LEAMING INDUSTRIES FMT415 II
STEREO MODULATOR

INSTRUCTION BOOK
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LEAMING INDUSTRIES
15339 BARRANCA PARKWAY
IRVINE, CA 92618
(949) 727-4144

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1.0 INTRODUCTION TO THE FMT415

The FMT415 Stereo Modulator provides an economical and space-efficient means of producing high-quality FM stereo audio. This modulator generates a U.S. broadcast-standard multiplex stereo signal from Left and Right baseband audio inputs.

The RF output frequency of this unit, like other Leaming products, is adjustable in the field without changing crystals. This design uses a master crystal oscillator and a programmable phase-lock-loop (PLL) system to precisely set the output to any standard frequency in the FM Broadcast Band. Other frequencies outside the 88-108 MHz Band are available upon special request.

The program output is also optionally available as baseband composite multiplex stereo, used to feed additional modulators.

The FMT415 has dual stereo inputs; the second input may be used for local ad insertion, or as an audio backup. Either input, if mono, can be internally synthesized into stereo (i.e. Input A, Input B, both inputs, or neither input).

The unit is equipped with peak-reading 5-segment LED bargraphs to enable accurate setting of the program level.

The FMT415 is enclosed in an extruded aluminum chassis which may be mounted onto the Leaming PMU401 universal rack panel. The FMT415 can be powered by either the KAC707 (for three or fewer FMT415s), or the PS420 power supply (for as many as five FMT415s). One or two FMT415's plus their KAC707 or PS420 may be mounted onto a PMU401 panel. The PMU401 requires 1-3/4" height in a standard 19" wide rack, and mounts three (or fewer) Leaming 400-series modules.

2.0 INSTALLATION AND OPERATING INSTRUCTIONS

NOTE: This section assumes that the FMT415 is tuned to the desired F.M. channel output frequency. If not, proceed to Appendix A, Tuning Procedures.

Remove from shipping container and inspect for shipping damage.

Mount the FMT415 on a PMU401 panel (1-3/4" high x 19" standard rack width). Attach the FMT415 with the four #6-32 x 3/4" screws provided. Connect to a -24 volt power source capable of delivering 150 mA. Either Leaming power supply model KAC707 or PS420 is suitable; either power supply can be mounted on the same PMU401, alongside the FMT415.

When power is applied, observe that the red OFF FREQUENCY LED illuminates and flickers off, indicating that the R.F. output is locked on frequency.

The UNLOCK LED will illuminate if the audio carrier is off-frequency. This typically occurs only if the RF output frequency has been reprogrammed incorrectly. Refer to Section 6, re-centering the AFC.

2.1 R.F. OUTPUT CONNECTION

Connect a coax cable between the FM CHAN OUTPUT-OUT and the cable head-end combiner input. Terminate the FM CHAN OUTPUT-IN with 75 ohms, or loop-thru from another unit with 75 ohms resistive termination.

If the R.F. output frequency must be changed, refer to Appendix A of this instruction book.

Adjust the R.F. output level (on front panel at right) to coordinate with the F.M. band levels standard for the cable system.

NOTE: Reversal of the F.M. channel output IN and OUT connections will result in a 20 dB reduction of output, due to the directional coupler.

Refer to the CONNECTIONS drawing at the end of this book for an illustration of how the FMT415 hooks to the other components in the system.

2.2 AUDIO INPUT

NOTE: The screw-terminal strips located on the back panel of the FMT415 may be removed (unplugged) for ease in wiring.

The FMT415 requires left and right audio input signals. For signals from a balanced source, run a pair of shielded two-conductor cables, one from the right channel of your source (e.g.: VideoCipher, Stereo Demodulator, etc.) to the right channel audio input of the FMT415. Run the second audio cable from the left channel of your source to the left input of the FMT415. Be sure that the "+" goes to the "+", and the "-" goes to the "-". When the audio feed is monaural, connect the left & right inputs in parallel, "+" to "+", and "-" to "-", for optimum performance.

For signals from an unbalanced source, connect the high to the "+" and the shield to the "-". Also, tie the "-" to the "G" (Ground) terminal if the two chassis are not otherwise electrically grounded to each other.

2.2.1 SECOND (B) AUDIO INPUT

Input "B" can either be used for local ad insertion or for backup audio. The B input is wired in the same procedure as that listed in Section 3.1, with the exception that it is wired into Input "B" (B Audio In) on the back of the FMT415 (rather than Input "A").

LOCAL & REMOTE-CONTROLLED AUDIO INPUT SELECTION

The Input Selector switch is recessed at the center of the FMT415's front panel. It may be operated by sliding its actuator horizontally with a small flat-blade screwdriver. In the REM (Remote) position (centered), the FMT415 uses Input "A" when the A/B terminal (pin 5) is not grounded and Input "B" when the A/B terminal is grounded. The front panel "A REM B" switch will override any remote connections on the back panel if placed in either the A or B position.

