 V 20% MC	C4,C10,C13-C14,C36,C38,C40,C46-C51,C53-C58	MALLORY	C20C104M5UICA
A04-1006JPNF1	4	.1 UF 5% 100V PY	C15,C17,C19,C21	WIMA	MKS4RM7 0.1/100/5 (7.5MM)
A04-1007GTNH1	1	1 UF 35 V DT	C26	SPRAGUE	199D105X0035BB1
A04-1007HPNF1	2	1 UF 5% 63V PY LS 10MM	C3 C5	Wima	MKS4RM10 1UF/5/63 (10MM)
A04-100AGANH1	4	1000 UF 35V AE 20%	C31-C32,C34-C35	PANASONIC	ECE-B1VGE102
A04-100BDANI1	1	10,000 UF 16 V AE	C33	SPRAGUE	53D103G016HL6
A04-1503UCBG1	1	150 PF DISC	C45	SPRAGUE	10TST15
A04-1504MCFG1	1	1.5 NF DISC	C24	CENTRALAB	DD-152
A04-2203UCBG1	1	220 PF CER DISK 0.25 LS	C30	SPRAGUE	10TST22
A04-2204HMAD1	1	2.2 NF 1% 50 V MC	C44	SFETECHNOL	G505BY222F
A04-2204JMEG1	2	2.2 NF 10% 100V MC	C23,C59	KEMET	C322C222K1R5CA
A04-2205JRNG1	1	0.022 UF 100 V 10% P	C9	WIMA	MKC2 .022/100/10
A04-3306KONG1	1	330 NF 10% 160V PP	C6	WIMA	MKP10 0.33/160/10
A04-3307FTNH1	1	3.3 UF 25 V DT	C25	AVX	TAP335M025S
A04-3902RCAF1	2	39 PF CER DISC, NPO, 0.25 LS	C27-C28	MALLORY	CMC390J
A04-4708BTNH1	2	47 UF 6 V DT	C37,C52	SPRAGUE	199D476X06R3DB1
A04-5001UCBG1	2	5 PF DISC	C1-C2	ARCO	CCD-050
A04-6802JMAG1	1	68 PF 100 V 10% MC	C11	KEMET	CN15A680K
A04-6803UCBG2	1	680 PF DISC	C12	SPRAGUE	10TST68
A04-6807FTNH1	4	6.8 UF 25 V DT	C8,C39,C41-C42	SPRAGUE	199D685X0025CB1
A10-163840001	1	16.384 MHZ XTAL	X1	JANCRYSTAL	MP-HC18
A99-THRMSTR01	1	THERMISTER 860 OHM 150V	R32		
B01-4003	4	RECTIFIER DIODE	D18-D21	VARIOUS	1N4003
B01-4148	20	GLASS DIODE	D1-D11,D15,D22-D27,D30-D31	VARIOUS	1N4150

B01-5822	2	SCHOTTKY DIODE	D16-D17	VARIOUS	1N5822
B02-4736	2	6.8 VOLT ZENER	D28-D29	VARIOUS	1N4736
B04-N3904	4	2N3904 NPN TRANSISTOR TO92	Q1-Q4	VARIOUS	2N3904
B04-P3906	1	LOW POWER PNP TRANSISTOR	Q5	VARIOUS	2N3906
C01-1F0000005	1	LM310N VOLTAGE FOLLOWER	U4	NATIONALSE	LM310N
C01-2F0000002	1	Dual OP AMP Nsc# House marked w/# SA4385	U2	NATIONALSE	LF412CN
C01-2F0000008	1	DUAL JFET OP AMP	U3	MOTOROLA	MC34082P (OR AP)
C01-2F0000009	1	DUAL JFET OP AMP	U1	MOTOROLA	MC34083P
C01-2F0000011	1	AD712JN DUAL OP AMP	U5	ANALOGDEVI	AD712JN
C01-4F0000001	1	QUAD OP AMP	U11	NATIONALSE	LF444CN
C02-1N501L001	1	(-5)VOLT REGULATOR T092 package	U27	MOTOROLA	MC79L05ACP
