OPERATING AND MAINTENANCE INSTRUCTION MANUAL

MODEL 525

AM-BROADCAST REFERENCE RECEIVER AND MODULATION MONITOR

INOVONICS
INCORPORATED

—— USER'S RECORD ——

Model 525 – Serial No. ___________

Date Purchased _________________

Warranty Card Mailed? — ❑

OPERATING AND MAINTENANCE INSTRUCTION MANUAL

MODEL 525

AM-BROADCAST REFERENCE RECEIVER AND MODULATION MONITOR

Rev. 1
March, 2008
(Initial Release)

INOVONICS INCORPORATED

1305 Fair Avenue • Santa Cruz, CA 95060
TEL: (831) 458-0552 • FAX: (831) 458-0554
Visit our Website: www.inovon.com

TABLE OF CONTENTS

Section I

INTRODUCTION

MODEL 525 PRODUCT DESCRIPTION

General The Model 525 is a Reference Receiver and Modulation Monitor for the medium-wave, AM broadcasting service. It allows the broadcaster to monitor and to measure the performance of his AM transmissions. Because the 525 can receive signals off-air, measurements will include performance of the antenna and antenna phasing and tuning circuits to a significant extent.

The 525 is a broadband receiver featuring wide audio response with user-selectable audio-monitor bandwidth characteristics. A phase-locked synchronous detector helps reject adjacent-channel interference and recovers only the amplitude-modulated component of IBOC 'hybrid'-digital (HD-Radio®) transmissions, even at the full-bandwidth setting.

The 525 comes with a large-aperture, untuned loop antenna. The directionality of this antenna helps reject strong signals on adjacent frequencies that could affect modulation readings.

Features Leading features of the Model 525 include:

- Maintains AM measurement accuracy in the presence of HD Radio® digital carriers.
- Easy menu-navigated setup and operation.
- A bright LCD readout shows positive and negative modulation peaks simultaneously. Metering can be switched to show RF signal level (RSSI) and asynchronous noise to validate modulation measurement accuracy.
- Audio-monitor bandwidth is menu-programmable in 1kHz steps between 10kHz and 2kHz while maintaining full measurement bandwidth.
- Two independent sets of peak flashers show user-programmed maximum modulation values in addition to the fixed, absolute modulation limits.
- Front-panel alarms and rear-panel tally outputs provide local and remote indication of overmodulation, loss of carrier and loss of program audio.
- Supplied with a weatherproof, large-aperture loop antenna.

MODEL 525 TECHNICAL SPECIFICATIONS

Tuning Range:
Tunable via the front-panel menu in 1kHz increments between 520kHz and 1720kHz. Five station-memory pushbutton presets are provided.

Modulation Display:
The front-panel bargraph readout is quasi-peak-responding and shows positive and negative modulation peaks simultaneously, with extended persistence of the most-recent, highest peak value. Measurement resolution is 2% between 20% and 50% modulation, and 1% between 50% and 100% (negative) and 50% and 140% (positive) modulation. The display switches to show the relative level of the incoming carrier (RSSI) and a relative measurement of asynchronous noise.

Peak Flashers:
- Absolute-limit flashers are factory-calibrated at –100% and +125% carrier modulation.
- A second set of flashers may be programmed by the user at values between –70% and –100% and +70% and +140%.

RF Inputs:
- The 75-ohm (F) antenna input connects to the supplied broadband loop antenna. Cable is not included, but up to 100 feet of general-purpose RG-6 TV-antenna coax may be used. A short wire antenna may prove adequate in high-signal areas that suffer minimal interference.
- A 50-ohm (BNC) high-level input accepts a direct RF sample between 1V and 7V r.m.s.

Measurement Bandwidth:
Carrier amplitude demodulation extends to 10kHz, ±0.2dB. Measurement is not affected by the user-selectable audio cutoff.

Audio Response:
User-selectable “FLAT” response, or restricted in programmable 1kHz steps between 10kHz and 2kHz (see Figure 1).

De-Emphasis:
A menu command imparts the NRSC ‘truncated’ 75μs de-emphasis characteristic (see Figure 2) to the program audio output with any restricted audio bandwidth selection.

Audio Distortion:
Less than 0.5% THD at 99% carrier modulation.

Audio Noise:
Typically better than 55dB below 100% modulation with 10kHz audio bandwidth and NRSC de-emphasis (see Figure 3).

Program Audio Outputs:
- The active-balanced, rear-panel program audio output (XLR) delivers +4dBm from a 200-ohm resistive source.
- Front-panel headphone jack (¼-inch, TRS).

Alarms:
Open-collector NPN transistor outputs (barrier block) for carrier loss, program audio loss and overmodulation.

Power Requirements:
105–130VAC (0.250A Fuse) or 210–255VAC (0.125A Fuse), 50/60Hz; 10W.

Size and Weight:
1¾”H x 19”W x 7”D (1U);
9 lbs. (shipping).

PROGRAM AUDIO RESPONSE AND NOISE GRAPHS

Figure 1 illustrates the effect of the menu-programmable audio-cut filter in the program audio and headphone-jack outputs of the Model 525. This filter *does not affect* the modulation measurement utility of the 525, which conforms to the FLAT response indicated, regardless of the audio bandwidth selection.

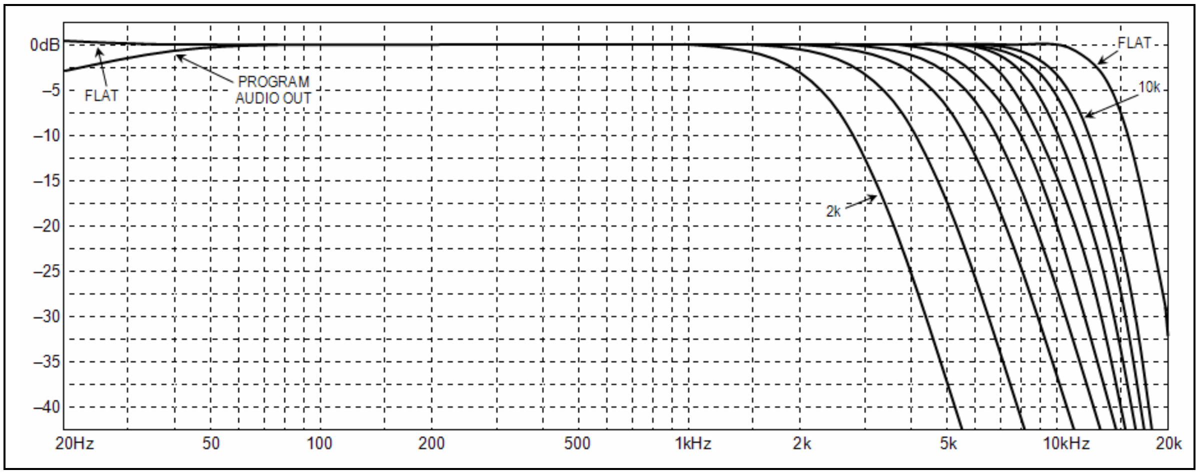


Figure 1 - Model 525 Off-Air Measurement Response (FLAT) and Program-Audio Cutoff Options

Figure 1 does not reflect the 'truncated' 75μs NRSC de-emphasis characteristic shown separately in Figure 2. De-emphasis is a menu option that is normally engaged to compensate for complementary transmission pre-emphasis mandated by the 1985 NRSC Specification.

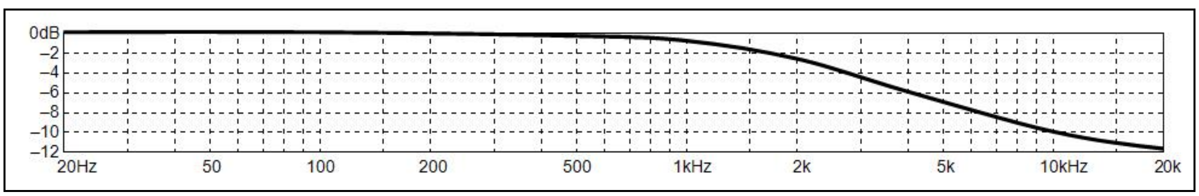


Figure 2 - NRSC De-Emphasis Curve for AM Broadcasting

Signal-to-noise performance of the 525 is almost entirely a function of the incoming RF carrier level. Figure 3 plots the program audio output noise level against RSSI values. The noise level shown is relative to 100% carrier modulation with a 10kHz cutoff and NRSC de-emphasis selected.

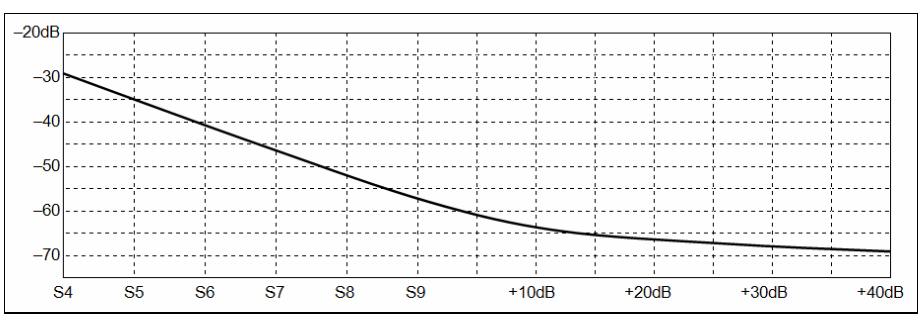


Figure 3 - Output Noise vs. RSSI

BLOCK DIAGRAM

Figure 3 is a simplified Block Diagram of the Model 525. A full set of schematic diagrams appears in the Appendix, Section V.

