OPERATING AND MAINTENANCE INSTRUCTION MANUAL

MODEL 540

FM SUBCARRIER MONITOR/DEMOD

INOVONICS
INCORPORATED

—— USER'S RECORD ——
Model 540 - Serial No. _____
Date Purchased _____
Warranty Card Mailed — ☐

OPERATING AND MAINTENANCE INSTRUCTION MANUAL

MODEL 540

RDS/RBDS RADIODATA ENCODER

January, 1998

(Effective with Serial No. 026)

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TABLE OF CONTENTS

Section I

INTRODUCTION

MODEL 540 PRODUCT DESCRIPTION

General

Inovonics' Model 540 enables accurate measurement and monitoring of FM broadcast subcarriers. These may include speech and music "SCA" (Subsidiary Carrier Authorization) transmissions, "RDS" (Radio Data System) information, and various existing-and-proposed "high-speed" digital services which provide paging and other one-way data communications.

The 540 accepts the demodulated FM "baseband" signal feed from any Modulation Monitor. It is frequency-agile, tuning any subcarrier frequency between 54kHz and 99kHz with digital precision. Bargraph metering displays subcarrier injection, as well as subcarrier deviation for SCA audio transmissions. Demodulated SCA audio may be monitored with headphones and is available at a rear-panel connector as well.

FCC Type Acceptance

Equipment for monitoring broadcast transmissions in the U.S. no longer requires "type acceptance" by the Federal Communications Commission. Though rules pertaining to *monitoring equipment* have been relaxed or abandoned, the broadcaster remains responsible in ensuring that his *transmitted signal* conforms to current FCC regulations.

Features

Features of the Inovonics 540 include:

- Works with any FM Mod-Monitor having a composite-baseband (MPX) output. Easily calibrated with built-in CAL facility.
- Measures injection level of SCA, RDS and high-speed data subcarriers.
- Demodulates audio SCAs and accurately displays subcarrier deviation.
- Triple-conversion design with precise, crystal-controlled digital tuning. Dual IF bandwidth gives optimum selectivity.
- An optional RDS data decoder module is available, and is supplied with comprehensive radio-data analysis software.

MODEL 540 TECHNICAL SPECIFICATIONS

Subcarrier Tuning Range:
54kHz to 99kHz in 1kHz increments.

Subcarrier Injection Measurement:
- **a:** ±1kHz to ±10kHz of main carrier deviation with ±250Hz resolution.
- **b:** 1% to 13% of main carrier modulation with 1/3% resolution (100% modulation equivalent to ±75kHz deviation).

Measurement Bandwidth:
- **WIDE:** 12kHz filter for SCA and certain high-speed data channels.
- **NARROW:** 3.5kHz filter for RDS and similar narrowband data channels.

SCA Deviation Measurement:
- **Absolute:** ±1kHz to ±10kHz audio subcarrier deviation with ±250Hz resolution
- **Relative:** dB scale indicates –20dB to +2.5dB. "0dB" is factory-set to ±5kHz deviation; may be recalibrated by user.

Calibration Provision:
Total, main-channel carrier deviation is monitored in the CALIBRATE mode and adjusted to reflect the station's primary Modulaton Monitor readings.

Metering:
The 38-segment bargraph display is peak-responding and incorporates a peak-hold feature.

SCA Audio Response:
±0.5dB, 50Hz to 5kHz. Switch selection of FLAT or 150-microsecond DE-EMPH(asis).

SCA Distortion and Noise:
Better than 40dB, unweighted, below ±5kHz deviation.

Audio Outputs:
- **a:** Rear-panel, active-balanced SCA program output.
- **b:** Front-panel headphone jack monitors SCA audio, switches to main channel (mono) in CALIBRATE mode.

Composite (MPX) Input:
Unbalanced, bridging; requires 1V p-p or greater signal equivalent to ±75kHz main channel deviation.

RDS Decoder Option:
A plug-in module formats raw RDS data to RS-232. Supplied software enables detailed RDS data analysis with any IBM-compatible PC.

Power Requirements:
105–130VAC or 210–255VAC, 50/60Hz; 15 watts.

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

BLOCK DIAGRAM

A simplified Block Diagram of the Model 540 is shown in Figure 1, below. Monitor circuitry is detailed in the Circuit Descriptions section beginning on Page 15. These descriptions reference Schematic Diagrams found in the Appendix.

