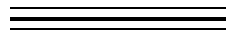


**OPERATING AND MAINTENANCE
INSTRUCTION MANUAL**

MODEL 531

FM-STEREO MODULATION ANALYZER



— USER'S RECORD —

Model 531 – Serial No. _____

Date Purchased _____

Warranty Card Mailed? —

**OPERATING AND MAINTENANCE
INSTRUCTION MANUAL**

MODEL 531

FM-STEREO MODULATION ANALYZER

March 2003



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Section I

INTRODUCTION

MODEL 531 PRODUCT DESCRIPTION

- General** The Inovonics Model 531 Modulation Analyzer (more commonly called a *Mod-Monitor*) teams a digitally tuned, wideband FM receiver with a trio of high-resolution bargraph displays. The 531 gives accurate, off-air readings of a station's carrier deviation (commonly called *total modulation*), and also recovers and displays the demodulated stereo program.
- FCC Type Acceptance** It's been many years since the US Federal Communications Commission has required *type acceptance* of broadcast modulation monitors. Nonetheless, the Model 531 conforms to, or surpasses, the accuracy and stability benchmarks harking to a more heavy-handed era. Despite the specs for monitor equipment being relaxed, the broadcaster nevertheless remains responsible for regulating his modulation to strict standards, based on whatever manner of measurement he sees fit. Use of application-specific, professional equipment, such as the Inovonics 531, will ensure peace of mind.
- Features** Features of the Inovonics 531 include:
- Separate inputs for antenna and high level, 'direct' RF samples.
 - Full-time display of signal strength and multipath effects to validate readings and simplify antenna alignment.
 - Synthesized tuning with digital readout and seven station presets (memories) to compare one's own signal with those of his market companions.
 - Synchronous (incidental) AM noise measurement to aid in transmitter alignment.
 - Selective display of common data and analog subcarrier injection levels.
 - Alarms for peak overmodulation, signal loss, program audio loss and multipath. Rear-panel closures to ground enable remote alarm indications.

MODEL 531 TECHNICAL SPECIFICATIONS

Tuning Range:

87.9MHz to 108.1MHz in 100kHz increments; seven station presets.

Receiver Sensitivity:

10 μ V (10dBf) for 50dB mono quieting; 250 μ V (60dBf) required for *valid* Total Modulation reading.

RF Inputs:

- 1) F connector for 75-ohm antenna.
- 2) BNC connector for alternate 50-ohm RF sample; 7Vr.m.s. maximum.

Baseband Output:

BNC composite/MPX demod output; 3Vp-p at 100%-modulation. (Refer to Figures 1 and 2 for frequency characteristics.)

Baseband Input:

BNC composite/MPX input to stereo decoder and subcarrier measurement circuitry. Accepts 100%-modulation levels of 1Vp-p or greater.

AM Noise Output:

BNC output monitors incidental AM modulation of the FM carrier. (Also monitored by headphones when selected.)

Program Audio Outputs:

- 1) Balanced XLR left- and right-channel stereo program outputs at +4dBm.
- 2) Front-panel headphone jack.

Panel Controls / Indicators:

(Please refer to the illustrated explanation starting on Page 15.)

Carrier Modulation Display:

Quasi-peak response with floating peak-hold. Measurement integration is user-programmable at 0.1ms, 0.2ms, 0.5ms, 1ms. The bargraph display can show +peaks, -peaks and \pm peaks with 1% resolution

between 120% and 80%, and with 2% resolution between 80% and 46%. The display also switches to show stereo pilot and subcarrier injection with 0.2% resolution between 14% and 2.6%.

Demod Metering Display:

Dual (stereo) display shows Left and Right or L+R and L-R demodulated program audio. The display is peak responding between +10dB and -30dB, and average responding between -30dB and -64dB. This display also switches to give a relative measurement of the incidental AM component of the FM carrier.

Stereo Demod Performance:

RESPONSE: ± 0.5 dB, 10Hz-15kHz.

NOISE: Unmodulated (stereo) carrier noise is better than 65dB below 100% modulation with de-emphasis applied.

STEREO SEPARATION: (See Figure 3.)

CROSSTALK MEASUREMENT: M/S and S/M crosstalk measurement is by the stereo sum/difference method. (See Figure 4.)

DE-EMPHASIS: May be turned on and off from front panel; internal jumper for 50 μ s or 75 μ s.

Preset Select:

Pre-programmed station presets may be remotely recalled with momentary closures to ground at the rear-panel terminal strip.

Alarms:

Front-panel indication and rear-panel terminal-strip closures to ground for these conditions:

PEAK FLASHER: Programmable in 1% increments between 120% and 95% of total modulation.

CARRIER LOSS: Alarm is set to a level of incoming RF, below which modulation measurements are not valid.

PROGRAM AUDIO LOSS: The default alarm coincides with either stereo channel remaining 10dB or more below “zero-VU” for a period that may be set between 10 seconds and 2 minutes.

MULTIPATH: This alarm coincides with a level of multipath distortion that would invalidate modulation measurements.

Power Requirements:
105–130VAC or 210–260VAC,
50/60Hz; 20 watts.

Size and Weight:
3½”H x 19”W x 12”D (2U);
14 lbs. (shipping).

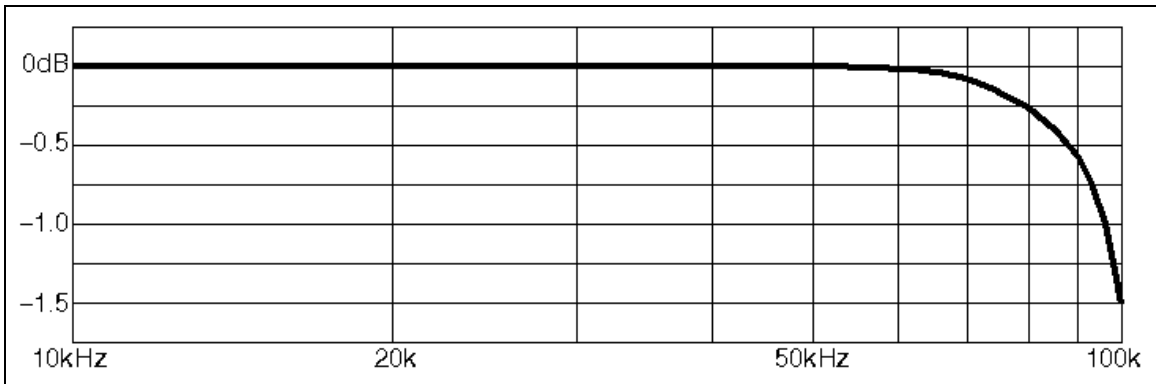


Figure 1 - Amplitude Response of Demodulated Composite Passband

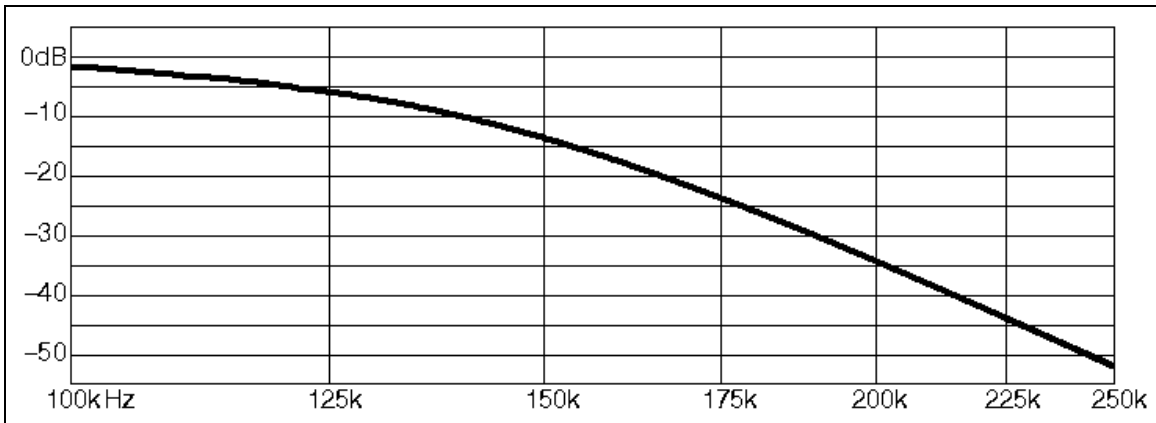


Figure 2 - Amplitude Response of Demodulated Composite Stopband

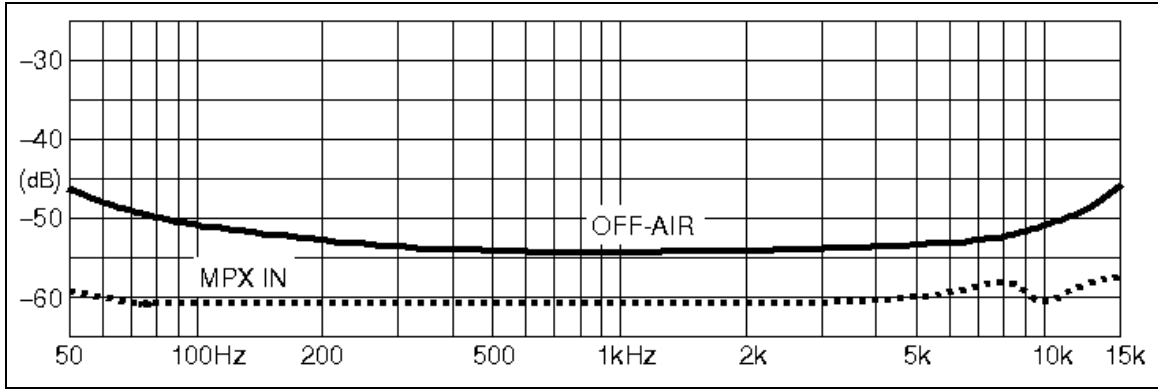


Figure 3 - Typical Stereo Separation

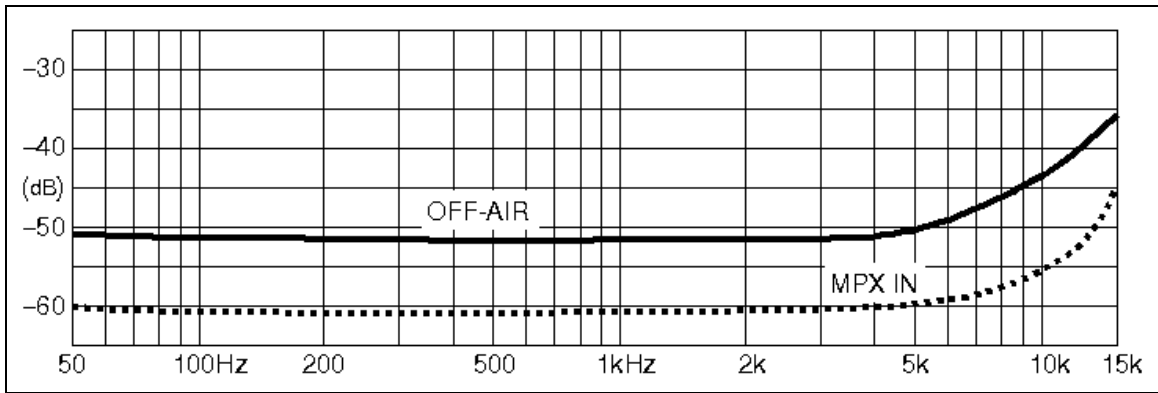


Figure 4 - Typical Crosstalk Measurement Limits

BLOCK DIAGRAM

A simplified Block Diagram of the Model 531 Modulation Analyzer is shown below. Circuitry is explained in detail under *Circuit Descriptions and Calibration Notes*, Section IV, which references the full set of Schematic Diagrams found in the *Appendix*, Section V.