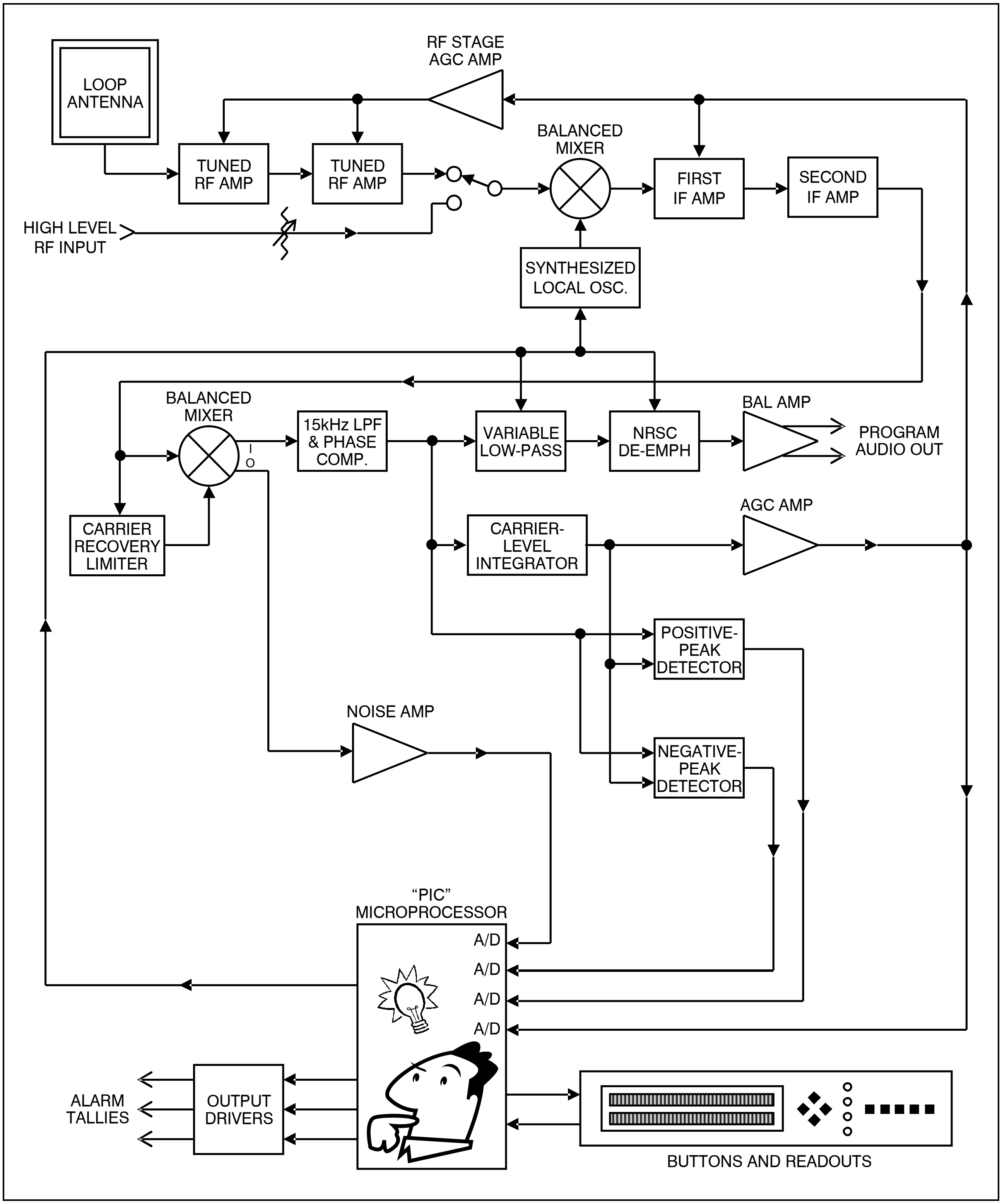


Figure 4 - Block Diagram, Inovonics Model 525

Section II

INSTALLATION

UNPACKING AND INSPECTION

As soon as the equipment is delivered, inspect carefully for possible damage sustained in shipment. If damage is suspected, notify the carrier at once, and then contact Inovonics.

We recommend retaining the original carton and packing materials, just in case return or transshipment becomes necessary. In the event of return for Warranty repair, shipping damage sustained as a result of improper packing for return *may invalidate the Warranty!*

IT IS VERY IMPORTANT that the Warranty Registration Card found at the front of this Manual be completed and returned. Alternatively, registration may be completed online at www.inovon.com. Not only will registration assure coverage of the equipment under terms of the Warranty and provide a means of tracing lost or stolen gear, but it also ensures that the user will automatically receive service or modification instructions when they are issued.

THE LOOP ANTENNA

The untuned loop antenna supplied with the 525 has a 'figure-8' pickup pattern with maximum sensitivity parallel to (in-line with) the loop plane. It is cleverly fashioned from regular-old PVC sprinkler pipe to be weatherproof under most circumstances, a specification easily stated by us Californians who don't have much experience with 'real' winters. Your own common sense and experience with wind, ice and other weather nasties should be factored into location and mounting considerations.

Cable Not Included

Cable to connect the antenna to the Model 525 has *not* been provided in the shipment. Cabling can be any ready-made RG-6 TV-antenna coax of 100 feet or less with F connectors on both ends. Look for a cable that has a rubber boot for the outdoor end.

Mounting the Antenna

The loop antenna is relatively lightweight and may be fastened to any flat surface with the included bracket as shown on the next page. Other mounting possibilities can easily be accommodated with the broad range of TV antenna mounting hardware available universally.

MOUNTING THE 525

Rack Requirement The Model 525 mounts in a standard 19-inch equipment rack and requires a mere 1¾ inches (1U) of vertical rack space. We recommend screws with built-in plastic washers to protect the painted finish around the mounting holes.

Heat Dissipation Consuming far less power than a '60s LavaLite®, the 525 generates negligible heat itself. The unit is specified for operation within an ambient temperature range extending from freezing to 120°F/50°C. Be aware that adjacent, less efficient equipment may radiate substantial second-hand heat, so be sure that the equipment rack is adequately ventilated to keep its internal temperature below the specified maximum ambient.

AC-MAINS POWER

Fuseholder The fuseholder is at the far left of the front panel. Apply downward pressure and pull the cap toward you to access the 5mm mains fuse. Note that the cap has space for a spare fuse as well. The cap is reseated by reversing the removal process. *This fuse also functions as a front-panel emergency power disconnect.*

Mains Voltage Selector Unless specifically ordered for export shipment, the 525 is supplied for operation from 115V, 50/60Hz AC mains. This can be confirmed by checking the designation beneath the mains connector on the rear panel. The *inappropriate* voltage and fuse value will have been crossed out at the factory with a felt marker pen.

To change the mains voltage, disconnect power and remove the top cover of the unit. A clearly marked slide switch is directly behind the AC mains connector on the circuit board. *With the unit unplugged*, use a small screwdriver to set the switch for 115VAC or 230VAC operation.

Be sure to install the appropriate fuse listed on the rear panel. You can remove the factory fuse indication with lacquer thinner or nail polish remover, and then cross out the inappropriate fuse value with a felt marker.

Power Cord The detachable IEC-type power cord supplied with the 525 is fitted with a North-American-standard male plug. If you need to cut this plug off to use another, be advised that the individual cord conductors may be color-coded in either of two ways, regardless of the shipping destination:

1) In accordance with US standards:

BLACK = AC "HOT"   WHITE = AC NEUTRAL
GREEN = EARTH GROUND

2) To European CEE standards:

BROWN = AC "HOT"   BLUE = AC NEUTRAL
GRN/YEL = EARTH GROUND

RADIO FREQUENCY INTERFERENCE (RFI)

Location The Model 525 is a high-performance, wideband AM receiver requiring reasonable caution when using it in the vicinity of high power transmitters. As a *receiver*, the 525 was intended for use at the studio, rather than at the transmitter site.

At the transmitter site, the rear-panel HIGH LEVEL RF input may be connected directly to an appropriate transmitter or feedline monitor tap. With a direct, high-level RF input connection it is doubtful that other stations can be received with the antenna, even if the antenna itself is located away from the tower.

Ground Loops The active-balanced program line output of the 525 is not transformer-isolated. A mains frequency or RF ground loop could be formed between output cable shield ground and the AC power cord ground. A 'ground-lifting' AC adapter may well remedy such a situation, although the chassis somehow must be returned to earth ground for safety. Generally, being screwed-down in the equipment rack will satisfy the safety requirement.

RF INPUT SELECTION

The rear-panel INPUT SELECT switch may be set to accept either ANTENNA or HIGH LEVEL (direct) inputs.

