

**OPERATING AND MAINTENANCE
INSTRUCTION MANUAL**

MODEL 708

FM-STEREO GENERATOR



— USER'S RECORD —

Model 708 - Serial No. _____

Date Purchased _____

Warranty Card Mailed —

OPERATING AND MAINTENANCE INSTRUCTION MANUAL

MODEL 708

FM-STEREO PROCESSOR/GENERATOR

September, 1995

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Section I

INTRODUCTION

MODEL 708 PRODUCT DESCRIPTION

General Inovonics introduced its first FM-Stereo Generator in 1992. The original Model 705 was the hallmark of simplicity, and was intended to answer the more basic of FM radio broadcasting needs.

The Model 708 includes several additional features, and boasts performance superior to that of its predecessor. Through efficient manufacturing techniques and automated calibration procedures, the 708 maintains the tradition of a value leader among FM Stereo Generators.

Features Features of the Inovonics 708 include:

- Accurate front-panel metering of the input program, externally-applied subcarriers, and output signal levels.
- Built-in, metered combining for two external (RDS or SCA) subcarrier sources.
- Extended-response low-pass filtering with proprietary overshoot compensation.
- Digital synthesis of pilot and subcarrier for unexcelled performance and freedom from drift and routine adjustment.
- Built-in, adjustable Composite Processor.

AUDIO PRE-PROCESSING REQUIREMENTS

The Inovonics 708 Stereo Generator incorporates two separate circuits to safeguard against carrier overmodulation (over-deviation). Nonetheless, it is anticipated that the 708 will be preceded by some form of “audio processing” system which places a ceiling on program peaks with specific allowances for protection of the pre-emphasis characteristic. It is essential that this need for *split-spectrum* audio processing be understood and met.

**Pre-emphasized
Transmission**

FM broadcasting practice imparts a high-frequency *pre-emphasis* (high-end boost) to the input program signal prior to transmission. At the receiver a complementary *de-emphasis* (high-end rolloff) network restores overall flat frequency response. The purpose of this exercise is to reduce the high frequency noise which is invariably added in

transmission. This noise is generally worse for listeners who are some distance from the broadcasting station.

If a low frequency tone of, say, 300Hz is applied to the transmitter at a level which yields full carrier modulation (100% or $\pm 75\text{kHz}$ deviation), a high frequency tone of 10kHz applied at this same input level would overmodulate the carrier (400% or more!) because of the transmission pre-emphasis equalization. Normal voice and music programs have comparatively low energy at the higher frequencies, and actual statistics of program spectral composition were taken into account when pre-emphasis characteristics were established years ago. Nevertheless, occasional high energy, high frequency peaks (sibilants, cymbals, etc.) can still cause carrier overmodulation, even when program peaks are broadband-limited to 100%-modulation values. This is especially true when modern-day recordings of contemporary music constitute the program source.

Split-Spectrum Peak Control

A pre-emphasis network *ahead* of a broadband limiter, and a de-emphasis circuit *following* it, will deal with this situation, although the overall level will “duck” whenever a high-end peak occurs. This imparts a “choppy” sound to the program and reduces both intelligibility and perceived loudness. What is instead required is a program limiter operating as a dual-band device; a *broadband* section to cope with normal program peaks, and an *independent* high-frequency limiter (with proportionally faster time constants) to deal with those program components accentuated by the transmission pre-emphasis characteristic. A limiter of this type, now common in both FM and AM broadcasting systems, has negligible audible effect on most program material while providing absolute protection from carrier overmodulation. Comprehensive FM audio processing systems are available from Inovonics, and from a number of other suppliers.

Internal Overmod Protection

Overmodulation protection circuitry internal to the 708 starts with a complex, active peak clipper integral with the patented low-pass filter overshoot compensator. Because of its unique mode of operation, a good deal more peak clipping may be tolerated than with more simple audio clipping circuits. The 708 may, in fact, even be used “barefoot,” or with minimal audio pre-processing, yet still yield acceptable performance.