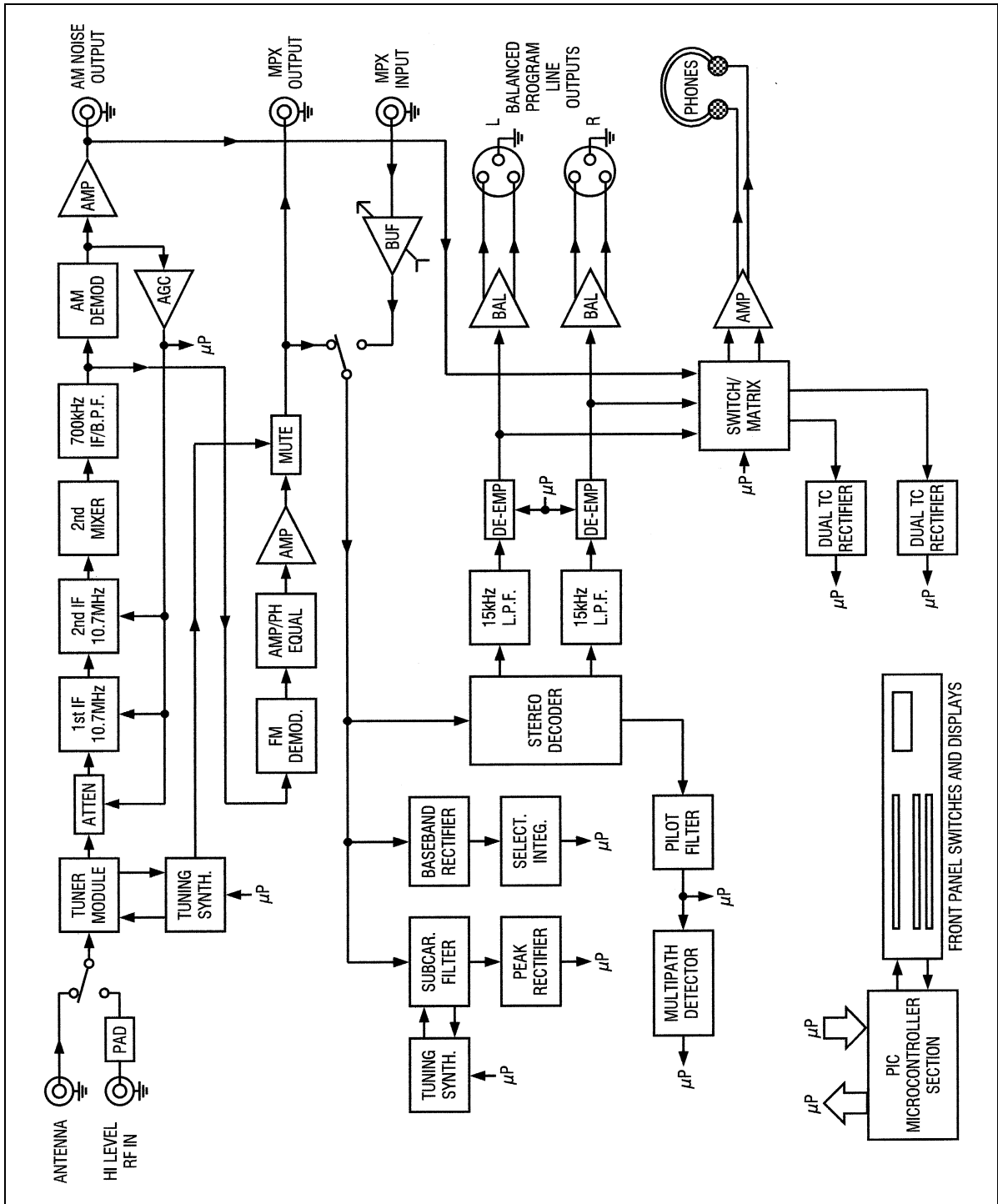


Figure 5 - Block Diagram, Model 531

Section II

INSTALLATION

UNPACKING AND INSPECTION

Immediately upon receiving the equipment, please make a careful inspection for any shipping damage. If damage is found or suspected, notify the carrier at once and then contact Inovonics.

We recommend that you retain the original shipping carton and packing materials in case return or reshipment 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 directly to Inovonics. Not only will this assure coverage of the equipment under terms of the Warranty and provide a means for tracing lost or stolen gear, but the user also will receive specific **SERVICE OR MODIFICATION INSTRUCTIONS** immediately and automatically when issued.

MOUNTING

Rack Requirement

The Model 531 mounts in a standard 19-inch equipment rack and requires only 3½ inches (2U) of vertical rack space. Plastic ‘finishing’ washers are recommended to protect the painted finish around the mounting holes.

Heat Dissipation

Consuming only one-half the power of a retro-replica Lava Lite[®], the Model 531, itself, generates negligible heat. The unit is specified for operation within an ambient temperature range extending from freezing to 120°F, or 50°C. Heat from adjacent equipment must be factored into the installation, however, so make sure that the equipment rack is adequately ventilated and that its internal temperature does not exceed the specified maximum ambient.

AC (MAINS) POWER

Mains Voltage Selector

Unless specifically ordered for export shipment, the Model 531 is set at the factory for operation from 115V, 50/60Hz AC mains. This

can be confirmed by checking the designation next to the fuseholder on the rear panel. The *inappropriate* voltage and fuse value will have been crossed out at the factory with an indelible felt marker.

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

Be sure to install the appropriate fuse as listed next to the fuseholder. You can remove the factory strikethrough with solvent and then cross out the inappropriate marking with an indelible felt pen.

NOTE: Fuseholder caps are available for either ¼-inch or 5mm fuses; contact the factory.

Power Cord The detachable IEC-type power cord supplied with the Model 531 is fitted with a North American-standard male plug. Nonetheless, the individual cord conductors are *supposed* to be color-coded in accordance with CEE standards; that is:

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

If this turns out *not* to be the case, we offer our apologies (cords come from a true diversity of sources) and advise that US color coding applies:

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

RADIO FREQUENCY INTERFERENCE (RFI)

- Location** The Model 531 is designed to operate alongside high-power RF gear. Nonetheless, do please practice reasonable care and common sense in locating the unit away from *abnormally* high RF fields.
- Ground Loops** Because the inputs and the outputs of the Model 531 are referenced to chassis ground, a mains frequency or RF ground loop could be formed between cable shield grounds and the AC power cord ground. A 'ground-lifting' AC adapter may well remedy such a situation, though the chassis somehow must be returned to local earth ground for safety considerations.

RF INPUTS

- Antenna Input and Antennas** To streamline installation, a consumer-standard F connector was chosen to couple the external antenna with the Model 531. Inexpensive ready-made cables in this format are available most anywhere.

A multi-element direction antenna is essential for any serious off-air pickup. “Turnstyle” or S-shaped, non-directional FM antennas are useless in this application. The Radio Shack 15-2163 Yagi is a low-cost option and a quite serviceable companion for the 531.

NOTE: If the lowly F connector is deemed insufficiently ‘professional’ or otherwise judged offensive, N connectors are available that will fit the same 3/8-inch “D” hole.

Though the nominal impedance of the antenna input is 75 ohms, a 50-ohm antenna (connected with 50-ohm cable!) should not demand a matching network.

“Direct” RF Input	High-level RF samples (from the transmitter’s directional coupler, for instance) may be fed to the Model 531 through a rear-panel BNC connector. However, this HI LEVEL RF IN connection does <i>not</i> bypass the tuner, the signal is simply padded-down and applied to the tunable front-end. High-level inputs should be restricted to a maximum of 7 volts to avoid cooking the internal terminating resistor, and of course the receiver must be tuned to the incoming frequency.
RF Input Switching	The rear-panel RF SOURCE SELECT switch must be in the proper position for ANT (antenna) or DIR (high-level) inputs.

COMPOSITE/MULTIPLEX CONNECTIONS

Composite Output	<p>The rear-panel MPX OUT connector is a direct output from the FM demodulator. An internal buildout resistor sets the source impedance at 100 ohms. This output is intended for oscilloscope monitoring or for feeding outboard analysis equipment with high impedance ‘bridging’ inputs. Long cables or other high capacitance loads should be avoided.</p> <p>NOTE: Highly capacitive or very low impedance loads connected to the MPX OUT connector may compromise front-panel modulation readings</p>
Composite Input	<p>The MPX IN connector lets the Model 531 monitor external baseband signals, either from another off-air source or directly from a composite STL receiver or stereo generator.</p> <p>When the MOD-MONITOR INPUT switch is in the EXT position, the RF tuner portion of the Model 531 is disconnected and the MPX IN baseband signal is routed to the level metering and stereo decoding circuitry. This is a 100k-ohm, unbalanced/bridging input that can accommodate levels of 1Vp-p or greater. A multi-turn EXT MPX IN LEVEL ADJUST control affords adjustment over the external baseband input.</p>
Composite Signal Selection	The MOD-MONITOR INPUT switch selects between AIR (off-air) and EXT (external baseband input).

AM NOISE OUTPUT

The AM NOISE OUT connector is a fulltime output from the receiver's AM demodulator. This is an uncalibrated 1k-ohm source that can feed an amplifier/speaker or an oscilloscope to help correlate incidental AM noise with transmitter tuning. This signal is also available from the front panel PHONES jack when AM noise is displayed on the bargraph readout.

PROGRAM LINE OUTPUTS

The LEFT and RIGHT PROGRAM LINE OUTPUT XLR connectors are +4dBm, balanced outputs from the stereo decoder. These are dedicated to the left and right program channels, and do *not* follow front-panel selection of stereo sum and difference or AM noise.

Keep in mind that the line outputs do respond to the front-panel DE-EMPH (de-emphasis) switch. A flat frequency characteristic is often necessary when using these outputs for external L/R measurements.

CONTROL AND TALLY TERMINALS

A 16-terminal tie-down strip is the interface for remote control and alarm connections. The screw-terminal part of this strip unplugs from the chassis to make wiring and servicing more convenient. Simply grab the plastic part that protrudes from the back panel and give it a hard pull.

Remote Preset Selection

The seven front-panel station presets are remotely selected with a momentary contact closure to ground. These lines have internal pull-up resistors to +5 volts, so a dry contact closure or NPN transistor saturation will bring up the preset station.

Front-Panel Tuning Lockout

A remote tuning selection command must always be a *momentary* closure to ground. If a *permanent* ground is applied, the front-panel station select buttons will be disabled. You can use this no-added-cost 'override' feature to advantage when it is important to have the 531 fixed-tuned to one frequency. Simply run a wire from the desired preset terminal directly to a ground terminal.

Alarm Tallies

The four alarm lines are open-collector NPN transistors that saturate to ground with an alarm. LOW SIGNAL, MULTIPATH and AUDIO LOSS conditions, as well as remote indication of the PEAK FLASHER, all have their corresponding rear-panel terminals to enable remote display.

These tally outputs can sink 50mA from an external power supply without stress. The +5 volts provided on the two right-hand terminals is current-limited. This is intended for LEDs, optical couplers or other low-consumption devices.

Figure 6, below, suggests a possible remote hookup, which includes a carrier-loss indication that would be difficult to ignore.

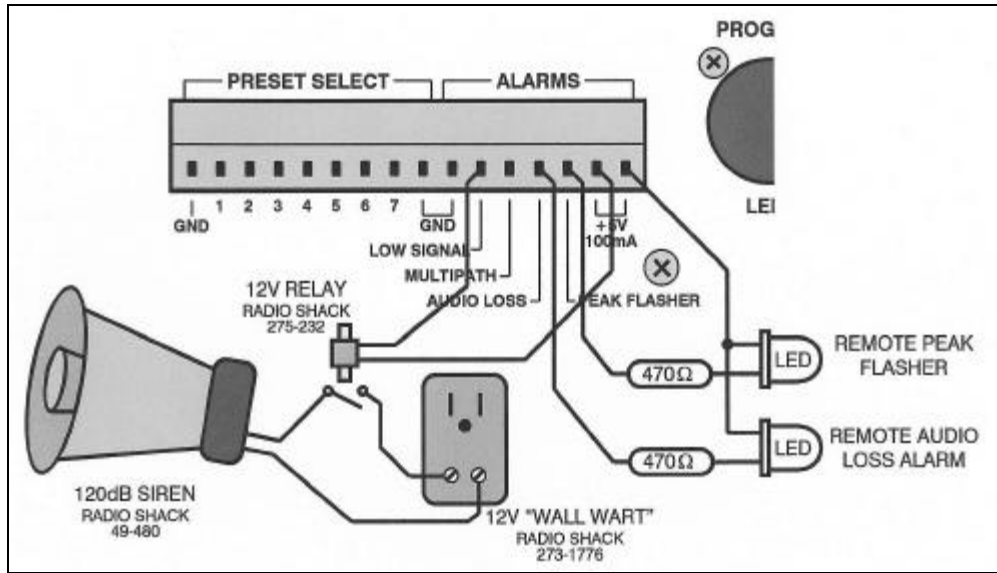


Figure 6 – Suggested Remote Alarm Connection

DE-EMPHASIS SELECTION

The 531 accommodates both the 75-microsecond (Western Hemisphere) and 50-microsecond (Europe and Asia) FM broadcasting pre-emphasis standards. De-emphasis appropriate to the shipping destination is jumpered at the factory, but this is easily changed if required.

Changing De-Emphasis

Remove the top cover of the 531. With the front panel facing you, locate the long row of integrated circuits just behind the rear-panel AM NOISE connector. On either side of IC35, you'll find 3-pin jumper strips, each with a removable shorting bar. The jumpers are labeled JP3 and JP4. Each is marked with a 50 and a 75, corresponding to the de-emphasis selection. Figure 7, below, shows proper placement of the jumpers for each characteristic.