C02-1NVARM001	1	LM337T VOLTAGE REG. ADJ.-1.5 AMP TO-220	U26 (Use MSI#K03-S1737220P sil-pad under this !!)	KC Ending	TI# LM337T
C02-1P501M004	1	(+5) V 1.5 AMP low drop regulator linear tech	U24 (Use MSI# K03-S1737220P sil-pad under this !!)	LINEARTECH	LT1086CT-5
C02-1PVARM002	1	LM317T VOLTAGE REG. ADJ +1.5 AMP TO-220	U25 (Use MSI# K03-S1737220P sil-pad under this !!)	MOTOROLA	LM317T
D01-401750001	1	QUAD `D` FLIP-FLOP	U12	NATIONALSE	CD40175BCN
D01-4020X0001	1	14-BIT BINARY COUNT	U29	MOTOROLA	MC14020
D01-4028X0001	1	BCD-DECIMAL DECODER	U8	MOTOROLA	MC14028BCP
D01-4051X0002	1	8-CH MULTI/DE-MULTIP	U10	MOTOROLA	MC74HC4051N
D01-4053X0002	1	74HC4053 HI-SPEED 3 X SPDT ANALOG	U28	RCA	74HC4053E
D01-4060X0003	1	XTAL OSC/FREQ DIV	U17	MOTOROLA	SN74HC4060
D02-000000003	1	HS DECADE COUNTER	U16	MOTOROLA	MC74HC4017N
D02-000000006	2	HI-SPEED CMOS HEX SC	U6,U14	TEXASINSTR	SN74HCT14N
D02-000000007	1	QUAD NAND	U20	MOTOROLA	SN74HCT00N
D03-000000019	1	32K X 8 250 NS CMOS OTP	U19	MICROCHIP	27C256-15/P
D03-000000020	1	8 X 8K SRAM (LOW POW)	U22	HITACHI	HM6264LP-15
D03-000000021	2	HI SPEED OCTAL LATCH	U9,U18	TEXASINSTR	SN74HCT374N
D03-000000023	1	MUART INTEL# P8256AH	U21	SIEMENS	SAB8256AP
D03-000000024	1	DUAL RS423/232 DRIVE	U23	TEXASINSTR	UA9636ACP
D03-000000025	1	8 MHZ V20 CPU	U15	NEC	UPD70108C-8
D03-000000026	1	256 BIT SERIAL EEPROM, 8PDIP	U13	NATIONALSE	NMC9306N
D05-IO0800001	1	8-BIT AD/DA IO PORT	U7	ANALOGDEVI	AD7569JN
E01-S20000003	1	HIGH INTENSITY RED L	D13	HEWLETTPAC	HLMP-3762
E01-S50000004	1	HIGH INTENSITY GREEN	D14	HEWLETTPAC	HLMP-3962
H05-008000001	7	8 PIN EDGE GRIP SS	US1-US5,US13,US23	AMP	2-640463-2
H05-014000002	4	14 PIN FACE GRIP SS	US6,US11,US14,US20	AMP	2-641261-20
H05-016000002	7	16 PIN FACE GRIP SS	US8,US10,US12,US16-US17,US28-US29	AMP	2-641262-20
H05-020000002	2	20 PIN FACE GRIP SS	US9,US18	AMP	2-641264-20

H05-024000003	1	24 PIN NARROW FG SS	US7	ROBINSON NUGENT	ICE-243-S-TG
H05-028000001	2	28 PIN FACE GRIP SS	US19,US22	AMP	2-641267-2
H05-040000002	2	40 PIN FACE GRIP SS	US15,US21	AMP	2-641268-20
H08-003PMS001	1	MASCON 3-PIN LATCHEADW/GOLD	PS1	PANDUIT	MLSS100-3-CA
H08-003PMW001	4	3 PIN WW STRIP	PS2-PS5	SAMTEC	TSW-103-09-GS
H08-003PMW002	1	3 PIN MASCON W/GOLD PLATING	PS6	PANDUIT	MFSS156-3