The 708 also features a built-in Composite Processor which can be adjusted to clip as much as 3dB into the multiplex signal. This clipping is performed *prior* to injection of the 19kHz stereo pilot and any auxiliary subcarriers. While this “composite clipping” technique is routinely used to increase perceived loudness, it is at the expense of introducing spurious harmonic products above the 54kHz upper band-edge of the composite stereo signal. Please refer to the further discussion on Page 17.

MODEL 708 TECHNICAL SPECIFICATIONS

Frequency Response (with pre-emphasis turned OFF, or through appropriate de-emphasis network):
± 0.5dB, 20Hz–15kHz; –1dB or less at 16kHz, –60dB or better at 19kHz.

Stereo Separation (L→R or R→L):
> 65dB, 20Hz–16kHz.

Distortion (1dB below 100% modulation):
< 0.1% THD in demodulated audio.

Noise:
Better than 80dB below 100% modulation in demodulated audio, 20Hz–16kHz. 38kHz residual and “digital” noise above 54kHz, –70dB or better.

Crosstalk (M→S or S→M):
Linear and nonlinear crosstalk, –50dB or better.

Stereo Pilot:
19kHz, ± 1Hz; injection level adjustable between 7% and 12%, relative to 100% modulation.

Program Line Inputs:
Active-balanced/bridging; accommodate input levels between –10dBu and +20dBu, equivalent to 100% modulation.

SCA / RDS Inputs:
10K-ohms, unbalanced; accept SCA or RDS subcarriers at 0dBu or greater levels for nominal 5% to 10% subcarrier injection, relative to 100% modulation.

Pre-emphasis:
May be jumpered for 75µs or 50µs characteristic; may be switched OFF at front-panel.

Composite Processor:
Adjustable between 0dB and 3dB clipping of the 100%-modulated multiplex waveform prior to 19kHz pilot insertion.

Composite (Multiplex) Output:
Adjustable between 2V p-p and 8V p-p; 75-ohm source impedance.

Digital Synthesis Sampling Rate:
608kHz (16X subcarrier oversampling).

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 708 is shown on the following page. Generator circuitry is explained in detail under Circuit Descriptions, Section V, which references Schematic Diagrams found in the Appendix, Section VI.

PATENT NOTICE

Low-pass filter overshoot compensation circuitry used in the Inovonics 708 is protected under U.S. Patent No. 4,737,725.

Figure 1 - Block Diagram, Model 708 FM-Stereo Generator

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 saved 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 MODIFICATION INSTRUCTIONS should they be issued by Inovonics.

MOUNTING

Rack Requirement

Inovonics' Model 708 is packaged to mount in a standard 19-inch equipment rack and requires only 1¾ inches (1U) of vertical rack space. The use of plastic "finishing" washers is recommended to protect the painted finish around the mounting holes.

Heat Dissipation

Consuming no more power than a bedside clock radio, heat generated by the 708 is insignificant. The unit is specified for operation within an ambient temperature range 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 the temperature below the stated maximum.

AC (MAINS) POWER

As Delivered

Unless specifically ordered for export shipment, the Model 708 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 the fuse supplied.

Voltage Selector A mains voltage selector switch is located beneath the top cover of the unit, adjacent to the AC mains connector on the circuit board. *With primary AC power disconnected*, slide the red actuator with a small screwdriver so that the proper mains voltage (115 or 230) is visible. You must always install an appropriate fuse, and should 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 solvent to redesignate.

BE SURE that the mains voltage selector setting and primary fuse value are appropriate for the mains supply before plugging the 708 into the wall outlet.

Power Cord The detachable power cord supplied with the 708 is fitted with a North-American-standard male plug. The individual cord conductors are *supposed* to be color-coded in accordance with CEE standards:

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

If this turns out *not* to be the case, we offer our apologies (cord vendors vary) and advise that U.S. color coding applies:

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

RADIO FREQUENCY INTERFERENCE (R F I)

Location Although we have anticipated that the 708 will be operated in close proximity to high-power transmitters, you should exercise care in locating the unit away from *abnormally* high RF fields.

