12.0 USER'S MANUAL

Cable AML

Installation and Maintenance Manual

MMDS Outdoor Broadband Transmitter

Model: OTX02-250

INSTALLATION AND MAINTENANCE MANUAL

for

MMDS Outdoor Broadband Transmitter

Model: OTX02-250

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1.0 INTRODUCTION

The MMDS Outdoor Transmitter OTX02-250 shown in Figure 1 is a solid-state broadband transmitter that converts VHF input signal of 220 to 403 MHz to a microwave signal of 2.5 to 2.686 GHz.

The OTX02-250 transmitter consists of the following assemblies (refer to Figure 3):

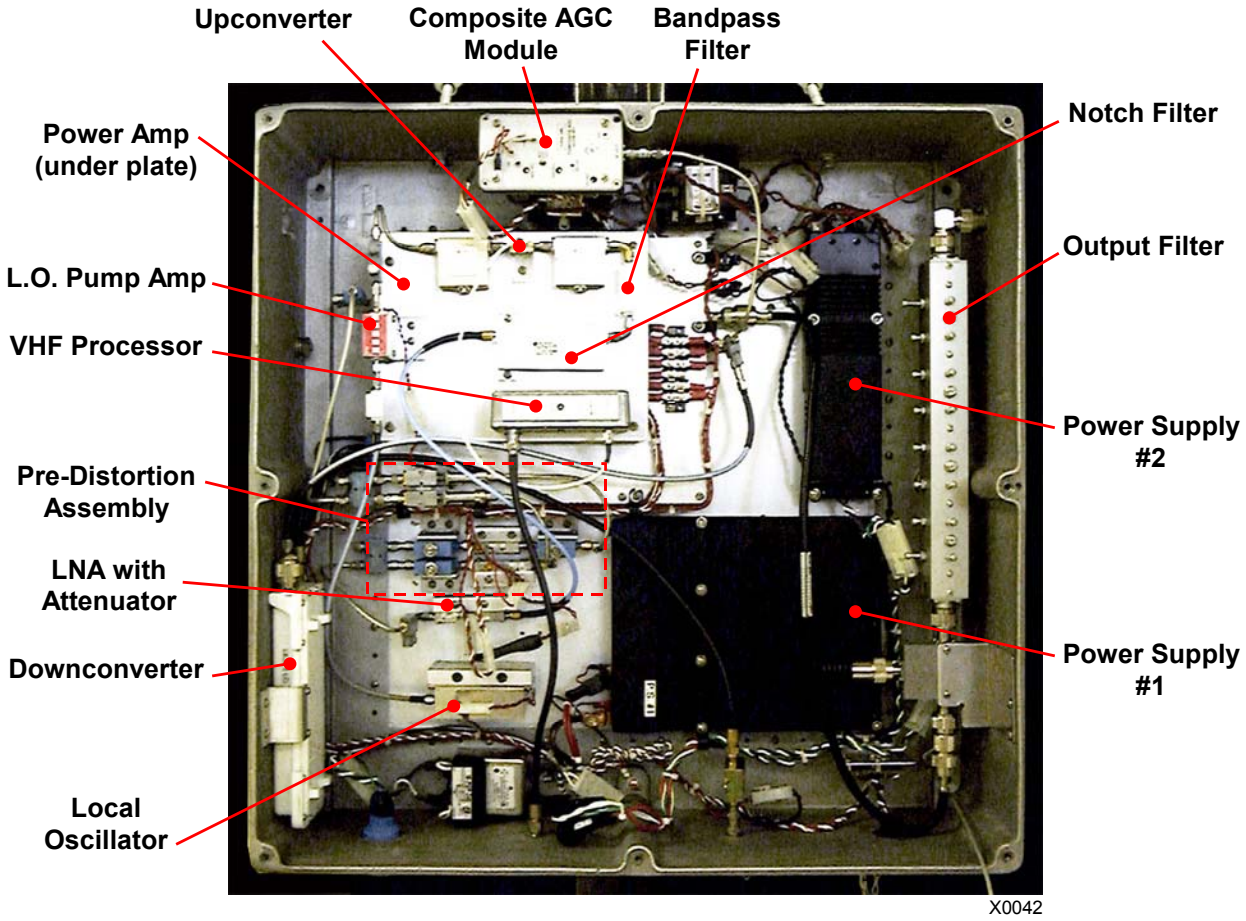
1. **Upconverter Assembly** – for converting the incoming VHF signal to microwave. The upconverter assembly contains all components necessary for upconversion, i.e. local oscillator, mixer, as well as bandpass and notch filters.
2. **Predistortion Linearity Assembly** – Transmitter linearity is significantly improved by the addition of a linearity enhancement circuit to the microwave power amplifier. The better the linearity, the lower the composite triple beat (CTB) distortion.
3. **Power Amplifier** – The amplification is accomplished with minimum distortion by a state of the art Gallium Arsenide FET microwave power amplifier with an established field reliability record. The power amplifier is protected from failure due to overheating by an internal temperature sensor. The sensor circuit automatically switches off the amplifier D.C. power when the amplifier temperature exceeds 158° F (70° C).
4. **Power Supply System** – The OTX02-250 utilizes two AC/DC power supplies. One provides +12 VDC power to the power amp, and the other provides +12 VDC power to all other devices.
5. **Monitoring and Diagnostic Circuits** –The output of the OTX02-250 can be continuously monitored without interruption of service with a standard field strength meter. Diagnostic DC voltages can also be continuously monitored via a multipin connector. Both test points are located on the bottom of the OTX02-250.
6. **VHF Processor Module** – The VHF input to the transmitter is sent to the VHF Processor Module. This is a level set attenuator. The VHF signal is then sent to the upconverter mixer.
7. **Low Noise Amplifier with AGC** – The OTX02-250 has a LNA with a built in attenuator circuit. The attenuator is controlled by a composite AGC module. The output of the OTX02-250 is keep at a constant level regardless of ambient temperature changes
8. **Fan Assembly** – The OTX02-250 is cooled by a +12 VDC fan controlled by a thermostat mounted on the heat sink.