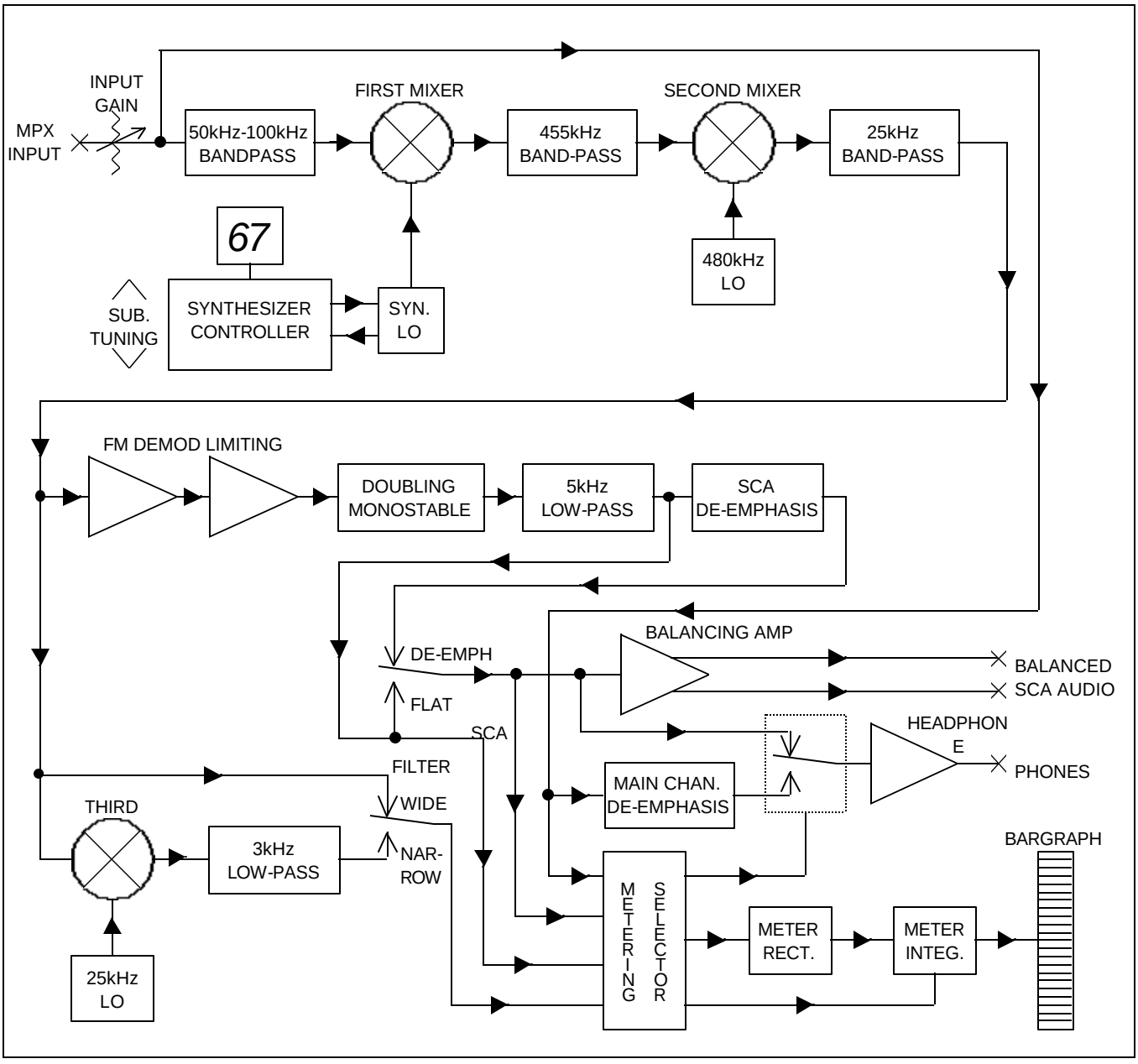

Figure 1 - Block Diagram, Model 540 FM Subcarrier Monitor/Demod

Section II

INSTALLATION

UNPACKING AND INSPECTION

Immediately upon receipt of the equipment, inspect carefully for any shipping damage. If damage is suspected, notify the carrier at once, then contact Inovonics.

It is recommended that the original shipping carton and packing materials be set aside for future reshipment. 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. Not only does this assure coverage of the equipment under terms of the Warranty, and provide some means of trace in the case of lost or stolen gear, but the user will automatically receive specific SERVICE OR MODIFICA-TION INSTRUCTIONS should they be issued by Inovonics.

MOUNTING

Rack Requirement

The Model 540 Monitor mounts in a standard 19-inch equipment rack and requires only 1¾ inches (1U) of vertical rack space. Plastic "finishing" washers will protect the painted finish around the mounting holes.

Heat Dissipation

Consuming about the same power as a single string of Christmas "twinkle" bulbs, the 540, itself, generates negligible heat. The unit is specified for operation within an ambient temperature range extending from freezing to 120°F/50°C. Because adjacent, less efficient equipment may radiate substantial heat, be sure that the equipment rack has sufficient ventilation to keep internal temperature below the specified maximum.

AC (MAINS) POWER

As delivered

Unless specifically ordered for export shipment, the Model 540 is set at the factory for operation from 115V, 50/60Hz AC mains. The rear-panel

designation next to the fuseholder will confirm both the mains voltage selected and the value of a proper fuse.

Voltage Selector

A mains voltage selector switch is located beneath the top cover of the unit, close to the AC mains connector on the circuit board. *With primary AC power disconnected*, you may slide the red actuator with a small screwdriver so that the proper mains voltage designation (115 or 230) shows. Be certain always to install an appropriate fuse, and check that the rear-panel voltage/fuse designation is properly marked. It is factory practice to cross-out the *inappropriate* designation with an indelible black marking pen. You can remove this strikethrough with lacquer thinner or a similar, probably carcinogous solvent to redesignate.

> **BE SURE** that the mains voltage selector setting and primary fuse value are appropriate for the mains supply before plugging the 540 Monitor into the wall outlet.

Power Cord

The detachable IEC-type power cord supplied with the Monitor is fitted with a North-American-standard male plug. Nevertheless, 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 = GROUND

If this turns out *not* to be the case, we offer our apologies (cord vendors sometimes lie to us) and advise that US color coding applies:

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

RADIO FREQUENCY INTERFERENCE (R F I)

Location

Although we have anticipated 540 installation in a broadcast environment, you should practice care in locating the unit away from *abnormally* high RF fields.

