LEAMING FMR 411 (AGILE) DEMODULATOR

INSTRUCTION BOOK
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by

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FMR411
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1.0 INTRODUCTION

1.1. PRODUCT DESCRIPTION, FMRÿ411 & KDÿ731

The FMR 411 Demodulator is intended for use in high quality audio program transmission systems via terrestrial or satellite microwave. The KD731 SCPC Demodulator is similar to the FMR411 (agile), but also includes a 3.75-Hz notch filter to remove any energy dispersal signals from the program audio.

Each FMR 411 receives one program channel. It is a superheterodyne receiver operating either in the 4 ... 10 MHz range (subcarrier over video) or the 42 ... 88 MHz range (Microwave transmitter IF) or the 88 ... 108 MHz range (F.M. Broadcast). An audio low pass filter is also provided to suppress out-of-band noise; the cutoff frequency may be 3.5 kHz, 7.5 kHz, 15 kHz, or 110ÿkHz, as specified at time of order. De-emphasis may be set at the factory to 75-, to-, 25-, or 17-us, or to the Intelsat standard, 333 mS. The de-emphasis may be bypassed (with an internal jumper-jack) for flat operation.

Each demodulator mounts in the PMU413, A 19" panel, 1 3/4" high, and uses a companion PS 420, -24 V power supply. The FMR411 is available without the alarm and the audio output relay and switch or the 3 3/4 Hz notch filter on special order.

The Leaming FMT411 or KM731 are suitable companion modulators for the FMR411 and KD731 demodulators.

Throughout this manual, wherever the FMR 411 is mentioned, the KDÿ731 is also included, unless specifically excluded.

1.2. SPECIFICATIONS (Standard; other values may be available on special order)

INPUT IMPEDANCE: Bridges a 50- or 75-ohm line

NOMINAL INPUT LEVEL: 0 dBmV ... 50 dBmV

TUNING STEPS: 12.5 kHz std.; 10 kHz or 11.25ÿkHz opt.

IF BANDWIDTH: Factory-set to (FM + Dev) x 2

RECOMMENDED MODULATION: ñ75 kHz @ 100%, std.

DE-EMPHASIS: 75 ms standard

FREQUENCY RESPONSE: 20 Hz ... 100 kHz, ñ0.5 dB

LOW PASS FILTER: 18 dB/oct, -0.5 dB @ 3.5ÿkHz,ÿ7.5 kHz, 15ÿkHz, or 60 kHz std. (one value only)

DISTORTION: < 0.5 % @ 100% modulation

NOMINAL OUTPUT LEVEL: < 10 dB (re 775 mV), adjustable

MAXIMUM OUTPUT LEVEL: + 24 dB (re 775 mV) balanced or floating load, +18 dB unbalanced

LOAD IMPEDANCE: > 600 OHM

POWER REQUIREMENTS: < 180 ma, -24 V dc

PHYSICAL DIMENSIONS: 40 mm (1.56 in) H
191 mm (7.50 in) W
270 mm (10.6 in) D
To fit 1/3 PMU413

WEIGHT: approx. 1 Kg (2.2 lb)

CONTROLS: Squelch Sensitivity
(Front) Audio Output Level
Audio On/Remote/Off

CONNECTIONS: Carrier Loop In
(rear) Carrier Loop Out
(BNC std., "F" opt.)

Remaining connections are barrier-strip screws:

-24V Power Input
Power Ground (Chassis)
Relay Actuate (grounding causes relay to switch Audio Output on & open Relay Contact
Relay Contact (grounded when carrier is off/squelched)
Audio Lo
Audio Hi

ADDENDUM
FMR 411 SPECIAL OFF-AIR FM-BAND RECEIVER SENSITIVITY and OVERALL SPECIFICATIONS

To receive off-air FM Stereo or Mono radio broadcasts with the FMR 411, it is necessary to provide a signal of at least 100 microvolts (and preferably greater than 300 microvolts for significant quieting) to the input of the FMR 411. This requirement may be directly met in a strong-signal area by using a good antenna, but it will probably require a booster amplifier between the antenna and the FMR 411 in an area with weaker signal strength.