The OTX02-250 transmitter can be equipped to operate on either 120 or 240 VAC at 50 or 60 Hz. This option is specified by customer request, and each unit is shipped according to this specification.

Complete specifications are listed in Section 6.0.

X0040

Figure 1. OTX02-250 Broadband Transmitter.



X0042

Figure 2. OTX02-250 Component Layout.

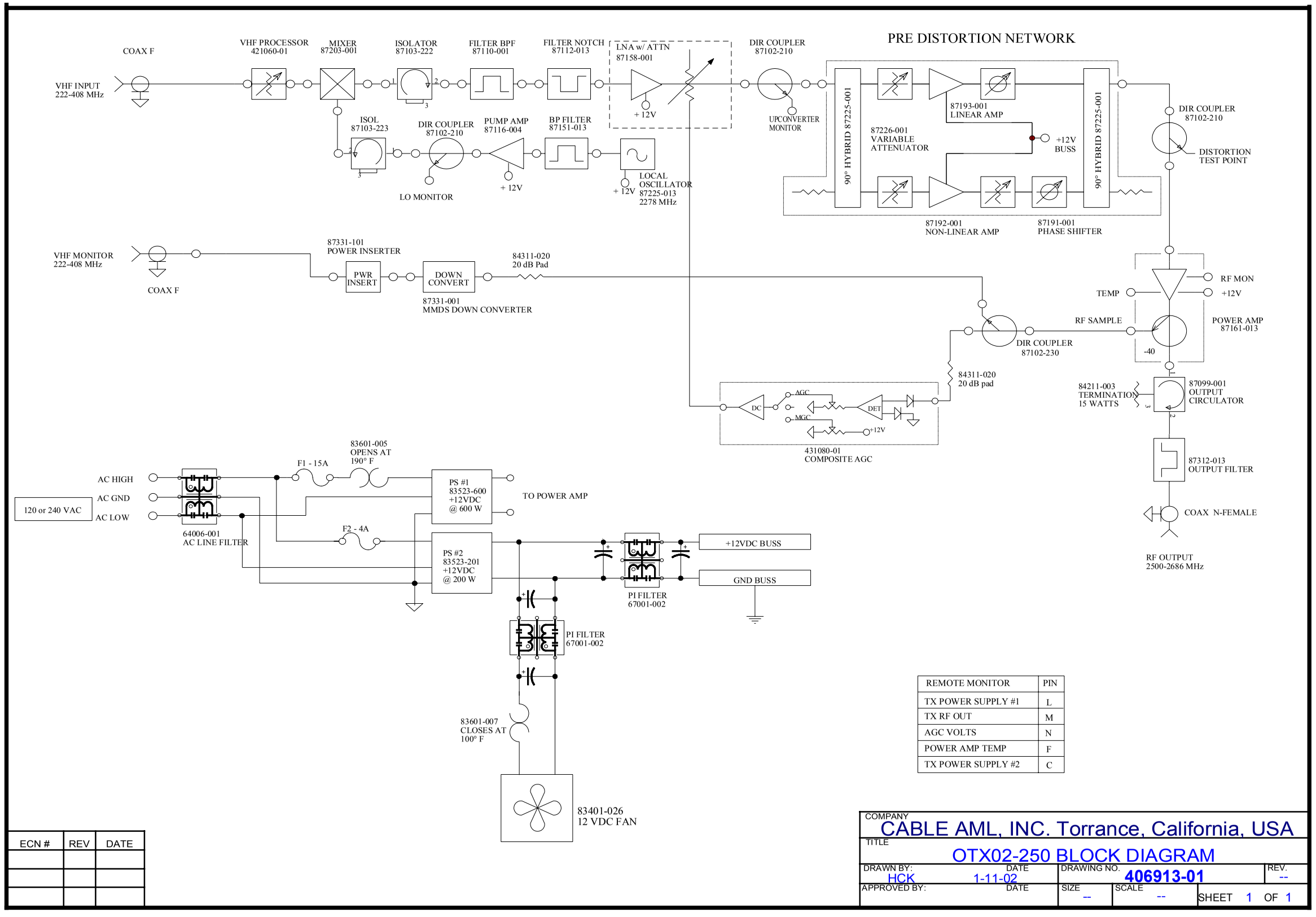


Figure 3. OTX02-250 Block Diagram.

2.0 CIRCUIT DESCRIPTIONS

The OTX02-250 Transmitter consists of the following circuits or modules:

1. Upconverter Section
2. Microwave Pre-distortion Assembly
3. Power Amplifier
4. Power Supply System
5. Monitoring and Diagnostic Circuits - connectors and switches.
6. Low Noise Amplifier With AGC
7. Fan Assembly

In addition, microwave isolators and filters are used as necessary to ensure the stability and purity of transmitted signals.

2.1 Upconverter Section

The Upconverter Section is comprised of the following major functional circuits or modules:

1. Hybrid Local Oscillator
2. Upconverter/ Mixer
3. Filter Assembly
4. VHF Processor Module

Hybrid Local Oscillator - The local oscillator consists of a crystal oscillator, frequency multiplier, and a band pass filter all encapsulated in solid 6061-T6 aluminum. The frequency of the oscillator is 2278 MHz. The frequency stability of the oscillator is .0005%. The output of the local oscillator provides pump power to the signal upconverter. The local oscillator is powered by +12 VDC.

Upconverter Mixer - The translation from VHF to microwave frequencies takes place here. The mixer is also called an "upper sideband upconverter". The desired output of the upconverter is a signal at a frequency, which is the sum of the local oscillator, and VHF input frequencies. The upconverter also generates unwanted signals that have to be filtered out, among them the "lower sideband", LO leakage, and others.

Filter Assembly - There are two filters. The group bandpass filter is tuned to pass the upper sideband. The notch filter is tuned to attenuate the local oscillator leakage without affecting the output signal.

VHF Processor Module – The VHF signals are sent to the Processor module first. The processor changes the impedance of the VHF signals from 75 ohms to 50 ohms, and the processor has a level set attenuator so minor level changes can be made.