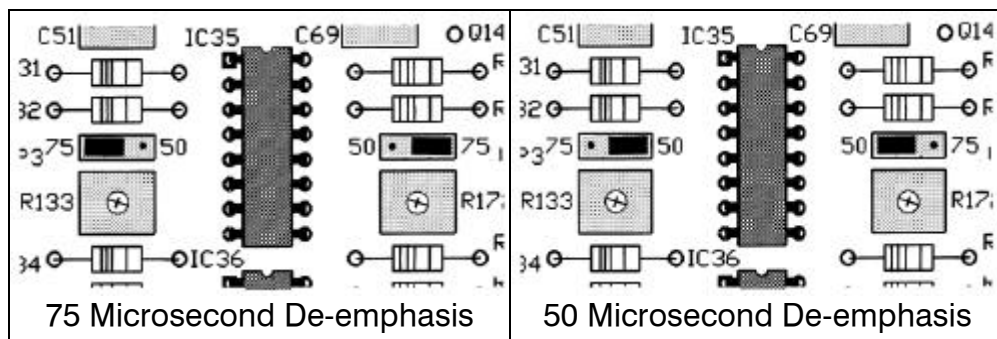


Figure 7 – De-emphasis Jumpering

TOTAL-MOD DISPLAY INTEGRATION SELECTION

Integration Defined	<p>“Peak Integration” is a euphemistic reference to the practice of allowing brief overdeviations of the FM carrier to sneak by unnoticed. In the case of the Model 531, non-repetitive modulation peaks lasting less than a predetermined period will <i>not</i> be displayed on the CARRIER MODULATION bargraph display.</p> <p>Broadcasting regulations, including those of the FCC in the US, are often a bit vague on the subject of peak integration. Nearly all Modulation Monitors include some provision for ignoring exceedingly fast program peaks, sometimes called “peaks of infrequent occurrence” or other similarly tenuous term. Certainly, non-repetitive overshoots that do not materially increase the broadcaster’s occupied bandwidth, and thus pose no threat of interference to an adjacent-channel signal, may legitimately be ignored in a measurement of total carrier deviation. But by allowing peaks resulting from, and directly related to, the dynamics of the program signal to “slide on by,” the broadcaster is courting the wrath of his appropriate regulatory agency.</p>
FCC Measurement Method	<p>One reliable guideline in determining just how far you can go with respect to total carrier modulation is to be aware of how at least one government authority monitors a broadcaster’s signal. As far as we have been able to determine, the United States FCC does not use a commercial Modulation Monitor with a metered readout. Instead they connect an oscilloscope to the composite baseband output of a wideband FM receiver and look for deviations beyond a predetermined peak-to-peak amplitude. As divulged by one Field Engineer, the FCC is not looking for the occasional overshoot, but for consistent and flagrant overmodulation, which is invariably <i>noticed</i> and <i>complained about</i> before the station is flagged for scrutiny.</p>
As Delivered	<p>The Inovonics 531 allows the user to select one of four integration times: 100μs, 200μs, 500μs, and 1.0ms. As delivered, the 531 is jumpered for the fastest (100μs) integration. This is the safest choice, but the one that consistently shows the highest total modulation reading for any given signal. Offered a selection, most broadcasters will opt for longer integration—sometimes as much as 10ms! We feel that this long an integration period equates to “fooling no one but yourself.” The longest (1.0ms) integration afforded by the Model 531 is <i>probably</i> safe under <i>nearly all</i> operating conditions, though the user is cautioned to compare his modulation with that of his companions in the market to avoid sticking out like the proverbial sore thumb.</p>
Changing Integration Time	<p>With the uncovered 531 facing you, locate the ribbon cable that connects the main board with the front panel assembly. Just behind this cable, below IC17, you’ll find a 4-position jumper strip labeled JP2. The shorting bar can be pulled off and replaced in any of 4 positions, each position identified in the PC board legend. Figure 8 at the top of the following page shows proper jumpering for each integration selection.</p>

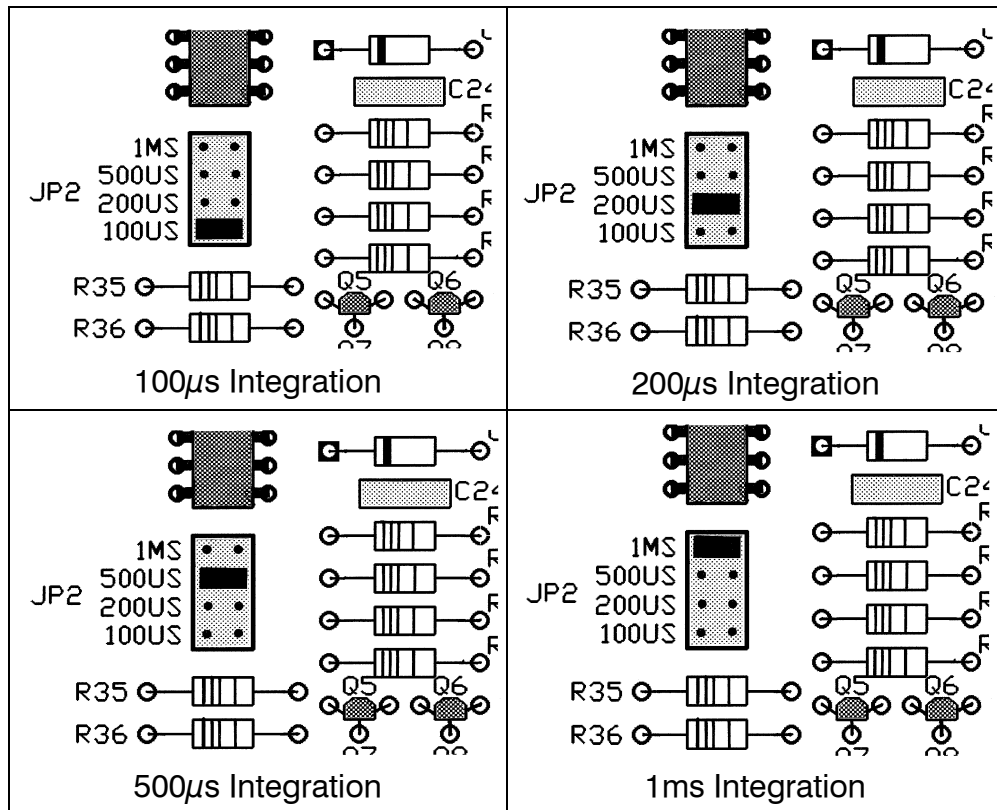


Figure 8 – Integration Period Jumpering

A WORD ABOUT LOUDNESS

(Reprinted with kind permission from the Inovonics Model 530 Manual)

Radio “loudness wars” began in the US in the mid-1960s. This is about the same time that radio programming began to be defined by “format,” with the broadcaster competing for advertising dollars with a growing number of stations in his same market, many of which were playing the very same songs. Rather than courting listeners with programming variety or amiable air personalities, station owners and Program Directors grasped at technical gimmicks to attract listeners.

At some point, *perceived loudness* emerged as a benchmark for broadcasting success. As if, “...who cares about programming, play it louder and it’ll grab the listeners. If the ratings slip, it’s the Chief Engineer’s fault!” Despite the obvious idiocy of this line of reasoning, the availability of more complex and more expensive audio processing equipment is a testament to its belief and to the paranoia and shortsightedness of station management.

Aggressive audio processing and the accurate measurement of resulting carrier deviation are interwoven in broadcasting today. But the high degree of *technical capacity* we now so easily acquire should never be confused with *technical excellence*. Innovative, refreshing *programming* and long-term *listenability* will continue to be the keys to any station’s enduring success.

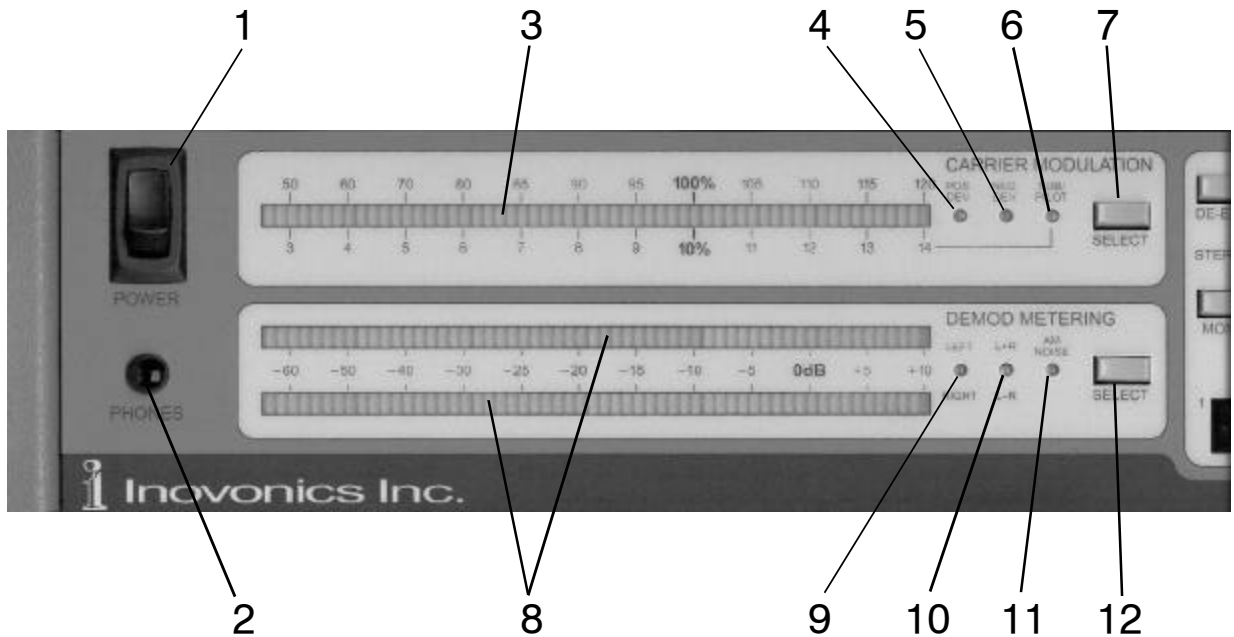
Section III

SETUP AND OPERATION

PANEL CONTROLS AND INDICATORS

The following overview of the Model 531 front panel is keyed to the coded illustrations. A guided tutorial follows this description to further familiarize the reader with the superior and outstanding features of the Model 531. To the conscientious reader, much of the information presented in this section may seem redundant, appearing both in the overview and in the tutorial. We have anticipated that an impatient user might miss valuable tips in either one part or the other, and apologize in advance for explanations that may seem unnecessary or demeaning.

THE READOUT SECTION (LEFT SIDE)



1 POWER

We are frequently asked why an AC mains switch is provided on a piece of gear that normally stays on 24 hours a day. Always on the defensive, and not infrequently with a snappy answer, allow us to cite a possible scenario: The Model 531 is mounted in a rack that separates two rooms, the interconnecting door is locked, and smoke is pouring from around the front

panel buttons... not that this could ever happen, of course.

2 PHONES

Headphones monitor the stereo program channel when DEMOD METERING 7 is switched to LEFT / RIGHT 9 or L+R / L-R 10. Alternatively, when the 531 is switched to show AM NOISE 11 the headphones then monitor the incidental AM noise component of the FM carrier.

Headphone volume is fixed and should prove adequate with most low- or medium-impedance headphones.

3 CARRIER
4 MODULATION

The top bargraph 3 defaults to a display of total carrier modulation. It is calibrated in percent, with 100% corresponding to $\pm 75\text{kHz}$ deviation. This display is peak-responding, and it updates-and-holds the highest peak as a 'dot' above the varying display.

When both the POS DEV 4 and NEG DEV 5 indicators are lighted, the highest deviation in either polarity is shown. This is the default display mode. By cycling the SELECT button 7, the display may be switched to read positive or negative carrier deviations independently.

The SELECT button 7 also switches the readout to display injection level of the 19kHz stereo pilot. The the SUB/PILOT indicator 6 lights and injection is read off the lower metering scale, which is calibrated in appropriately smaller percentages of total carrier deviation.