To peak the received signal and reduce unwanted signals, two adjustable LÄC bandpass filters are provided at the RF input of the FMR 411. These filters are manually tunable by means of variable capacitors. If the FMR 411 is set to receive a different frequency from that for which these input filters were tuned, the input sensitivity may be improved by retuning these filters for best noise performance.

To tune the input RF filters, remove the top cover of the FMR 411. The two variable capacitors nearest the input connectors are the ones to be adjusted. While listening to the signal being received, carefully adjust each filter for minimum noise in the received audio.
NOTE: If these filters are off-tuned, or if the signal is extremely weak, the receiver may fail to un-squelch, even with the squelch control fully clockwise. To permit listening to the signal regardless of the signal strength or squelch setting, connect a jumper plug (or clip) between the two .025" square pins located just inboard from Pin 16 of the LM3189 (CA3189) integrated circuit. This jumper should be removed for normal operation, where the squelch control is set to mute the receiver if the signal becomes too weak for satisfactory reception.

Listed below are the overall system performance specifications when connected to receive a stereo FM broadcast, and remodulate it (using a Leaming FMT411 wideband audio / composite multiplex stereo modulator) to a different frequency in the FM broadcast band.

Frequency Response: 20 Hz to 15 kHz ñ1 dB
Channel Separation: >20 dB
Signal-to-Noise Ratio: >55 dB
Tot. Harmonic Distortion: <1%

NOTE: The frequency response of the FMRÿ411 alone, when used for composite-stereo re-broadcast, is configured to ñ0.25ÿdB from 50ÿHz to 50ÿkHz / ñ3ÿdB from 10ÿHz to 110ÿkHz, and "flat" (no de-emphasis).

2.0 INSTALLATION

2.1. UNPACKING AND INSTALLATION

The FMR 411 SCPC Demodulator was carefully inspected, mechanically and electrically, before it was shipped from the factory. Inspect it for mechanical damage incurred in transit and test the unit's electrical performance. If there is any damage or deficiency, immediately notify the carrier, or the Leaming distributor from which you purchased the unit, or the factory. In the event of mechanical damage, the packing materials and carton should be held for inspection by the carrier.

2.2. PREPARATION FOR USE

2.2.1 POWER REQUIREMENTS

The FMR 411 requires a power source capable of providing -24 V DC, 180 mA. The Leaming PS 420 is recommended.

2.2.3. POWER CONNECTIONS

See figure 2-1.

1. Make sure that the power supply is disconnedted from the AC mains.
2. There are two power terminals on the barrier strip on the rear of the FMR 411. Connect the ground terminal to the positive terminal of the power supply.
3. Connect the "-24 V" terminal to the negative side of the power supply.

2.2.5. COOLING

The temperature of the surrounding air should not exceed 55°C (131°F). Under normal operating conditions, no extra vertical clearance will be required in rack mounting. However, If a strong heat source is located below the FMR 411, extra vertical clearance for cooling may be necessary.

2.2.6. RACK MOUNTING

The FMR 411 is designed to be mounted in a PMU413 rack mounting unit. A PMU413 will hold up to three FMR 411's. All necessary hardware for mounting in a standard 19-in relay rack is provided with the PMU413. One rack unit (1.75 in) is required.

2.2.7. CABLING

High-quality cable should be used. The audio output line should be shielded, twisted-pair cable such as Belden Type 8760 or equivalent. Other signal cables should be 50- or 75-ohm coaxial cable. The audio output is via two terminals on the rear panel barrier strip. All RF signal connections are via BNC Connectors.

3.0 OPERATION

3.1. SIGNAL CONNECTIONS

3.1.1. AUDIO OUTPUT

Figure 3-1 shows the rear panel layout of the unit. The program audio output is via two of the terminals on the barrier strip on the rear.

Connect the high and low signal lines to the terminals as shown on the rear panel lable. Do not connect the shield line to the ground connection on the barrier strip if the load equipment is properly connected to the AC mains safety ground. The shield line should be grounded at the input terminals on the far end of the cable.

3.1.2. RF CONNECTIONS

The RF loop-through connections are via BNC jacks located on the rear of the demodulator. Feed the R.F. signal to the loop-through (daisy chain) input of the FMR 411. The FMR 411 then feeds the next element in the daisy chain. See Figures 3-2 and 3-3. Note that the loop-out of the FMR 411 must be terminated with the characteristic impedance of the signal source (typically 50 or 75 ohms).