2.2 Microwave Predistortion Network

Predistortion Linearizer Assembly enhances the linearity of the amplifier by generating distortion products equal in amplitude but with opposite phase to those generated in the power amplifier, thus canceling a significant amount of the distortion. The signal coming

into the predistortion network is split into two circuits by a quadrature hybrid. The linear circuit consists of a variable attenuator, a linear amplifier, and a line stretcher. The non-linear circuit consists of a variable attenuator, a non-linear amplifier, and another variable attenuator, and a line stretcher. The outputs of these two circuits are recombined by another quadrature hybrid.

The phase shifters are adjusted so that the output of the non-linear amplifier is out of phase with the output of the power amplifier. The non-linear attenuators control the amount of distortion generated in the non-linear amplifier.

2.3 Power Amplifier Chains

The power amplifier is self-contained, separately manufactured unit with a 1 dB compression point of 100 Watts (50 dBm). The addition of the pre-distortion network increases the 1 dB compression point to 250-Watts average. The total gain of the amplifier is approximately 50 dB. In addition to the microwave circuits, the amplifier includes DC voltage regulator circuits and output RF monitoring circuits. The power amplifier requires +12 VDC @ 45 amps.

2.4 Power Supply Assembly

Two power supplies are used in the OTX02-250. A 12VDC @ 600 watts power supply is used for the power amplifier. The other power supply is a 12 VDC @ 200 watts which is used to power everything else.

2.5 Diagnostic Circuits

VHF Monitor - There is one monitor connector on the bottom of the enclosure. The transmitter's output at VHF can be viewed at the OUTPUT MONITOR". The "OUTPUT MONITOR" selects the VHF spectrum downconverted from a sample of the microwave output of the power amplifier. The downconversion is performed by an internal MMDS downconverter with the same LO as the compact transmitter.

DC Monitor - Certain test points in the transmitter can be monitored externally at the "Remote Monitor" output multi-pin connector. The output connector is designed for use with diagnostic test boxes such as the Cable AML DTB-1, the WRM-2, or the RM-2A. The test points and corresponding connector pin connections are shown in the Transmitter Block Diagram.

The DC diagnostics are connected to the output connector through a signal conditioning circuit. The signal conditioning circuit is a network of resistors that provides short circuit protection for the transmitter diagnostics sources.

2.6 Low Noise Amplifier with microwave AGC

The Microwave AGC Circuit consists of a Composite AGC module and a LNA with attenuator in the output stage. The purpose of the AGC circuit is to keep the output of the transmitter at a constant level.

The transmitter's output signal is sampled by the 40 dB coupler internal to the power amplifier and fed to the Composite AGC module, where it is detected by a coaxial tunnel diode detector. The detector output is then amplified and conditioned to drive the LNA with attenuator in the output stage. The microwave detector is temperature compensated to minimize output level variation with temperature.

The AGC module has one switch and three adjustments.

The AGC/MGC switch located near the middle of the module has three positions:

1) AGC. In this position the microwave Automatic Gain Control is on.
2) OFF. In this position the diode attenuator is at a minimum.
3) MGC. In this position the Manual Gain Control is on.

The three adjustments are as follows:

1) The "AGC ADJUST" is a potentiometer that adjusts the AGC threshold voltage. This sets up the output power of the transmitter at a constant output level regardless of input level variations.
2) The "MGC ADJUST" is a potentiometer that controls the microwave attenuation when the switch is in the MGC position.
3) The "DETECTOR BALANCE" is a potentiometer that allows you to set the voltage at the detector test point to zero when there is no input signal.

The transmitter is set up with 5 dB of AGC to compensate for the output power variations due to ambient temperature changes.

2.7 Fan Assembly

The OTX02-250 has a 12VDC-powered fan to keep the components cool. A thermostat mounted next to the power amplifier controls this fan. The fan will turn on when the temperature of the heat sink exceeds 100°F.

3.0 INSTALLATION

3.1 Unpacking

Inspect shipment for obvious damage then carefully check for other possible shipping damage such as bent or loose connections that may result in signal leakage. **If any damage is suspected, notify Cable AML and the shipper before proceeding with installation of the equipment.**

Check the packing list against the parts shipped and verify that the correct material has been received. Communicate any discrepancies to Cable AML immediately.