H08-005PMS001	1	MASCON 5-PIN HEAD. W/ GOLD	PS7	PANDUIT	MLSS100-5-DA
H08-016PMW001	1	8 X 2(16 PIN) WW STR	H4	SAMTEC	TSW-108-09-GD
H10-015F00001	1	15-P SH FEM `D` RT A	J1	Circuit Assembly Corp.	CA-15DSRL-12
H10-025M00005	1	25-P SH MALE `D` RT NORCOMP	J2	TEXTECHS	P25P-21
H19-002000001	5	0.1` WW PIN JUMPER		3M	SHC-1002-001010-BOS
I07-001100501	3	5 VOLT FORM A (SPST)	K1-K3	POTTERBRUM	JWS-117-1
J03-P240X0001	4	Black 24 AWG stranded hook-up wire, UL1007	C33(POS) TO PS7P2 (qty in inch)		
K01-A02COV001	1	20-T TRIMPOT COVER	RVC1	BOURNS	H-83-P
K02-000000003	3	ELECT. ISOLATING THE		BERGQUIST	K4-62
K02-3051	3	NO 2 SHOULDER BUSH		KEYSTONE	3051
K03-S1737220P	3	SIL-PAD 600 T0-220 Insulator for regulators	used under 3 voltage regulators!!!	U24-U26	
Z01-000	1	O OHM 1/4W 5% CF	TP19	VARIOUS	.4" JUMPER
Z01-102	1	10 OHM 1/4W 5% CF	R33	VARIOUS	1/4 W 5 % CF
Z01-105	8	10K 1/4W 5% CF	R7,R13,R19,R22,R26,R28,R35,R37	VARIOUS	1/4 W 5 % CF
Z01-106	6	100K 1/4W 5% CF	R10-R11,R36,R38,R40-R41	VARIOUS	1/4 W 5 % CF
Z01-107	1	1 M 1/4W 5% CF	R1	VARIOUS	1/4 W 5 % CF
Z01-108	1	10 M 1/4W 5% CF	R39	VARIOUS	1/4 W 5 % CF
Z01-156	1	150K 1/4W 5% CF	R34	VARIOUS	1/4 W 5 % CF
Z01-222	1	22 0HM 1/4W 5% CF	R12	VARIOUS	1/4 W 5 % CF
Z01-225	1	22K 1/4W 5% CF	R21	VARIOUS	1/4 W 5 % CF
Z01-227	2	2.2 M 1/4W 5% CF	R8,R49	VARIOUS	1/4 W 5 % CF
Z01-333	1	330 OHM 1/4W 5% CF	R20	VARIOUS	1/4 W 5 % CF
Z01-334	1	3.3K 1/4W 5% CF	R27	VARIOUS	1/4 W 5 % CF
Z01-336	1	330 K 1/4W 5% CF	R42	VARIOUS	1/4 W 5 % CF
Z01-396	1	390 K 1/4W 5% CF	R4	VARIOUS	1/4 W 5 % CF
Z01-472	1	47OHM 1/4W 5% CF	R23	VARIOUS	1/4 W 5 % CF
Z01-473	2	470 OHM 1/4W 5% CF	R30,R53	VARIOUS	1/4 W 5 % CF
Z01-475	1	47 K 1/4W 5% CF	R24	VARIOUS	1/4 W 5 % CF
Z01-563	1	560 OHM 1/4W 5% CF	R47	VARIOUS	1/4 W 5 % CF
Z01-683	1	680 OHM 1/4W 5% CF	R29	VARIOUS	1/4 W 5 % CF
Z02-1005	1	10.0 K 1/4W 1% MF	R3	VARIOUS	1/4 W 1 % MF

Z02-1104	1	1.10 K 1/4W 1% MF	R2	VARIOUS	1/4 W 1 % MF
Z02-1183	1	118 OHM 1/4W 1% MF	U26P1 TO U26P3 (TOP)	VARIOUS	1/4 W 1 % MF
Z02-1824	1	1.82 K 1/4W 1% MF	R44	VARIOUS	1/4 W 1 % MF
Z02-2213	1	221 OHM 1/4W 1% MF	R43	VARIOUS	1/4 W 1 % MF
Z02-3324	1	3.32 K 1/4W 1% MF	R50	VARIOUS	1/4 W 1 % MF