Antenna Input The rear-panel F connector is meant to accept only the loop antenna supplied with the 525. This is a low-impedance, current-sensing input that swamps the RF resonance developed by loop inductance and cable capacitance.

If the 525 is co-located with the transmitter, but a direct connection to an appropriate tap is not convenient, chances are that a short length of insulated wire stuck into the center of the F connector will bring sufficient signal into the 525. This does not maintain the interference-reduction advantage afforded by the loop, however.

High Level Input A rear-panel BNC jack can accept a high level RF input directly from an appropriate transmitter or feedline tap. This input terminates the source in a 50-ohm, 1-watt resistor, so the r.m.s. level of the input must be kept at 7 volts or less.

Signals applied to the high level input still must be tuned-in from the front panel. This input does not benefit from the tuned RF amplifier stages, thus it has no rejection of image frequencies. The 525 will tune the signal applied to this input at its normal frequency, and also at an indicated frequency 600kHz above the actual transmission if this is within the tuning range of the 525.

High Level Gain Set A 15-turn potentiometer marked LEVEL SET is adjacent to the BNC connector. This is used to trim the gain of the high level input for the signal applied. This input benefits from a certain degree of AGC action, although not with the same wide range as antenna inputs are afforded. The LEVEL SET pot should be set for an RSSI indication between S9 and S9+40dB when the SIGNAL AND NOISE measurement option is selected (see Page 14).

PROGRAM AUDIO OUTPUT

The rear-panel PROGRAM AUDIO OUT XLR-male connector is an electronically-balanced (transformerless) line output. This is an active-balanced output with a symmetrical resistive source impedance of 200 ohms. The nominal “0VU” output line level is +4dBm.

ALARM “TALLY” OUTPUTS

The 525 has rear-panel alarm tally outputs for three general fault conditions: 1) OVERMODULATION, 2) CARRIER LOSS and 3) PROGRAM AUDIO LOSS. These tallies are coincident with front-panel alarm indications, which are covered under their corresponding discussions.

The alarm outputs are NPN transistor saturations to ground. These outputs can sink up to 100mA at source voltages to about 30VDC. +5V and GND (ground) are provided on the terminal strip as well. The +5V source is current-limited to about 50mA, which is sufficient to drive an opto-coupler or a remote LED indicator. The alarm tally barrier strip may be unplugged from the chassis for easy connection.

A common, “any fault” remote alarm will be generated if the three independent outputs are simply strapped together.

Section III

SETUP AND OPERATION

NAVIGATING THE MENU AND SELECTING OPTIONS

The lower, right-hand side of the LCD display is dedicated to MENU AND ALARMS, leaving the greater part of the screen area for the high-resolution bargraph display of POSITIVE PEAK MODULATION and NEGATIVE PEAK MODULATION. Relative indications of signal strength and asynchronous noise utilize these same bargraph readouts and are delineated with numerical values as well. The receive frequency is always shown beneath FREQ.

In the following discussion of the menu, specific LCD-screen callouts will be identified in the manual text with this font: `MENU ITEM`.

Display Default

NOTE: `PEAK MODULATION` is the default display of the front-panel LCD. With the exception of the `SIGNAL AND NOISE` measurement, all menu screens automatically return to show `PEAK MODULATION` if no updates are made to selected menu items within 10 seconds after calling them up.

Front-Panel Buttons

Metering selection and other functions of the Model 525 use the cluster of four pushbuttons in concert with the LCD menu screen. The up/down ▲ and ▼ MENU buttons scroll among menu options to show what is available for selection or change. The left/right ◀ and ▶ SEL (select) buttons are then used to make the changes to that menu item. Changes are automatically held in non-volatile memory and will not be lost in the event of a power interruption.

Menu 'Tree'

From "top to bottom," as accessed with the ▲ and ▼ MENU buttons, these are the various display screens:

`SET FREQUENCY` (defaults to `PEAK MODULATION` after 10 seconds)
`SIGNAL AND NOISE`
`AUDIO CUT` (defaults to `PEAK MODULATION` after 10 seconds)
`NRSC DE-EMPH` (defaults to `PEAK MODULATION` after 10 seconds)
`POS PK FLASH` (defaults to `PEAK MODULATION` after 10 seconds)
`NEG PK FLASH` (defaults to `PEAK MODULATION` after 10 seconds)
`SET CARRIER LOSS` (defaults to `PEAK MODULATION` after 10 seconds)

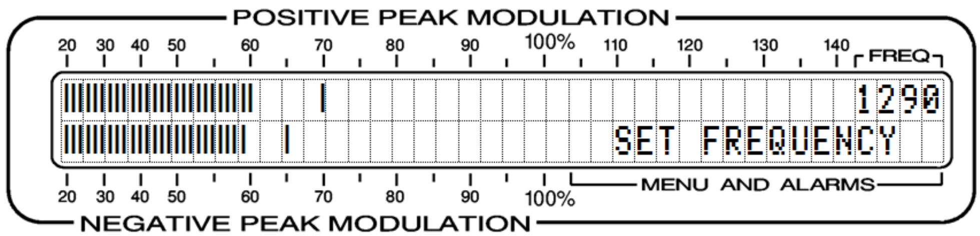
Alarm Priority

Reception fault conditions trigger flashing front-panel indications concurrent with rear-panel tally logic outputs. These alarms are detailed in the appropriate discussions.

NOTE: With no station tuned-in a `□□□AUDIO--LOSS□□□` and/or a `□□□LOW--SIGNAL□□□` alarm will appear, depending on the noise floor at that frequency. Pressing any front-panel button will reset the flashing indication for 10 seconds allowing menu items to be selected and controlled. The corresponding rear-panel tally will *not* be reset, requiring instead that the fault condition be cleared.

TUNING

Use the ▲ MENU button to cycle to the 'uppermost' SET FREQUENCY screen.



The SEL buttons may be used to set the receive frequency, which is always displayed in the upper-right corner of the LCD screen under FREQ. The SEL buttons may be incremented in single 1kHz steps, or held-down to scan quickly up and down the band.

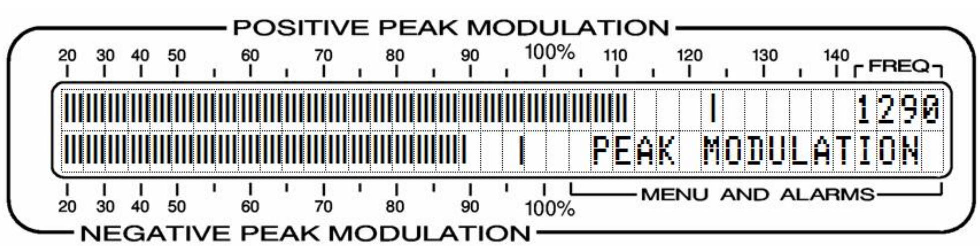
Tuning Lockout 10 seconds after setting the frequency, the SET FREQUENCY screen defaults back to PEAK MODULATION. This locks-out the ◀ and ▶ SEL (select) buttons. To return to SET FREQUENCY, press the ▲ MENU button again.

Tuning Presets Up to five stations may be entered into non-volatile memory for instant recall. Station presets are not subject to lockout and will retune the 525 regardless of what screen is showing. To set these buttons, simply tune the 525 to the desired frequency and then hold down any one of the buttons in the TUNING PRESETS group. After a couple of seconds the frequency readout will 'wink' once to indicate that the memory has been set. Repeat the process to enter other frequencies or to change any memory entry.

If keeping tuned to the station's frequency is critical, set all five TUNING PRESETS to the same frequency to guard against accidental retuning by some clumsy person bumping against the unit.

READING MODULATION

The PEAK MODULATION screen, as well as some others, display carrier modulation in the active display area.



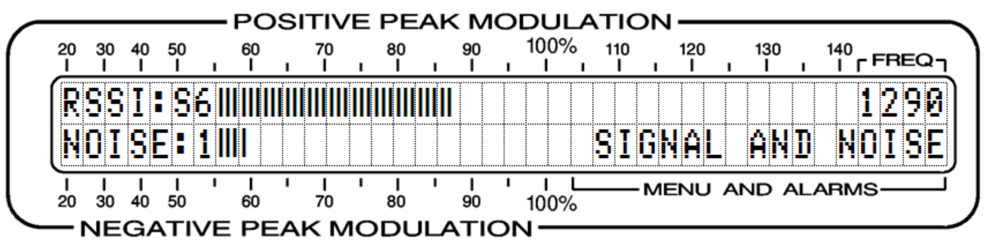
The two bargraphs show positive and negative carrier modulation independently and concurrently. The bargraphs will follow the modulation to the extent that an LCD can keep up with rock 'n' roll, and single segments representing the highest positive and negative peaks will 'hang' above the bars for about a second to ensure that the highest instantaneous value will be displayed with no ambiguity.

Indicated modulation will be an accurate measurement, consistent with the signal level and interference factors that are addressed next.