Ground Loops In some installations a mains frequency or RF ground loop may be formed between the input or output cable shield grounds and the AC power cord ground. Use of a "ground-lifting" AC adapter should remedy the situation, though the chassis ultimately must be returned to earth ground for safety. Generally, being screwed-down in the equipment rack will satisfy this requirement.

LINE INPUT AND INPUT RANGE SELECTION

Input Connections The Inovonics 708 has electronically-balanced (transformerless) left- and right-channel PROGRAM LINE INPUTS. These are brought out to a screw-terminal barrier strip on the rear panel and include chassis ground connections for cable shields. *Please note that the screw-terminal barrier block can be unplugged from the chassis!* This makes initial connection easier and permits quick removal of the 708 from the rack should maintenance ever be required.

Balanced Inputs A balanced program audio feed to the 708 will use both the + and the – terminals, plus the associated G (ground) terminal for each of the two stereo channels. Since these are “bridging” (high impedance) inputs, they provide no termination for an audio processor or other equipment which feeds the 708. Please feel at liberty to connect a 600-ohm resistor across the input terminals should you feel this really necessary. Most professional equipment nowadays features low output impedances and high input impedances. The concept of 600-ohm “line-matching” dates from the age of transformer coupling and is rooted in the mystique of telephone engineering. More often than not, audio line impedance matching is ignored by today’s enlightened broadcasters (you) and leading-edge equipment manufacturers (us).

Unbalanced Inputs When the generator is fed from a test oscillator or other equipment with unbalanced outputs, the single center conductor of the shielded input lead should be connected to the + terminal, and the shield to G. *In addition*, a jumper wire should be installed between the – terminal and G.

Input Gain Range The 708 can accommodate line-level program inputs with a nominal “Zero-VU” value between –10dBu and +20dBu. This 30dB range is divided into two 15dB ranges by internal jumpering.

As shipped, the generator is jumpered for “professional” input levels between + 5dBu and + 20dBu, corresponding to 100% modulation. Most processor and STL receiver outputs will fall into this range, + 6dBu, + 8dBu and + 10dBu being typical levels.

Lower levels, between –10dBu and + 5dBu, may be encountered with feeds via lossy studio-transmitter telephone line circuits. The extra gain for the low-level range is enabled by changing jumpers beneath the top cover.

Gain Jumpers Under the top cover, and just behind the PROGRAM LINE INPUT barrier strip, you will find two jumper pin strips, each with a “push-on” jumper. The strips are identified as JMP2 and JMP3 in the circuit board legend, and each has an H and an L marking to indicate the proper jumper placement for high level and for low level inputs, respectively. Figure 2 illustrates jumpering options.