Z02-3654	1	3.65 K 1/4W 1% MF	R17	VARIOUS	1/4 W 1 % MF
Z02-4325	1	43.2 K 1/4W 1% MF	R54	VARIOUS	1/4 W 1 % MF
Z02-4994	1	4.99 K 1/4W 1% MF	R18	VARIOUS	1/4 W 1 % MF
Z02-5623	1	562 OHM 1/4W 1% MF	R9	VARIOUS	1/4 W 1 % MF
Z02-5624	1	5.62 K 1/4W 1% MF	R48	VARIOUS	1/4 W 1 % MF
Z02-6194	1	6.19 K, 1/4W,1% MF	R25	VARIOUS	1/4 W 1 % MF
Z02-6814	1	6.81 K 1/4W 1% MF	R46	VARIOUS	1/4 W 1 % MF
Z02-6816	1	681 K 1/4W 1% MF	R16	VARIOUS	1/4 W 1 % MF
Z02-8253	1	825 OHM 1/4W 1% MF	U26P1 TO C40GND (BOTTOM)	VARIOUS	1/4 W 1 % MF
Z02-XXXX	1	RESISTOR 1% SELSCT AT TEST	R45	VARIOUS	1/4 W 1 % MF
Z14-1005	4	10.0K RN55.1% 1/4W 50 PPM # RN55C1002B	RN5	CORNING	LC83XX
Z14-1005	2	10.0K RN55.1% 1/4W 50 PPM # RN55C1002B	R5-R6	Match/record if not .05%	
Z16-154	1	1.5 K	R55	VARIOUS	FLAME-PROOF 1/2 W 5% CF
Z20-100404S01	1	4 X 1K SIP	RN3		
Z20-100604S01	1	4 X 100K SIP	RN4		
Z20-470409S01	2	4.7K X 9 SIP RESISTOR NETWORK	RN1, RN2		

MSI Part Number	Qty	Description	Reference Designators	Manufacturer	Manufacturer Part Number
VO1-FMDM					
A04-XXXXXXXXX	1	CAPACITOR SELECT AT TEST	C48	VARIOUS	XXXXXX
A02-S104FT003	1	TRIMPOT, 01T 1K00 TOP	RV1	BOURNS	3323P1-102
A02-S503FTSM1	1	500 OHM 1T FLAT TP	RV2	BOURNS	3323P1-501
A04-1002HCAF1	2	10 PF 5% 50V SMT	C3,C31	MURATA ERIE	GR42-6COG100D50V
A04-1004HCEG1	3	1 NF 10% 50V SMT	C11,C16-C17	MURATA ERIE	GR42-6X7R102K50V
A04-1005HCEG1	9	10 NF 10% 50V SMT 1206	C4,C8-C9,C28-C29,C34,C53,C59,C68	MURATA ERIE	GR42-6X7R103K50V
A04-1006FCHI1	21	.1 UF +80-20% 25V SMT	C10,C12-C15,C18,C24-C27,C32-C33,C43,C45-C46,C51-C52,C55-C56,C63,C64	MURATA ERIE	GR42-6Z5U020C50V
A04-1007GTNH1	2	1 UF 35 V DT	C42,C58	SPRAGUE	199D105X0035BB1
A04-1007HPNF1	1	1 UF 5% 63V PY LS 10MM	C54	WIMA	MKS4RM10 1UF/5/63 (10MM
A04-1202HCAF1	2	12 PF 5% 50V SMT	C1,C7	KEMET	C1206C120J5GAC
A04-2201HCAK1	1	2.2PF +-.25P 50V SMT	C69	MURATA ERIE	GR42-6COG022C50V
A04-2204HMAD1	1	2.2 NF 1% 50 V MC	C22	SFETECHNOL	G505BY222F
A04-2701HCAK1	1	2.7 PF 1206 CASE SIZE .25% 50V	C6	MURATA ERIE	GR42-6COG027C50V
A54-3302HCAF1	6	33 PF 0805 50V 5%	C2,C35-C36,C49-C50,C70	MURATA ERIE	GR42-6COG330J50V
A54-3903HCAF1	1	390 PF 0805 50V 5%	C30	MURATA ERIE	GR42-6COG391J50V