MONITORING SIGNAL STRENGTH

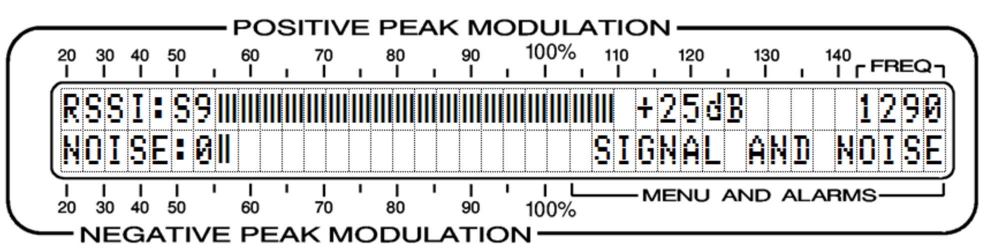
Use the MENU buttons to bring up the SIGNAL AND NOISE screen.

NOTE: The SIGNAL AND NOISE screen will *not* automatically revert to read PEAK MODULATION after 10 seconds. This screen may be kept active indefinitely to facilitate antenna alignment or to monitor carrier level.

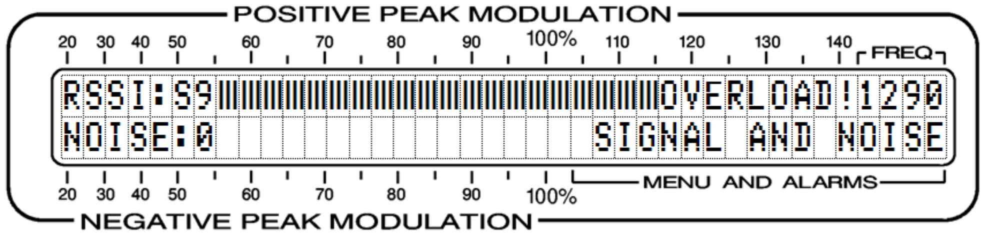


The upper bargraph now represents a Received Signal Strength Indication, or RSSI. The quasi-log LCD bargraph gives a relative indication of incoming RF level, and a numerical 'S' value is displayed to the left of the bar. This will vary between S0 (zero) and S9. An increase of one S unit represents a signal increase of 6dB. Generally a reading of S8 or higher is required to assure modulation measurement accuracy.

Once a receiver reaches a 'full signal' indication of S9, additional RF level is considered 'so many dB over S9.' The Model 525 displays this numerical value in 5dB steps at the right of the bar.



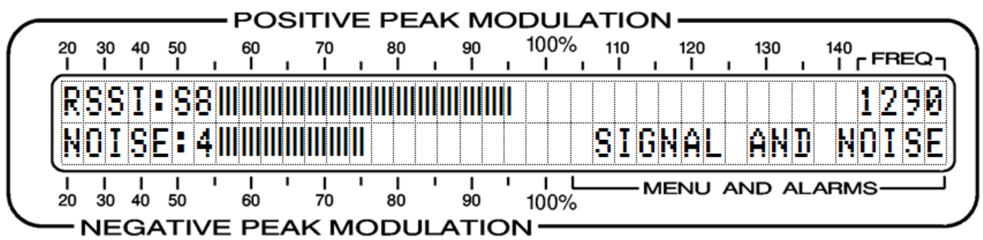
AGC action of the 525 can handle inputs up to 40dB over S9. When the AGC reaches the end of its control range, the word OVERLOAD! appears to the right of the bar as shown on the next page.



Modulation measurements cannot be trusted as accurate either at very low signal levels or with an input overload. When OVERLOAD! appears in normal operation, either reduce the antenna signal by replacing the loop antenna with a short length of wire, or use a direct, high-level input connection and adjust the rear-panel LEVEL SET pot for an indication between S9 and S9+40dB.

MONITORING INTERFERENCE

To a reasonable extent, the synchronous detector of the 525 is able to reject input signals that are not coherent in frequency and phase with the AM carrier. On the SIGNAL AND NOISE screen, the lower bargraph gives a relative indication of certain noise components that may not be audible, but can nevertheless compromise the accuracy of modulation measurements.



This noise measurement utility displays a relative level of “stuff that shouldn’t be there,” which may include modulation splatter or spillover from adjacent stations. With 1kHz tuning increments, it is easy to be off-frequency, which is another condition that will cause a high noise reading.

Noise is quantified on an arbitrary numerical scale of zero to nine with the bargraph scaled proportionally. Anything over a value of 3 gives reason to suspect the accuracy of modulation measurement. Aiming the antenna away from an offending source may help reduce the noise contribution.

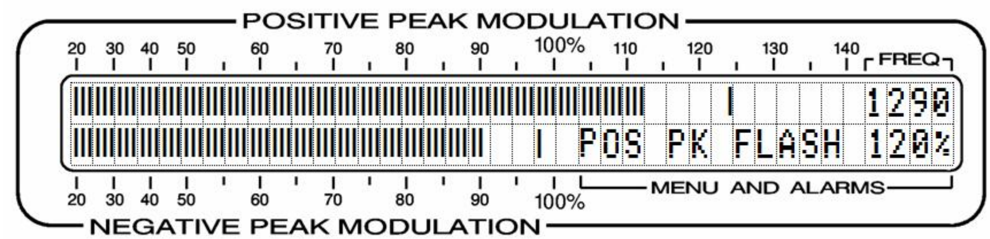
Metered noise is not the only non-program component that can sabotage modulation readings. Impulse noise and other spurious signals that may happen to be in phase with the received carrier at a particular instant may not show up on the NOISE: scale. Use your ears to discern this type of interference.

Generally, impulse noise will inflate the reading of positive carrier modulation, while splatter or spillover will cause both positive and negative indications to read high.

SETTING THE PEAK FLASHERS

The 525 has two sets of LED peak flashers for overmodulation conditions. The larger top and bottom red LEDs indicate the absolute US legal limits of –100% and +125% modulation. The two smaller green LEDs may be programmed by the user to show when an alternative values are exceeded.

Bring up the POS PK FLASH screen with the MENU buttons. Using the SEL buttons, set the flasher trip point to any desired value between 70% and 140%.



In like manner, the NEG PK FLASH screen may be programmed to trip anywhere between 70% and 100%.

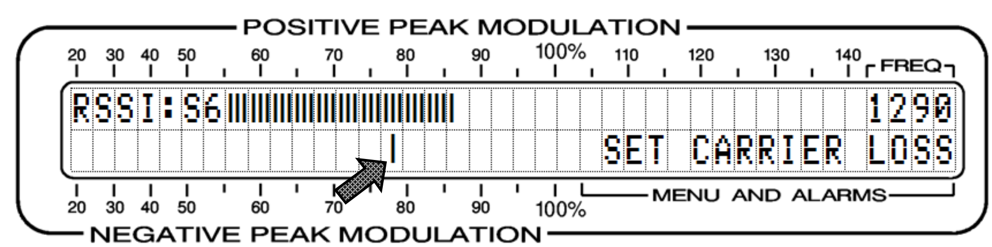
Peak flashers are programmed with 1% resolution. Settings are held in non-volatile memory and will not be lost from a power outage. These setup screens will revert to PEAK MODULATION after 10 seconds.

Overmodulation 'Tally' Alarm Outputs

The rear-panel OVERMODULATION terminal is driven to ground when either red LED lights, indicating –100% or +125% modulation.

SETTING THE CARRIER LOSS TRIP POINT

The carrier-loss alarm works in conjunction with the RSSI RF signal-strength meter. The alarm trip point is set by bringing up the SET CARRIER LOSS screen with the MENU buttons.



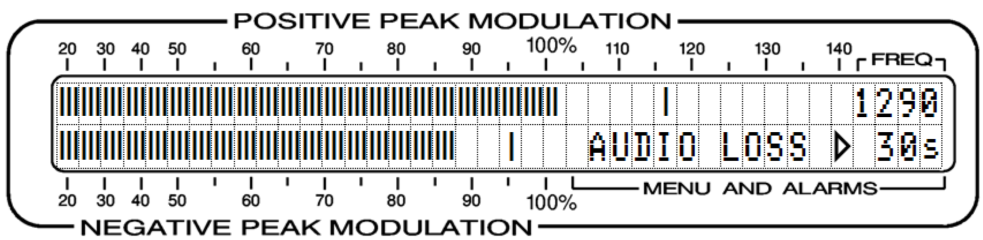
The single LCD segment below the RSSI display corresponds to the alarm trip point. This segment is identified here with an arrow. It may be positioned with the SEL buttons anywhere in the RSSI metering range. The carrier loss alarm is activated immediately whenever the RF level falls below the set point.

When setting the carrier loss alarm, remember to make allowance for a different nighttime power setting if power changes after dark. Also factor-in normal variations in signal strength from propagation and fading effects. Keep the trip point above the residual noise level at the receive frequency when the carrier is absent.

The alarm setting for the station that is normally monitored will not hold true for other stations when the 525 is used to monitor market companions. When surfing the band or "DXing," it may be necessary to temporarily reset the carrier-loss alarm to a very low value to keep it from activating unnecessarily. Do remember to restore the proper setting afterward, however.

SETTING THE PROGRAM AUDIO LOSS ALARM

The Model 525 gives a front-panel alarm and a rear-panel 'tally' output in the event that carrier modulation falls below 60% and remains there for a period of time specified by the user. Use the MENU buttons to bring up the AUDIO LOSS screen.