3.3. SETTING THE DEMODULATOR RECEIVE FREQUENCY

The FMR 411 demodulator is a superheterodyne receiver. The local oscillator (L.O.) is tuned above the frequency of the received signal, offset by the intermediate frequency (I.F.).

The frequency of the Local Oscillator is to be set to as follows:
LOF = CF + IF, where LOF is the local oscillator frequency, CF is the carrier frequency of the received signal, and IF is the intermediate frequency.

The DIP switches next to U303, an MC145151-1 PLL, are used to set the L.O. operating frequency.

The IF is dependent on tuning step size. For units with 10.0 kHz or 12.5 kHz increments (8.192 MHz or 10.240 MHz crystal, respectively), IF = 10.70 MHz. For units with 11.25 kHz increments (9.216 MHz crystal), IF = 10.71 MHz.

3.3.1. The LOF is equal to the sum of the values of the active (open) DIP switches. A switch is active when the numbered end of its rocker is raised.

Crystal: 10.240 MHz 9.216 MHz 8.192 MHz

Switch Number   Weighting (with divider/prescaler)

A1	12.5 kHz	11.25 kHz	10 kHz
A2	25 kHz	22.5 kHz	20 kHz
A3	50 kHz	45 kHz	40 kHz
A4	100 kHz	90 kHz	80 kHz
B1	200 kHz	180 kHz	160 kHz
B2	400 kHz	360 kHz	320 kHz
B3	800 kHz	720 kHz	640 kHz
B4	1.6 MHz	1.44 MHz	1.28 MHz
B5	3.2 MHz	2.88 MHz	2.56 MHz
B6	6.4 MHz	5.76 MHz	5.12 MHz
B7	12.8 MHz	11.52 MHz	10.24 MHz
B8	25.6 MHz	23.04 MHz	20.48 MHz
B9	51.2 MHz	46.08 MHz	40.96 MHz
B10 (B0)	102.4 MHz	92.16 MHz	81.92 MHz

NOTE: Certain receivers operating in the range below 20 MHz may have step weighting of one-tenth that indicated above. This is done when necessary to use finer frequency increments. The step weighting shown above applies if an SPÿ8660 divide-by-ten prescaler is used at the input to pin 1 or the large PLL integrated circuit (Motorola MC145151, 28 pins) adjacent to pin 1 of the large I.C. If it is not present, a wire jumper will be installed in its place. If the jumper wire is used instead of the SP8660 divider, move the decimals in the above table one place to the left (such that switch A1 would be worth either 1.25 kHz, 1.125 kHz, or 1.0 kHz, depending on the crystal used, and switch B10 would be worth either 10.24 MHz, 9.216 MHz, or 8.192 MHz).

3.3.2. SET FREQUENCY SWITCHES

NOTE: Although the frequency setting switches may be programmed over a very wide range, the oscillator will only work within the range of frequencies originally specified; attempts to operate far outside the specified range will be without success unless other components are changed.

3.3.3. The sum of the active (open) switch frequency values is the LO (Local Oscillator) frequency.

3.3.4. Begin with all switches = 0 (closed; numbered end of rocker depressed). Starting with the most significant (largest) number, check to see if adding that frequency increment to the total will exceed the desired LO frequency. If so, leave that switch closed. If not, open that switch and add its frequency to the total.

3.3.5. EXAMPLE (using 9.216 MHz crystal and divide-by-ten pre-scaler):
If 79.65 MHz is the desired (target) frequency:

SW 10, 92.16 MHz is over target; leave closed. The total is still 0.

SW 9, 46.08 MHz, is under target; open it. The total is now 46.08 MHz.

SW 8, 23.04 MHz, added to 46.08 MHz, is under target; open it. Total: 69.12 MHz.

SW 7, 11.52 MHz, if added to 69.12 MHz, is over target; levae closed. Total is still 69.12 MHz.

SW 6, 5.76 MHz, added to 69.12 MHz, is under target; open it. Total: 74.88 MHz.