2.4 STEREO SYNTHESIS

The FMT415 is equipped with a built-in stereo synthesizer, for use whenever the source programming is mono (e.g. local commercials). The FMT415 is normally in true stereo. By simply installing one jumper on the remote connector, combinations of true and synthesized stereo can be selected: "A" & "B" true stereo; "A" true & "B" synthesized, or both "A" & "B" synthesized.

The stereo synthesizer is actuated by grounding pin 4 of the remote terminal plug on the back panel of the FMT415. Leaving pin 4 open (ungrounded) results in true stereo capability and no stereo synthesis.

To automatically select synthesized stereo whenever the "B" input channel is selected (either locally or remotely), connect pin 4 to pin 5 on the Remote terminal plug. Then, when pin 5 is grounded (e.g. by local commercial insertion equipment) pin 4 is also grounded, thereby selecting the "B" input and stereo synthesis together.

If the program source is mono and the corresponding FMT415 input is configured for synthesized stereo, the listener will hear an apparently stereo source with considerable ambience and some (artificial) directionality.

If a stereo program source is fed through the synthesizer, some directionality remains, and the ambience will be changed. If the original stereo had very little ambience, it will be increased noticeably; if the original program had considerable ambience, it will be reduced somewhat. The overall effect is generally quite pleasing.

NOTE: If the selection of "B" input is by remote control, the selection of the stereo synthesizer will automatically follow if the two remote selections are strapped together by jumping pin 5 to pin 4. The stereo synthesizer will not automatically follow if the remote controller is forcing pins 4 & 5 to either high or low and the front panel A/B selector is used to override the remote controller. Under these conditions the input will be as selected on the front panel of the FMT415, but the stereo/synthesis will be as forced by the remote controller. Typically, this is of little consequence, and is likely to occur only if the remote controller is attempting to select the "B" input, but the FMT415's input selector has been placed in "A" to prohibit remote selection. The result will be the desired program ("A"), but in synthesized stereo. This can be overcome, if necessary, by inhibiting the remote controller.

2.5 AUDIO LEVELS

The FMT415 is furnished with two sets of level controls on the front panel: "A LEFT" and "A RIGHT" for input "A" and "B LEFT" and "B RIGHT" for input "B". Audio program levels are monitored with dual peak-reading LED bargraph meters.

Using the corresponding level controls, set the levels so that both the left and the right meters read approximately 0 dB (yellow LED) with average program peaks, and rarely illuminate the red LED.

2.6 COMPOSITE (BASEBAND) STEREO MULTIPLEX OUT (option)

Verify that your modulator is capable of accepting a baseband composite stereo audio signal. Some modulators require modifications to pass a stereo signal at baseband. For example, the pre-emphasis should generally be eliminated, and the modulator must have a wide "audio" bandwidth (53 kHz minimum).

3.0 SPECIFICATIONS

3.1 AUDIO PERFORMANCE:

Frequency Response: 20 Hz to 15 kHz, ±0.5 dB (overall)

Distortion: 0.5% max THD

Separation: >40 dB @ 1000 Hz
>30 dB, 20 Hz to 15 kHz

Signal-to-Noise Ratio: >65 dB

Nominal Input Level (APL): 0 dBm, adjustable ±10 dB

Peak Input Level: 10 dB above nominal

Audio Input Impedance: 100 kΩ, balanced

3.2 F.M. STEREO BAND OUTPUT:

Frequency: (Field Adjustable) 88 to 108 MHz in 12.5 kHz steps standard; others available.

Frequency Stability: ±25 PPM; ±1 kHz typical

Level & Impedance: +20 to +45 dBmV (30-500 mVp-p), adjustable; directional coupler loop-thru on 75 ohm line.

Modulation: ±75 kHz deviation (broadcast standard):
Sum (L+R) channel at baseband;
Difference (L-R) multiplexed on 38 kHz double-sideband suppressed-carrier;
19 kHz pilot @ ±7.5 kHz deviation.
75 microsecond pre-emphasis.

Spurious Output: >50 dB below carrier at +40 dBmV

3.3 COMPOSITE BASEBAND STEREO MULTIPLEX OUTPUT (option)

Level: +10 dBm at 100% modulation (6.9 Vp-p, internally adjustable).

Impedance: Balanced/unbalanced, low Z, to drive 600 Ω minimum load Z.

3.4 FRONT PANEL CONTROLS & INDICATORS

Controls: Input Level: "A" L & R, "B" L & R
A/B Input Sw. w/ Remote position
R.F. Carrier Level

LED Indicators: Dual (L&R) 5-segment Bargraphs
A/B Input
Carrier Freq. Unlocked

3.5 REAR PANEL CONNECTORS:

RF Output Loop: Two BNC std.; F-type opt.

The following connectors are detachable screw-terminal plugs:

Audio Input Connectors:
(Two, "A" & "B")

PIN 1	R+
PIN 2	R-
PIN 3	G
PIN 4	L+
PIN 5	L-

Composite Multiplex Output Connector (option):

PIN 1	+
PIN 2	-
PIN 3	G
PIN 4	Reserved
PIN 5	Reserved

Remote Control & Power Input:

PIN 1	-24 V Input
PIN 2	Ground
PIN 3	Reserved
PIN 4	Stereo Synth. Select
PIN 5	A/B Input Select

3.6 SIZE & MOUNTING:

Requires 1/3 Leaming PMU401 mounting panel, which fits standard 19" wide rack, 1-3/4" high, 10-1/2" deep (remaining 2/3 PMU401 accommodates Leaming KAC707, -24 V, 1/2 A power supply, and another FMT415 or any other Leaming product requiring 1/3 PMU401 mounting.)