Ground Loops

Because the input and the output of the Model 540 are chassis-ground-referenced, a mains frequency or RF ground loop could be formed between the input or output cable shield grounds and the AC power cord ground. A "ground-lifting" AC adapter will probably remedy any problem, though the chassis somehow must be returned to earth ground for safety. Generally, being screwed-down in the equipment rack will satisfy the safety requirement.

JUMPERING OPTIONS

The Model 540 has but a single jumpering option. It selects either 50µs or 75µs de-emphasis for the monaural, main-channel program audio

which is routed to the front-panel PHONES jack in the CALIBRATION mode.

The de-emphasis jumper strip is located to the left of IC28. The circuit board legend identifies the “50” and “75” (microsecond) positions for the movable jumpering shunt; this jumper will have been positioned appropriately for the original shipping destination.

Section III

SETUP AND OPERATION

PANEL CONTROLS AND INDICATORS

This section starts with an overview of front-panel controls and indicators. Please at least scan this section to verify that your understanding is in agreement with our terminology.

METER SELECT

This pair of up/down buttons cycles the Model 540 among its various monitoring functions. The selected function is indicated by an attendant LED. The functions are:

CALIBRATE – in this setup mode, metering and audio monitoring is switched-over to a measurement of total baseband modulation (primary carrier deviation). The corresponding set point (above the 10% scale designation) allows gain to be adjusted such that this mark coincides with full carrier modulation; that is, "100%" or ±75kHz carrier deviation. For proper annotation in this mode, multiply the indicated percentage or kHz-deviation numbers by 10. (FS=130% or ±100kHz)

PERCENT INJECTION – this scale and the ±kHz INJECTION scale are active when measuring the modulation contribution of the tuned subcarrier. The 10% point on the upper scale is opposite the ±7.5kHz point on the one below, indicating the relationship of these measurements to "full" modulation; that is, 100% or ±75kHz carrier deviation.

SCA ±kHz DEVIATION – this measurement option displays the actual deviation of the audio-modulated SCA subcarrier. It is a valid measurement *only* for SCA, and is *completely meaningless* for digital data subcarriers. This measurement is not affected by SCA AUDIO (de-emphasis) selection.

SCA AUDIO LEVEL – this is a *relative*, dB-calibrated scale for measurement of SCA program levels, and will reflect a FLAT or a DE-EMPH(de-emphasized) SCA AUDIO selection. Factory calibration sets this

measurement to indicate "0dB" at an SCA subcarrier deviation of ±5kHz, at a frequency below the influence of de-emphasis. This calibration may be reset for another reference if desired, the procedure is given on Page 20.

SUBCARRIER TUNING — Use this pair of up/down buttons to tune the subcarrier frequency. Press-and-release to tune up and down in individual 1kHz steps, or hold the button down to scan rapidly.

FILTER — IF bandwidth is controlled by this switch. The selected filter, WIDE (SCA), or NARROW (DATA), is indicated by an attendant LED. Select the WIDE mode for SCA and *high-speed* digital subcarriers. RDS and similar low-data-rate services may be crowded close to one another or to the main FM baseband signal, inviting a NARROW filter selection.

SCA AUDIO — Demodulated SCA audio may be monitored with either a FLAT frequency characteristic, or with standardized 150-micro-second DE-EMPH (de-emphasis). The chosen audio characteristic will be imparted to the front-panel PHONES jack, the rear-panel SCA BALANCED AUDIO connector, and to metering in the SCA AUDIO LEVEL (dB-scale) measurement mode.

PHONES — This stereo jack accommodates a pair of standard headphones. In the CALIBRATE mode, a de-emphasized baseband *monaural* program signal is routed to this jack. In all other operating modes the headphones will monitor the output of the audio SCA demodulator. When an SCA channel is tuned the audio subcarrier program will be heard. RDS or other data channels will yield a noise characteristic of a data signal. Since the subcarrier is heard through an FM demodulator, the *sound* may not have the anticipated *character*.

POWER — Interests of national security forestall our elaboration into the function of this switch.

MPX INPUT AND LEVEL SET

Input Connection — Cable the rear-panel COMPOSITE MPX INPUT connector directly to the composite, "baseband" output of the station's Modulation Monitor. Check the mod-monitor's instruction manual to verify that its output

has a flat frequency characteristic, and that it provides at least one volt, peak-to-peak, at 100% carrier modulation (±75kHz deviation).

Correcting for Response Errors

Subcarrier injection measurement accuracy is a function of mod-monitor output flatness. If mod-monitor demodulation response exhibits HF roll-off as it approaches 100kHz, use the manufacturer's published correction chart (or make one of your own!) to assure accuracy of subcarrier injection readings.

The input impedance of the Model 540 is 100k-ohms, essentially an open circuit. To obviate any need to address impedance matching or source termination, keep the interconnecting cable as short as possible.

Input Level Adjustment

The 540 Monitor is most accurately calibrated by applying a steady-state input signal equivalent to 100% carrier modulation; that is, a carrier deviation of ±75kHz. If the mod-monitor has a built-in calibrator which drives its own indicator to this figure, and if that same test signal is delivered to the mod-monitor's composite output connection, calibration of the 540 is very easy. Simply adjust the 540's rear-panel INPUT GAIN control until the bargraph display reaches the CALIBRATE mark on the scale. (This is directly above the "10%" designation and corresponds to 100% carrier modulation.)

If the mod-monitor does *not* have a built-in calibration source, an equally accurate adjustment may be made by driving the exciter to full modulation with a test oscillator signal, probably best done during a maintenance period. Set INPUT GAIN as described above.