3.2 Location

The OTX02-250 is designed for tower mounting near the transmit antenna. Two U-Bolts are provided to mount the transmitter to the antenna pole. Simply bolt the U-Bolts to the two adapters on the transmitter body.

3.3 Input Voltage Requirements

Cable AML transmitters can be equipped to operate on either 120 or 240 VAC at either 50 or 60 Hz. This option is specified by customer request, and each unit is shipped according to this specification.

3.4 Operating and Diagnostic Connections

Operating Connections

- **RF Output** - The transmitter's RF output connector is a type N female coaxial, to which the output cable to the transmit antenna is connected.
- **VHF Input** - The transmitter's VHF input connector is a type F female, to which the VHF inputs are connected.

AC Power Connections - This unit is equipped with an AC power cord that is wired for single-phase operation. It is necessary to attach a plug to the power cord before putting the unit into operation. It is important that the following color code be followed when wiring up the transmitter!!

The **BLACK** or **BROWN** wire is **HOT** or **MAIN** lead.

The **WHITE** or **BLUE** wire is the **NEUTRA**L lead.

The **GREEN** or **GREEN/YELLOW** is the **GROUND** or **EARTH** lead.

Table 1. Typical Channel Loading for OTX02-250 Input/Output Levels[1]

Number of Channels	Average Power dBm/Channel	Peak Power dBm/Channel
9	31.5 dBmV/Channel	34.0 dBm/Channel
12	30.0 dBmV/Channel	32.5 dBm/Channel
18	28.0 dBmV/Channel	30.5 dBm/Channel
24	26.0 dBmV/Channel	28.5 dBm/Channel
30	25.0 dBmV/Channel	27.5 dBm/Channel

Figure 4. Rear Mounting View.

1 See Data Manual for actual values.

4.0 OPERATION

The OTX02-250 transmitter requires no adjustments when used in the configuration recommended in the Data Manual. To properly operate the transmitter, simply apply the required AC power and input signal. The OTX02-250 transmitter can be equipped to operate on either 120 or 240 VAC at 50 or 60 Hz. This option is specified by customer request, and each unit is shipped according to these specifications.

4.1 Output Level Setting

The output power for each OTX02-250 Transmitter Unit depends entirely on the input level. If the input level at VHF is higher than the recommended value, both the output power and the CTB (Composite Triple Beat) distortion will increase. For every one dB of higher input level, there will be one dB of higher output power and two dB higher distortion.

CONSEQUENTLY, IT IS NOT RECOMMENDED TO CHANGE OR ADJUST THE TRANSMITTER OUTPUT LEVELS UNLESS THERE ARE SIGNIFICANT CHANGES IN THE NUMBER OF INPUT CHANNELS OR OTHER SYSTEM PARAMETERS.

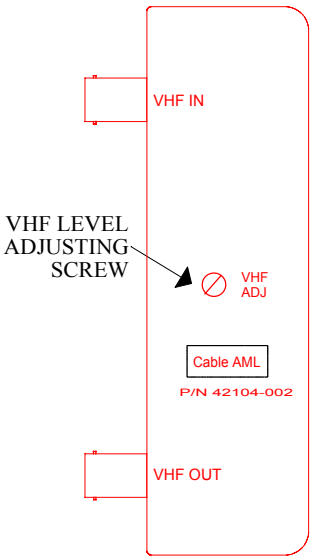


Figure 5. Output Level Adjustment.

This operation requires a microwave Power Meter and Spectrum Analyzer.

With the AGC switch on the AGC Module set to "OFF", the output level can then be set by adjusting the VHF Processor Module's level set attenuator labeled "VHF ADJ" for the required output level required by the system design. The adjusting screw is shown in Figure 5. If a power meter is not available, the transmitter output monitor reading can be used in conjunction with a table provided with the transmitter performance data sheets provided in the Data Manual.

Observe the output of the transmitter with the spectrum analyzer. Using the "VHF ADJ" set the channel levels to the desired level plus the 5 dB margin for the AGC circuit. An individual channel that is out of line with the others must be adjusted at its source. Switch the AGC from “OFF” to “AGC” and adjust the level according to the required output.

4.2 Ambient Conditions

The OTX02-250 transmitter is designed to operate with no external cooling devices. Internal cooling fans maintain component temperatures at desirable levels when ambient conditions are in the range specified in Section 6.0 - Specifications.