Size:	1.6 inches H x 5.5 inches W x 16 inches D.
Weight:	3-1/2 lb.
Power:	-24 V, 150 mA

4.0 **FUNCTIONAL DESCRIPTION**

The FMT415 can be considered to be made up of the following subsections:

4.1 Dual stereo audio input unbalancers and level controls.
4.2 A/B input and Synthesized Stereo selector switches.
4.3 Audio low-pass filters.
4.4 Audio level indicators (5-LED bargraphs).
4.5 75 µS pre-emphasis networks.
4.6 Sum & Difference matrix and multiplex modulator.
4.7 Stereo pilot and carrier generators.
4.8 88-108 MHz frequency modulated oscillator and output coupler.
4.9 Programmable-frequency phase-lock control.
4.10 Voltage regulators.
4.11 Optional baseband composite multiplex output amplifier.

Where the subsections are dual, the description will be of the left channel only. Adjustment of the controls is covered in Section 6.0, Tuning Procedures.

4.1 DUAL STEREO AUDIO INPUT UNBALANCERS AND LEVEL CONTROLS

Each audio input ("A" Left, "A" Right, "B" Left, & "B" Right) is separately applied to an active differential amplifier to convert it from a balanced line (if necessary) to an unbalanced/single-ended signal for use within the FMT415. These four amplifiers each have a fixed-gain of -6 dB, and each is followed by one of the four adjustable level controls on the front-panel.

4.2 A/B PROGRAM INPUT & SYNTHESIZED STEREO SELECTOR SWITCHES

The selection of either "A" or "B" stereo inputs is by a solid-state switch which is controlled by a three position slide switch ("A"; "REM"; "B"), accessible from the front panel of the FMT415. When in the center "REM" position, the switch of audio input from "A" to "B" may be remotely controlled by grounding the A/B SELECT terminal on the back panel.

The stereo synthesizer is also controlled by a solid-state switch, which is activated by grounding the SYNTH SELECT terminal on the back panel.

Those terminals are normally at +5 volts, at a nominal impedance of 10 kΩ. Either may be activated by pulling it to within one volt of ground by any convenient means, such as a hard contact switch or relay, or a semiconductor switch (CMOS, TTL, transistor collector, etc.). When the terminals are open (or at more than 4 V), the "A" input and true, not synthesized, stereo are selected.

4.3 AUDIO LOW-PASS FILTERS

Following the A/B selector is a 15 kHz three-pole active low-pass filter. This is to reduce out-of-band noise, which could degrade the stereo program. The filter is comprised of resistors, capacitors, and an LF353 op-amp. The output of the low-pass filter is split, to drive the audio level indicators and to drive the pre-emphasis amplifiers.

4.4 AUDIO LEVEL INDICATORS

The audio signal is detected by an LM358 op-amp and a 1N4148 diode. This is filtered and is fed to an LM3915 A-to-D display driver IC. The displays are 5-LED bargraphs. The result is an indication of near-peak audio levels, with a response fall time similar to a mechanical VU meter. This permits setting peak program levels while observing normal fluctuations of speech and music levels.

4.5 75 µS PRE-EMPHASIS

Following the 15 kHz low-pass filter is the pre-emphasis stage, comprised of resistors, a capacitor, and a jumper-plug to permit selection of 75 µS pre-emphasized or flat frequency response. Alternate pre-emphasis may be specified for certain applications, but in the U.S.A., the F.C.C generally requires that F.M. broadcasts in the 88-108 MHz band use the 75 µS standard.

4.6 STEREO PILOT AND CARRIER, U9 AND U10

The stereo pilot and carrier frequencies (19 and 38 kHz) are digitally synthesized with U10, which is driven by U9, a crystal-controlled oscillator with multiple frequency dividers. This provides stable frequency, amplitude, and phase relationships. The two synthesized sine-wave outputs are actively filtered to very low distortion by amplifiers LF353A & B, utilizing C473-C475, R476, and RV471 (19 kHz) and C483-C486, R485, and R486 (38 kHz). The pilot phase and injection level controls are RV471 and RV472.

4.7 SUM & DIFFERENCE MATRIX

The U.S. standard F.M. broadcast standard can transmit two related channels of program audio. In order to maintain compatibility with mono F.M. broadcasts and receivers, the two program channels, which are normally Left and Right, are processed by a Sum and Difference matrix network. The result is still two channels, but one is the Sum, L+R (which is the mono information), and the other is the Difference, L-R (which is later recombined in the receiver to recreate the original Left and Right channels). The Sum is applied to the main F.M. oscillator, via level control RV401. The Difference modulates a 38 kHz carrier.