Another calibration method allows you to use normal program material for setup. The INPUT GAIN control may be set with acceptable accuracy by setting program peaks displayed in the CALIBRATE mode to the same total-peak-modulation values indicated by the mod-monitor. In CALIBRATE, multiply the Model 540's scale markings by 10 to show peak excursions of 10% to 130% modulation (10kHz to 100kHz carrier deviation). Since 540 metering is peak-responding and incorporates a peak-hold feature, it should indicate the same peak levels indicated by the mod-monitor. However, if mod-monitor metering is *not* a true, peak-responding display, defer instead to calibrated *peak flasher* set points.

Section IV

RDS-DECODE OPTION

The Model 540 accommodates an optional plug-in assembly which independently demodulates digital "radiodata" broadcast by stations supporting RDS, the Radio Data System. RDS transmissions serve a number of purposes: automatic receiver tuning to search for specific formats, "radiotext" displays for station promos or advertising, personal paging services, and "housekeeping" functions which enhance a broadcaster's service to his listeners.

The RDS data channel is transmitted as a low-level, double-sideband, suppressed-carrier "subcarrier" at 57kHz, just above the spectrum of the composite stereo program signal in the FM baseband. The data transmission (baud) rate is modest, yet it is "robust," thanks to data redundancy and error correction.

The plug-in RDS Option for the Model 540 demodulates the 57kHz subcarrier and reformats the RDS data stream into RS-232 serial digital data which may be fed to any IBM-compatible computer. Supplied software decodes the RDS data so that it may be read.

INSTALLING THE OPTIONAL PLUG-IN RDS CARD

If the Model 540 was supplied without the RDS Option, the rear-panel RDS DATA OUT connector cutout will have been covered by a plastic escutcheon. This may be removed, and the plug-in Option card installed as follows.

First, remove two jackscrews from the DB-9 connector of the plug-in Option card, and the spare 4-40 screw from the single threaded standoff on the back of the board. Angle the Option card downward so that the DB-9 connector pokes through the back-panel cutout. While gently forcing the six Option connecting pins toward the back panel with your thumb, align these pins with the mating connector strip on the main circuit board and push the Option into its seated position. Re-install the two jackscrews and the 4-40 screw to complete the installation.

COMPUTER REQUIREMENTS

RDS decoding and analysis software runs under DOS on any IBM-compatible computer with a 286-or-better processor. The program will run equally well on an old DOS machine, or under Windows® from the **MS-DOS Prompt** command.

Connect the Model 540 to either the COM 1 or the COM 2 port of the computer. Use a *serial* interface cable terminating in a DB-9 connector. Cables with the larger DB-25 connectors will require a 9-to-25-pin adapter on the end plugging into the Model 540.

INSTALLING THE SOFTWARE

Software is supplied on a 3½-inch floppy diskette. Since disk access time is not a factor once the program is resident in computer RAM, it may be run directly from the diskette if this is preferred. Most users will want to copy the diskette to the computer's hard drive. Two methods are given here, choose whichever is more convenient.

DOS-Based Computers

Insert the diskette into the computer's A drive. At the **C:\>** DOS prompt, type: **a:** to access the diskette drive and bring-up an **A:\>** prompt. At this new prompt type: **install**. This will create a C-drive directory labeled **540RDS**, and will copy all files from the diskette to the hard drive.

Computers Running Windows®

Invoke the **Run** command under the **Start** utility. On the **Open** line type: **a:\install**. This will create a C-drive directory labeled **540RDS** and will copy all files from the diskette to the hard drive.

RUNNING THE *DETECT* PROGRAM

Starting the Program Under DOS

Two versions of the *DETECT* RDS-decode program have been included in the **540RDS** directory. The version you are most likely to use is for a 9600 baud data interchange rate. A second version supports 2400 baud, though the only reason to use this slower rate might be to communicate with the Model 540 over a dial-up modem. For the 2400 baud rate a jumper must be changed on the RDS Decode Option plug-in board (see Page 18).

From a **C:\> DOS** prompt, type **cd 540rds** to change to the proper directory. Once the prompt has switched to **C:\ 540RDS>**, a properly configured command line will start the program.

The command line must contain the *number* of the COM port which is cabled to the Model 540, as well as the *baud rate* for the RS-232 serial data. For COM 1 the command line would be typed like this: **detect96 /1**. For COM 2 type in: **detect96 /2**. (For 2400 baud substitute the number **24** for the **96** in either instance.)

Running Under Windows®

The *DETECT* program may be started under Windows®, simply by "clicking" on the **MS-DOS Prompt** icon, then typing-in the command line as described above. Users familiar with the Windows® operating system can probably create a "shortcut" for click-starting the *DETECT* program.

The *DETECT* Screens

The opening *DETECT* screen lists the functions which will be decoded, and the RDS groups which contain this information. Press e to bring up the main, data display screen. Pressing v will exit the program and return to a DOS prompt at any point.

The first line of the data display screen shows the station's hexadecimal **PI Code** (Program Identification), or "digital address." This hex code is automatically calculated from the station call letters in the RDS encoding process. This is immediately followed by the Program Service Name (PS) which can carry the station's call letters or a "street name" such as "LIVE 95" or "BIG 104." The third item on this line is the **PIN** (Program Item Number), an encoded schedule for a particular program, its date and time.

The next line, **PTY** (Program Type) identifies the station format from one of several pre-defined categories. The **Travel** field indicates whether or not the station is one which routinely broadcasts traffic bulletins for motorists (TP), and indicates if such a message is currently being broadcast (TA).