8 DEMOD
9 METERING

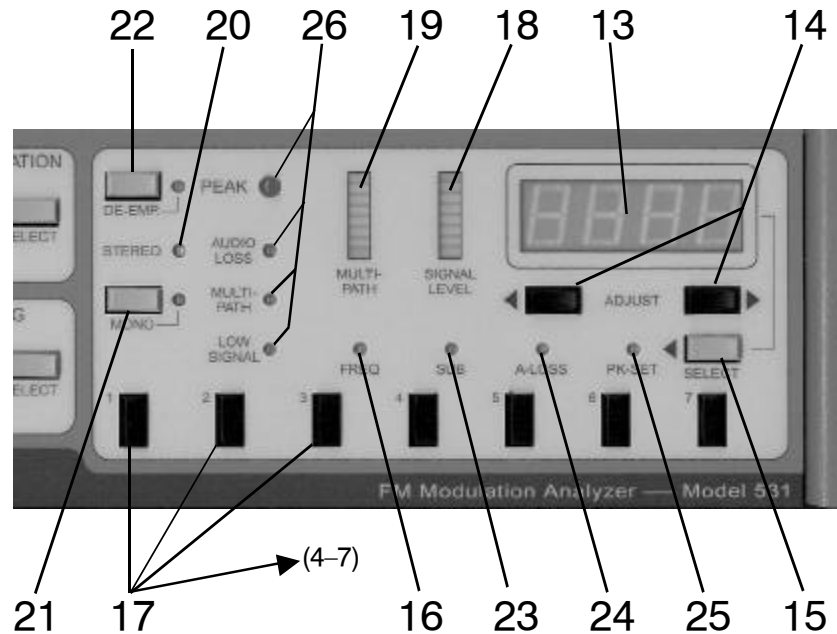
The SELECT button 12 associated with this section cycles the two lower bargraph displays 8 among their various metering options, each identified with an associated LED indicator 9, 10, 11.

10
11
12

The default selection displays left- and right-channel program audio 9. Alternatively, stereo sum-and-difference 10 may be metered. All program audio measurements are quasi-peak-responding above an indicated level of -30dB , and average-responding below the -30dB point.

When the SELECT button 12 is cycled to measure AM NOISE 11, a *relative* reading of AM carrier noise is displayed on the upper of the two bargraph readouts, and the lower readout is blanked. Though a meter reading of 0dB does correspond to 100% carrier amplitude modulation, meter scaling is not a true linear-dB function below this point and should be considered a relative (more vs. less) measurement. When AM NOISE 11 is selected, the incidental AM component is heard in the headphones.

THE RECEIVER SECTION (RIGHT SIDE)



- | | | |
|----|------------------------------|---|
| 13 | DIGITAL | Basically, the SELECT button 15 cycles the digital display 13 among its several functions, and the two up/down ADJUST buttons 14 change appropriate parameters. What actually is shown on the four-digit readout depends on what measurement function is active. |
| 14 | READOUT | |
| 15 | | |
| 16 | FREQ | The default mode for this display gives the frequency of the monitored off-air signal. FREQ indicator 16 lights when frequency is displayed, and the receiver may then be tuned up or down with the two ADJUST buttons 14 . |
| 17 | STATION
MEMORIES
1 – 7 | Memory buttons 17 allow as many as seven stations to be programmed into non-volatile memory for instant recall. Once the 531 has been tuned to the desired frequency with the up/down ADJUST buttons 14 , then simply <i>hold down</i> one of the seven memory buttons 17 . After a couple of seconds the digital readout 13 will 'wink' to show that the frequency has been entered into that memory slot. Thereafter, simply give the button a normal, momentary push to recall the programmed station. |
| 18 | SIGNAL LEVEL | As discussed in additional detail on Page 19, the 531 requires a strong, noise-free signal to ensure an accurate off-air measurement of total carrier modulation. The SIGNAL LEVEL bargraph 18 gives a <i>relative</i> indication of incoming RF signal strength. Generally, three or more display segments must be lighted for valid modulation readings. The LOW |

SIGNAL alarm **26** will light when sufficient RF is not present.

NOTE: If *all* SIGNAL LEVEL readout **18** segments (*including the top-most*) are lighted, the receiver should be considered *overloaded* for purposes of AM noise measurement (only). Total modulation readings will remain valid, however.

- | | | |
|----------|---------------------------|--|
| 19 | MULTIPATH | As detailed on Page 20, multipath distortion effects will invalidate off-air modulation measurements. The 531 incorporates a multipath detector for qualifying the incoming signal in this regard, and the MULTIPATH bargraph 19 displays multipath severity. Generally, three or more lighted segments will indicate excessive multipath and activate the alarm 26 . |
| 20
21 | STEREO
FORCED MONO | <p>The stereo decoder section of the Model 531 is active both for off-air readings and for composite baseband signals applied to the rear-panel MPX IN connector. When the 19kHz stereo pilot is recognized, the green STEREO indicator 20 will light.</p> <p>The MONO button 21 can be used to turn off the stereo decoder. The red LED next to the button will indicate a “forced-mono” mode.</p> |
| 22 | DE-EMPHASIS | <p>The DE-EMP button 22 turns program audio de-emphasis on and off. ‘On’ is indicated by the green LED next to the button. De-emphasis is generally left on, but it may be defeated for stereo separation and other measurements using test tones. De-emphasis applies to the metered values 8 as well as to the program audio available at the PHONES jack and at the rear-panel PROGRAM LINE OUTPUT connectors.</p> <p>Program de-emphasis may be jumpered for 75μs or 50μs as described on Page 12.</p> |
| 23 | SUBCARRIER
MEASUREMENT | <p>The SELECT button 15 also enables subcarrier injection level measurements. When the SUB indicator 23 is lighted, the digital display 13 gives the subcarrier frequency, which can be tuned with the up/down ADJUST buttons 14. Subcarrier frequency choices are 57kHz (RDS/RBDS), and 67kHz and 91kHz (SCA). 38kHz (residual stereo subcarrier) may be measured as well, though this measurement will be meaningless in the presence of program audio.</p> <p>Subcarrier injection shows up on the CARRIER MODULATION display 3. The SUB/PILOT indicator 6 lights and percent-injection may be read against the lower scale markings.</p> |
| 24 | AUDIO LOSS | Loss of program audio gives a front panel indication 26 and a rear-panel AUDIO LOSS tally. When SELECT |

- button **15** is cycled to light the A-LOSS indicator **24**, the digital readout **13** displays a delay, in seconds, between program audio loss and the alarm. Use the two up/down ADJUST buttons **14** to program the delay between 10 and 120 seconds.
- 25** PEAK FLASHER With SELECT button **15** cycled to light the PK-SET indicator **25**, the digital readout **13** displays the PEAK (flasher) **26** threshold in percent-modulation. The two up/down ADJUST buttons **14** can set this value between 90% and 120% in 1-percent increments. This setting applies to the trip level of both the front-panel indicator **26** and the rear-panel PEAK FLASHER alarm tally.
- 26** ALARM INDICATORS These LED alarm condition indicators **26** are duplicated with corresponding ‘tally’ closures to ground on the Model 531 rear panel. See Page 11 for a discussion of connecting remote indicators.

MEASUREMENT PITFALLS AND LIMITATIONS

NOTE: It is important that the user recognize various inherent limitations of making transmission performance measurements ‘off-air.’ Although the Model 531 has a high level, ‘direct’ RF input, the signal still passes through tuned RF and IF stages. Thus even these directly coupled measurements are subject to some of the same limitations as an off-air signal.

Signal Strength The term “FM Advantage” refers to the inherent freedom from noise that a frequency-modulated signal enjoys over its amplitude-modulated counterpart. Nevertheless, random noise does result in a certain amount of ‘dither’ at carrier zero-crossings, which translate to jitter in the time domain that can sabotage accurate measurement of total carrier deviation.

The basis for FM receiver sensitivity specifications dates to the early days of monaural FM broadcasting. Tuners used to boast sensitivities in the low-microvolt range. Honest and forthright manufacturers would qualify this specification with: “signal required for 50dB of quieting,” which referred to a *monaural* transmissions. This isn’t a particularly difficult spec to meet in mono receivers, which can tolerate and profit from a much narrower IF bandwidth than what is required for decent stereo performance.

Stereo reception adds all the noise present in the 23kHz – 53kHz ‘sub’ band that rides above the 30Hz–15kHz monaural reception range. What’s worse, it’s the amplitude component (AM) of the sub band that is converted down to audible noise and added to the program signal. That’s why the noise performance of FM-stereo can be as much as 20dB worse than that of a monaural broadcast.

Reverting to the specification from days gone by, the Model 531 exhibits 50dB of mono quieting with only $10\mu\text{V}$ coming in, actually pretty decent considering the “broad as a barn” RF/IF passband that’s required for stereo signal quality monitoring. For the *valid* measurement of total modulation over the entire baseband signal range (10Hz–100kHz), the 531 requires $150\mu\text{V}$ (55dBf) for a total-mod reading that’s no more than 2% in error, and $250\mu\text{V}$ (60dBf) for a 1% maximum error.

The front-panel SIGNAL LEVEL bargraph is a *relative* display and should not be considered at all linear, either in terms of field strength or transmission power. Generally, at least three or four segments must be lighted for valid total-mod readings. The LOW SIGNAL alarm comes on when a total-mod reading would be compromised by more than 1%.

Multipath Distortion

Multipath effects arise from the reception of a radio signal from more than one direction (multiple paths). The primary path is generally ‘direct’ (line-of-sight), and subsequent arrivals of the same signal come along after it has bounced off buildings or natural terrain. This multiplicity of arrival times compromises certain parameters of the otherwise robust FM transmission. Long before its effects can be heard, multipath can invalidate accurate measurement of total carrier deviation.

The Model 531 incorporates a multipath distortion detector and bargraph readout. Used together, the MULTIPATH and SIGNAL LEVEL displays can be an aid in aiming the receiving antenna for best reception. A multipath alarm comes on when more than about three segments of the MULTIPATH bargraph are lighted. The associated alarm is preset to the maximum value of multipath distortion that can be tolerated for an accurate total-mod reading.

Composite Clipping

A small amount of well-regulated “hard clipping” of the composite waveform is a technique commonly employed by broadcasters in their attempt to secure maximum modulation efficiency and, consequently, the highest ‘perceived loudness.’ Modern composite clipping circuits perform their action prior to injection of the stereo pilot, or they may ‘detour’ the pilot signal to prevent its being clipped as it rides along with the program signal. This does not mean, however, that composite clipping does not generate harmonics at 19kHz. These can add to and subtract from the legitimate pilot tone, essentially manifesting as ‘pilot modulation.’

Because the Model 531 translates a measurement of pilot modulation to an equivalent degree of multipath distortion, excessive composite clipping may show up on the MULTIPATH display, even when no secondary signal path is present (as would be the case in a direct, high-level RF connection).

This does not mean that a multipath alarm should be ignored when no possibility of multipath exists. If excessive composite clipping does indeed cause the multipath indication, chances are that occupied bandwidth limits are being exceeded despite proper constraints on peak deviation.

Adjacent Carriers

The inherent broad bandwidth of the Model 531 receiver makes it vulnerable to interference from stations that are first-, and even second-adjacent to the frequency being monitored. Of course signal strength will be a factor in this equation: the stronger the interfering carrier, the greater the interference effect.

One technique to identify adjacent-channel interference is to observe independent negative- and positive- deviation readings. Unless an FM transmission has audio processing problems or gross exciter non-linearity, program deviation should be fairly symmetrical about the carrier frequency.

Using the SELECT button associated with the CARRIER MODULATION display, compare the POS DEV and NEG DEV readings. If POS DEV measures considerably *higher* than NEG DEV, interference from a strong station *above* the monitored frequency would be indicated... and vice-versa. In this example, the NEG DEV measurement can *probably* be trusted as an indication of total carrier modulation, though this should be confirmed with an interference-free ‘nearfield’ reading of the transmitter. In any event, steps should be taken to eliminate the interference. A more directional antenna may solve the problem, or a band-pass filter may be required at the primary frequency or a trap at the interfering frequency.

A GUIDED TOUR OF MODEL 531 OPERATION

This short “hands-on” tutorial walks you through setup and typical operation of the Model 531. By taking this informal guided tour, you will gain a better understanding of procedures and pitfalls that will prove useful in day-to-day use of the unit.

Numbers shown in the following text refer back to the keyed photos of the Model 531 front panel on Pages 15 and 17.

Items Required You’ll need a pair of good stereo headphones and a connection to an outside antenna. (If the transmitter is close by, a 3-foot length of insulated hookup wire ought to suffice for this ‘guided tour.’)

Getting Ready Attach the power cord to the Model 531 and plug the free end into the wall socket. Plug the headphones into the front-panel PHONES jack **2**. If you have no connection to an outside antenna, twist a stripped end of the 3-foot wire and carefully insert it into the very center of the rear-panel ANTENNA connector. To ensure the continued integrity of this connector, do not force the wire into it; rather, find a wire that fits securely but that does not distort the connector.

Check to make sure that the rear-panel RF SOURCE SELECT switch is in the ANT (antenna) position, and that the MOD-MONITOR INPUT switch is set to AIR (off-air operation).