SEL buttons are used to set the alarm timeout to any period between 5 seconds and 120 seconds (2 minutes).

NOTE: The audio-loss alarm is *not* a reliable indicator of the station going off the air. AGC action may well bring up random noise at the carrier frequency to an indicated 60% modulation in the absence of an unmodulated carrier.

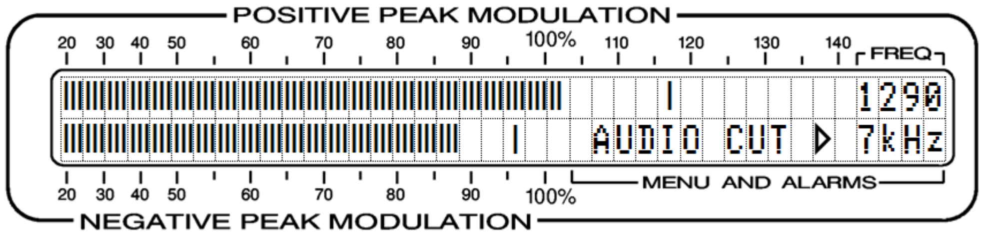
AUDIO MONITOR SETTINGS

Audio Bandwidth Selection

Synchronous detection recovers amplitude modulation by 'zero-beating.' The RF (or IF) is sampled at the same rate as the incoming carrier with absolute carrier phase lock. This creates a virtual final IF frequency of zero.

Overall receiver bandwidth is defined in large part by audio filtering that follows the detector. The range of audio cutoff characteristics provided by the 525 allows the broadcaster to hear his program as it might sound with different choices of transmission filtering, or from the perspective of the wide variety of radios that exist in the marketplace. Modulation measurements, on the other hand, are always made with full audio bandwidth. User-selected audio bandwidth options have no effect on modulation measurements.

Use the MENU buttons to navigate to the AUDIO CUT screen.



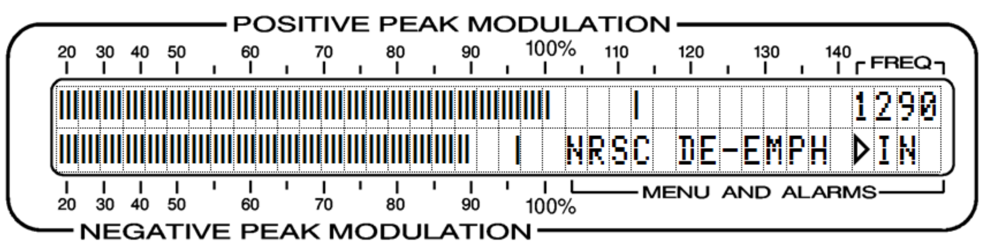
The SEL buttons set the audio cutoff to FLAT, or in 1kHz increments from 10kHz down to 2kHz. Figure 1 on Page 5 shows a plot of this family of curves. The frequency indicated by the display is the –3dB point of a fourth-order (24dB/octave) low-pass filter. This cutoff applies only to the rear-panel PROGRAM AUDIO OUT connector and to the front-panel PHONES jack.

NRSC De-Emphasis

AM broadcasting in the U.S. employs fixed transmission pre-emphasis defined by the National Radio Systems Committee (NRSC) in their July, 1985 Specification. To obtain flat overall response, the receiver supplies a complementary de-emphasis curve. Figure 2 on Page 5 shows this truncated 75-microsecond NRSC characteristic.

NRSC de-emphasis for AM broadcasting was established in the mid-1980s when 10kHz audio bandwidth was a quality benchmark for the AM band. Of course the full advantage of complementary pre- and de-emphasis has been reduced as many broadcasters have voluntarily opted to curtail high frequencies to lower figures in recent times. The 525 allows de-emphasis to be engaged from the front panel at any of the audio cutoff settings, except for the FLAT position that automatically defeats de-emphasis.

MENU buttons bring up the NRSC DE-EMPH selection option and SEL buttons toggle between IN and OUT.



De-emphasis is normally left IN for listening, but may be switched OUT when making measurements through the rear-panel PROGRAM AUDIO OUT connector. Again, de-emphasis is automatically switched out when AUDIO CUT is set to FLAT. As with the audio bandwidth selection, de-emphasis affects only the audio outputs and has no effect on modulation measurements.

Consistent with signal strength and noise concerns already covered, the carrier peak modulation readings will be trustworthy under most all circumstances.

A solid, strong incoming carrier, preferably S8 or greater in level, is necessary for the most accurate modulation readings. But even a strong signal can be sabotaged by co-channel 'skip' after daylight hours. Watch for a 'beat' on the RSSI display and listen for an intruding program at the received frequency.

A strong adjacent-channel signal can also skew peak modulation readings. The 525 is, after all, a very wideband receiver. Although synchronous detection *should* reject an adjacent channel, the 525 compromises this feature somewhat with its very tight carrier phase lock, which is necessary to reject the effects of incidental phase modulation that might be present in the desired signal.

The front-panel noise reading will reveal several reception anomalies including adjacent-channel signals that may not be audible in the program audio. Use the signal-nulling capability of the loop antenna to reject an intruder as well as to optimize the desired signal.

Performance Limitations

Although the Model 525 carries the name "Reference Receiver," don't be too disappointed if performance seems to fall short of an old Philco console you might remember or, for that matter, a contemporary car radio. This is a very wideband unit that works on a different principle from most AM radios, in that it wants to lock onto a strong, clean carrier, even if that carrier is a channel or more away!

The principal utility of the 525 is its use as a Modulation Monitor, not as a hotshot receiver with razor-sharp tuning. Although the 525 can log some respectable DX on clear channels, there may well be reception limitations even when the 525 is within sight of the transmitting tower.

Section IV

CIRCUIT DESCRIPTIONS

INTRODUCTION

This Section details the circuitry of the Inovonics Model 525 Reference Receiver and Modulation Monitor. Circuit descriptions refer to the three pages of Schematic Diagrams contained in the Appendix, Section V.

Component Annotation Schematics for the 525 may appear to have component reference designations assigned in a somewhat haphazard manner, but this is not really the case. Rather than annotate the schematic in a logical sequence, we have instead elected to designate the actual components on the main circuit board in a top-to-bottom and left-to-right manner, following the physical placement of the parts in their neat little rows. This should actually simplify any necessary troubleshooting, as the physical component can be located quickly following analysis of the schematic.

RECEIVER CIRCUITRY

RF Amplifier The loop antenna is fed directly to the emitter of Q26. This represents a low-impedance termination for the antenna that swamps resonance from the inductance of the loop antenna and the capacitance of the connecting cable. The gain of Q26 is controlled by AGC bias applied to its base. CR12 in the emitter of Q26 helps linearize the stage at low currents when AGC reduces gain to minimum.

The second RF amplifier stage is a cascode connection of Q22 and Q23. Gain of this stage is also controlled by AGC bias. The tank circuits in both RF amplifier stages are stagger-tuned for bandwidth considerations, and source-follower Q21 isolates the RF stages from the load of the balanced mixer.

The RF input to the mixer is selected by a CMOS analog switch, IC20. Either the amplified antenna signal or a high-level input taken directly from a transmitter or feedline tap is routed to the balanced mixer. The LO (local oscillator) input to the mixer is 300kHz higher than the tuned signal, establishing 300kHz as the IF frequency.

Balanced Mixer Q18 and Q19 are cross-connected to form a simple and effective balanced mixer with particularly good performance at high injection levels. This configuration is attributable to a Plessey integrated circuit design from a number of years ago.

Synthesized Local Oscillator

Q24 and Q25 are a high-gain pair used in a Franklin (no, not Benjamin Franklin!) oscillator configuration. The high input impedance of Q24 and the high value of feedback resistor R130 isolate the tuned circuit from any loading effects by the amplifier stages. The output of this oscillator is a symmetrical squarewave.

IC22 is a phase-locked-loop (PLL) synthesizer chip serially addressed by the microprocessor, IC5. Error voltages from IC22 are amplified by IC21A to steer varactor tuning diodes V1, V2 and V3 in local oscillator and RF amplifier stages.

IF Amplification

The output of the balanced mixer is filtered by a triple-tuned bandpass network centered at 300kHz and buffered by source-follower Q20. Q15, Q16 and Q17 form a discrete-device implementation of the obsolete CA3028 monolithic IF amplifier. That IC is easily replicated with inexpensive, garden-variety junction transistors. This particular configuration of the CA3028 was suggested by Wes Hayward in his book, *Radio Frequency Design*, published by the ARRL. It utilizes a 'current-robbing' technique for AGC and has wide dynamic and control ranges. Linearity is good, especially at high signal levels.

The output of this first IF stage is filtered by a double-tuned bandpass network at the 300kHz IF frequency. The second IF amplifier is the Q13/Q14 transistor pair with fixed gain. Servo amplifier IC18A establishes a solid ground reference for the IF.

Synchronous Detector

The 300kHz IF is limited, or squared-up, by three hex-inverter sections: IC19F, IC19E and IC19D. These CMOS digital inverters are forced, kicking and screaming, into quasi-linear operation by local DC feedback. The output of this 3-stage limiter is a reasonably stable squarewave representing the carrier-frequency component of the received signal.