Continue through until the total is equal to the desired frequency; remaining switches, if any, remain closed.

3.3.6. The following table is a convenient way of noting the correct switch positions; the example frequency is again 79.62ÿMHz, as above, the crystal is 9.216 MHz, and the pre-scaler is installed.

Frequency	Running	Switch	
Switch	Increment	Total	Open = 1
Number	MHz MHz	Close = 0	
B10	92.160	92.16	0
B 9	46.080	46.02	1
B 8	23.040	69.12	1
B 7	11.520	80.58	0
B 6	5.760	74.88	1
B 5	2.880	77.76	1
B 4	1.440	79.20	1
B 3	0.720	80.00	0
B 2	0.360	79.56	1
B 1	0.180	79.74	0
A 4	0.090	79.65	1
A 3	0.0450	.	0
A 2	0.02250	.	0
A 1	0.01125	.	0

To reiterate: Open switch if total is less than or equal to the desired frequency.

Close switch if total is greater than the desired frequency.

Open = 1, rocker raised at the end of the switch nearest MC145151 I>C>

Closed = 0, rocker depressed at the end nearest MC145151.

When the PLL is unlocked, the demodulator is not tuned to receive at the proper input frequency. The red LED mounted near the MC145151 will flash or glow when the PLL is unlocked.

3.4. SETTING THE SQUELCH

1. Apply a carrier to the demodulator RF input. The carrier signal strength should be equal to the minimum level to be used in the system. The recommended minimum input level is 1 mV. 10 ... 100 mV is a typical level.

2. Turn the "SQUELCH" control counter-clockwise, so that the green "CARRIER ON" LED is off.

3. Now, adjust the "SQUELCH" control clockwise, so that the "CARRIER ON" LED "just" lights.

4. Reduce the level of the RF input signal.

The demodulator should squelch. That is, the audio output should mute and the carrier on LED should turn off.

The squelch is now adjusted.

3.5. MODULATION CALIBRATION

1. Apply a 1 kHz signal at nominal operating level ("0 VU", 100% modulation) to the input of the modulator at the transmit end of the system. Make sure that the modulator has been properly aligned according to the manufacturer's recommendations.

2. While receiving the signal described above, adjust the "LEVEL" control (through a hole in the front panel) on the FMRÿ411 so that the audio output is at nominal level ("0 VU").

This completes the receive level calibration.

3.6. ALARM OUTPUT

If the input carrier level drops so that the unit's squelch circuit operates, the demodulator's output is muted. When this occurs, a relay contact closes, connecting the "ALARM" terminal on the rear barrier strip to ground. This signal may be used to operate a warning device or other external equipment. The contact rating of the relay is 1 A, 30 V DC.

The output will mute and the alarm ground closure will occur if the incoming signal is outside the demodulator's AFC capture range. This will hapen regardless of signal strength.

The audio output will mute and the alarm ground closure will also occur if the PLL which tunes the LO in the demodulator is unlocked. When the PLL is unlocked, the demodulator is not tuned to receive at the proper input frequency.

The alarm ground closure also occurs on power failure. The de-energized position of the relay makes the connection.

The alarm ground closure is also made when the front-panel switch is in the OFF position, or in the REM position and the REM terminal is not grounded.

3.7. REMOTE CONTROL AND REDUNDANT OPERATION

It is possible to operate the output muting relay by remote control. This closure may be obtained by shorting the "RLY ACT" and "GND" terminals on the rear of the FMR 411. The closure may also be provided by a remote switch, relay, or optoisolator. When the closure occurs, the terminal is pulled up to ground through a 20 k-ohm resistor from -24 V.

It is possible to use this remote control feature and the alarm function of the FMR 411 to allow redundant operation with a hot standby receiver. Consider figure 3-5. Both demodulators are tuned to the same signal. If the master unit fails, its alarm ground closure will pull up the remote control line of the slave. The master unit will be disconnected from the program line while the slave is on. When the problem clears in the master unit, its alarm ground closure will cease and the slave will be disabled.

If the remaining RLY ACT and ALM terminals are also connected, the two receivers are cross-connected in a redundant fashion such that, with both switches in the REM position, whichever receiver was last sequenced (or switched off momentarily) will remain off, and the output will be continually provided by the other receiver.