4.3 Thermal Sensor Switch

To protect the power amplifier from overheating due to fan failure or excessive ambient temperature, an internal temperature sensor automatically cuts off AC input power to the power amplifier when the temperature exceeds a factory set threshold of 158° F (70° C). If the cause of overheating is fan failure, the failed unit should be replaced before applying power.

5.0 MAINTENANCE AND TROUBLESHOOTING

5.1 Maintenance

Maintenance is not normally required for the OTX02-250 after initial installation. However input and output power levels should be measured periodically and adjustments made if necessary.

The output power level should be measured and adjusted as described in Section 4.0 of this manual. The VHF input levels should be verified before making significant adjustments in the transmitter. If the VHF input level is correct and the transmitters output cannot be set properly, external troubleshooting is necessary as described in the next section.

5.2 External Troubleshooting

In the event of low or no output from the transmitter, first verify the following:

1. Verify the AC power input by checking the fan on the transmitter for motion. If not operating then check the line fuse.
2. Frequency and level of the VHF input.
    - Incorrect input frequencies may produce output frequencies that are unable to pass through the two filters or the power amplifier. (refer to Table 1).

If these items are found acceptable, check the VHF Transmitter Monitor output:

1. If the Transmitter Monitor OUTPUT selection produces low or no output, check the DC diagnostics with a test box.

DC Diagnostics (Table 2 lists expected values for each function)

NO +12 VDC. Internal troubleshooting is necessary.

Table 2. Cable AML DTB -1 Test Box - Function Values.

Receiver Function	Dial Position	Meter Scale	Meter Reading	Pin Connection
+12 VDC supply #1	+24V	Volts DC	+12 ± 0.5	L
+12 VDC supply #2	-12V	Volts DC	+12 ± 0.5	C
Tx AGC Voltage	VHF AGC	Volts DC	0.3 to 1.5 VDC	N
Temperature-Power Amp	+15V	Volts DC	<0.75 VDC	F
Detected Microwave Output Power:	PWR OUT	Volts DC	0 ± 0.7	M

* Depends on power output and channel loading. See transmitter data sheet for actual reading.

PWR OUT – Measures the relative power the transmitter is making, expressed as a negative voltage. Upon initial installation of the transmitter, this voltage should be logged for future reference. Should this voltage change, the output power of the transmitter has changed. The change in power can be found using:

Change in dB = 20 log [pwr out(original)/pwr out(present)]

Example: The initial power out (pwr out) voltage is –0.7. Some time later the voltage reads-0.35. **dB = 20 log[-0.7/-0.35]; The change in transmitter output power is 6 dB.**

5.3 Internal Troubleshooting

WARNING

Internal troubleshooting requires that:

- Power remains on.
- Transmitter cover is removed.

CONTACT WITH LINE VOLTAGE CAN BE FATAL!

It is recommended that internal troubleshooting be limited to personnel skilled in maintenance of microwave transmitters or receivers.

IF IT IS NECESSARY TO REPLACE COMPONENTS, THE REPLACEMENT OF PARTS SHOULD BE DONE WITH THE EXTERNAL AC POWER DISCONNECTED.

⌘

Internal Quick Check.

A quick check should show that the fan is operating and the power amplifier and its power supply are warm to the touch.

Fan not operating

If the fan is not operating check for +12 VDC on the terminal strip, where the fan is connected. If +12 VDC is present and the fan is not operating, replace the fan.

Lack of +12 VDC

If internal trouble shooting is required due to lack of +12 VDC in the external DC diagnostic test then check for internal +12 VDC on the terminal strips. If either of these voltages is missing, first disconnect the wires from the power supply output terminals and recheck the voltage.

If the power supply voltage with no load is not +12 VDC then the power supply is defective and should be replaced.

If the voltage is normal, the load on the power supply is too high causing the supply to go into crowbar and shut down. At this point, examine the wiring harness for an obvious wiring fault. If no fault is found, then one of the modules supplied by that power supply is shorted internally and should be replaced. To identify the module remove the DC power wire for each module one at a time from the terminal block until the DC power bus is restored to normal.