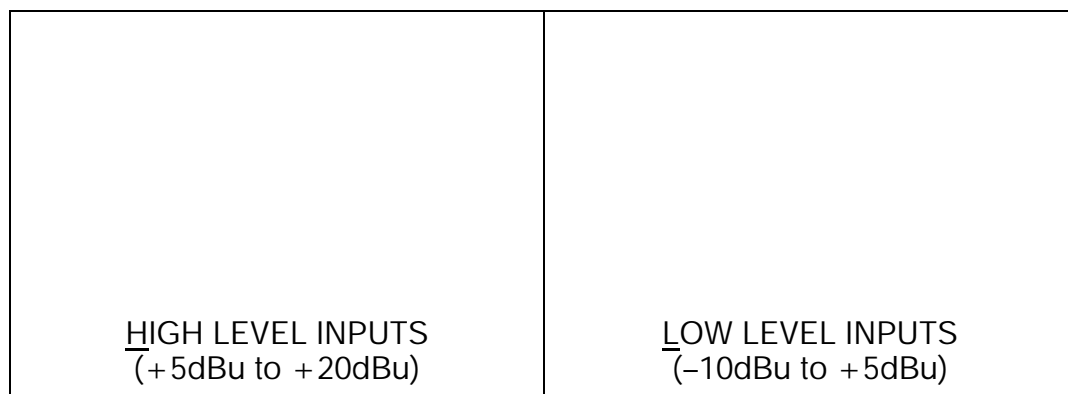


Figure 2 - PROGRAM LINE INPUT Range Selection

PRE-EMPHASIS SELECTION

The Model 708 Stereo Generator supports the 75-microsecond FM broadcasting pre-emphasis standard common to the Western Hemisphere and parts of the Orient, and the 50-microsecond standard used in Europe and Asia. Pre-emphasis appropriate to the shipping destination is jumpered at the factory, but this is easily changed if necessary.

Beneath the top cover and about two inches behind the input barrier strip are two jumper pin strips, each with a push-on jumper. These are identified as JMP1 and JMP4 in the circuit board legend, and each is designated with a 75 μ s and a 50 μ s marking to indicate proper jumper placement for the two available pre-emphasis characteristics. Figure 3 illustrates the jumpering options

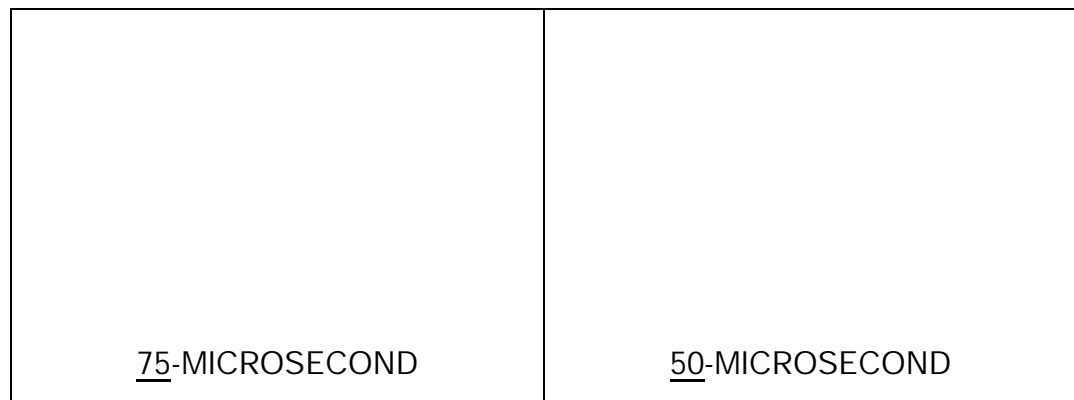


Figure 3 - Pre-emphasis Jumpering

SUBCARRIER INPUTS

Internal combining is provided for two auxiliary subcarriers for SCA and/or RDS services. The rear-panel SUBCARRIER INPUT connectors are unbalanced inputs with a load impedance in the neighborhood of 10K-ohms.

An RDS subcarrier normally accounts for 5% or less of the total composite multiplex output signal, making it 26dB or more below peak program modulation. SCA subcarriers typically have a higher injection level, about 10%, or 20dB below program peak deviation. Subcarrier inputs at a level of 0dBu or greater may be fed to the SUBCARRIER INPUT connectors, and can be regulated to the proper injection level by the front-panel SUB INJ. level controls.

Front-panel metering of the RDS or SCA subcarrier levels allows accurate adjustment of the injection level(s), even in the absence of a Modulation Monitor with a specific display of subcarrier injection.

COMPOSITE OUTPUT

The unbalanced COMPOSITE OUTPUT of the Inovonics 708 has a resistive source impedance of 75 ohms. This permits runs of moderate length (about 50 feet, maximum) to the exciter or microwave link input. If the cable length is more than just a few feet, the cable should, itself, have a 75-ohm characteristic impedance and be terminated in 75 ohms at the far end.

A Stereo Generator must always be connected to an exciter or link (STL) input specifically intended for multiplex stereo. This is a “flat” input, rather than a monaural program input with signal pre-emphasis. Program signal pre-emphasis is imparted by the 708.