A04-3903RSND1	6	390 PF 1% SM	C19,C37-C41	VARIOUS	DM15FD391F03
A04-4703HCAF1	2	470 PF 5% 50V SMT	C5,C67	MURATA ERIE	GR42-6COG470J50V
A04-4708BTNH1	3	47 UF 6 V DT	C44,C60,C65	SPRAGUE	199D476X06R3DB1
A04-5603HMAD1	1	560Pf 300V 1%Polypropylene Film 5.9 mm ls	C21	SFETECHNOL	G505BY561F
A04-6807FTNH1	5	6.8 UF 25 V DT	C47,C57,C61-C62,C66	SPRAGUE	199D685X0025CB1
A06-1505F0001	1	15uH,0.5"LS	L9	DALE	IMC1812-15UH +-10%
A06-A10050001	1	10 UH HI FREQ INDUCT	L8	RENCOELECT	RL2525-10
A06-A12030001	1	.12 UH HI FREQ INDCU 10%	L1	COILCRAFT	1008CS-121
A06-A22040001	2	Series 1210 case size Surf/Mnt Inductor	L2,L16	COILCRAFT	1008CS-222
A06-A68040001	2	6.8 UH HI FREQ INDUC	L7,L15	RENCOELECT	RL2525-6.8
A10-050000001	1	5.000 MHZ,FUND,18PF,HC-49	X1	RXD# MP49 5MHZ	5.000 MHZ,FUND,18PF,HC-
A56-FBEAD0001	9	Smd Ferrite Bead Taped & Reeled)	L3-L6,L10-L14	FAIRRITEPR	2743019446
A99-MIXER0001	1	RF MIXER Mini Circuits# SBL-1	MIX-1		
B01-109L	2	VARICAP DIODE SOT-23	D1-D2	MOTOROLA	MMBV109L

B04-F7000	1	LOW POWER MOSFET TO92	Q7	SILICONIX	2N7000
B14-N23690001	3	NPN TRANSISTOR	Q4-Q6	MOTOROLA	MMBT2369L
B04-N4401	1	LOW POWER TRANSISTOR	Q8	VARIOUS	2N4401
B04-N571	3	RF LP TRANS NPN SOT	Q1-Q3	MOTOROLA	MMBR571
B51-2805	3	SCHOTTKY DIODE SOT-143	D3,D4,D5.	HEWLETT PACKARD	HSMS-2805
C01-1B0000008	1	HI SPD OP AMP - SOIC	U2	ANALOGDEVI	AD844JR
C01-2F0000008	2	DUAL JFET OP AMP	U9,U13	MOTOROLA	MC34082P (OR AP)
C01-2F0000009	1	DUAL JFET OP AMP	U6	MOTOROLA	MC34083P
C02-1P501L002	1	5V PRECISION REFEREN	U11	LINEARTECH	LT1021DCN8-5
C02-1PVARM002	1	VOLTAGE REG. ADJ +1.5 AMP TO-220.	U12	MOTOROLA	LM317T
C04-200000003	2	HI SPEED COMPARATOR	U3-U4	LINEARTECH	LT1016CS8
C04-400000001	1	QUAD COMPARATOR	U10	MOTOROLA	LM339AN
C08-100000004	1	PRESCALER DIVIDE 20/21 SOIC	U1	MOTOROLA	MC12019D
D01-4028X0001	1	BCD-DECIMAL DECODER	U7	MOTOROLA	MC14028BCP
D01-451580001	1	PLL FREQ SYNTH DUAL	U8	MOTOROLA	MC145158P2
D02-000000008	1	CMOS HEX INVERTER	U5	MOTOROLA	MC74HC04
H01-002F00004	1	CM FEM BNC RG316 CRIMP		PASTERNACK	PE4079
H02-002X00001	1	panel mnt cable crim BNC/Use A/D or	Conec#301 A 10999 X	PASTERNACK	PE4106
H05-008000001	4	8 PIN EDGE GRIP SS	US6,US9,US11,US13	AMP	2-640463-2