Power Amplifiers not Warm

If the amplifier is cool, then check for 12 VDC at the input to the amplifier.

If 12 VDC is present at the input to the amplifier and the amplifier is cool then replace the amplifier.

Power Supplies O.K. and Power Amplifier Warm, but Low or No Output

Check all internal RF connections. For the SMA connectors, a 5/16" open-end wrench is required. "Finger-tight" is not acceptable for microwave connections.

Disconnect the Local Oscillator line at the input to the pump amplifier. Check for the power level. If the level is within specifications (nominally +15 dBm), reconnect the Local Oscillator line and disconnect the line at the output of the pump splitter feeding the upconverter and measure the pump (LO) power. It should be about 20 dBm. Make sure to pad down the output since most power meters can only handle 20 dBm input. If not, replace the amplifier.

Source Power and Upconverter LO Power O.K.

Reconnect all lines. Disconnect the output line at the upconverter and measure its output at microwave. If no or low output is observed, the upconverter is defective.

Upconverter Output O.K.

Check the output at the filter assembly feeding the power amplifier. This should be 1 to 2 dB lower than measured out of the upconverter. If there is no output at this point, the filter is defective.

Filter Assembly Output O.K.

Remove the SMA coaxial cable on the 40 dB directional coupler at the output of the power amplifier. Measure the microwave power at the coupler output. It should be about 10 dB above the power measured at the upconverter or filter assembly output. If not, the amplifier is defective. Replace the power amplifier and its power supply.

6.0 SPECIFICATIONS

OTX02-250

<table>
<tr><th colspan="2">Transmitter</th></tr>
<tr><td>Input Frequency[2]:</td><td>220 to 420 MHz</td></tr>
<tr><td>Nominal Input Level for 12 TV:</td><td>+29 dBmV (-29 dBm)</td></tr>
<tr><td>Output Frequency[2]:</td><td>2.5 to 2.686 GHz</td></tr>
<tr><td>Output Level for 50 dB C/CTB:
(measured with CW carriers)[3]</td><td>
<table>
<tr><th>Channels</th><th>Average Power dBm/Channel</th><th>Peak Power dBm/Channel</th><th>C/N (dB)</th></tr>
<tr><td>9</td><td>31.5</td><td>34.0</td><td>64.5</td></tr>
<tr><td>12</td><td>30.0</td><td>32.5</td><td>63.0</td></tr>
<tr><td>18</td><td>28.0</td><td>30.5</td><td>61.0</td></tr>
<tr><td>24</td><td>26.0</td><td>28.5</td><td>59.0</td></tr>
<tr><td>30</td><td>25.0</td><td>27.5</td><td>58.0</td></tr>
</table>
</td></tr>
<tr><td>Local Oscillator Frequency[2:]</td><td>2278 MHz</td></tr>
<tr><td>Frequency Response:</td><td>±1 dB</td></tr>
<tr><td>Frequency Stability:</td><td>0.0005%</td></tr>
<tr><td>Input Return Loss:</td><td>15 dB</td></tr>
<tr><td>Input Connector:</td><td>Type "F" Female</td></tr>
<tr><td>Output Return Loss:</td><td>18 dB</td></tr>
<tr><td>Output Connector:</td><td>Type "N" Female</td></tr>
<tr><td>Temperature Range:</td><td>-40° to 122°F (-40° to 50°C)</td></tr>
<tr><td>Humidity:</td><td>100% max.</td></tr>
<tr><td>Primary Power:</td><td>120/240 VAC, 50/60Hz (per customer specification)</td></tr>
<tr><td>Power Consumption:</td><td>840 VA RMS</td></tr>
<tr><td>Mounting:</td><td>Antenna Pole Mount</td></tr>
<tr><td>Weight:</td><td>160 lb. (72.5 kg)</td></tr>
<tr><td>Dimensions:</td><td>24" W x 24" H x 15" D
(61 W x 61 H x 38.1cm D)</td></tr>
</table>

[1] Specifications subject to change without prior notice.
[2] Other frequencies available.
[3] The C/CTB with modulated carriers is approximately 6 dB better than with CW carriers.