Output Ground Loops

Because the Stereo Generator output and the exciter input are both unbalanced, it is best to locate the 708 near the exciter and power both from a common AC mains circuit. This will help avoid ground loops and mains-related hum in the transmitted signal.

Section III

SETUP AND OPERATION

PANEL CONTROLS AND INDICATORS

A brief description of the front-panel controls and indicators is given here. Do scan this section to at least verify that our terminology agrees with yours.

PLEASE NOTE that all front-panel multi-turn trim controls require *fifteen to twenty complete rotations* of the adjusting screw to cover their total operating range. Depending on the trim-pot manufacturer, the end of the range may, *or may not*, be identified by a “click-click” sound or other audible/tactile sensation.

| | |
|---------------|--|
| INPUT GAIN | These two controls at the far-right end of the front panel adjust the 708's input sensitivity for the nominal program level applied to the LEFT and RIGHT channel PROGRAM LINE INPUT barrier strip terminals on the rear panel. The controls have a 15dB range which is multiplied by input gain range jumpering to an input acceptance range of 30dB (see Page 9). The INPUT GAIN controls are adjusted so that the 100%-modulation “ceiling” imposed by Model 708 internal circuitry coincides with the input program peak level which corresponds to 100% modulation. |
| PRE-EMPHASIS | System pre-emphasis is imparted by the Stereo Generator in most situations. With the front-panel PRE-EMPHASIS switch IN, the selected characteristic (see Page 10) is <i>enabled</i> and the attendant green LED will light. If, on the other hand, pre-emphasized audio is applied to the 708, the switch should be set to the OUT position to avoid “double” pre-emphasis. This alternate mode is indicated by the red LED. |
| O'SHOOT COMP. | The Model 708 incorporates a patented overshoot compensation circuit which inhibits overshoots in the primary 16kHz audio low-pass filter sections. The switch is normally left in the IN position, indicated by the green LED. Compensation may be switched OUT for system tests which require carrier deviation in excess of 100% (maximum); this will light the red LED. The yellow LED to the right of the green one displays circuit action and will flash almost continuously when “bright” music is being broadcast. |

| | |
|--------------------------|---|
| PILOT | The PILOT switch lets the user manually turn off the 19kHz stereo pilot for certain tests. Since the 19kHz pilot is necessary for proper system operation, the switch should always be left ON. The green LED indicates normal operation, the red LED lights whenever the pilot has been turned off. |
| MODE | <p>Under some circumstances it may be advisable to broadcast monaurally. For example, should the station suddenly suffer an emergency power loss, temporarily reverting to mono transmission would help regain some of the lost coverage until full power is restored.</p> <p>When switched to MONO, the MODE switch removes both the stereo subcarrier and the 19kHz pilot. The transmitted signal will consist of L+ R, the algebraic sum of the left and right program channels. The MODE switch does <i>not</i> remove RDS or SCA subcarriers. Green and red LEDs indicate the MODE selection.</p> |
| COMPOSITE ADJUSTMENTS | <p>The PILOT INJ. and SUB 1/SUB 2 INJ. controls set the injection levels of the 19kHz stereo pilot and externally-applied SCA or RDS subcarrier(s). The OUTPUT LEVEL control varies the overall composite output level delivered to the exciter or STL. OUTPUT LEVEL is a “master” adjustment and does not affect the relationships (level ratios) between the stereo program, pilot and RDS/SCA subcarrier.</p> <p>MPX EQUAL. is a composite (multiplex) equalization trimmer in the output stage of the 708. This has been factory-set for best stereo separation into a resistive load, but can be used to compensate for frequency response deficiencies in a composite STL or in the input section of the exciter.</p> |
| COMPOSITE PROCESSING | <p>In the fully-counterclockwise OUT position, an output “safety” clipper acts on only those very fast program peaks and overshoots which sneak by the earlier protection circuitry. As the COMPOSITE PROCESSING control is rotated clockwise, the level applied to the safety clipper is increased by the dB value indicated on the front panel. Composite clipping will increase apparent loudness, but at the expense of generating some spurious harmonic products. The tabulation at the top of the next page is approximate; please refer to the discussion about additional implications of composite clipping on Page 17.</p> |