4.8 STEREO DIFFERENCE MODULATOR

The L-R channel is applied to one input of an MC1496 operating as a stereo multiplex modulator. The other input is driven by the 38 kHz carrier generator. The output is a double-sideband, suppressed-carrier amplitude-modulated signal centered on 38 kHz. The differential output of the MC1496 is amplified and converted to a single-ended signal in an NE5532 op-amp. This signal is added to the L+R signal at the input to the F.M. oscillator, along with the 19 kHz pilot signal, also from U10.

4.9 FREQUENCY MODULATED OSCILLATOR

Q501 and associated components comprise a voltage-controlled (F.M) oscillator operating in the 88-108 MHz F.M. stereo band. The frequency deviation is set by RV501, the master modulation control, which varies the drive to D501, a voltage-controlled capacitor. This, with L501, controls the resonant frequency of the oscillator. Q502 buffers the output of Q501 and drives Q503, the R.F. output transistor. The R.F. output level is set by RV503, adjustable from the front panel with a small screwdriver. The output of Q503 is tuned to peak the desired frequency and reduce harmonics by C515-517 and L502-504. L504 is also the output directional coupling, in conjunction with R529.

4.10 PHASE-LOCK-LOOP

The F.M. oscillator center frequency is set by comparing its output with a precision frequency derived from a crystal oscillator. A portion of the F.M. oscillator output from Q502 is applied to U513, a frequency-divide-by-ten circuit, then to U514, which divides by the number programmed on frequency set switches SW501-SW514. The total division is down to 1.250 kHz, which is also the frequency generated by the reference crystal oscillator after it is separately divided. The two 1.250 kHz signals are applied to a phase comparator in U514. The output of the phase comparator is a control voltage proportional to any phase (and frequency) difference between the reference and the F.M. oscillator; this voltage is applied to voltage-variable-capacitors D504 & D505 which, with L501, corrects the F.M. oscillator center frequency. Whenever the F.M. oscillator free-running frequency is outside the control range, the red UNLOCK lamp on the front panel lights, indicating that the R.F. output frequency is not controlled by the reference crystal. (See Section 6.3, Tuning Procedures, F.M. Channel Frequency Change, to correct this condition, which normally occurs only when switching to a new R.F. output frequency.)

4.11 VOLTAGE REGULATORS

U18 is a three terminal voltage regulator, set to -18 V. All power used in the FMT415 passes through U18, essentially eliminating any fluctuations due to variations of the -24 V.

supply. Most of the unit operates directly from -18 V., although U513 and U514 operate from -5 V, set by a small 3-terminal regulator.

5.0 **MAINTENANCE**

No routine maintenance is required. However, you may wish to check the output amplitude periodically to verify that the FMT415 output is normal. It is recommended that the FMT415 not be re-adjusted in the field, except for system changes of the F.M. channel output frequency and amplitude, per Section 6. All other adjustments require specialized test equipment. In order to avoid degrading the overall performance, do not adjust any control in the FMT415 "by ear". In the event of a malfunction of the FMT415, please contact the factory. We will generally recommend that the unit be sent to the factory for repair and recalibration. However, if repair in the field must be accomplished, basic re-adjustment procedures follow in Section 6.

6.0 **TUNING PROCEDURES**

TEST EQUIPMENT REQUIRED AND MODEL RECOMMENDED

A. Audio sine-wave generator, Krohn-Hite 4300
B. Deviation meter, Radiometer Copenhagen Model AFM-2
C. Oscilloscope, Tektronix Model 2235
D. Distortion analyzer, Hewlett-Packard Model 339

6.1 STEREO MULTIPLEX ALIGNMENT

6.1.1 With no audio input, connect a scope probe to pin 7 of the LF353/MC34002 difference amplifier following the MC1496. Adjust RV451 (CB, Carrier Balance) for best 38 kHz carrier null. Use a scope display triggered on the 1 kHz signal directly from the signal generator. Set adjacent 38 kHz envelopes at equal peak-to-peak amplitude (ignore any waviness in the baseline between envelopes for now).

6.1.2 Check the setting of Master Modulation control, RV501. Don't readjust if off-center, but remember that it is in a possibly-abnormal setting if not somewhere near mid-position. Adjust RV472 for a pilot deviation of ±7.5 kHz as measured on the modulation meter connected to the F.M. band output.

6.1.3 Connect the audio generator, set to 1000 Hz & approx. 0 dBm, to both Left and Right channels of "A" (or "B") audio input. Invert the relative polarity between the L & R terminals; connect L+ to R- and L- to R+. Select the "A" audio input by placing the input selector switch in its left position. Set all input level controls on the front panel of the FMT415 to maximum sensitivity (fully clockwise). Reduce the signal level at the generator to illuminate the fourth LED (Yellow) at half-intensity. Adjust RV452 (BB, Baseband Balance) for best baseband null. This will eliminate any baseline waviness observed in 6.1.1 above (Readjust RV451, CB, if envelope amplitude imbalance becomes apparent; the two nulling controls, CB and BB, do not interact, but it sometimes appears to the eye that they do).