Two lines display the 64-character, plain-text **Radio Text Messages** used for station promotions, contests or advertising. These messages can be broadcast either in group 2**A** or group 2**B**.

Alternative Frequencies (AF) is a list of all dial positions at which *identical* programming can be heard. This will include the station's main transmitter and all "translators," or re-broadcast facilities. The list is displayed as received, and with a little practice you should be able to catch all frequencies as they flash before you.

Audio Decoder Information identifies mono or stereo transmissions (DI), and whether the program being broadcast is music or speech (M/S).

MJD (Modified Julian Day) is a display of the current date and time. A raw hexadecimal presentation is followed by the decoded day of the week and date: day-month-year. The time display is current local time, AM or PM, this is followed by an offset, in hours, from Coordinated Universal Time (UTC). An offset of 7– would denote a local time 7 hours behind UTC, or that UTC is 7 hours ahead of local time.

The **Enhanced Other Networks Data** (EON) field gives some of the same RDS features described above, but for program services separate from the one being received. (Other stations in the same network with their individual programming, for instance.)

Data Error Display

A digital counter at the bottom of the *DETECT* screen maintains a running count of radiodata errors. The occasional "hit" is to be expected, probably resulting from a noise burst or multipath effects. Errors which appear to accumulate at a steady and regular rate, particularly when signal strength is adequate, is a symptom of a legitimate RDS data encoding problem and should be investigated.

Section V

CIRCUIT DESCRIPTIONS

This section details circuitry of the Inovonics Model 540 FM Subcarrier Monitor/Demod, and also includes procedures for the comparatively few calibration adjustments. Circuit descriptions refer to four pages of Schematic Diagrams contained in the Appendix, Section V, Pages 25, 26, 27 and 28.

INTRODUCTION

Navigating the Schematics

Schematic component reference designations have not been assigned in as haphazard a manner as they might at first appear. Instead of annotating the *schematics* in a logical sequence, we have instead chosen to designate the *components on the circuit board* following their physical placement, top-to-bottom, left-to-right. We expect this practice will prove useful when troubleshooting, making it easier to locate the physical part following analysis of the diagram.

The Model 540 schematic diagram consists of four sheets. Sheets 1 and 2 cover the main circuit board. Sheet 3 shows components on the separate front-panel circuit assembly, and Sheet 4 is a diagram of the optional RDS data-recovery plug-in module. Main-board components begin with the number "1"; i.e.: R1, C1, IC1. Front-panel components are in the five-hundred series; i.e.: R501, S501. Since it is a separate circuit altogether, the RDS plug-in has its own, very short series of numbers, again beginning R1, C1, etc.

The front-panel circuit assembly interconnects with the main board with short ribbon-cable jumpers. J503 on the front-panel assembly mates with J3 on the main board, J504 to J4, and J505 to J5.

The "PIC" and Front-Panel Logic

The Model 540 employs a device called a "PIC," or Peripheral Interface Controller. This is a single-chip microcontroller of limited intelligence, but ideal for elementary logic and simple control functions. It is factory-programmed to perform certain bonehead routines, most of which deal with the front-panel buttons and indicators.

INPUT CONDITIONING AND FIRST TWO CONVERSIONS (Schematic Sheet 1)

Input Stage and Band-Pass Filter

The composite/MPX input from the station's mod-monitor is adjusted with INPUT LEVEL control R14 to calibrate the unit at full carrier modulation. Buffer IC7A drives a high-pass L/C filter to attenuate main-channel program frequencies below 50kHz, and following a second buffer stage, IC7B, an L/C low-pass function attenuates out-of-

band noise above 100kHz. The selected band of frequencies is buffered by IC8A which, along with companion inverting stage IC8B, provides push-pull drive to the first balanced mixer, IC9.

Programmable First LO

Front-panel SUBCARRIER TUNING buttons S503 and S504 are read by the PIC, IC6. A self-clocking up/down counter within the PIC controls both the front-panel digital display, decoded by IC11 and IC17, and tuning synthesizer controller IC5. The VCO section of phase-locked-loop IC1 rounds-out the synthesizer circuit. The frequency range of this first local oscillator extends from 401kHz to 356kHz, corresponding to subcarrier frequencies between 54kHz and 99kHz, respectively. Thus the first intermediate frequency is 455kHz, with an up-converted spectrum inverted from that of the input signal.

First IF and Second LO

The 455kHz first IF is band-passed by the stagger-tuned, coupled-transformer pair, T2 and T3. T3 feeds a second double-balanced mixer, IC15. Local oscillator IC16 is crystal-controlled at 480kHz, down-converting the tuned subcarrier to a second IF of 25kHz.

SECOND IF AND SCA DEMODULATION (Schematic Sheet 2)

Second IF Filter

IC13A and IC12A constitute a four-pole low-pass filter, IC12B and IC13B form a four-pole high-pass section. The resulting band-pass function is the WIDE (SCA) characteristic of the front-panel FILTER selector. This signal is presented to analog switch section IC28B to select injection measurement bandwidth, also to the SCA demodulator, and to yet another conversion process for further subcarrier selectivity filtering.

SCA Demodulator

One section of hex inverter IC18A is biased into a quasi-linear operating mode to afford broadband, open-loop gain. IC18B and IC18C give additional amplification and pre-demodulation limiting of the tuned subcarrier.