| <u>COMPOSITE PROCESSING</u> | <u>PEAK VALUE OF CLIPPING PRODUCTS</u> |
|-----------------------------|--|
| OUT | >60dB below 100% |
| 1dB | 50dB below 100% |
| 2dB | 45dB below 100% |
| 3dB | 40dB below 100% |

Composite clipping is performed *prior* to injection of the 19kHz stereo pilot and any subcarriers. This averts pilot clipping or other pilot amplitude modulation. Nevertheless, crosstalk of the program audio into RDS or SCA subcarriers is exacerbated by composite clipping and its inevitable intermodulation and harmonic generation. *Use this feature sparingly!*

"MULTIMETER"

An up/down momentary toggle switch cycles the front-panel metering among the various display options; LEDs identify the function monitored. The metered values are:

| | |
|-------|--|
| L | Left program input channel. |
| R | Right program input channel. |
| L+R | The sum of the left and right channels. |
| L-R | The difference of the left and right channels. |
| MPX | The composite multiplex output. |
| PILOT | The 19kHz stereo pilot. |
| SUB 1 | Subcarrier #1 |
| SUB 2 | Subcarrier #2 |

POWER

(Sorry, the function of this switch is classified.)

BARGRAPH METERING

The front-panel bargraph meter is useful in initial level-setting and to verify proper operation of the 708 Stereo Generator. The up/down switch to the right of the display cycles the meter through its various measurement functions.

The meter is peak-responding, and is scaled both in percent-modulation and in dB, with 0dB corresponding to 100% modulation. When switched to show measurements of PILOT, SUB 1 or SUB 2, an additional 20dB

(10X) circuit gain re-scales the measurements for these lower-level signals. For these measurements, the 100% marking should be read as 10%, and 0dB as -20dB.

NORMAL SETUP PROCEDURE

This setup procedure presupposes a normal installation with the Model 708 PROGRAM LINE INPUT fed *directly* from the output of a properly adjusted audio processor. As explained on Pages 3 and 4, the processing system must maintain program peaks at a ceiling value corresponding to 100% modulation, and incorporate “pre-emphasis protection” (independent high frequency) limiting in addition to broadband peak control. This procedure further supposes a *direct* connection of the COMPOSITE OUTPUT to the wideband input of an exciter/transmitter. Variations from these conditions, such as an intermediate STL or other link, analog or digital, in either the input or the output path of the 708, may call for considerations not addressed here.

At this point the 708 should be installed in the program chain with power applied, and have all front-panel function switches ON.

Input Gain Calibration

1. Double-check PC board jumpering options for proper line input range selection and for proper pre-emphasis selection.
2. Feed the *audio processor left* channel input, only, with a 500Hz sinewave test signal which yields 6dB to 10dB of indicated signal limiting. This should drive the processor left channel line output to its “ceiling” value and present the left channel input of the 708 with a signal representing 100% modulation of that channel.

NOTE: Good engineering practice prescribes a standardized audio line level at any equipment interface. This facilitates setup, troubleshooting, and “patching” alternate gear in and out of the program signal path. Take this opportunity to set the output level of the processing system at a preferred “zero-dB” level: +6dBm, +10dBm, or any other value common to station operation.

3. Set the bargraph meter to measure left channel (L) level. Adjust L INPUT GAIN for a 0dB, or 100%, indication.
4. Repeat steps 1 -3 for the right program channel. Be sure that *only* the right channel input of the processing system is driven.