The limited squarewave is coupled to the L1/C46 tuned network to reduce out-of-band components generated by the high-gain squaring stages. Further squaring follows the tuned circuit to provide a clean, symmetrical squarewave for the switching detector.

Tight phase lock between a synchronous detector and the incoming carrier is important for accurate recovery of the amplitude-modulated component of the incoming RF signal. Incidental phase modulation, either already a part of the incoming carrier or as additional skew from tuned circuits in the receiver, compromises resolution of the amplitude-modulated component of the carrier. A synchronous detector based on PLL techniques cannot easily follow phase modulation at high audio frequencies, hence our selection of the "homodyne" technique (from 1922!) used here.

IC17 is a double-pole, double-throw CMOS switch. It is driven by the squarewave output of IC19B and its antiphase complement from IC19C. The differential inputs of IC16A are alternately presented with the IF signal at a 300kHz rate. The output of IC16A is the amplitude-modulated component of the carrier riding at a DC voltage that represents the mean level of the unmodulated carrier.

A 5-pole, 15kHz low-pass filter follows the synchronous detector to remove 300kHz IF and other out-of-band components. IC16B is an all-pass stage giving first-order compensation for the phase response of this filter and of RF and IF stages.

Noise Amplifier

Q10, Q11 and Q12 comprise a unipolar, discrete-component op-amp. This amplifier monitors the commutating output of the synchronous detector that *should* never assume a positive value. Certain reception conditions, such as mistuning, co-channel interference, strong adjacent carriers and non-canceling asynchronous noise result in a positive potential at the monitored point. This is amplified and fed to the microprocessor for front-panel noise-level display.

AGC SYSTEM

Carrier Level Recovery and AGC

The filtered output of the synchronous detector has a mean DC value that represents the level of the unmodulated RF carrier. The DC component is recovered by integrator IC14B. This DC bias serves both as a reference for peak modulation readings and to establish the gain of RF and IF stages.

DC from IC14B is fed to one input of comparator IC14A and a fixed bias is applied to the other input. The AC gain of the comparator is spoiled by the series combination of C34 and C35. The output of this comparator is fed directly to the variable-gain IF amplifier, and also to IC18B, an offset-and-inverting AGC amplifier for the RF gain stages.

PEAK LEVEL DETECTORS

IC10 and IC11 are peak detectors for positive and negative modulation, respectively. The differential inputs of these detectors compare the output of the synchronous detector with the integrated DC that represents the unmodulated carrier level. A token amount of measurement integration is afforded by R51 and R58 that feed peak-hold capacitors C28 and C37. The buffered peak values are fed to A-to-D inputs of microprocessor IC5 through voltage-limiting gates Q9 and Q8.

AUDIO OUTPUT CIRCUITRY

Programmable Low-Pass Filter

The four op-amp sections of IC12 and IC13 comprise a fourth-order low-pass filter. The four 6.6k resistive elements (two 3.3k resistors) are each in series with CMOS analog switches, the four sections of IC9. These are switched on and off at a 150kHz rate by the PWM output of IC5.

The duty cycle of the 150kHz switching waveform determines the cutoff frequency of the filter. With a 100% CMOS switch ‘on’ time, the 6.6k resistive elements appear exactly that value and the cutoff frequency conforms to the calculated function. With a 50% duty cycle, the resistance is effectively doubled to 13.2k and the cutoff frequency falls by one octave. With a 25% 'on' time, the resistance is multiplied by a factor of four and the cutoff falls by this factor.

NRSC De-Emphasis

With FET Q6 turned on, R32, R33 and C24 impart the 'truncated' 75μs NRSC de-emphasis characteristic to the program audio. IC8A buffers the de-emphasis network. Q6 is switched by IC5 per menu selection.

FET Q4 serves to mute the audio output of the 525 during initialization and to mute inter-station noise when tuning presets are selected.

Output and Headphone Amplifiers

Power-gain stage IC8B includes a second-order low-pass function to remove any residual 150kHz switching component from the programmable filter. IC8B drives one side of the balanced line output, and unity-gain inverting stage IC7B drives the other side. IC7A is a separate buffer and gain stage for the front-panel headphone output.

THE 'PIC' MICROCPROCESSOR

IC5 is a 'PIC' microprocessor that provides the smarts for the Model 525. It accepts analog voltages from the peak detectors, the AGC and the noise amplifier and converts these levels to digital values for display by the LCD bargraph and to perform other tasks.

Front-panel pushbutton logic is binary-encoded by IC6 and sent to the PIC. The PIC also drives the peak flashers and rear-panel alarm tallies.

IC4 is a serial EPROM used for non-volatile memory. Station presets, peak flasher values and other user selections are written to this memory chip as they are made.

POWER SUPPLY

Power transformer T1 has dual primary windings that may be switched in parallel or in series for 115V or 230V AC mains. Bridge rectifier BR1 delivers raw DC to the three linear voltage regulators, IC1, IC2 and IC3. These deliver +9V, –9V and +5V, respectively.

Section V

APPENDIX

This section of the Model 525 Manual contains Parts Listings, Schematic Diagrams and an explanation of Inovonics' Most Generous Warranty Policy.

PARTS LIST

EXPLANATION OF PARTS LISTINGS

This section contains listings of component parts used in the Inovonics 525 AM Reference Receiver and Modulation Monitor. Not all components are listed by schematic reference designation; those that are considered 'generic' may have qualification notations, however.

Component descriptions may or may not specify a particular manufacturer or vendor. When no manufacturer is called out, the term (open) advises that any manufacturer's product carrying the given part number (or the same description in the case of a generic part) is acceptable.

Should you need to order part that is not listed here, call, write, fax or e-mail the factory with a brief description of what it is that you need. We'll then do our very best to figure out what to send you… hopefully something you can use!

PARTS LISTINGS

BR1 Bridge Rectifier; Mouser 512-DF04M

Unless specifically noted by component reference designation, **capacitors** are specified as follows:

a: Under 100pF are general-purpose disc ceramic capacitors with no specific technical specification. The letter 'p' following the value indicates picofarads.

b: 100pF to 0.47μF are of the metallized Mylar or polyester variety. Whole number (XXXp) values are picofarads, decimal values are microfarads. All capacitors in this category have 5% tolerance and are rated at 50VDC or better. The style used in the 264 is the "minibox" package with lead spacing of 0.2 inch. The preferred manufacturer is WIMA, their FKS-2 or MKS-2 series. Possible alternates are the CSF-Thompson IRD series or the Vishay-Roederstein KE-1808 or KT-1817 series.

c: 1.0μF and above are general-purpose aluminum electrolytics with radial leads. A safe voltage rating for any electrolytic in the 264 would be 25V, but because of size and other considerations a replacement capacitor should always carry the same rating as the one being replaced.

C1,2 Capacitor, Y-class Ceramic Disc, .0047μF, 440VAC; Murata/Erie DE7150 F 472M VA1-KC

C10,11	Capacitor, Electrolytic, radial leads, 2200µF, 35V "snap-in"; Digi-Key P7 466-ND
C15,16,49,54,55,57,64, 72,79,82,89,90,98	Capacitor, Monolithic Ceramic, 0.1µF, 35V; (open)
C24,25,53,71,72, 73,75,80,84,86	Capacitor, Ceramic Disc, 0.001µF, 50V; (open)
C60,66,70,7475, 83,86,87,92	Capacitor, Ceramic Disc, 0.01µF, 50V; (open)
C73,77,91	Capacitor, Variable, 5-50pF; Mouser 24AA024
CR1,2	Diode, Silicon Rectifier; (open) 1N4005
CR3-12	Diode, Silicon Signal; (open) 1N4151
F601	Fuseholder; Littlefuse 0286067 (The fuse itself is a 5mm normal "fast blow" type; the value should match the specification stated on the rear panel.)
I501,504	T1¾ Red LED; Kingbright L53ID
I502,503	T1 Green LED; Kingbright L934GD
IC1	Integrated Cct.; (open) LM317-T
IC2	Integrated Cct.; (open) LM337-T
IC3	Integrated Cct.; (open) LM7805
IC4	Integrated Cct.; (open) 24C04-DIP
IC5	Integrated Cct.; Microchip 17C74 'PIC' *(Requires factory programming, available only from Inovonics)*
IC6	Integrated Cct.; (open) 74HC147
IC7,8,10-16,18,21	Integrated Cct.; (open) LF353-N
IC9,17	Integrated Cct., (open) CD4066B
IC19	Integrated Cct.; (open) CD4069
IC20	Integrated Cct.; (open) CD4053
IC22	Integrated Cct.; Motorola MC145170-2 (SMD part)
J1	Connector, AC Mains; Switchcraft EAC303
J2	Connector, Headphone Jack; Switchcraft RN112BPC
J4	Connector, 6-position 'Barrier'; Weco 121-M-211/06 Plug-In Terminal Block is Weco 121-A-111-06
J7	Connector, XLR Male; Neutrik NC3MAH
J601	Connector, "F"; Digi-Key CP-1010-ND
J602	Connector, BNC Bulkhead; Mouser 523-31-221-75RFX
L1-6	Inductor, 1mH Variable; Toko A7BRS-11871Z
L7,9,10	Inductor, 220µH Variable; Toko A7BRS-11863Z
L8	Inductor, 220µH; Mouser 434-23-221J
Q1-3	Transistor, NPN; (open) 2N3904
Q4,6,14,20-22,24	Transistor, N-Channel FET; (open) 2N3819
Q5,7,12,13	Transistor, NPN; (open) 2N3906
Q8-11,15-19,23,25,26	Transistor, NPN; (open) 2N5088

Except at noted by reference designation, **all resistors** used in the 525 are the value specified on the schematic, qualified as follows:

a: **Resistors** with values carried to decimal places implying a 1% tolerance (*example:* 232, 3.01k, 10.0k, 301k) are ¼-watt, 1% metal film type.

b: **Resistors** with values typical of a 5% tolerance (*example:* 220, 3.3k, 10k, 270k) are ¼-watt, 5% carbon film type.