H05-014000002	1	14 PIN FACE GRIP SS	US10	AMP	2-641261-20
H05-016000002	2	16 PIN FACE GRIP SS	US7-US8	AMP	2-641262-20
H08-003CFW001	1	3 PIN CM END CONNECT W/GOLD PL		PANDUIT	CE100F24-3-CA
H08-003PMW001	1	3 PIN WW STRIP	PS2	SAMTEC	TSW-103-09-GS
H08-005CFW001	1	5 PIN END CONNECTOR,GOLD PLAT		PANDUIT	CE100F24-5-DA
H08-009CFW001	1	9 PIN CM END CONNECT W/GOLD		PANDUIT	CE100F24-9-DA
H08-009PMS002	1	Straight Mascon Header	H4	PANDUIT	MLSS100-9-DA
H08-016CFC001	1	16 COND CM FEM PLUG		3M	3452-6016
H08-016PMW001	1	8 X 2(16 PIN) WW STR	H1	SAMTEC	TSW-108-09-GD
H11-CRN160401	1	Crimp lug, screw size 6 22-18 awg		ZIERICKMAN	A3651W/.144"HOLE
J04-P05026002	12	50 OHM COAX RG-316/U CABLE	M1 (BOTTOM SIDE, QTY IN)		
J10-188000001	1	SHRINK TUBING 3/16" (Black)	M1 (QTY IN INCH)		
K04-1450C	4	4/40 X 1/2` HEX SPACER		KEYSTONE	1450C
Z01-564	1	5.6K 1/4W 5% CF	R66	VARIOUS	1/4 W 5 % CF
Z03-1374	1	1.37K 1/4W 1% MF RN55 50PPM	R29	MILITARY	RN55CF
Z03-2614	1	2.61K 1% 1/4W MF RN55 50PPM	R33	MILITARY	RN55CF
Z03-2874	1	2.87 K 1/4W 1% MF RN55 50 PPM	R28	MILITARY	RN55CF
Z03-4993	2	499 OHM 1/4W 1% MF RN55 50 PPM	R21-R22	MILITARY	RN55CF

Z03-4994	4	4.99K 1/4W 1% MF RN55 50 PPM		R31-R32,R36-R37	MILITARY	RN55CF
Z03-7683	2	768 OHM 1/4W 1% MF RN55 50 PPM		R20,R30	MILITARY	RN55CF
Z03-8873	1	887OHM 1% 1/4W 50PPM		R34	MILITARY	RN55CF
Z17-103	3	100 OHM 1206 5% 1/8W		R12-R13,R38	VARIOUS	1/8 W 5% - SMT
Z17-104	3	1K OHM 1206 5% 1/8W		R14,R23,R62	VARIOUS	1/8 W 5% - SMT
Z17-105	2	10K OHM 1206 5% 1/8W		R40,R54	VARIOUS	1/8 W 5% - SMT
Z17-106	1	100K OHM 1206 5% 1/8W		R41	VARIOUS	1/8 W 5% - SMT
Z17-107	2	1 M OHM 1206 5% 1/8W		R35,R53	VARIOUS	1/8 W 5% - SMT
Z17-152	3	15 OHM 1206 5% 1/8W		R4,R6,R10	VARIOUS	1/8 W 5% - SMT
Z17-155	1	15K OHM 1206 5% 1/8W		R44	VARIOUS	1/8 W 5% - SMT
Z17-183	1	180 OHM 1206 5% 1/8W		R7	VARIOUS	1/8 W 5% - SMT
Z17-223	1	220 OHM 1206 5% 1/8W		R63	VARIOUS	1/8 W 5% - SMT
Z17-224	5	2.2K OHM 1206 5% 1/8W		R1,R17,R42-R43,R51	VARIOUS	1/8 W 5% - SMT
Z17-273	2	270 OHM 1206 5% 1/8W		R11,R55	VARIOUS	1/8 W 5% - SMT
Z17-333	1	330 OHM 1206 5% 1/8W		R5	VARIOUS	1/8 W 5% - SMT
Z17-334	4	3.3K OHM 1206 5% 1/8W		R18,R24,R26,R52	VARIOUS	1/8 W 5% - SMT