Pilot and Subcarrier Adjustments

1. Set the bargraph meter to measure PILOT. Adjust the 19kHz stereo pilot (PILOT INJ.) control for desired injection; typically 9%. Keep in mind that the 100% point on the meter is actually 10% for this measurement.
2. Cycle the meter to read any subcarriers applied to the 708. The SUB 1 INJ. and SUB 2 INJ. controls may be adjusted for the desired injection levels for subcarriers. Typically, RDS subcarriers are set

to about 5%, SCA subcarriers to 10%. Again, the 100% mark on the meter should be read as 10% for these measurements.

**Output
Pre-check**

The initial portion of the output adjustment procedure is performed under *simulated* “on-air” operating conditions. Feed typical program material to the stereo generator via the processing system, but *stereo temporarily disconnected the generator from the exciter* until the pre-check verifies normal operation.

The processor, itself, should now indicate normal values of gain reduction, including a minimum of 6dB peak limiting of program audio peaks. Under this condition the 708 bargraph display will show consistent left (L) and right (R) channel signal activity peaking at 0dB. A display much in excess of 0dB indicates limiter overshoots and a possible deficiency of the processing system in maintaining a consistent output “ceiling.” Occasional overshoots up to +1dB or +2dB are to be expected, but anything above these values is cause to question processing effectiveness.

Temporarily set the front-panel COMPOSITE PROCESSING control fully clockwise to the 3dB point. With typical program audio applied, check bargraph metering of the composite multiplex output (MPX). Peak modulation should remain within the limits shown:

- Stereo program modulation only — 100%
- Stereo program and RDS only — 105%
- Stereo program and one SCA only — 110%
- Stereo program, RDS and SCA — 115%
- Stereo program and two SCAs — 120%

NOTE: MPX metering relates to the total composite output voltage peak excursion before the OUTPUT LEVEL control, *not* the actual FM carrier deviation. The 100% reference point represents a normal stereo signal without subcarriers; actual measurements will reflect the algebraic addition of any subcarriers.

**OUTPUT LEVEL
Adjustment**

PLEASE be certain that you understand operation of the station Mod-Monitor, and that it is properly calibrated and connected to the correct transmitter/exciter RF sample point. The remainder of this procedure is performed “on-air.”

1. Turn the 708 OUTPUT LEVEL control fully counterclockwise and connect the generator’s COMPOSITE OUTPUT to the input of the exciter.
2. Turn off or disconnect any subcarrier inputs to the 708. With only the stereo programming applied, advance the OUTPUT LEVEL control for a Mod-Monitor indication of *frequent* 100%-modulation peaks.
3. Back-down the OUTPUT LEVEL control slightly, so that the 100% peak flasher(s) light only occasionally.

4. Switch the Modulation Monitor to display the injection level of the 19kHz stereo pilot and confirm 9% injection. Touch-up the PILOT INJ. control, if necessary, then re-confirm 100% carrier deviation.
5. If an RDS or an SCA subcarrier is to be broadcast, re-connect it to the 708 at this time. Using the Mod-Monitor, or other means of reading the auxiliary subcarrier injection level, verify proper injection.
6. Reset the Mod-Monitor to read total carrier modulation. If necessary, trim the OUTPUT LEVEL control to maintain carrier deviation within legal limits. Depending on current operating rules and practices, when either an SCA or an RDS subcarrier is broadcast, total peak carrier deviation *may be permitted* to exceed the customary 100%-modulation figure. The station (or consulting) engineer should be aware of legal guidelines in effect and assume responsibility for any adjustment which deviates from this procedure.
7. Reset the COMPOSITE PROCESSING control to the full-counterclockwise, OUT position.

IMPLICATIONS OF COMPOSITE PROCESSING

In the FM “loudness war,” the ultimate tool in the broadcaster’s arsenal is *composite processing*. This is more appropriately called *composite clipping* since linear gain-reduction techniques cannot easily be applied to the “interleaved” multiplex stereo signal. The historic justification for composite clipping reflects the need to control the overshoots of uncorrected low-pass filters in early stereo generators.