Differentiation and diode steering trigger IC18F on both the leading and the trailing edges of the squared 25kHz IF waveform. Inverters IC18D and IC18E complete a monostable (one-shot) multivibrator by adding differentiated positive feedback through CR15. This yields a string of fixed-width pulses, the 50kHz repetition rate of which is frequency-modulated by SCA audio

IC25A and IC25B comprise a fifth-order, low-pass filter with a flat frequency characteristic to just beyond 5kHz. This filter integrates the string of 50kHz FM pulses, completing the demodulation process for SCA audio program subcarriers.

De-Emphasis, Audio Output and Monitoring

150-microsecond de-emphasis is imparted by C76. Switch-selected DE-EMPH or FLAT SCA audio is switched by IC28A. The selected signal is metered for the SCA AUDIO LEVEL measurement, and also routed to

IC26A and IC26B which deliver a balanced audio output to the rear-

panel BALANCED SCA AUDIO connector.

IC27A is a driver stage for the front-panel PHONES jack. This jack monitors demodulated SCA audio in all measurement modes except the CALIBRATE (±75kHz) position, in which IC28C instead routes de-emphasized main-channel audio to the jack.

THIRD(!) CONVERSION (Schematic Sheet 2)

LO and Mixer The 25kHz IF signal is fed to a third mixer, IC30; the local oscillator for this conversion is 25kHz from crystal oscillator/divider IC29. Grammar-school arithmetic suggests a third IF frequency of either 50kHz or zero. The latter is actually the case. Politically-correct or not, this "homodyne" technique allows a simple low-pass filter to establish IF selectivity.

IF Filtering The third IF filter incorporates IC21B, IC21A and IC20A and has a 6-pole low-pass function. IC19A compensates filter phase response, and IC19B makes-up conversion loss. The effective IF bandwidth at this point is about 3kHz. This third IF signal is useful only for injection-level metering in the NARROW (DATA) position of the front-panel FILTER selector. Down-converted essentially to DC at this point, the signal is useless for further demodulation or audio monitoring.

METERING (Schematic Sheet 1)

Metering Selector The front panel up/down METER SELECT buttons are read by the PIC microcontroller, which in turn sends a 2-bit binary address to a dual, 1-of-4 analog switch, IC10. IC10A lights LEDs to indicate which scale and metering function have been selected, IC10B routes the selected signal to the metering rectifier.

In the 540's CALIBRATE (±75kHz) mode, a composite/MPX sample from input buffer IC7A is delivered to the meter. For subcarrier injection measurements, both the PERCENT INJECTION and ±kHz DEVIATION LEDs are lighted, and the input to the metering circuit is either the WIDE (SCA) or the NARROW (DATA) IF signal from FILTER selector IC28B. Calibrated, FLAT SCA program audio is fed to the meter for SCA ±kHz DEVIATION measurements, and for an indication of SCA AUDIO LEVEL, either FLAT or DE-EMPH SCA program audio is delivered to the metering circuit to be read on the lower dB scale. This level is factory calibrated to read 0dB at ±5kHz SCA subcarrier deviation, but this may be set to another reference value if desired. (See Page 20.)

Meter Rectifier Gain stage IC22A feeds a full-wave, peak-responding rectifier using IC23A, IC24A, IC24B and the four associated diodes. An input to the meter immediately charges C66 to the instantaneous peak value. Discharge of C66 is though constant-current source Q3. IC22B is a slope detector which gives a positive output pulse whenever a new peak

exceeds the existing value. This pulse turns Q2 on, charging C65 which holds Q3 off. C65 discharges through R78 and R80, ultimately enabling current source Q3 and allowing a linear fallback of the bargraph display. This action provides the peak-hold feature which makes even the quickest deviations clearly visible.

Bargraph Display

The output of the metering rectifier is fed to a series of four bargraph display drivers (Schematic Sheet 3), IC501 through IC504, and hence to the 38-segment LED readout. Q501 is turned on during subcarrier injection measurements, this brings C502 into the circuit to reduce display "bounce" from accompanying noise. Notwithstanding the integration imposed by C502 and R509, the display remains peak-responding due to the peak-hold provision of the rectifier.

RDS OPTION PLUG-IN ASSEMBLY (Schematic Sheet 4)

IC4 is an application-specific RDS decoder circuit originally developed for receiver applications. It accepts the composite MPX signal directly and performs on-chip signal filtering and data recovery. IC4 delivers two logic-level outputs, *clock* and *data*, both derived from the incoming RDS subcarrier.

Shift register IC3 converts RDS clock and serial data to an 8-bit parallel format. This "scrolling" data "byte" is presented to a PIC microcontroller, used in this instance as a sort-of "transmit-only UART" (Universal Asynchronous Receiver/Transmitter). RDS clock pulses are also fed to the PIC. Between these two input sources the PIC magically sorts-out incoming data to yield a coherent output in RS-232 format.

Baud Rate Jumper

Data to the computer is available at two baud rates, these are selected by a jumper on the RDS Option plug-in assembly. Though there is no silk-screened legend on this little board, the baud rate is 9600 when the jumper is closest to the DB-9 connector, and 2400 when it is moved toward the AC mains connector. The factory setting is 9600 baud.

POWER SUPPLY (Schematic Sheet 2)

Model 540 circuitry utilizes ±9-volt supplies for op-amps and other linear circuitry demanding signal headroom, and a +5-volt supply for digital logic. These three sources are each regulated by a "3-terminal" linear voltage regulator; IC2 for +9 volts, IC4 for –9 volts, and IC3 for +5 volts.

The power transformer has dual primary windings which may be switched in parallel or in series to accommodate 115V or 230V mains, respectively.