Power ON!	Flip the POWER switch 1 on. The 531 powers-up to default measurement options, though non-volatile memory will hold (remember) the last frequency selected.
Tuning In	<p>Find a strong, local station. Use the up/down ADJUST buttons 14 to tune the 531 to a good signal at your location. If your own signal cannot be picked up easily, choose a station that does come in well.</p> <p>You may wish to set some of the station presets 17 to your own and other local signals. Enter your first choice into memory #1 by holding down the #1 memory button. In a couple of seconds the frequency readout 13 will ‘wink,’ signaling that the choice is entered.</p> <p>Re tune the 531 to other stations and enter each into additional memory positions in the same manner. Once frequencies are entered, give any button a momentary push to bring up the stored frequency.</p>
Signal Quality Evaluation	<p>Even with a 3-foot wire antenna, a strong local station should light at least half the segments of the SIGNAL LEVEL display 18. Be sure that the station you select has low multipath distortion as well, no more than a couple of the segments in the MULTIPATH bargraph 19 should be lighted. Try repositioning the 3-foot wire to minimize multipath pickup. Neither the LOW SIGNAL nor the MULTIPATH alarm indicators 26 should light. If either alarm condition is indicated, choose another station or connect a roof-mounted antenna.</p> <p>NOTE: When the 531 is in actual Mod-Monitor service, the two signal-quality warning indicators <i>must be off</i> if measurements are to be trusted. This usually calls for a rooftop antenna with a rotator for meaningful comparative measurements of other stations in your market.</p>
Carrier Modulation Display	<p>Neglecting the effects of a low signal or multipath distortion condition, the CARRIER MODULATION display 3 shows peak deviation as a percentage, with 100% equivalent to $\pm 75\text{kHz}$ carrier deviation.</p> <p>The default measurement mode for total modulation looks for carrier deviations in both directions and gives the higher of the positive or negative deviation peaks. The 531 is in the default mode when <i>both</i> the POS DEV 4 and NEG DEV 5 indicators are lighted. As previously discussed under <i>Measurement Pitfalls and Limitations</i> on Page 19, the SELECT button 7 also enables independent monitoring of positive and negative deviation. Refer back to that discussion for how and when to use this feature.</p> <p>Unless there is a reason for doing otherwise, the CARRIER MODULATION display 3 should be kept in the default mode (LEDs 4 and 5 both on) for the most exact confirmation of the station’s maximum carrier deviation.</p>

Also, refer back to *Total-Mod Display Integration Selection* on Page 13 for the discussion of jumpering options that will effect this reading.

Peak Flasher The 531 includes the usual ‘Peak Flasher,’ an alarm for carrier deviations beyond an acceptable maximum value. There is a front-panel PEAK indicator **26**, as well as a rear-panel closure to ground for a remote flasher or other alarm.

The peak flasher follows the total modulation measurement, which, by default, is the composite of positive and negative carrier deviations. This also means that if the display has been switched to monitor only positive or only negative excursions, the peak flasher will respond accordingly.

Cycle SELECT button **15** to light the PK-SET indicator **25**. The digital readout **13** now shows the flasher trip level directly in modulation percentage. Using the up/down ADJUST buttons **14** set this trip point at any value between 90% and 120%.

The flasher may be programmed for a modulation level that will give frequent indications of modulation peaks. For instance, if the audio processor has been set for a maximum deviation of 100%, the flasher can be set at 99% to show that modulation is consistently meeting a deviation goal. Using this feature as the intended alarm, on the other hand, requires that the trip level be set somewhat above the maximum modulation point. Again, if the processor is set to hold peaks at precisely 100%, an alarm value of 105% might be selected. This would represent a value that should never be attained in normal operation, one that would indicate a legitimate fault.

Pilot Injection SELECT button **7** also cycles the CARRIER MODULATION display **3** to read the injection level of the 19kHz stereo pilot. When the SUB/PILOT indicator **6** lights, pilot injection is read off the lower metering scale. Stereo pilot is typically set to 9% injection.

Subcarrier Measurements The CARRIER MODULATION readout **3** is also used to display the injection levels of analog and digital subcarriers. This measurement mode is accessed with SELECT button **15**, over on the right side of the 531.

NOTE: The 531 does not *demodulate* data or analog subcarriers, but it does give a peak-based indication of the *injection level* with good accuracy. A companion product, the Inovonics 540, can be connected to the rear-panel MPX OUT jack of the 531 to provide full demodulation of SCA and RDS/RBDS information.

Cycle the SELECT button **15** to light the SUB indicator **23**. The digital display **13** now indicates the frequency, in kHz, of the subcarrier being measured. The default frequency is the 57kHz RDS/RBDS RadioData subcarrier.

Use the ADJUST buttons **14** to bring up analog SCA subcarriers at 67kHz and 91kHz, as well as the ‘residual’ of the 38kHz suppressed stereo subcarrier (see next page).

RDS/RBDS and SCA injections are read on the CARRIER MODULATION display **3** using the lower meter scaling. Typically, RDS/RBDS will be in the 3% to 4% range, and SCAs up around 10%.

38kHz “Residual”

Stereo-FM broadcasts encode the L–R channel ‘stereo-difference’ information as a double-sideband, suppressed-carrier signal, which is added to the L+R (mono) program. Historically, this DSB subcarrier was generated with analog multiplier circuits, and these had to be carefully balanced to null (suppress) the 38kHz carrier frequency completely. Although modern FM stereo generators employ digital (or digital synthesis) techniques to generate the entire composite baseband signal, regulating agencies may nonetheless still specify a maximum level for the 38kHz residual component in the absence of audio modulation.

For measuring the 19kHz stereo pilot and analog or digital subcarriers, a narrow filter is used to extract the targeted signal from the composite baseband. The pilot and subcarriers are protected by guardbands, or a dead space above and below. Sidebands of the 38kHz stereo subchannel, on the other hand, can, in theory, extend right down to the subcarrier frequency. Thus program modulation *must be turned off* to get a meaningful measurement of any residual 38kHz component. What shows on the display when program information is present is low-frequency stereo-difference information.

Demod Metering

The default mode for DEMOD METERING **8** displays left- and right-channel program material with the LEFT / RIGHT indicator **9** lighted.

There is a good reason for leaving this display in the default mode, it has to do with operation of the audio-loss alarm. See the discussion on Page 26.

Use the SELECT button **12** to cycle the DEMOD METERING display **8** to show stereo sum and difference. The L+R / L–R indicator **10** will light, but headphones continue to monitor the L/R stereo program.

Unless something is terribly wrong (like one channel missing entirely), the L+R sum will always have more energy than the L–R difference. In the real world this energy rule applies to nearly all recorded music. Two notable exceptions are: 1) pop music that has been processed with ‘spatial enhancement’ devices that augment the stereo difference information, and: 2) classical music that has been recorded as ‘true binaural’ using only two microphones. (Nearly all popular music is initially recorded as a multiplicity of monaural tracks, and then manipulated to create an artificial ‘stereo soundstage’ during the mix-down process.)

In some instances the L+R and L–R meters may be close in value, but the L–R meter should generally lag the L+R meter by at least a few dB. For voice announcements without background music or for other mono sources the L–R indication may drop almost off-scale.

Forced-Mono Reception

Press the MONO button **21**, which will light the adjacent red LED indicator. With ‘forced mono’ engaged, the stereo decoder is disabled and the station is received monaurally with left and right program channels equally combined.

You should notice a couple of things in the MONO mode: 1) a big difference in the sound, especially when monitored with headphones. The stereo image will collapse and much of the detail may be missing from the music. It may even sound as if some of the top-end has disappeared. Also: 2) the L+R meter will jump up a bit in mono, but the L-R meter will drop almost off-scale. Actually, a perfect monaural signal should have no L-R component, but circuit and component tolerances within the Model 531 make something in the -50dB range about the best L-R cancellation. Keep this in mind because this represents the best sub/main, main/sub crosstalk reading obtainable from the 531, even though actual system crosstalk may be lower. See Figure 4 on Page 6 for typical crosstalk measurement performance limits.

Program De-emphasis

While listening to off-air program audio, press the DE-EMP button **22**. The green LED indicator next to the button will go out and program audio will sound considerably brighter, even to the point of shrillness. Pressing the button again will turn de-emphasis back on. As you cycle program de-emphasis on and off, you may notice that, although the audio sounds quite different, the left- and right-channel program audio displays **8** do not change much, if at all. Despite a very audible difference, there is very little musical *energy* at the high frequencies. It’s the subtle overtones that are boosted out of proportion without proper de-emphasis.

Unless you are doing system crosstalk or other proof-of-performance tests that require ‘flat’ program audio, the DE-EMP button **22** should be left in the default ‘on’ position with the green LED lighted. After listening for a short time with de-emphasis turned off, a return to the proper tonal balance will sound somewhat dull. This notion will pass after listening properly again for a short while.

AM Noise Measurement

While monitoring the local signal source, press SELECT button **12** until the AM NOISE indicator **11** lights. What you now hear in the headphones should bear only a vague similarity to the program audio signal monitored in the LEFT / RIGHT or L+R / L-R measurements modes. What you are listening to is the amplitude-modulation component of the FM carrier.

A perfect FM carrier would have no ‘incidental’ or ‘synchronous’ AM component. What’s more, this parameter of the FM carrier is difficult to measure off-air, as the receiver must have a broad, flat bandwidth characteristic and a linear IF amplifier. Without these qualities the receiver can introduce its own AM component to the incoming signal.

The Model 531 is not a perfect receiver in this regard, but it does yield useful *comparative* readings. When switched to read AM noise, the upper DEMOD METERING bargraph **8** gives a *relative* indication of the demodulated AM component. This metered value does *not*

have linear-dB scaling. What is *heard* in the headphones (or via the rear-panel AM NOISE output connector) will have the greatest significance in exposing incidental AM noise in the FM carrier.

It is important to have a strong signal for AM noise measurements. As you listen off-air and tune among local stations, the amount of ‘non-synchronous’ background noise (noise *not* associated with the transmitted program) will vary quite a lot. What you want to listen for *is* the program-related noise, which should have only a second-harmonic content. The 531 can be used as a tool in tuning transmitter stages for minimum program-related ‘garbage’; just remember that *what you hear* through the headphones or over an audio monitor is more important than *what is displayed* on the meter.

Though the 531 can prove an effective tool in monitoring and minimizing AM noise, an off-air measurement should not be considered a substitute for a dedicated broadband AM-noise measuring set connected directly to the FM transmitter. We acknowledge the *Radio Design Labs ACM-2* as the definitive such device and recommend it as an excellent aid in transmitter stage tuning.

Audio Loss Alarm

The Model 531 detects program audio loss, lighting the AUDIO LOSS indicator **24**, and providing a rear-panel closure to ground for remote indication.

NOTE: The following points are important.

- ✓ When DEMOD METERING is left in the default LEFT / RIGHT position **9**, an alarm is initiated when *either channel* of the stereo pair drops below -10dB on the metering scale. This is the most useful alarm mode, as a low or dead channel will initiate an alert.
- ✓ If metering is left in the L+R / L-R position **10**, the alarm responds only to the L+R (mono) program level. This means that if one channel is lost the level will drop only about 6dB and no alarm will result.
- ✓ Should metering be left in the AM NOISE position **11**, the alarm then monitors total carrier modulation. This situation is essentially the same as L+R, above.

Therefore, keep DEMOD METERING at the default!

Cycle the SELECT button **15** to light the A-LOSS indicator **24**. The digital readout **13** now shows the delay, in seconds, between audio loss and the alarm. This delay can be programmed with the ADJUST buttons **14** from 10 seconds to 2 minutes in 1-second increments. Delay timing is held in non-volatile memory.

Section IV

CIRCUIT DESCRIPTIONS AND CALIBRATION NOTES

Model 531 circuitry described in this section references the seven pages of schematic diagrams found in the Appendix, Section V.

INTRODUCTION

Component Designation System

Inovonics has adopted its own and very sensible convention for designating components. This well may differ from what you're used to.

Many equipment manufacturers will assign component reference designations in a methodical manner on the schematic diagram. This is fine for walking an electronics class through circuits because Q1 will feed Q2 through C1, with R1 terminating the input, etc. But when you try to locate the physical component on the circuit board it may take quite a while to spot that elusive R6... smack-dab in the center of the board between R67 and R103.

Instead, what we do is sequentially number the actual components on the circuit board, beginning in the upper-left-hand corner and working down one neat, even row, then jumping up to the top of the next row, and so-on.

Of course this means that working in the other direction, from the circuit board to the schematic, can be somewhat problematical. Should you have a need to locate a scorched R182 on the schematic, you'll find it easier to note the integrated circuit it's next to (and probably connected to); in this case, IC39. There are far fewer ICs than resistors.