4.0 PRINCIPLES OF OPERATION

4.1. SIMPLIFIED BLOCK DIAGRAM

Figure 4-1 is a block diagram of the FMR 411. There are six principal sections:

1. RF Amplifier
2. Mixer/IF Amp/AGC
3. Local Oscillator
4. Detector
5. Audio
6. Power Regulators/Control Logic

4.2. DETAILED CIRCUIT DESCRIPTION

Refer to the schematic diagram in Section 7.

4.3.1. RF AMPLIFIER

The RF input is applied to an amplifier built around Q101, a 40822 or 3N201 dual-gate MOSFET. The stage is broadly tuned with a low Q LC circuit which is the drain loan impedance. Varicap diodes D101 and D102 form the capacitors in the drain circuit. These diodes are controlled by the same signal, fed via R106, which tunes the local oscillator (LO); thus, the input tuning tracks the LO. The stage gain is normally around 0 dB. AGC action is obtained by feeding the AGC control signal from U201 to the second gate of the FET via R105.

4.3.2. MIXER/IF AMP/AGC

4.3.2.1. Mixer

The outputs of the RF Amp and the LO feed the Mixer. The Mixer is a section of U201 (ULN2243A). It is a linear and fully balanced analog multiplier. The Mixer's output (both the sum and the difference of the input signal and the L.O.) is fed via the 1st IF filter to the IF Amp. This filter passes the difference signal and rejects the sum signal.

4.3.2.2. IF Amp

The IF Amp is also a section of U201. The maximum gain is about 46 dB. AGC is also used in this stage. In this case, the control signal is from the AGC output of the Detector stage. The IF Amp feeds the 2nd IF filter.

4.3.2.3. AGC Detector

The AGC Detector is yet another section of U201. It is fed through a small coupling capacitor, C207. This stage supplies the AGC control signal for the RF Amp.

4.3.2.4. IF Filters

The 1st and 2nd IF filters are identical double tuned bandpass filters. As noted in section 3.3, the IF frequency may be either 10.70 or 10.71 MHz (depending on the tuning step size).

4.3.3. LOCAL OSCILLATOR

4.3.3.1. Voltage Controlled Oscillator (VCO)

The VCO consists of a transistor oscillator, Q301, with an emitter follower buffer, Q302, and a common emitter output stage, Q303. All three transistors are 2N3906's. The control signal for tuning the VCO comes from PLL integrator U301A. The output signal from Q303 is fed to a Mixer input on U201 and to U302 (SP8660), a divide-by-ten counter.

4.3.3.2. Phase Locked Loop (PLL)

A PLL is used to control the LO tuning and, thus, the demodulator receive frequency. The LO signal frequency is first divided by 10 in U302. The divided signal is then fed to U303 (MC145151-1), a PLL chip. This chip contains a reference oscillator (controlled by crystal U301), a reference divider, a divide-by-N counter, and a digital phase detector. The referenced oscillator signal is divided by 8192 to get a PLL comparison frequency equal to one-tenth of the tuning step size. The crystal frequencies for the various step sizes are:

Step Size	Crystal Frequency
10.0 kHz	8.192 MHz
11.25 kHz	9.2160 MHz
12.50 kHz	10.240 MHz

The LO frequency is divided first by 10 and then by the modulo of the divide-by-N counter. The modulo of the counter is set with the DIP switches, S301 and S302.

LOF = CF + IF

Where LOF is the local oxcillator frequency, CG is the carrier frequency of the received signal, and the IF is the intermediate frequency. For units with 10.0 kHz or 12.5 kHz channel spacing, IF = 10.70 MHz. For units with 11.25 kHz channel spacing, IF = 10.71 MHz. (10.70 MHz is not evenly divisible by 11.25). The LOF is equal to the sum of the values of the switch setting on the DIP switches. Opening a switch causes the switch weighting to be added to the LOF. (See Section 3.3.) The error signal from the phase detector is integrated by U301B (1/2 LF353) to become the tuning control signal for the RF AMP and the VCO.