6.1.4 With the audio generator still set to 1000 Hz, and at the same level (slightly lower than 0 dBm), Change the relative polarity of the inputs to normal. That is, matched polarity between the L & R terminals; connect L+ to R+ and L- to R-. Adjust the Sum Channel (L+R) control, for a total deviation of ±82.5 kHz (75 kHz program plus 7.5 kHz pilot).

6.1.5 Disconnect or reduce the Right Channel signal level to zero (fully counter-clockwise). Adjust the Difference control (L-R) for a total deviation of ±82.5 kHz. Verify correct setting by observing with oscilloscope the demodulated output of FMT415 through a wideband receiver, such as the AFM-2 Modulation Meter on 75 kHz audio bandwidth setting. The waveshape should be a 1 kHz sine-shaped envelope, with alternate upper and lower halves filled with 38 kHz. The baseline should be perfectly straight, and filled to a thickness of approx. one-tenth the peak-to-peak envelope with 19 kHz. If the baseline is bowed up or down within the individual half-cycles of the 1 kHz envelope, it indicates incorrect relative amplitudes of the Sum (L+R) and Difference (L-R) channels, which may be corrected by readjusting these controls in the FMT415. If the baseline is tilted (rather than bowed) within the half-cycles of the 1 kHz envelope, it indicates a relative phase difference between the Sum and Difference Channels. This generally indicates a frequency-response rolloff in the demodulator or oscilloscope. Phase shift is seldom a problem within the FMT415, and no adjustment is available.

6.1.6 The stereo carrier (and pilot) frequencies are crystal-controlled to better than ±1 Hz accuracy. The crystal frequency may be trimmed over a narrow range by adjusting C472. As this is an extremely stable circuit, re-adjustment is unnecessary unless the crystal is replaced by one not tuned for a 20 pF load.

6.1.7 In order to provide optimum stereo separation, the 19 kHz pilot phase zero crossings must coincide in time with the 38 kHz carrier zero crossings.

Connect one probe of a dual-trace scope to 19 kHz at pin 7 of the 19 kHz low-pass filter, an LF353. Trigger the scope on this signal only. Adjust the vertical for precisely center scale with the input shorted and for full scale deflection with the signal A.C. coupled.

Adjust the time base for one full cycle visible and the triggering to position the positive-to-negative zero crossing at center scale. Connect the second probe to

38 kHz at pin 1 of the 38 kHz low-pass filter, the same LF353. Adjust the vertical for precisely center scale with the input shorted, and for approximately half-scale deflection with the signal A.C. coupled.

The above technique permits simultaneous observation of the phase relationship and the waveshape. However, if the waveshape has already been determined to be a visually-perfect (undistorted) sine, it may be quicker to switch the scope to an X-Y mode to view the fully symmetric figure-eight lissajous pattern which is created by two sine-wave signals when their frequencies are in a 2:1 ratio and their zero crossings coincide.

Adjust the 19 kHz phase, RV471, relative to the 38 kHz phase, to align the positive-to-negative zero crossings, and/or make the lissajous pattern fully symmetric. The scope's scales may be expanded to facilitate accuracy.

6.2 BASEBAND MULTIPLEX OUTPUT ADJUSTMENT

6.2.1 If your unit is equipped with the baseband multiplex output option, connect a 600 Ω load across terminals 1 & 2 of the "C" connector block on the rear panel of the FMT415. Connect an oscilloscope probe across the load resistor. With the input as in step 6.1.4, above, adjust the multiplex output level to 6.9 Vp-p (+10 dBm), or to a level standard for your system).

6.2.2 Disconnect the right channel input, as in step 6.1.5 above, and observe the same display on the oscilloscope as described in that step. Any difference indicates either a defective component in the FMT415, or an error in the measurement. No adjustment other than output level is provided.

6.3 F.M. CHANNEL FREQUENCY CHANGE

The FMT415 R.F. output is controlled by a phase-lock-loop (P.L.L.) automatic frequency control system. As long as the average frequency of the F.M. carrier is equal to the reference frequency, the red OFF FREQUENCY LED on the front panel will not light. To change frequency, refer to Appendix A of this instruction book.

APPENDIX A, LEAMING 400 SERIES and KM 731

R.F. OUTPUT FREQUENCY PROGRAMMING

To change the R.F. output frequency of Leaming 400 Series & KM 731 modulators, three steps are essential:

1) Set the new frequency for the PLL (Phase-Locked Loop) with the DIP switches on the circuit board, SW501-SW514 (See the following tables for the switch positions).

2) Center the AFC (Automatic Frequency Control) range with the variable inductor (coil) after setting the switches.

If either of these first two steps is skipped, the frequency will be incorrect and/or will drift.

3) Peak the R.F. output filter.

A1.0 SET FREQUENCY SWITCHES

A1.1 Set DIP switches SW501-SW514 (located inside the top cover) in accordance with the binary code for the desired frequency (The frequency equivalent of each switch is in the attached tables). The frequency is set by the switches which are open; open is when the numbered end of the switch actuator is raised. Closed is a logic-0, open is a logic-1 in the attached tables.

The sum of the open switch frequency increments is the output frequency.

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.