MODEL 540 CALIBRATION PROCEDURES

The Model 540 circuitry is inherently very stable and does not require routine alignment. There are so relatively few internal adjustments that a separate Manual section for calibration is hardly justified. Instead, the action of each trim adjustment will be discussed individually, and hints given on how proper calibration may be attained.

To calibrate or verify proper performance you will need:

1) A stable audio generator (oscillator) good to 100kHz. This should have both a 10dB-per-step and a variable output attenuator.
2) A frequency counter to monitor the output of the audio generator.
3) A decent oscilloscope with a 10:1, high impedance probe is always handy to have on-hand.

R14: INPUT GAIN and Flatness Check

This is the rear-panel control which establishes overall "system" calibration; that is, the relationship between Model 540 input sensitivity and full carrier modulation as measured by the station's mod-monitor. The setting of this control is not relevant to 540 internal calibration. R14 is adjusted at the factory so that the 540 indicates the "set point" in the CALIBRATE (±75kHz) mode when a 76kHz sinewave is applied to the COMPOSITE MPX INPUT at a peak-to-peak level of 3 volts.

1. An existing setting of the INPUT GAIN control need not be disturbed. With the generator frequency set to 76kHz, simply adjust the variable output attenuator for a "set point" indication in the CALIBRATE ±75kHz position of the METER SELECT switch.
2. As you tune the generator between 100Hz and 100kHz, there should be no more than a ±1-division deviation in the front panel display.

T2 and T3: First IF Tuning

The tuning of these resonant transformers establishes bandwidth of the first IF at 455kHz. Each transformer is "peaked" at a particular frequency.

1. Set the front-panel METER SELECT for the PERCENT INJECTION / ±kHz INJECTION metering mode, SUBCARRIER TUNING to 76kHz, and FILTER selection to WIDE.
2. Apply an input signal from the audio generator at exactly 76kHz, and at a level which drives the front-panel bargraph display to approximately the 0dB point on the bottom scale. This need not be exact.
3. Reset the audio generator frequency to 81kHz. Tune T2 for a maximum bargraph indication.
4. Reset the audio generator frequency to 71kHz. Tune T3 for a maximum bargraph indication. The bargraph display should not deviate more than 1 division when the audio generator is tuned

between 71kHz and 81kHz, indicating a flat 10kHz passband in the WIDE measurement mode.

R19 and R64: Injection and Data Level Set

1. Reset the audio generator frequency to 76kHz, and the level to obtain a "set point" indication in the CALIBRATE ±75kHz position of the METER SELECT switch.
2. Reduce the generator output by exactly 20dB.
3. Set SUBCARRIER TUNING to 76kHz, the FILTER to WIDE (SCA), and select the PERCENT INJECTION / ±kHz INJECTION metering mode. Slowly sweep the generator frequency to either side of 76kHz to verify maximum response at the tuned frequency, or that the passband is "centered." If necessary, trim R19 for an exact 10% bargraph indication.
4. Switch the FILTER to the NARROW (DATA) position. The bargraph reading should be identical. Again slowly sweep the generator frequency to either side of 76kHz to verify maximum response, and leave the generator frequency set at the point which gives the highest reading. At this point set R64 for 10% injection.

NOTE: To verify or to calibrate the SCA subcarrier deviation measurement, you will require an SCA subcarrier generator or a specialized laboratory function generator. Either piece of gear must be capable of accurate frequency modulation to a known calibration standard. Bessel nulls can be used to accurately set the deviation of an SCA generator, but description of this technique is beyond the scope of this Manual. Lacking the required equipment for this calibration, you can still proceed with the injection measurement checks. If you find these close to where they belong you can probably assume that the SCA deviation measurement retains accurate factory calibration.

R20: SCA Deviation

R20 is set for an accurate display of SCA subcarrier deviation in the SCA ±kHz DEVIATION metering mode with a WIDE (SCA) FILTER selection and SUBCARRIER TUNING set to the subcarrier center frequency. Keep the modulating frequency at 1kHz or below for this adjustment, and deviation between 5kHz and 7kHz.

R21: SCA Audio Level Set

With conditions identical to the previous step, and with a modulating frequency of 100Hz, set R21 for 0dB on the SCA AUDIO LEVEL scale when deviating the subcarrier to whatever is considered "peak" program level. Though there is no specification for subcarrier deviation, 5kHz or 6kHz are oft-cited figures. Check that, at a modulating frequency of 100Hz, there is no significant difference between the FLAT and DE-EMPH selections of the SCA AUDIO switch.

Section VI

APPENDIX

The following section of this Manual contains Parts Lists and Schematic Diagrams for the Model 540, and an explanation of Inovonics' Warranty Policy.

PARTS LIST

EXPLANATION OF PARTS LISTINGS

This section contains listings of component parts used in the Inovonics 540 FM Subcarrier Monitor/Demod. These are listed either *en-masse,* or by schematic component reference designation. The listing may, or may not, specify a particular manufacturer. When no manufacturer is called-out, the term "open mfgr." advises that any manufacturer's product is acceptable, so long as it carries the proper generic part number.

If a particular component 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 or FAX the factory with a brief description. We'll do our best to figure out what you need and get it on its way to you quickly.