R21	Resistor Array, 8x10k 'SIP'; Mouser 266-10K-RC
R601	Resistor, Carbon Film, 56 Ohm, 1 Watt; (open)
S1	Switch, Voltage-Selector; ITW 18-000-0022
S2	Switch, SPDT Toggle; C&K 7101-M-D9-A-B-E
S501-509	Switch, Pushbutton; ITT KSLOM312 Button Cap is TEE G004A
T1	Transformer, Power; Signal LP-20-600 (or direct cross-ref.)
V1-3	Varactor Diode; Toshiba 1SV149-B *(Inovonics Stock)*
Y1	Crystal, 20MHz; Digi-Key X439-ND
Y2	Crystal, 3.2MHz; Standard Crystal 2AAK3M2000
LCD DISPLAY	2 X 40 Alphanumeric; Optrex C-51850NFQJ-LW-AAN

SOURCES FOR COMPONENT PARTS

Inovonics strives to maintain factory stock of the parts used in products that we manufacture. A majority of the components in the Model 525 are ‘generic’ and may be obtained from a wide variety of sources.

A few parts may be more-or-less proprietary. These either are manufactured specifically for Inovonics or purchased from a manufacturer that sells only in production quantities, or they may be parts, such a memory chips, that require factory programming.

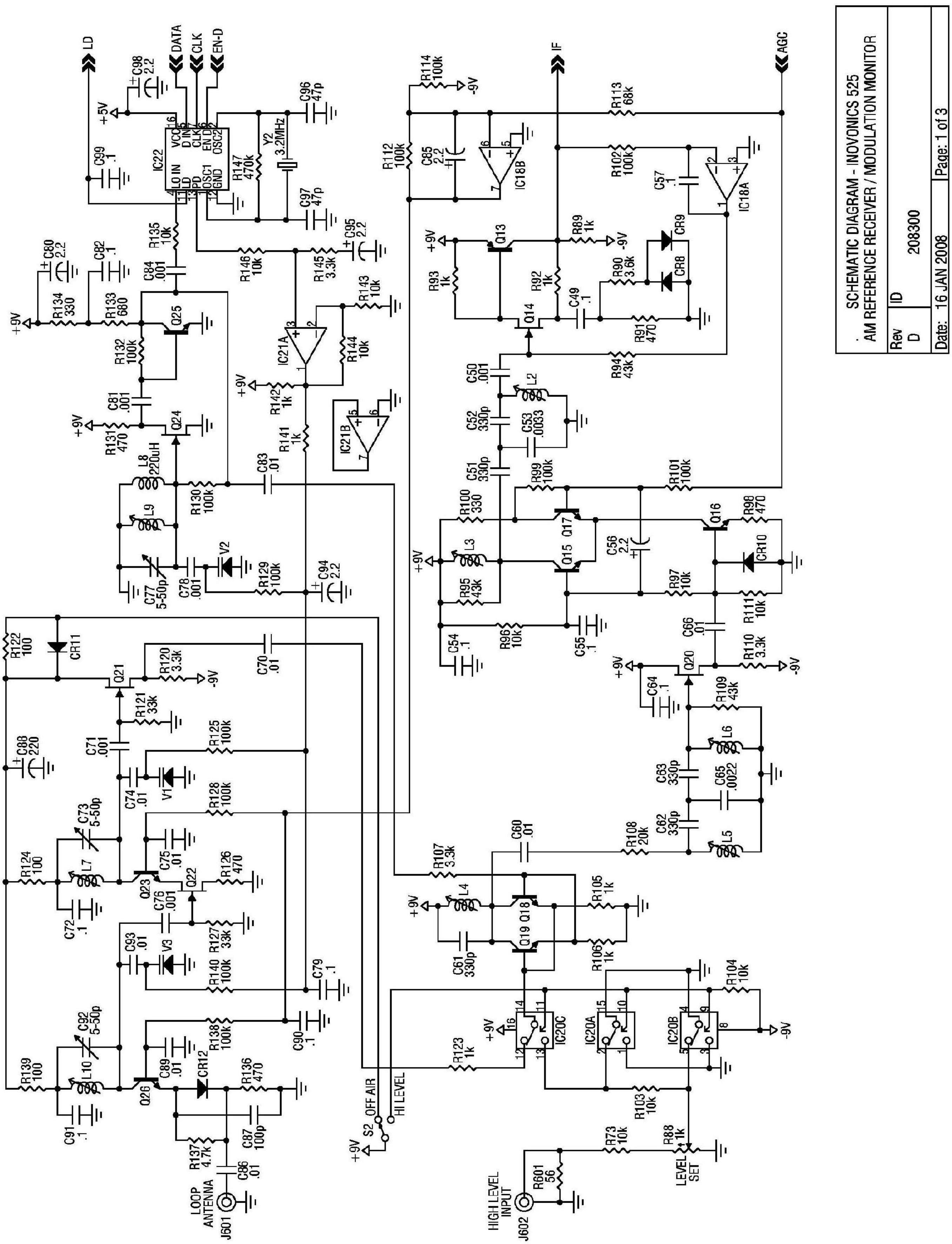
Inovonics does not depend on component sales to inflate our profits, nor do we impose a minimum charge for parts. In some cases we will elect to supply ‘nuisance’ parts at no charge, rather than bothering to generate the necessary paperwork. Always check with the factory, as it may well prove your best source for replacement components.

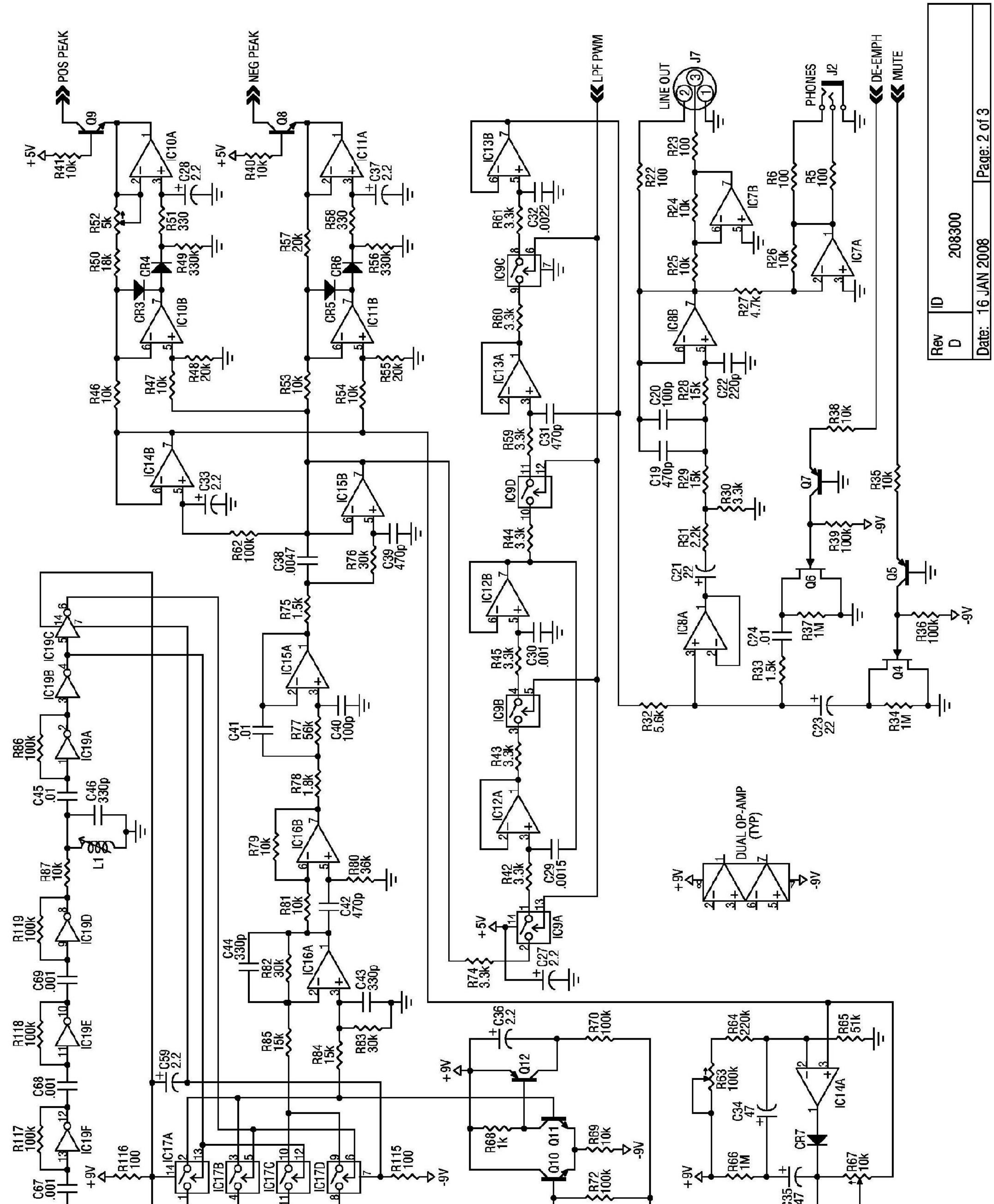
These component distributors have proven themselves reputable and reliable suppliers for small quantities of component parts for broadcasters and other commercial or professional users.