The "PIC" Microcontroller

The Model 531 uses two "PIC" (Peripheral Interface Controller) large-scale integrated circuits to perform the bulk of 'housekeeping' chores. These PICs include multiple on-chip analog-to-digital converters, which translate the various DC voltages derived from incoming signal parameters into digital data for front-panel display. The PICs also poll the front-panel pushbuttons, control the various indicator LEDs and transmit alarm commands.

You will find little information on what goes on between derived DC voltage levels and the resulting front-panel display. This is the realm of software and embedded code that does not show up on schematics.

RF AND IF SECTION (Schematic Sheet 1)

- Front-End Module** TUN1 is a bought-out FM “front end” module chosen for its superior stability, bandwidth, tracking and dynamic performance. It contains a triple-varactor-tuned RF amplifier, local oscillator and first mixer. The dense, critical internal layout of this module relegates its servicing to complete replacement in the unlikely event of its failure. Just like an electric coffeemaker, “There are no user-serviceable parts inside.”
- Rear-panel switch S3 selects either a direct connection to an external antenna or a padded-down high-level RF input. R601 is wired directly across the HI LEVEL RF IN connector and is rated at one watt. This means that about 7 volts r.m.s. is the maximum level that should be applied to this input.
- Tuning Synthesizer** The 531 is digitally tuned with the aid of a highly integrated synthesizer chip, IC61. A serial address from PIC microcontroller IC5 sets up IC61 with the proper prescaler modulus and Y3 crystal reference divisor. The internal frequency and phase comparator generates a DC error voltage, which is amplified by IC62B and filtered by C139 and C137 to tune the four varactor diodes in TUN1.
- IC61 also has lock-detect logic. This is translated by Q17 and Q18 to hold Q19 off and mute the composite/MPX output while synthesizer lock is being acquired.
- First IF** The 10.7MHz output from TUN1 first encounters the diode attenuator, CR40 and CR41. Attenuation is controlled by the AGC loop to preserve the linearity of subsequent IF amplifier stages.
- Back in the heyday of linear integrated circuits, RCA developed the CA3028, a dandy little chip equally at home in a cascode or a differential configuration for IF amplifier service. Other firms made this part too, and the CA3028 was ubiquitous for more than two decades. Well, no one makes it now, and what’s more you can’t find an equivalent simple, multiple-sourced IF amp. Fortunately, RCA put the ‘equivalent schematic’ of the CA3028 in their Linear Databook. If you connect three general-purpose transistors according to their drawing, this discrete approach works as well as the chip and at a fraction of the cost!
- Q20, Q21 and Q22 comprise the first CA3028 knockoff. 10.7MHz IF transformer T2 feeds an identical second stage of IF amplification. These two stages, along with the diode attenuator preceding the first stage, are gain-controlled by DC from AGC amplifier IC65B.
- The output of TUN1 and the primaries of both IF transformers are ‘swamped’ by comparatively low values of resistance to secure a wide IF bandwidth.
- Second Mixer and Second IF** IC63 is the latest iteration of the long-popular NE602, a double-balanced mixer and local oscillator on a single substrate. Y4 sets the local oscillator frequency at 10.0MHz, and the mixer down-converts the 10.7MHz first IF to a second IF at 700kHz.

Q24 and Q23 buffer the output of IC63 and add about 10dB gain. L5 through L8 and their attendant capacitors comprise a band-pass filter centered at 700kHz. This filter establishes much of what modest selectivity the Model 531 can boast, and filter variability is used to equalize group delay of the entire IF system. Q26 and Q25 buffer the 700kHz band-pass filter and add about 15dB gain.

AGC AMPLIFIER AND AM NOISE DETECTOR (Schematic Sheet 1)

Q27 may appear to be out of place, or perhaps connected incorrectly. Actually, turned upside-down and biased the way it is, Q27 forms a very linear envelope detector. This configuration, attributable to Art Hogrefe of Puma Instrumentation, overcomes the 'dead zone' of a simple diode and can clamp or rectify AC signals at voltage levels near zero. The 700kHz IF, coupled through C128, is clamped at ground on the negative excursion, and a second-order low-pass filter (IC64A, etc.) gets rid of the 700kHz component. The output of IC64A assumes a DC level corresponding to one-half the peak-to-peak value of the 700kHz IF. This point also follows the envelope of the IF waveform, recovering the amplitude-modulation component.

IC65B is the AGC amplifier. The R337/R338 voltage divider makes this stage a comparator, and because of the ratio of R336 to R335, the gain above the comparator threshold is very high. C150 ensures that action of this stage is very slow.

When the 700kHz IF is below 2Vp-p, the output of IC65B sits at the positive supply rail. This biases the diode attenuator (CR40 and CR41) out of the signal path, and imparts maximum gain to the two 10.7MHz IF stages. At an IF level of 2Vp-p, IC65 regulates gain to maintain this value. The AGC voltage also drives the front-panel SIGNAL LEVEL display via the analog RA.2 input of PIC2 microcontroller IC4.

The output of IC64A is also fed to a high-pass filter using IC64B and its associated components. This filter blocks DC and slow, time-varying changes in the output of the envelope detector. The amplitude-modulated component of the IF signal is routed to the rear-panel AM NOISE OUT connector, and also to metering circuitry for front-panel display of AM noise.

FM DEMODULATION (Schematic Sheet 1)

'Pulse-Counting' Discriminator

The 700kHz IF is fed through C132 to hex inverter IC66. IC66A is biased into linear operation with R312 and R311, imparting high AC gain to the IF signal. Subsequent inverter stages 'square up' the IF waveform. IC65A monitors and compares the average, 'antiphase' values at the outputs of IC66C and IC66D, adjusting bias to IC66A so that the limited 700kHz squarewave is perfectly symmetrical.

Opposing phases of the 700kHz IF drive FET switch transistors Q33 and Q34. Each FET forces the fixed charge of current stored in C155 or C154 through CR43 or CR42 to the emitter of current amplifier Q29. Current pulses, now at a doubled, 1.4MHz repetition rate, are integrated at the collector of Q29 by C135. At 700kHz, this point sits approximately midway between ground and the +9-volt rail, with frequency deviations of the IF giving proportional DC offsets. Q28 buffers the output of the current amplifier, and the C113/L4 parallel-tuned trap attenuates the 1.4MHz FM carrier frequency.

**Composite
Frequency and
Phase
Equalization**

IC60B is a variable-Q “bootstrap” low-pass filter. Though examples of the bootstrap filter date to vacuum tube days, seemingly little has been written about this design. In his book, *The Art of Linear Electronics*, British circuit guru John Linsley Hood makes mention of, and gives some design guidance for, this little-used configuration. In its classic form, a third-order bootstrap filter is capable of slightly more than the expected 18dB/octave rolloff, but its implementation in the Model 531 instead makes full use of the high Q inherent in its traditional Chebyshev approximation.

R283 sets the position of the first filter pole, giving leverage over the ‘tilt’ of the filter between 20kHz and 100kHz. R282 spoils the filter’s Q, affecting only the corner-frequency peak at the 100kHz cutoff point. These two amplitude equalization controls are juggled to secure the flattest overall response in the composite/MPX output, consistent both with lowest overshoot from clipped modulating waveforms and best stereo separation.

IC60A is a unity-gain, all-pass phase equalizer with R245 varying the phase-lead imparted to the composite signal. This control is adjusted to best null (minimize) the overshoots from clipped modulating waveforms.

IC59A is the composite/MPX output amplifier. R244 sets circuit gain for a meter indication of 100% at a carrier deviation of ± 75 kHz. IC59A is ‘servoed’ by IC59B to subtract the quiescent (unmodulated) DC component from the composite/MPX output signal. Q19 mutes the output while the receiver synthesizer acquires lock.

STEREO DECODER (Schematic Sheet 2)

Rear-panel MOD MONITOR INPUT switch S2 connects the off-air signal or an external baseband input to the stereo decoding and subcarrier/demod metering circuitry. IC49A buffers external baseband inputs, with R166 affording control over input sensitivity. IC49B is a gain stage servoed by IC50B to remove any DC offsets from the input signal.

**Pilot
Regeneration**

IC50A is a band-pass filter centered at 19kHz. The Q of this stage is purposely kept very low to assure good phase stability. The primary 19kHz pilot filters are synchronous “sampling” circuits that employ

CMOS analog SPDT switches.

IC56 is a CMOS phase-locked-loop IC, used here only as a voltage-controlled oscillator. It free-runs in the vicinity of 76kHz, or four times the 19kHz stereo pilot. The VCO output of IC56 is twice divided by binary flip-flops IC58A and IC48B. The (approximate) 19kHz dividend commutates the IC51B analog switch between the inverting and non-inverting inputs of a differential amplifier composed of IC54A and IC55A. If the incoming stereo pilot is either in-phase or out-of-phase with the IC51B switching frequency, the differential amplifier steers the PLL for a 90-degree phase relationship with the stereo pilot. Once lock is acquired, Q16 is turned off by pilot-sensing circuitry. This imparts a huge DC gain in the PLL feedback loop, fine-tuning the quadrature phase relationship and minimizing phase jitter.

Pilot Rectifier IC51C is a second commutating switch driven at 19kHz and locked to the stereo pilot. The drive for IC51C comes from binary divider IC48A, the output of which is in quadrature with drive to IC51B. As the output of the PLL differential amplifier (IC54A and IC55A) is servoed by circuit action to zero volts, the differential amplifier comprising IC52A and IC53A assumes a positive DC value proportional to the level of the stereo pilot. This is low-passed by IC52B to feed the RA.3 analog input of PIC2 microcontroller IC4 for pilot level display.

Multipath Detector DC derived from the stereo pilot is AC-coupled to a full-wave rectifier through C107. IC53B and IC55B produce a DC output proportional to any amplitude-modulation component of the stereo pilot signal. This is then fed to the RA.1 analog input of PIC2 microcontroller IC4 for a readout of multipath distortion.

Stereo Decoder The inputs of the left- and right-channel low-pass filters are connected to the “wipers” two CMOS analog SPDT switches, IC46A and IC46B. These switches are actuated at a 38kHz rate divided from the 76kHz PLL frequency by IC58A. The composite, baseband signal is fed through R206 and presented to each channel on alternate half-cycles of the 38kHz switching waveform. When *not* connected to the composite signal, the left or right channel is instead presented with an inverted and attenuated version of the composite from IC47B. The relationship between the baseband and its attenuated mirror image meet the criteria for a basic “switching-type” stereo decoder. R209 and R210 are included so that stereo separation for each program channel may be optimized.

Mono Modes Comparator IC57B monitors the level of the rectified stereo pilot from IC52B. When this level falls below what corresponds to about 5% injection, the output of IC57B goes high and turns on Q15. This switches IC45C and IC45B to deliver the composite baseband signal directly to both the left and the right channels. R204 and R205 establish the proper attenuation for this direct signal to match the commutated (switched) level in the stereo mode. Q15 can also be turned on directly by PIC1 microcontroller logic for ‘forced mono’ operation.

The IC57B comparator also controls Q16 in the pilot PLL circuit. PLL capture is accelerated when Q16 turns on, killing the gain of IC57A. When pilot is acquired, Q16 turns off, IC57A then kicking-in additional DC gain for phase jitter reduction.

SUBCARRIER MEASUREMENT (Schematic Sheet 2)

The composite baseband signal is applied to high-pass filter IC47A to attenuate program-audio components. Filtered baseband is then applied to a CMOS analog SPDT switch, IC46C.

IC33 is a frequency synthesizer that is addressed by PIC1 microcontroller IC5. When a subcarrier frequency is selected for measurement, IC33 uses the VCO portion of IC32 to generate a frequency that is offset from the subcarrier frequency by about 200Hz. IC46C is switched at this rate, and differential amplifier using IC31B and IC31A recovers sidebands (sum-and-difference products) of the switching frequency and the subcarrier.

IC30B and IC29B are configured as a 4-pole low-pass filter. This isolates the difference products and establishes a measurement bandwidth of about 4kHz. IC29A inverts the filtered signal, and CR25 and CR24 give full-wave peak rectification. CR32 and CR31 in the feedback path of IC29B compensate for forward drop of the rectifier diodes. CR30 charges to the peak value of the rectified subcarrier signal, which is then filtered by C31 to remove 'bounce' from the subcarrier level display. Subcarrier-derived DC voltage is delivered to the RA.5 analog input of PIC2 microcontroller IC4.

BASEBAND RECTIFIER (Schematic Sheet 3)

PIC1 microcontroller IC 5 actuates CMOS analog SPDT switches IC17C and IC17A via level-shifting transistors Q9 and Q10. The composite baseband signal is connected directly to one switch, and through unity-gain inverter IC19B to the other. Both switches are on for normal measurements of total modulation. IC17A can be switched to ground for independent measurement of positive deviation, and IC17C to ground for negative deviation measurement.