PARTS LISTING

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

a) **Under 100pF** are the "dipped," or "silver" mica type; DM-15 (or CM-05 military series) size designation; "P" value is picofarads, ±5%, 200VDC; (open mfgr.).

b) **100pF to 0.47µF** are of the metalized mylar or polyester variety. Whole number "P" values are picofarads, decimal values are microfarads, ±5%, 50VDC or better. The style used in the 540 is the "minibox" package with a lead spacing of 0.2 inch. **Preferred part:** Wima MKS-2 or FKC-2 series. **Alternates:** CSF-Thompson IRD series, or Roederstein KT-1808 or KT-1817 series.

c) **1.0µF and above** are radial-lead electrolytics, value per schematic, 25VDC; (open mfgr.).

C1,2	Capacitor, Ceramic Disc "Safety" Mains Bypass, .0047µF, 440VAC; Murata/Erie DE7150 F 472M VA1-KC (preferred)
C7,8	Capacitor, Electrolytic, axial leads, 1000µF, 35VDC; (open mfgr.)
C6,12,13,16,27, 29,44,57,79,82	Capacitor, Monolithic Ceramic, 0.1µF, 50VDC; (open mfgr.)
C15	Capacitor, Memory Back-Up, 1 Farad, 5.5VDC; (open mfgr.)
CR1-8	Diode, Silicon Rectifier; (open mfgr.) 1N4005
CR9-19	Diode, Silicon Signal; (open mfgr.) 1N4151 or equiv.

F1	Fuseholder, PC-mounting; Littlefuse 345-101-010 with 345-101-020 Cap for ¼-inch (U.S.) fuses, or 345-121-020 Cap for 5mm (European) fuses. (Fuse is normal "fast-blow" type in value specified on rear panel with reference to mains supply.)
I501-503	10-Segment LED-bar display module, green; Kingbright DC-10GWA
I504	10-Segment LED-bar display module, yellow; Kingbright DC-10YWA
I505	LED Indicator, pastel red, T-1 package; Stanley MVR 3378S
I506-508, 512,515	LED Indicator, pastel green, T-1 package; Stanley MPG 3878S
I509,513,514	LED Indicator, pastel yellow, T-1 package; Stanley MAY 3378S
I510,511	7-Segment LED alphanumeric display module; Liteon LTS 4940 AHR or ParaLight C401E/G/W
IC1	Integrated Cct.; (open mfgr.) CMOS 4046B
IC2,3	Integrated Cct.; (open mfgr.) LM317-T (Uses Aavid 574602 B03700 Heat Fin)
IC4	Integrated Cct.; (open mfgr.) LM337-T (Uses Aavid 574602 B03700 Heat Fin)
IC5	Integrated Cct.; Motorola MC145151
IC6	Integrated Cct.; *SPECIAL FACTORY-PROGRAMMED "PIC,"* type 16C62A. Order by designation, reference Model 540.
IC7,8, 12-14,19-27	Integrated Cct.; (open mfgr.) LF353N
IC9,15,30	Integrated Cct.; Philips NE602N
IC501-504	Integrated Cct.; (open mfgr.) LM3914N
J1	AC Mains Connector, PC-mounting; Switchcraft EAC303
J5,6	PC-mounting TRS (stereo) 'phone jack; Switchcraft RN 112 BPC
J601	Connector, chassis-mounting male "BNC"; Amphenol 31-221
L1-4	Inductor, 1mH; J.W. Miller 9220-2
Q1,2,3,501	Transistor, NPN; (open mfgr.) 2N3904

All resistors are specified as follows:

a) **Fixed resistors** with values carried to decimal places implying a 1% tolerance (*example:* 3.01K, 10.0K, 15.0K, 332K) are ¼-watt, 1% metal film type.

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

c) **Multi-Turn Trimming Potentiometers** (front-panel adjustable) are Tokos RJC097P series, Beckman 89PR series, or equivalent "cermet" types.

d) **Single-Turn Trimmers** (circuit board) are Tokos GF06U1 series or Beckman 91AR series.

S1	Switch, DPDT Slide, Voltage Selector; C&K V202-12-MS-02-QA
S501-506	Switch, SPDT Momentary Pushbutton; ITT-Schadow D6-04-01, with F14-04 gray cap
S507	Switch, Power Rocker; Carling RA 911-RB-O-N

T1	Power Transformer, PC-mounting; Signal LP-20-600 or direct cross-reference
T2,3	Transformer, 455kHz IF; Mouser 42IF102
XTAL1	Crystal, 2.048MHz (open mfgr.)
XTAL2	Crystal, 7.68MHz; (open mfgr.)
XTAL3	Crystal, 3.2MHz; (open mfgr.)

MAIL-ORDER COMPONENT SUPPLIERS

The following electronic component distributors have proven themselves reputable suppliers of both large and small quantities of parts. Any semiconductor, IC, capacitor, resistor or connector used in the Model 540 is *probably* available from one or more of these firms. Each supplier publishes a full-line catalog, available free for the asking. Minimum-order restrictions may apply; and export orders may be difficult.

Mouser Electronics — Call (800) 346-6873

Digi-Key Corporation — Call (800) 344-4539

ACTIVE (div. of Future Electronics) — Call (800) 677-8899

Allied Electronics (div. of Avnet) — Call (800) 433-5700

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 shipped" condition.

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

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

B. 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. Warranty does not apply to damage caused by misuse, abuse or accident. Warranty is voided by unauthorized attempts at repair or modification, or if the serial identification 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 90 days of the date of delivery will be repaired free of charge, or the equipment will be replaced, at the option of Inovonics.

B. Additionally, parts for repairs required between 90 days and one year from the date of delivery will be supplied free of charge. Labor for factory installation of such parts will be billed at the prevailing "shop rate."

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, and should be prominently displayed 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 factor is not covered under terms of the Warranty, and may occasion additional charges.