4.3.3. AFC

The Detector stage produces an AFC signal when its incoming signal is not centered in the IF pass band. This signal is applied to varicap diodes D303 and D304 (MV209) which are used to alter the tuning of the reference crystal. The LO frequency is then pulled slightly, to center the program signal in the IF passband.

4.3.4 DETECTOR

4.3.4.1. FM Detector
The Detector stage is built around an LM3189 (U401). This IC contains a limiter and quadrature detector. The detector is tuned with an LC network. Its tuning capacitor is varicap diode D401 (MV2107).

4.3.4.2. AFC
The AFC output of U401 is integrated by U402B (1/2 LF353), which feeds the AFC diodes in the PLL.

4.3.4.3. Squelch
The LM3189 has a squelch function to mute its audio output if the input signal level is too far away from the center of the IF passband for satisfactory capture of the signal by the AFC. The IC also has an output designed to drive a signal strength meter. Both of these signals are used to drive the output mute relay logic. The green "CARRIER ON" LED is also controlled by these signals via Q403 (MPSA13).

4.3.5 AUDIO
4.3.5.1. 1st Audio Stage
U501B (1/2 LF353) boosts the audio output of the detector.

4.3.5.2. The audio is fed to a de-emphasis network comprised of R505, R506, and C503. Jumper P501 can be moved on J501 to select either de-emphasis or flat operation. When Intelsat de-emphasis is used, the "FLAT" position operates with attenuation equal to the loss of the de-emphasis network at 1 kHz. U501A is a buffer amp to isolate the de-emphasis from loading by the following stage.

4.3.5.3. 3.75-Hz Notch Filter (KDÿ731 only)
U502 (LF353) and its associated components make up a notch filter tuned to 3.75 Hz. This filter is used to remove any energy dispersal signal from the program. Such signals can cause mistracking in a noise reduction system.

4.3.5.4. High Pass Filter (HPF)
A 3-pole HPF is also in the circuit to eliminate low frequency noise. It is a Sallen and Key type, and is built using U503A.

4.3.5.6. OUTPUT LEVEL Control
The Level control is a 10-k ohm pot (R523). U504B (1/2 LF353) functions as a buffer amp following the potentiometer.

4.3.5.7. Program Amplifier
U505 (NE5532) is a balanced output program amplifier. The feedback loops for the two halves are cross coupled so that the gain does not change significantly if one side of the output is grounded while driving an unbalanced load. Although the gain doesn't change, the available output swing drops 6 dB if one side is grounded. In order to have sufficient output swing, this stage is operated from the 24ÿV supply.

4.3.6. POWER SUPPLY AND CONTROL LOGIC

4.3.6.1. Regulators
The power supply is positive ground. D601 (1N4004) prevents damage to the unit if the supply connections are reversed. U601 (7915T) has an output of 15 V.

U602 (78L05) is a 5 V positive regulator. It is connected between the -15 V supply and ground to provide 10 V.

4.3.6.2. Control Logic

If the PLL is unlocked (unit off frequency), the incoming signal too far off for the AFC to capture, or the incoming strength too low, Q602 (MPSA13) will not conduct. This will turn off relay K601. This disconnects the program amplifier from the output terminals and makes the alarm ground closure connection.

5.0 MAINTENANCE

5.1. PERFORMANCE TESTING

5.1.1. RECOMMENDED TEST EQUIPMENT

The following test equipment is recommended for testing and adjusting the FMRÿ411:

Oscilloscope	Tektronix 2235
RF Spectrum Analyzer	HP 8558B with 853A Display and 1124A Active Probe
Counter	Fluke 1912A
RF Signal Generator	Boonton 102F
Audio Oscillator	Tektronix SG505
Audio Analyzer	Tektronix AA501
Load Resistor	604 ohm
BNC Terminating Load	75 ohm

Equivalent instruments may be substituted.

These performance tests should be passed by any properly operating unit. If a unit fails these tests, it may be out of adjustment or need repair.

5.1.2. INITIAL TURN ON

1. With the FMR 411 disconnected from the power supply, remove the top cover and verify that the L.O. tuning DIP switches are set properly. Refer to Section 3.3. Make sure that the de-emphasis jumper (P501) is in the "FLAT" position (connecting the center pin with the one nearest the front panel).
2. Slide the top cover onto the FMRÿ411.
3. Apply -24 V, ñ1 V. Make sure the lead polarity is correct (negative supply "hot", positive ground).
4. Check to see that the current drawn is less than 180ÿmA.
5. Allow the unit to run for at least 15 minutes to reach operating temperature before testing.