Q7, Q8, Q6 and Q5 comprise an elementary differential amplifier with *two* non-inverting inputs. One + input (base of Q8) senses positive carrier deviations; the other + input (base of Q7) senses the (inverted) negative deviations. The collector of Q5 is the output of this full-wave, peak-responding rectifier. This output is fed back directly to the inverting input (base of Q6) for a net gain of unity.

Instantaneous peaks are held by C24 and buffered by IC16B. Integration of the modulation peaks is afforded by C19 and whatever resistor is selected by the jumper on JP2. Another buffer, IC16A, feeds the RA.0 analog input of PIC microcontroller IC4.

PROGRAM LOW-PASS FILTERS (Schematic Sheet 3)

The left- and right-channel outputs of the stereo decoder are fed to IC44, a pair of controlled-Q ‘bootstrap’ low-pass filters. These filters have 2-pole Chebyshev response and are included chiefly to reduce ‘digital’ noise outside the audible range. These stages have the added value of performing a bit of tip-up equalization just before the cutoff frequency. R196 adjusts the right-channel response to match that of the left-channel.

Phase EQ IC43 is a unity-gain, all-pass phase equalizer that optimizes low-pass transient response. R195 allows the phase lead of the right channel to be matched to that of the left.

The primary 15kHz low-pass filters are a 7-pole elliptic “FDNR” configuration involving IC37 through IC42. In the right channel, R192 adjusts low-frequency response, and R193 trims high-frequency phase response. These controls are used to match the two channels.

De-Emphasis IC36 buffers the low-passed program audio; variable controls in the feedback paths calibrate the gain. The front-panel DE-EMP button controls CMOS analog SPDT switches IC35B and IC35A to select either a de-emphasized or a ‘flat’ signal for display and monitoring; JP3 and JP4 set the de-emphasis characteristic.

LINE OUTPUTS AND DEMOD RECTIFIERS (Schematic Sheet 4)

IC8 and IC9 are active-balanced program line output amplifiers. The first stage in each case is a simple voltage amplifier, and the second is a unity-gain inverter to provide the opposite signal phase.

Matrix Switching IC21B adds the two program channels to yield a left-plus-right stereo *sum* signal, and IC21A derives the left-minus-right stereo *difference*. These, along with left- and right-channel program audio and AM noise, are selected by IC22 according to what DEMOD METERING display function has been called up by front-panel buttons. Q11 and Q12 shift logic levels between the 5-volt PIC microcontroller and the 9-volt CMOS analog switches.

Headphone Monitor CMOS analog SPDT switches IC10C and IC10A route the stereo program or AM noise to the headphone amplifier; amplitude noise is fed to both headphone channels. IC11 drives the headphones, with gain structured for a higher monitoring level in the AM NOISE measuring mode.

DEMOD METERING Rectifier Two identical rectifier circuits are dedicated to the upper and the lower DEMOD METERING display bargraphs. The upper bargraph (also the upper of the two identical circuits on the schematic) displays LEFT, L+R and AM NOISE measurements. The lower bargraph displays RIGHT and L–R readings. The upper circuit will be described.

IC12B, IC13B and IC14B make up the unity-gain, peak-responding section of the rectifier. The minimal integration afforded by R51 and C21 prevents the display of very fast, non-repetitive transients. IC15B buffers the peak-derived DC level and feeds one input of a dual, 12-bit A-to-D converter, IC19.

The audio signal is amplified by IC23B and fed to a second, similar rectifier, though this one is average responding because of significant integration by the R111 and C41. IC27B clamps the rectifier output at a ceiling value determined by the R113/R114 divider, and the buffered DC is sent to the second input of the A/D converter.

IC19 digitizes the DC levels applied to the two inputs. The PIC microcontroller keeps track of these serial streams and sends a 'composite' of the data to the front-panel display. Input signals below -30dB are displayed with average response, and above that point the PIC selects data from the peak-responding rectifier. This gives the measurements 24-bit resolution with optimized ballistics for the range of levels displayed.

MICROCONTROLLERS (Schematic Sheet 5)

Sheet 5 of the schematic shows all connections to and between the two PIC microcontrollers. This page also shows front-panel buttons and some of the LED indicators.

NOTE: Components in dashed boxes carrying 500-series designations are physically located on the front-panel circuit board.

IC504 is an 8-line to BCD encoder. This condenses eight front-panel buttons to four PIC data inputs. All other buttons are connected directly. Similarly, IC20 reduces the seven PRESET SELECT remote tuning selection lines down to three PIC data inputs.

Q1 through Q4 are the open-collector transistors that saturate to ground for remote alarm indications. +5 volts is available from two of the terminals, but is current-limited with 100-ohm series resistors. Current from this source is adequate for driving optical couplers or reed relays, but an external power supply should be used for greater loads. The transistors can sink 50mA, or maybe a bit more.

FRONT-PANEL CIRCUIT BOARD (Schematic Sheets 6 and 7)

The three bargraph readouts, the 4-digit numerical display and many of the discrete LED indicators on the Model 531 front panel are connected in a series of matrices and driven by four display-driver ICs. Serial data from the PICs is time-multiplexed by the drivers for efficient and economical operation.

POWER SUPPLIES (Schematic Sheet 7)

Power transformer T1 has a split primary making it suitable for 115V or 230V AC mains. See instructions on Page 8 for resetting the mains voltage.

“Three-terminal” linear voltage regulators IC2 and IC1 deliver the positive and negative 9-volt supplies for all analog and CMOS digital circuitry. Step-down switchmode regulator IC3 delivers +5 volts at high current for the multiplexed front-panel displays.

CALIBRATION CONSIDERATIONS, GUIDELINES AND WARNINGS

The Model 531 has been designed as the broadcaster’s primary indicator of carrier deviation. Clearly, any piece of equipment entrusted to yield this kind of accuracy requires very careful calibration using test equipment and standards that, themselves, have a minimum of five times the desired measurement accuracy.

Attention to design details, use of quality components and employment of solid construction practices mitigate 531 drift and long-term measurement inaccuracies. There is no particular requirement for routine calibration of the 531, although 2 years might be considered a proper interim for verification of total-mod display accuracy.

It is resolutely recommended that any repair or recalibration of the Model 531 be referred to the factory, where specialized and efficient procedures, test fixtures and skilled, wide-awake technical staff will result in the most professional, prompt and courteous service, thus assuring the best *maintenance value*.

PLEASE BE ADVISED AND FOREWARNED that field calibration of the Inovonics 531 by the guidelines presented in this Manual cannot guarantee the measurement accuracy stated in the product specification.

Having declared this caveat, we nonetheless concede that return to the factory may not always be possible under many field maintenance circumstances. Calibration of the 531 by the user is not only discouraged, but a complete and foolproof calibration procedure is beyond the scope of this Manual. In place of a detailed procedure, we present an accurate description of: 1) the *function* of each calibration’s adjustment, and: 2) the *desired effect* of proper adjustment in each case. This assumes that whoever performs field calibration has read and understands the Model 531 Circuit Descriptions, and also is knowledgeable with broadcasting technology and with analog circuitry in general.

Circuitry Division Calibration of the 531 is divided into two parts separated by the composite/MPX interface between the FM demodulator and the measurement section: 1) the stereo decoding and metering section,

and: 2) the RF/IF and detector section.

NOTE: It is important that the calibration steps be performed in the order presented with the measurement section verified first.

**Equipment
Required**

- A. **Sine/Square Audio Generator** with a range of at least 100kHz and with 10dB/step coarse and vernier attenuators.
- B. **AC R.M.S. Voltmeter** with dBu scaling (0dB=0.775V).
- C. **NOTE:** A and B represent an absolute minimum requirement for this equipment. A much better alternative is one of the “unitized” audio test sets, such as the *Audio Precision Portable One Plus*, which has digital frequency and level readouts.
- D. **Frequency Counter** with a range to 1MHz with 1Hz resolution.
- E. **Laboratory-Grade Stereo Test Generator** with a composite baseband output as well as an internal frequency-agile (synthesized) RF modulator for the FM broadcast band. In addition to a built-in stereo encoder, the unit must also have a separate broadband input to the RF modulator and a reasonably accurate readout of carrier deviation. The internal RF modulator must have coarse and fine output attenuators.

**Demod Level
Setup**

1. Feed the Sine/Square Audio Generator to the rear-panel MPX IN connector of the Model 531 and set the MOD-MONITOR INPUT switch in the EXT position. Defeat de-emphasis (DE-EMP indicator off); the POS DEV and NEG DEV indicators should both be on.
2. Set the generator for a 1kHz sinewave output. Using the generator’s output control and/or the rear-panel EXT MPX IN LEVEL ADJUST trimmer, adjust signal level so that the 100% LED segment just comes on solidly.
3. With DEMOD METERING set to monitor LEFT and RIGHT, adjust R133 and R172 to light the 0dB segment on both lower displays. When the generator level is slowly run up and down, the 100% segment and both 0dB bargraph segments should go on and off at the same point.

**Low-Pass Filter
Matching**

There are *five* controls that may be used to match the characteristics of the right stereo program channel to that of the left. The channels are matched by nulling L–R energy when a monaural signal (the sine/square audio generator) is applied. The five controls are interactive, so a good deal of patience and back-and-forth action will be required to achieve the best results. Refer to Figure 4 on Page 6 for expected L–R measurement limitations.

1. At a frequency of 1kHz, use the right-channel level trimmer, R172, and the phase adjustment, R195, to null L–R energy. It should not be necessary to move R133 very much if levels were set correctly in the previous steps.
2. At a frequency of 50Hz, null L–R with R 192.

3. Re-check the null at 1kHz. Adjusting R192 may have made a difference here, meaning that now there are three controls to juggle to get the lowest L–R reading between 50Hz and 1kHz.
4. Once R172, R195 and R192 have been set for lowest L–R at low and mid frequencies, tune the generator to 10kHz and adjust R196 for the deepest null. This may have some effect at mid frequencies, so R172 and R195 may again have to be juggled a bit for the lowest reading at 1kHz.
5. R193 has leverage over phase response at the filter cutoff frequency. It can be used to improve a null at 10kHz, but the generator should be swept between 1kHz and 15kHz to make sure the best L–R rejection has been achieved over the entire upper passband. It's best to sacrifice a few dBs to obtain an overall smooth response without big L–R peaks or valleys.

Stereo Separation Trim

For this adjustment the composite, baseband output from the test generator's stereo encoder is run directly into the rear-panel MPX IN connector. With the test generator set for full L+R stereo modulation at 1kHz, set the level of the test signal for 100% on the CARRIER MODULATION display. LEFT and RIGHT bargraph displays should indicate –1dB, as 9% of total modulation is taken up by the stereo pilot.

Switching the test generator to drive one channel at a time, adjust R210 to null the right channel when the left channel is driven, and R209 to null the left channel when the right is driven. See Figure 3 on Page 6 for typical separation figures for a direct, composite/MPX input.

IF Alignment

The 10.7MHz and 700kHz intermediate-frequency amplifier stages are adjusted for maximum gain at the center of the passband. The 531 does not stagger-tune the IF to broaden the response, but some offset may be used for elementary group-delay compensation.

The method that gives maximum tuning sensitivity entails monitoring the final IF output and peaking the various tunable coils while the signal level is kept below the threshold of the AGC amplifier. The final IF is monitored at the collector of Q25; the left-hand end of R302, just below Q25, is a convenient point to monitor.

Connect a 'scope probe directly to this point, and also feed this signal to the AC voltmeter through a 1k-ohm resistor. The series resistor will eliminate any risk of introducing instability in this stage through capacitive loading by the interconnect cable. Because of the series resistor, the AC voltmeter reading will not indicate the true r.m.s. level of the IF signal. All that is required, however, is a relative "tune for maximum" indication.

Connect the RF output of the stereo test generator to the rear-panel ANT input of the 531. Set the unmodulated output of the stereo test generator to 98.1MHz (mid-band) and tune the 531 to the same frequency. Adjust the RF signal level to yield an IF level of about 1.5Vp-p, somewhat below the 2Vp-p AGC threshold.

Starting with the single slug-tuned coil in the front-end RF receiver module, TUN1, adjust all IF transformers and filter inductors for maximum. Use the test generator's output level control to maintain the monitored level in the vicinity of 1.5Vp-p (as observed on the 'scope) so that it remains below the 2Vp-p AGC threshold. Following the unmarked front-end coil, tune T2, T3, L5, L6 and L8 for max. Be patient, especially with the 10.7MHz transformers, T2 and T3; these are particularly sensitive. And even though the three 700kHz IF coils have far less adjustment sensitivity, it is still important to center these at the very top of their rather broad peaks. There is some interaction between these three, so repeat the adjustments until you are sure that they are optimized.

Composite Equalization

The finite bandwidth of the IF system necessitates a certain amount of amplitude equalization to guarantee composite baseband flatness.