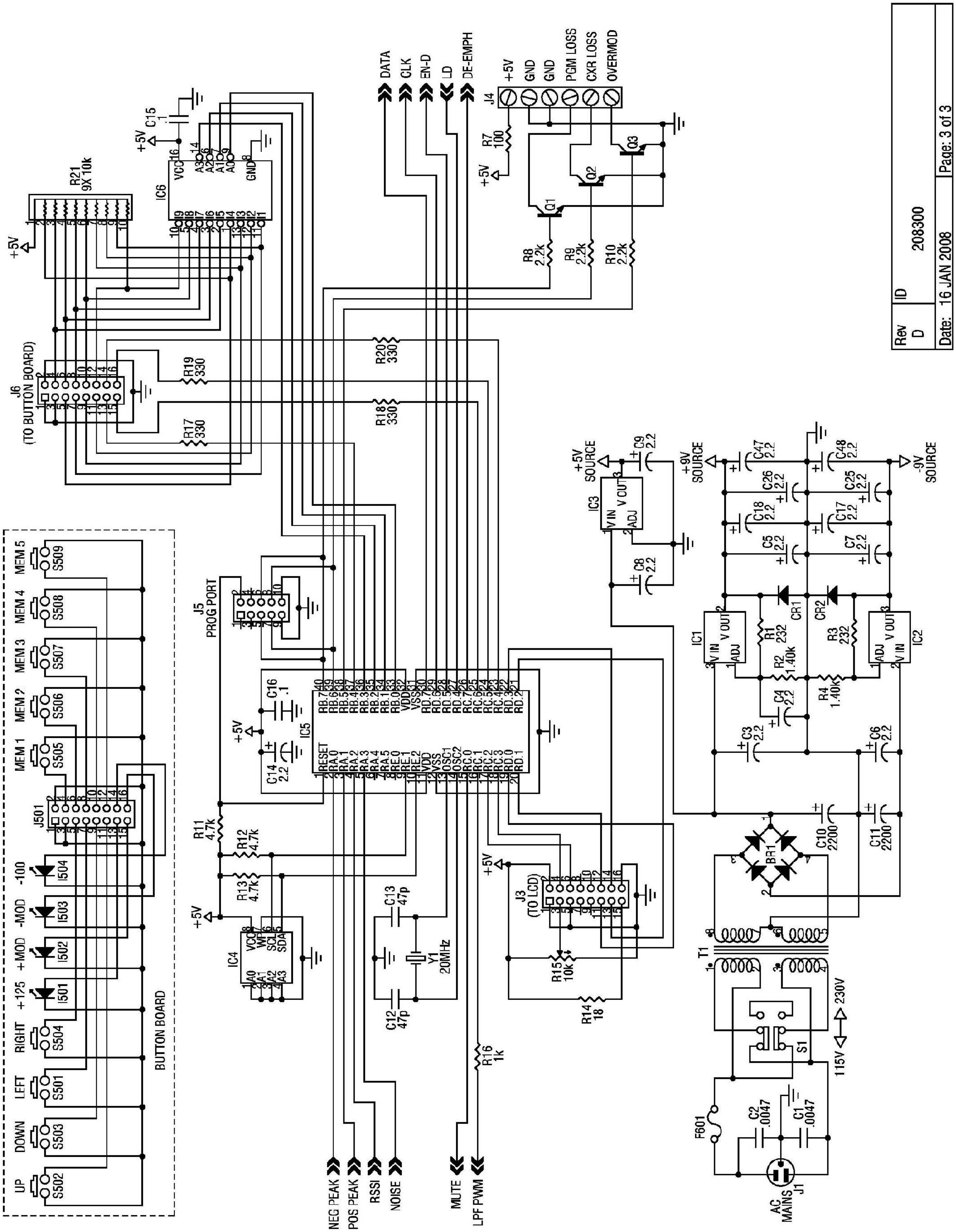
Mouser Electronics
www.mouser.com — 1(800) 346-6873

Digi-Key Corporation
www.digikey.com — 1-(800) 344-4539

Most of the ICs, capacitors, resistors and connectors used in the 525 will be available from one or more of these firms. Both suppliers maintain a Website and publish a full-line printed catalog, which is free for the asking. Minimum-order restrictions may apply, and export orders may prove somewhat problematical.


SCHEMATIC DIAGRAM - INOVONICS 525
AM REFERENCE RECEIVER / MODULATION MONITOR
Rev
D
ID
208300
Date: 16 JAN 2008
Page: 1 of 3


POS PEAK
NEG PEAK
LPF PWM
LINE OUT
J7
PHONES
J2
DE-EMPH
MUTE
IF
NOISE
AGC
RSSI
DUAL OP-AMP (TYP)
Rev D
ID 208300
Date: 16 JAN 2008
Page: 2 of 3


Rev D
ID 208300
Date: 16 JAN 2008
Page: 3 of 3
BUTTON BOARD
UP S502
DOWN S503
LEFT S501
RIGHT S504
+125 I501
+MOD I502
-MOD I503
-100 I504
J501
MEM 1 S505
MEM 2 S506
MEM 3 S507
MEM 4 S508
MEM 5 S509
J6 (TO BUTTON BOARD)
R21 9X 10k
IC6
C15 .1
R17 330
R18 330
R19 330
R20 330
DATA
CLK
EN-D
LD
DE-EMPH
J4
+5V
GND
GND
PGM LOSS
CXR LOSS
OVERMOD
R7 100
Q1
Q2
Q3
R8 2.2k
R9 2.2k
R10 2.2k
J5 PROG PORT
IC5
C16 .1
C14 2.2
IC4
R11 4.7k
R12 4.7k
R13 4.7k
C13 47p
C12 47p
Y1 20MHz
J3 (TO LCD)
R15 10k
R14 18
R16 1k
NEG PEAK
POS PEAK
RSSI
NOISE
MUTE
LPF PWM
IC3
C8 2.2
C9 2.2
+5V SOURCE
+9V SOURCE
-9V SOURCE
IC1
IC2
CR1
CR2
R1 232
R2 1.40k
R3 232
R4 1.40k
C3 2.2
C4 2.2
C5 2.2
C6 2.2
C7 2.2
C17 2.2
C18 2.2
C25 2.2
C26 2.2
C47 2.2
C48 2.2
C10 2200
C11 2200
BR1
T1
S1
115V
230V
F601
C1 .0047
C2 .0047
AC MAINS J1

INOVONICS WARRANTY

I **TERMS OF SALE:** Inovonics products are sold with an understanding of "full satisfaction"; that is, full credit or refund will be issued for products sold as new if returned to the point of purchase within 30 days following their receipt, provided that they are returned complete and in an "as received" condition.

II **CONDITIONS OF WARRANTY:** The following terms apply unless amended *in writing* by Inovonics, Inc.

A. The Warranty Registration Card supplied with this product *must* be completed and returned to Inovonics within 10 days of delivery.

B. This Warranty applies only to products sold "as new." It is extended only to the original end-user and may not be transferred or assigned without prior written approval by Inovonics.

C. This Warranty does not apply to damage caused by misuse, abuse, accident or neglect. This Warranty is voided by unauthorized attempts at repair or modification, or if the serial identification label has been removed or altered.

III **TERMS OF WARRANTY:** Inovonics, Inc. products are warranted to be free from defects in materials and workmanship.

A. Any discrepancies noted within ONE YEAR of the date of delivery will be repaired free of charge, or the equipment will be replaced with a new or remanufactured product at Inovonics' option.

B. Parts and labor for factory repair required after the one-year Warranty period will be billed at prevailing prices and rates.

IV **RETURNING GOODS FOR FACTORY REPAIR:**

A. Equipment will not be accepted for Warranty or other repair without a Return Authorization (RA) number issued by Inovonics prior to its return. An RA number may be obtained by calling the factory. The number should be prominently marked on the outside of the shipping carton.

B. Equipment must be shipped prepaid to Inovonics. Shipping charges will be reimbursed for valid Warranty claims. Damage sustained as a result of improper packing for return to the factory is not covered under terms of the Warranty and may occasion additional charges.

Revised Feb. 2003