A2.0 CENTER AFC RANGE

This procedure sets the PLL system to the center of its control range at the new output frequency. The red OFF FREQ L.E.D. must be out when L501 is correctly set; when illuminated, the output frequency is not locked to the reference crystal frequency.

The OFF FREQ indicator will take approximately 20 seconds before it extinguishes when power is first applied, and a few seconds when the frequency programming switch is changed and L501 re-tuned.

A2.1 After the switches are set to the new frequency, connect the AFC DEFEAT pins together with a jumper plug or clip lead. (The AFC DEFEAT pins are on the circuit board, under the top cover, in front of the large MC145151 I.C.)

With a non-metallic flat-blade tuning tool, slowly tune L501 (the variable inductor), until the red OFF FREQ LED extinguishes.

NOTE: When changing to a lower output frequency, raise the core to increase the inductance; lower the core if the new frequency is to be higher.

Remove the AFC DEFEAT jumper from J516; the OFF FREQ LED will remain off.

A3.0 OUTPUT FILTER TUNING

Retune the output filter by adjusting C515 & C516, the two variable capacitors nearest the output connectors, for peak output level. The output (with R.F. output level control at maximum) should be at least +45 dBmV.

NOTE: Reversing connections to the F.M. channel IN and OUT on the rear panel will reduce readings about 20 dB, due to the directional coupler being reversed.

A4.0 SWITCH SETTINGS

Use TABLE A-2 if the desired frequency is not listed in TABLE A-1.

TABLE A-1, 88-108 MHz

Settings of ten-position DIP switch in Leaming 400 Series Modulators (and similar units) for F.C.C. standard F.M. band output frequencies.
0 = Switch closed; rocker depressed at end nearest MC145151.
1 = Switch open; rocker raised at end nearest MC145151.

Table A-1 is also applicable to units with additional four-position DIP switch:

Close switches 1,2, & 3, and open switch 4 (switch 4 replaces "STRAP" in table).

TABLE A-1 assumes a standard 10.240 MHz crystal reference oscillator and X10 prescaler. See TABLE A-2 for switch frequency increments for other common crystal reference oscillator frequencies.

SWITCH	10	9	8	7	6	5	4	3	2	1	STRAP
FREQUENCY	102.4	51.2	25.6	12.8	6.4	3.2	1.6	.8	.4	.2	.1 MHz
88.1	0	1	1	0	1	1	1	0	0	0	1
3	0	1	1	0	1	1	1	0	0	1	1
5	0	1	1	0	1	1	1	0	1	0	1
7	0	1	1	0	1	1	1	0	1	1	1
9	0	1	1	0	1	1	1	1	0	0	1
89.1	0	1	1	0	1	1	1	1	0	1	1
3	0	1	1	0	1	1	1	1	1	0	1
5	0	1	1	0	1	1	1	1	1	1	1
7	0	1	1	1	0	0	0	0	0	0	1
9	0	1	1	1	0	0	0	0	0	1	1
90.1	0	1	1	1	0	0	0	0	1	0	1
3	0	1	1	1	0	0	0	0	1	1	1
5	0	1	1	1	0	0	0	1	0	0	1
7	0	1	1	1	0	0	0	1	0	1	1
9	0	1	1	1	0	0	0	1	1	0	1
91.1	0	1	1	1	0	0	0	1	1	1	1
3	0	1	1	1	0	0	1	0	0	0	1
5	0	1	1	1	0	0	1	0	0	1	1
7	0	1	1	1	0	0	1	0	1	0	1
9	0	1	1	1	0	0	1	0	1	1	1
92.1	0	1	1	1	0	0	1	1	0	0	1
3	0	1	1	1	0	0	1	1	0	1	1
5	0	1	1	1	0	0	1	1	1	0	1
7	0	1	1	1	0	0	1	1	1	1	1
9	0	1	1	1	0	1	0	0	0	0	1
93.1	0	1	1	1	0	1	0	0	0	1	1
3	0	1	1	1	0	1	0	0	1	0	1
5	0	1	1	1	0	1	0	0	1	1	1
7	0	1	1	1	0	1	0	1	0	0	1
9	0	1	1	1	0	1	0	1	0	1	1
94.1	0	1	1	1	0	1	0	1	1	0	1
3	0	1	1	1	0	1	0	1	1	1	1
5	0	1	1	1	0	1	1	0	0	0	1
7	0	1	1	1	0	1	1	0	0	1	1
9	0	1	1	1	0	1	1	0	1	0	1
95.1	0	1	1	1	0	1	1	0	1	1	1
3	0	1	1	1	0	1	1	1	0	0	1
5	0	1	1	1	0	1	1	1	0	1	1
7	0	1	1	1	0	1	1	1	1	0	1
9	0	1	1	1	0	1	1	1	1	1	1