R283 is a 'slope' equalizer that effects the entire 20kHz to 100kHz frequency range. R282, on the other hand, is a 'peaking' circuit that controls only those frequencies that are very close to the 100kHz top edge of the baseband. Between these two controls, it is possible to secure flat response all the way to 100kHz. With perfectly flat response, however, overshoots from squared-off composite signals would result in a total-mod reading that is artificially high, so response is given a more Gaussian characteristic, as shown in Figure 1 on Page 5.

The easiest way to set equalization is for the best stereo separation from an off-air signal.

Feed the RF output from the test generator to the rear-panel ANT input at a level that lights most segments of the SIGNAL LEVEL display. With one channel driven at 1kHz, adjust R283 for best stereo separation. R245, a phase equalizer in the composite path, has second-order effect over separation. Optimum adjustment of R245 and R242 will be detailed later. For now, leave these near center rotation.

Once separation has been maximized:

1. Disable the stereo encoder portion of the test generator and run the sine/square audio generator directly into the wideband input of the RF modulator.
2. Set the sinewave frequency to 1kHz and the amplitude (modulation level) for a 100%-modulation indication on the CARRIER MODULATION display (POS DEV and NEG DEV).
3. Increase the modulation frequency to 100kHz. Adjust R282 for a CARRIER MODULATION display of 85%.
4. Sweep the modulating frequency between 10kHz and 100kHz. Check it against Figure 1 on Page 5. 85% modulation corresponds to approximately -1.5dB.
5. Switch the audio generator for a squarewave output. (*This assumes that the peak-to-peak level of the signal is the same as*

that of a sinewave output.) The CARRIER MODULATION display will indicate more than 100%.

6. Switch the display between POS DEV and NEG DEV. If the difference between the two readings is more than a couple of segments, IF alignment must be repeated with more attention to securing the absolute maximum peak at the center frequency. If the difference is only 1 or 2 segments, L6 may be trimmed to equalize the two readings.
7. When POS DEV and NEG DEV are equal, adjust the phase equalizer, R245 for minimum indicated total-mod, or the lowest overshoot with a squarewave test signal. Filter-induced overshoots should be in the order of 5%, or a reading of 105% total modulation.
8. Next, restore the composite stereo signal to the input of the RF modulator. With one channel driven, recheck stereo separation. Touch-up R282 as required for maximum separation.
9. It will be necessary to repeat steps 1 through 8 until all adjustment criteria are met.

AM Noise Null

If IF alignment is perfect, only the second harmonic of the modulating frequency will appear at the rear-panel AM NOISE OUT connector. This is most easily ascertained by modulating the RF generator with a 1kHz squarewave tone and listening with headphones in the AM NOISE measurement mode. With proper adjustment, the 1kHz fundamental and all odd-order harmonics are nulled completely. Since a squarewave contains no even-order harmonics, very little will be heard in the 'phones.

Minor readjusting of L5 and L8 should null any residual fundamental at 1kHz. These IF filter components have little effect on overall composite frequency response, and slight readjustment will not compromise stereo separation. If readjustment of L5 and L8 does not make a difference in the monitored noise, alignment of the IF stages should be rechecked, which will necessitate readjustment of composite equalization.

Total-Mod Calibration

Modulate the test generator with a 1kHz sinewave at precisely 100% ($\pm 75\text{kHz}$ deviation). The generator output level should be adjusted to light most of the SIGNAL LEVEL display segments. Then adjust R244 for a CARRIER MODULATION display (POS DEV and NEG DEV) of 100%.

Total-Mod Accuracy

A very important concern to the broadcaster should be *monitoring accuracy*. Setting the mod-monitor's 100%-modulation point requires a precisely modulated carrier with $\pm 75\text{kHz}$ deviation. Traditionally, equipment required for this adjustment has been beyond easy reach of broadcasters, except for those (usually in major markets) with unlimited big-corporation financial resources at their disposal.

Nevertheless and notwithstanding, a relatively simple circuit has been developed by our clever Inovonics design team, a circuit that

puts the unassailable “Bessel Null” method of deviation measurement in the hands of broadcasters of modest resources. A “Bessel Null Calibrator” of incontrovertible accuracy may easily be constructed using component parts commonly available through mail-order catalog suppliers. Full details are available from the Inovonics Website <www.inovon.com>, or upon our receipt of a #10 self-addressed, stamped envelope with sufficient postage for 2oz.

Section V

APPENDIX

This section of the Model 531 Manual contains Parts Listings, Schematic Diagrams and an explanation of Inovonics' Generous and Liberal Warranty Policy.

PARTS LIST

EXPLANATION OF PARTS LISTINGS

This section contains listings of component parts used in the Inovonics 531. Not all components are listed by schematic reference designation; those that are considered 'generic' are qualified, however.

Descriptions may or may not specify a particular manufacturer. 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.

If a part is not listed at all, this means that we do not consider it a typical replacement item. Should you need to order an unlisted part, 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.

Components with reference designations below 500 are contained on the main printed circuit board. Designations in the 500s are associated with the front panel subassembly, and those in the 600s are chassis-mounted components.

PARTS LISTINGS

BAR501-504	10-Segment Yellow LED Bargraph Array; Kingbright DC-10YWA
BAR505,506, 512,518,519	10-Segment Red LED Bargraph Array; Kingbright DC-10EWA
BAR507-511, 513-517,520	10-Segment Green LED Bargraph Array; Kingbright DC-10GWA

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 0.47 μ F are of the metalized Mylar or polyester variety. Whole number (XXp) 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 Model 531 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: 1.0 μ F and above are general-purpose aluminum electrolytics with radial leads. A safe voltage rating for any electrolytic in the Model 531 would be 25V, but because of size and other reasons a replacement capacitor should always carry the same rating as the one being replaced.

C1,2	Capacitor, Y-class Ceramic Disc, .0047 μ F, 440VAC; Murata/Erie DE7150 F 472M VA1-KC
C9,10,120,123	Capacitor, Ceramic Disc, 0.001 μ F, 50V; (open)
C11-14,17,23,27,38, 39,95,96,124,138,140, 142,501-503,505,507	Capacitor, Monolithic Ceramic, 0.1 μ F, 50V; (open)
C51,52,54,55,57-61, 64,69,71-73,75-80,89, 90,128,129,133,134	Capacitor, "High-Q" Polypropylene, 0.0033 μ F, 2.5%, 100VDC; WIMA MKP-2 series
C103	Capacitor, Non-Polar Electrolytic, 22 μ F, 25V; (open)
C119,121,122,125,141	Capacitor, Ceramic Disc, 0.01 μ F, 100V; (open)
CR1-6	Diode, Silicon Rectifier; (open) 1N4005
CR7	Diode, Power Schottky; (open) 1N5820
CR8-48	Diode, Silicon Signal; (open) 1N4151
DISP501	4-Digit, 7-Segment LED Display; Fairchild MSQ6X41C
F1	Fuseholder, PC-mounting; Littlefuse 345-101-010 with 345- 101-020 cap for 1/4-inch fuses or 345-121-020 cap for 5mm fuses. (The fuse itself is a normal "fast blow" type; the value should match the specification stated on the rear panel.)
I501-506,515-517	T1 Yellow LED; <i>Inovonics P/N 2034</i>
I507,508,514	T1 Green LED; <i>Inovonics P/N 2021</i>
I509,511-513	T1 Red LED; <i>Inovonics P/N 2022</i>
I510	T1-3/4 Red LED; <i>Inovonics P/N 2023</i>
IC1	Integrated Cct.; (open) LM337-T (with Aavid 574602V30700 Heatsink)
IC2	Integrated Cct.; (open) LM317-T (with Aavid 574602V30700 Heatsink)
IC3	Integrated Cct.; National LM2575 (with Aavid 574602V30700 Heatsink)
IC4,5	Integrated Cct.; Microchip PIC1C74B (<i>Pre-programmed pair available only from Inovonics.</i>)
IC6	Integrated Cct.; Microchip 24C04A
IC7,19	Integrated Cct.; Microchip MCP3202
IC8,9,11-16,19,21,25, 26,28,29,31,34,36-44, 47,49,50,52-55,57,59, 60,62,64,65	Integrated Cct.; (open) LF353N
IC17,45,46,51	Integrated Cct.; (open) CD4053B
IC20,504	Integrated Cct., (open) 74HC148
IC22	Integrated Cct.; (open) CD4052B
IC32,56	Integrated Cct.; (open) CD4046B
IC33,61	Integrated Cct.; Motorola MC145170D2

IC48,58	Integrated Cct.; (open) CD4013B
IC63	Integrated Cct.; Signetics SA602AN
IC66	Integrated Cct.; (open) CD4069B
IC501-503,505	Integrated Cct.; Maxim MAX7219B
J1	AC Mains Connector; Switchcraft EAC303
J2	Headphone Jack; Switchcraft RN112BPC
J3,4	XLR Male Connector; Mouser 568-NC3MAH
J6	16-Position Terminal Strip; Weco 121-M-211-16
L1	Inductor, Switching Regulator; Renco RL1952
L2,3	Inductor, 47 μ H Molded; Mouser 43LS475
L4	Inductor, 220 μ H Molded; Inductors, Inc. CTM2-221K
L5,8	Inductor, 56 μ H Variable; Toko A119ANS-T1042Z
L6	Inductor, 1mH Variable; Toko 126ANS-T1094Z
L7	Inductor, 1mH molded; Inductors, Inc. CTM3-102
Q1-4,9-15-24,26-32	Transistor, NPN; (open) 2N3904
Q5,17,18,25	Transistor, PNP; (open) 2N3906
Q6,7,8	Transistor, NPN; (open) 2N5088
Q16,19,33,34	Transistor, N-JFET; (open) J109

Except as noted by reference designation, **all resistors** used in the Model 531 are of the value specified on the schematic, qualified per the following:

- a: Fixed Resistors** with values carried to decimal places implying a 1% tolerance (*example: 232, 3.01K, 10.0K, 301K*) are 1.4-watt, 1% metal film type.
- b: Fixed Resistors** with values typical of a 5% tolerance (*example: 220, 3.3K, 10K, 270K*) are ¼-watt, 5% carbon film type.
- c: Single-Turn Trimming Potentiometers** (circuit board) are Tocos GF06U1 series.

R166	Multi-Turn Potentiometer, 10K; Tocos RJC097P103K
S1	Switch, Voltage-Selector; ITW 18-000-0022
S2,3	Switch, SPDT Toggle; C&K 7101-M-D9-A-B-E
S501-514	Switch, Pushbutton; ITT/Schadow D6-04-01, with F14-01 black cap or F14-04 gray cap.
S601	Switch, Power Rocker; Carling RA911-VB-B-0-B
T1	Transformer, Power; Signal LP 24-1000 (or direct cross-ref.)
T2,3	Transformer, 10.7MHz IF; Toko 154AC-40072NO
TUN1	FM Tuner Module; <i>Inovonics P/N 1266</i>
Y1	Ceramic Resonator, 20.0MHz; Digi-Key X909-ND
Y2	Crystal, 2.048MHz; Mouser 520-HCA204-12
Y3	Crystal, 3.20MHz; <i>Inovonics P/N 1238</i>
Y4	Crystal, 10.00MHz; Digi-Key CTX057-ND

PARTS SUPPLIERS

Inovonics strives to maintain factory stock of all parts used in the products we manufacture. A large proportion of the components in

the 531 is 'generic' and may be obtained from a wide variety of sources.

A few parts are more-or-less proprietary. These may either be: 1) manufactured specifically for Inovonics, 2) purchased directly from a manufacturer that sells only in production quantities, or 3) may require pre-installation service such as programming.

Inovonics does not depend on parts sales to fatten our coffers. We do not impose a minimum charge for parts, and in some cases we will elect to supply parts at no charge, rather than generate the necessary paperwork. Always check with the factory, we may well prove the best source for the exact replacement.

The electronic component distributors listed below have proven themselves reputable suppliers for small quantities of component parts for broadcasters and other commercial or professional users.

With all due-diligence, please avoid the temptation to use cross-referenced hobbyist or TV/VCR Repair Shop "direct replacement (ha!) parts."

Nearly any semiconductor, IC, capacitor, resistor or connector used in the Model 531 will be available from one or more of these firms. Each supplier maintains a Website and publishes a full-line printed catalog, which is free for the asking. Minimum-order restrictions may apply, and export orders may be somewhat problematical.

Mouser Electronics

www.mouser.com — 1(800) 346-6873

Digi-Key Corporation

www.digikey.com — 1-(800) 344-4539

Future-Active Industrial Electronics

www.future-active.com — 1-(800) 655-0006

Allied Electronics

www.alliedelec.com — 1-(800) 433-5700

NOTES AND DOODLES



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.

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