Z17-394	1	3.9K OHM 1206 5% 1/8W		R19	VARIOUS	1/8 W 5% - SMT
Z17-473	3	470 OHM 1206 5% 1/8W		R15-R16,R61	VARIOUS	1/8 W 5% - SMT
Z17-474	6	4.7K OHM 1206 5% 1/8W		R2-R3,R25,R27,R49,R65	VARIOUS	1/8 W 5% - SMT
Z17-475	1	47K OHM 1206 5% 1/8W		R50	VARIOUS	1/8 W 5% - SMT
Z17-562	2	56 OHM 1206 5% 1/8W		R8-R9	VARIOUS	1/8 W 5% - SMT
Z17-563	2	560 OHM 1206 5% 1/8W		R39,R64	VARIOUS	1/8 W 5% - SMT
Z17-684	2	6.8K OHM 1206 5% 1/8W		R57-R58	VARIOUS	1/8 W 5% - SMT
Z17-823	1	820 OHM 1206 5% 1/8W		R56	VARIOUS	1/8 W 5% - SMT
Z52-10051206	3	10K OHM 1206 1% 1/8W	CHIP RESISTOR	R45, R48, R59		PAN ERJ-8ENF1002
Z52-11551206	2	11.5K OHM 1206 1% 1/8W		R46, R60		
Z52-13051206	1	13K OHM 1206 1% 1/8W		R47		

MSI Part Number	Qty	Description	Reference Designators	Manufacturer	Manufacturer Part Number
VO2-FMMH					
A04-1004SCDG1	1	1 NF 10% DISC		CENTRALAB	CE102
A04-1203UCBG1	1	120 PF DISC		ARCO	CCD121
A04-4705JMCH1	1	.047 PF 100V MC		CENTRALAB	CZ20A473M
A06-FBEAD0001	1	FERRITE BEAD		FAIRRITEPR	2743002111
A08-D24212202	1	12.6 VOLT PC MT TRANSFORMER		MAGNETCOIL	4-05-4302(-4012W/WIRES)
A09-S3AG02501	1	FUSE, SLOW BLOW, 1/4 AMP		LITTLEFUSE	313.25
H02-002F00003	1	LONG BUSHING BNC CONNECTOR		KINGS	KC79-46
H08-003CFW001	1	3 PIN CM END CONNECT W/GOLD PL		PANDUIT	CE100F24-3-CA
H08-003CFW002	1	3-PIN .156 END CONN		PANDUIT	CE156F20-3
H11-CRN160401	1	Crimp lug, screw size 6 22-18 awg		ZIERICKMAN	A3651W/.144"HOLE
H99-003000001	1	POWER INPUT MODULE CORCOM 6J4		CORCOM	6J4
J07-P18000005	1	POWER CORD 2.3 METER THIN LINE		BELDEN	17251
K09-H10SCL001	4	`D` SUB SCREWLOCK-SET OF 2 PCS		KEYSTONE	7231
K99-000000001	1	NYLON FLAT WASHER		HHSMITH	2678
O11-000000004	1	0.562" CABLE MNT CLAMP	MOUNTING CLAMP FOR ATTENUATOR		
V03-FMML	1	PWB ASSY, DISPLAY, FMMM-1, -2			
O09-000000003	4	Counter sunk,alum.body,w/steel head			
Z07-103	1	100 OHM 5% 1/2W CC EB TYPE		ALLENBRADL	EBTYPE1/2W5%CC

MSI Part Number	Qty	Description	Reference Designators	Manufacturer	Manufacturer Part Nu
VO5-FMC1					
H01-002M00003	1	CM MALE BNC RG316 CRIMP		PASTERNACK	PE4043
H02-002X00001	1	PANEL MNT CABLE CRIM BNC Use A/D or Conec#301 A 10999 X		PASTERNACK	PE4106
J03-RG174	6	COAX RG174 Belden# 8216 Black 26 awg 50 ohm U Type			