SWITCH	10	9	8	7	6	5	4	3	2	1	STRAP
FREQUENCY	102.4	51.2	25.6	12.8	6.4	3.2	1.6	.8	.4	.2	.1 MHz
96.1	0	1	1	1	1	0	0	0	0	0	1
3	0	1	1	1	1	0	0	0	0	1	1
5	0	1	1	1	1	0	0	0	1	0	1
7	0	1	1	1	1	0	0	0	1	1	1
9	0	1	1	1	1	0	0	1	0	0	1
97.1	0	1	1	1	1	0	0	1	0	1	1
3	0	1	1	1	1	0	0	1	1	0	1
5	0	1	1	1	1	0	0	1	1	1	1
7	0	1	1	1	1	0	1	0	0	0	1
9	0	1	1	1	1	0	1	0	0	1	1
98.1	0	1	1	1	1	0	1	0	1	0	1
3	0	1	1	1	1	0	1	0	1	1	1
5	0	1	1	1	1	0	1	1	0	0	1
7	0	1	1	1	1	0	1	1	0	1	1
9	0	1	1	1	1	0	1	1	1	0	1
99.1	0	1	1	1	1	0	1	1	1	1	1
3	0	1	1	1	1	1	0	0	0	0	1
5	0	1	1	1	1	1	0	0	0	1	1
7	0	1	1	1	1	1	0	0	1	0	1
9	0	1	1	1	1	1	0	0	1	1	1
100.1	0	1	1	1	1	1	0	1	0	0	1
3	0	1	1	1	1	1	0	1	0	1	1
5	0	1	1	1	1	1	0	1	1	0	1
7	0	1	1	1	1	1	0	1	1	1	1
9	0	1	1	1	1	1	1	0	0	0	1
101.1	0	1	1	1	1	1	1	0	0	1	1
3	0	1	1	1	1	1	1	0	1	0	1
5	0	1	1	1	1	1	1	0	1	1	1
7	0	1	1	1	1	1	1	1	0	0	1
9	0	1	1	1	1	1	1	1	0	1	1
102.1	0	1	1	1	1	1	1	1	1	0	1
3	0	1	1	1	1	1	1	1	1	1	1
5	1	0	0	0	0	0	0	0	0	0	1
7	1	0	0	0	0	0	0	0	0	1	1
9	1	0	0	0	0	0	0	0	1	0	1
103.1	1	0	0	0	0	0	0	0	1	1	1
3	1	0	0	0	0	0	0	1	0	0	1
5	1	0	0	0	0	0	0	1	0	1	1
7	1	0	0	0	0	0	0	1	1	0	1
9	1	0	0	0	0	0	0	1	1	1	1
104.1	1	0	0	0	0	0	1	0	0	0	1
3	1	0	0	0	0	0	1	0	0	1	1
5	1	0	0	0	0	0	1	0	1	0	1
7	1	0	0	0	0	0	1	0	1	1	1
9	1	0	0	0	0	0	1	1	0	0	1
105.1	1	0	0	0	0	0	1	1	0	1	1
3	1	0	0	0	0	0	1	1	1	0	1
5	1	0	0	0	0	0	1	1	1	1	1
7	1	0	0	0	0	1	0	0	0	0	1
9	1	0	0	0	0	1	0	0	0	1	1
106.1	1	0	0	0	0	1	0	0	1	0	1
3	1	0	0	0	0	1	0	0	1	1	1
5	1	0	0	0	0	1	0	1	0	0	1
7	1	0	0	0	0	1	0	1	0	1	1
9	1	0	0	0	0	1	0	1	1	0	1
107.1	1	0	0	0	0	1	0	1	1	1	1
3	1	0	0	0	0	1	1	0	0	0	1
5	1	0	0	0	0	1	1	0	0	1	1
7	1	0	0	0	0	1	1	0	1	0	1
9	1	0	0	0	0	1	1	0	1	1	1

TABLE A-2: SWITCH FREQUENCY INCREMENTS for Leaming Modulators with
a total of 10 or 14 DIP switches to set frequency.

SWITCH NUMBER		INCREMENT, MEGAHERTZ			
		Below 20 MHz (No Prescaler)	Above 20 MHz (With 10 X Prescaler)		
		10.240 MHz REF	10.240 MHz REF	9.216 MHz REF	8.192 MHz REF
SW 501	A1	.00125	0.0125	0.01125	0.010
	A2	.00250	0.0250	0.02250	0.020
	A3	.0050	0.050	0.0450	0.040
	A4	.010	0.10	0.090	0.080
SW 514	B1	.020	0.20	0.180	0.160
	B2	.040	0.40	0.360	0.320
	B3	.080	0.80	0.720	0.640
	B4	0.160	1.60	1.440	1.280
	B5	0.320	3.20	2.880	2.560
	B6	0.640	6.40	5.760	5.120
	B7	1.280	12.80	11.520	10.240
	B8	2.560	25.60	23.040	20.480
	B9	5.120	51.20	46.080	40.960
	B10	10.240 MHz	102.40 MHz	92.160 MHz	81.920 MHz

Note that for all series modulators the ten-position DIP switch is directly equivalent to the same switch on other Leaming modulators with a similar switch and Y502 reference crystal frequency. In addition, some models are equipped with four other switches, which permit smaller output steps, as listed above, in order to provide appropriate offset frequencies. Note also that units with an output frequency greater than 20 MHz have frequency increments which are ten times larger than those with an output frequency less than 20 MHz, due to the inclusion of the X10 prescaler. The reference crystal, Y502, is normally 10.24 MHz. However, as various other frequencies are also used, verify the frequency of Y502 prior to setting a new frequency on the DIP switches.