5.1.3. AUDIO OUTPUT LEVEL AND DISTORTION

6. Connect an RF signal generator to the FMR411's Carrier Input jack and the 75 ohm dummy load to the FM Carrier Loop Output jack.

7. Connect an audio oscillator to the external modulation input of an RF signal generator. Set the RF generator for an output signal of 10ÿmV at the demodulator's input frequency. Set the audio oscillator to 1 kHz and adjust its output level and the RF generator's input level for a peak deviation of 75 kHz.

8. Adjust the demodulator SQUELCH control as per Section 3.4.

9. Connect a 604 ohm load resistor to the "H" and "L" audio output terminals on the rear of the unit. Also, connect the balanced input of the audio analyzer to these terminals on the rear of the unit. Connect an oscilloscope to the function monitor output of the analyzer.

10. Set the demodulator's audio output LEVEL control to maximum (fully CW). With the audio analyzer in voltmeter mode the waveform on the scope should be clipped symmetrically.

11. Decrease the setting of the LEVEL control to just eliminate the clipping. The RMS reading on the analyzer should be not less than 12 V. The unit should not be drawing more than 180 mA from the power supply. Place audio the analyzer in THD mode; the distortion should be less than 1% (0.3 to 0.5% is typical).

12. Put the audio analyzer back in voltmeter mode. Decrease the setting of the LEVEL control so that the RMS output level from the FMR 411 is about 2.5 V (+10 dB re 775 mV)> The distortion should be less than 0.5% (0.25% to 0.4% is typical).

5.1.4. FREQUENCY RESPONSE

13. Sweep the audio oscillator from 20 Hz ... 15 kHz. the response at the output of the FMR 411 should be flat ñ0.5 dB up to 15 kHz for a "standard" FMR 411, or to the rated upper frequency. The response should be down 3 dB at about 1 1/2 times the rated upper frequency.

14. Remove the top cover of the FMR 411. Replace the de-emphasis jumper in the "DE-EMPHASIS" position (connecting the center pin and the pin toward the rear). Re-install the top cover.

15. Set the audio oscillator to 800 Hz and set the RF generator for a peak deviation of 25 kHz. Set the "LEVEL" control on the demodulator for an output level of 0 dB (re 775 mV) from the FMR 411.

16. Step the audio oscillator through the frequencies listed in the table below. If the de-emphasis is correct, the output level will follow the values in the table within the 0.5 dB.

	Intelsat De-emphasis (333 mS)	75 mS De-emphasis
Frequency (Hz)	Output Level (dB)	Output Level (dB)
50	5.6	.6
200	5.0	.5
400	3.4	.4
800	0	0
2 K	-6.1	-2.2
4 K	-10.0	-6.0
6.4 K	-11.6	-9.6
8 K	-12.1	-11.4

5.2. ADJUSTMENTS

Remove the top cover of the unit and follow the insturctions below.

3. With a digital multimeter (DMM), check the internal supply potentials at the following test points:

IC/Pin Number	Potential
U302, pin 3 *	-10 V, ñ1.0 V
U302, pin 2 *	-15 V, ñ750 mV
U505, pin 4	-24 V, ñ1.0 V

5.2.3. Local Oscillator

4. Set the LO frequency control DIP switches to the desired frequency according to the instructions in Section 3.3.

5. Connect the counter to U302, pin 4, the output of the divide-by-ten counter. The signal frequency should be approximately one-tenth the desired LO frequency. Turn the "AFC LIMIT" control (R319) to one end then the other. Note which setting results in the minimum LO frequency error and set the pot at that end. This disables the AGC. Leave the AGC disabled until step 16.

5.2.4. Setting the IF Filters

6. Connect the RF signal generator to the FM CARRIER IN jack.

7. Set the RF generator output level to about 1 mV at the desired input frequency for the FMR 411.

8. Connect the audio oscillator to the external modulation input of the RF generator. Set the audio oscillator frequency to about 1 kHz and adjust its output level and the FM modulation control of the RF generator for maximum deviation of the generator. The output of the generator should now be sweeping across a band centered at the desired receive frequency. The sweep should be much wider than the desired bandwidth (180ÿkHz typical) of the demodulator IF.

9. Connect the RF spectrum analyzer (tuned to the IF frequency, 10.70 or 10.71 MHz, depending on tuning step size) to the output of the 1st IF filter (U201, pin 1). Adjust C210 and C215 for maximum amplitude and minimum bandwidth, symmetrically shaped about the IF centered frequency. The response measured at this point should be 1.5 dB down at 90 kHz above and below the IF center frequency. The bandpass should be slightly raised at the center frequency, not dipped.

10. Now, connect the spectrum analyzer probe to the output of the 2nd IF filter (U401, pin 1). Tune C217 and C221 for the same general characteristics as above, except that the bandpass will be slightly narrower, and the skirts will be noticeably steeper. The response measured at this point should be 3 dB down at 90 kHz above and below the IF center frequency.

5.2.5. Checking the AGC

11. Leave the analyzer probe connected to U401, pin 1. Reduce the deviation of the RF generator carrier to about ñ75 kHz.

12. Reduce the RF input level 10 dB, to about 10ÿmV. The signal level at the test point should not drop more than 5 dB.

13. Increase the RF input level 20 dB to about 100 mV. The signal level at the test point should not rise more than 10 dB from that noted in Step 12.

14. Reset the RF input level to approximately 10 mV. With the generator still running at the desired receive frequency, set the deviation at 75 kHz with a 1 kHz modulating tone.

5.2.6. Adjusting the Detector

15. Set the "SQUELCH" control to maximum sensitivity (fully CW). The green "CARRIER ON" LED should be on.

16. Set the "AFC LIMIT" pot for full AFC operation. This is the opposite end setting from the way you left it in Setp 5.

17. Connect a DMM or scope to the AFC line of the LM3189 (U401, pin 7). Adjust the "DISCRIM TUNE" pot for an AFC DC potential of -7 V, ñ1 V.

18. Connect a 604 ohm load resistor between the "H" and "L" audio output terminals on the rear of the unit. Also, connect the balanced input of an audio analyzer to these terminals. Connect an oscilloscope to the function monitor output of the analyzer.

19. Place the de-emphasis jumper (P501) in the "FLAT" position (connecting the center pin with the one nearest the front panel).

20. Set the "LEVEL" control to maximum (fully CW). With the audio analyzer in voltmeter mode, the waveform on the scope should be clipped symmetrically.

21. Decrease the setting of the "LEVEL" control to just eliminate the clipping. The RMS reading on the analyzer should not be less than 12 V. The unit should not be drawing more than 180 mA from the power supply.

22. Decrease the setting of the "LEVEL" control so that the RMS output level of the FMR 411 is about 2.5 V (+10 dB re: 775 mV). Set the analyzer to measure THD. Adjust the "DIST NULL" trimmer capacitor (C407) for minimum distortion. There is some interaction between the "DIST NULL" and "DISCRIM TUNE" controls. Go back and adjust the "DISCRIM TUNE" pot for -7 V on the AFC line. Then, recheck the distortion null. Continue these interactions until the distortion is minimized and the AFC line is at -7 V. The distortion should be less than 0.25% at 1 kHz with +10 dB output if the input signal deviation is ñ75 kHz.

23. Replace the de-emphasis jumper in the "DE-EMPHASIS" position (connecting the center pin and the pin toward the rear).

5.2.7. Setting the 3.75-Hz Notch Filter (KDÿ731 only)

24. Disconnect the RF signal generator from the FMR 411. Connect the SCPC modulator via the 40 dB attenuator to the "FM CARRIER IN."

25. Short the audio input terminals of the modulator and turn on its 3.75 -Hz energy dispersal signal.

26. Set the audio analyzer in voltmeter mode. A low frequency signal should be visible on the scope. Set the "NOTCH FREQ" and the "NOTCH DEPTH" controls for a minimum low frequency output.

Turn off the power supply and disconnect all of the test equipment. Re-install the top cover. The unit is now ready for use.