The output frequency must be an integral multiple of the smallest step size available with the reference crystal that is installed in your unit. For a 10.24 MHz reference crystal, the smallest step size is, as shown in the table: .00125 MHz if no 10 X prescaler is used, and .0125 MHz if the 10 X prescaler is used. The prescaler is used in all units operating above 20 MHz, and in certain units operating at lower frequencies. Thus, for a unit with the 10 X prescaler and a 10.24 MHz crystal, the output frequency must be *n* times .0125 MHz, where *n* may be any whole number between 3 and 16,383. If no prescaler was used, the output frequency would be *n* times .00125 MHz.

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.

A4.2.0 SETTING THE SWITCHES (For frequencies not listed in Table A-1)

The sum of the individual switch's frequency increments is the output frequency. The switch is counted (binary 1) when it is open, which is when the numbered end of the rocker is raised.

A4.2.1 Begin by making a note of your target output frequency. Then close all switches (numbered end of rocker depressed).

A4.2.2 Starting with the most significant (largest number) switch, check to see if that switch's frequency increment is less-than/equal-to, or greater-than the target output frequency.

A4.2.3 If that increment is less-than or equal-to the target, open that switch, and reduce the target by subtracting that frequency increment from the target.

A4.2.4 If that increment is greater-than the target, leave that switch closed, and the target unchanged.

A4.2.5 Proceed to the next lower switch, and check to see if its increment is less-than/equal-to, or greater-than the (reduced) target.

A4.2.6 Again, if this increment is less-than or equal-to the (reduced) target, open this switch and again reduce the target by subtracting this switch's increment.

A4.2.7 If this increment is greater-than the target, leave this switch closed and proceed to the next switch and its increment.

A4.2.8 Repeat step A4.2.5 for each switch (or jumper), in sequence, until the target reaches zero.

When the target reaches zero, the switches/jumpers are set.

If zero cannot be set exactly, it is probable that the target frequency is not an integral multiple of the smallest frequency increment. In this case, either select a new target frequency, or a new crystal to change the increment size. (See Table A-2)

A4.3 EXAMPLE 1: Using a 10 X prescaler, the minimum increment is .0125 MHz, as provided by the standard 10.24 MHz reference crystal and divider (as noted in Table A-2). Using 88.5 MHz as the target output frequency:

SW 10 102.4 MHz, is greater than the target; leave closed. The target remains 88.5 MHz.

SW 9 51.2 MHz, is less than the target; open SW 9 and subtract its increment from the target.
88.5 minus 51.2 equals 37.3, which becomes the next target.

SW 8 25.6 MHz, is less than the new target; open SW 8 and subtract its increment from the target.
37.3 minus 25.6 equals 11.7, which becomes the next target.

SW 7 12.8 MHz, is greater than the target; leave closed.

SW 6 6.4 MHz, is less than the target; open SW 6 and subtract its increment from the target.
11.7 minus 6.8 equals 5.3, the next target.

SW 5 3.2 MHz, is less than the target; open SW 5.
5.3-3.2=2.1

SW 4 1.6 MHz, is less than target; open SW 4.
2.1-1.6=0.5

SW 3 0.8 MHz, is greater than target; leave closed.

SW 2 0.4 Mhz, is less than target; open SW 2.
0.5-0.4=0.1

SW 1 0.2 Mhz, is greater than target; leave closed.

SW 4 The next "switch" may be a wire jumper or #4 of a bank of four additional switches. Its increment is 0.1 MHz, which is equal to the target. Open this switch/jumper. The target is now zero, so the remaining switches, if present, remain closed.

A4.4 CHECK: In order to double-check the switch settings, add together the increments of each open switch. The sum should equal the original target output frequency.

A4.5 EXAMPLE 2: The following table is a convenient way to determine the correct switch settings. The frequency used in this example is again 88.5 MHz, and a 10 X prescaler is fitted. If the prescaler was not used, all frequencies in the table must be divided by ten (shift the decimal one place to the left).

SWITCH NUMBER	FREQUENCY INCREMENT MHZ	SWITCH OPEN=1 CLOSED=0	RUNNING TARGET MHZ
10	102.4	0	88.5
9	51.2	1	37.3
8	25.6	1	11.7
7	12.8	0	11.7
6	6.4	1	5.3
5	3.2	1	2.1
4	1.6	1	0.5
3	0.8	0	0.5
2	0.4	1	0.1
1	0.2	0	0.1
4	0.1	1	0
3	0.05	0	
2	0.025	0	
1	0.0125	0	

The switch is open and counted when the numbered end of the rocker is raised. This is indicated by a binary "1" in the tables. To repeat:

Open = binary 1, adds to total frequency.
Switch is open when numbered end of rocker is raised (end of switch nearest MC145151 I.C.).

Closed = binary 0, not added to frequency. Switch is closed when numbered end of rocker is depressed (end nearest MC145151).