Despite refinements in filter technology, which all but eliminate overshoot as a potential overmodulation problem, it seems that a small gain in perceived loudness can always be achieved by clipping peak excursions of the multiplex signal just before it is fed to the exciter. This clipping action is not without certain tradeoffs, however, among which are modulation of the 19kHz stereo pilot and the generation of out-of-band distortion components.

Pilot Modulation

The 19kHz stereo pilot, already at a level some 20dB below 100% modulation, is subject to amplitude perturbations by program peaks when overall composite clipping is employed. With more than about 1dB of clipping, the pilot can actually be lost for the duration of the clipped peak. The receiver’s stereo decoder may even lose phase-lock; this was a serious problem with early add-on composite clippers.

More sophisticated stand-alone composite clipping devices strip the 19kHz stereo pilot from the composite signal, clip the remaining multiplex stereo components, then re-apply the pilot. The Inovonics 708 simply performs its clipping function prior to initial pilot injection.

Out-of-Band Components

Simple clipping of a symmetrical waveform will invariably generate odd-order harmonics of the fundamental frequency. The level of, and signal degradation by, these harmonics will depend in large part on the *depth* of the clipping action. Because of its complementary pre- and de-emphasis, FM broadcasting can forgive a surprising amount of baseband clipping, insofar as audible distortion is concerned. Nonetheless, clipping products can clutter that part of the baseband spectrum reserved for RDS and SCA subcarriers, potentially creating crosstalk into those services. With one or two dB of clipping, distortion products will probably be tolerable. Much more clipping than this will not only compromise subcarrier services, but can interfere with adjacent stations as well.

Figures 4a through 4d reveal out-of-band components generated by composite clipping. These “worst case” examples were created by feeding a stereo generator from a CD player. No overmod-protection audio processing was employed, stereo generator input gain was adjusted such that the internal clippers associated with the pre-filter overshoot compensation circuit were active more than 90% of the time. The stereo generator output was monitored by a Tektronics 7L5 Spectrum Analyzer which accumulated data for the duration of the 6-minute rock music selection.



Figure 4a - Clipping OFF



Figure 4b - 1dB Clipping

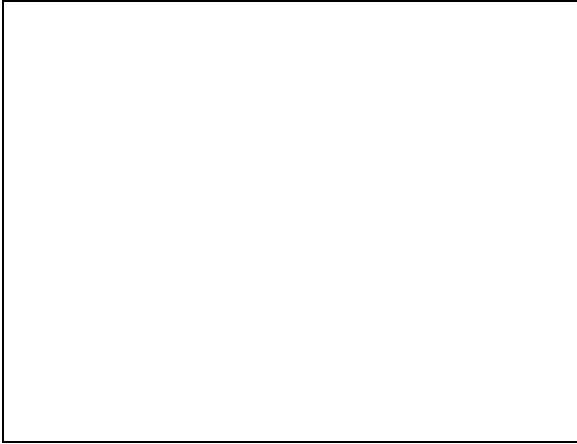


Figure 4c - 2dB Clipping

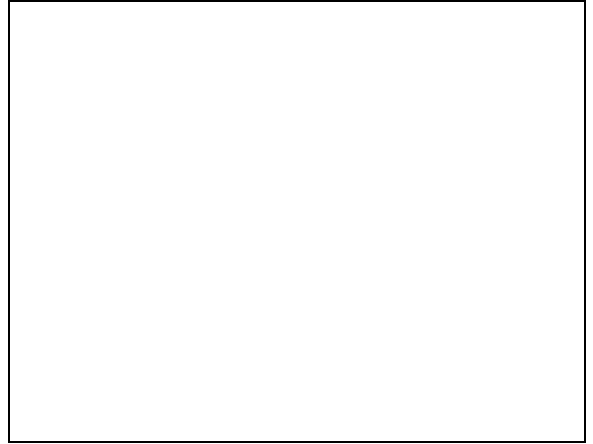


Figure 4d - 3dB Clipping

Section IV

CALIBRATION

“Routine” calibration of the Model 708 Stereo Generator is never required, its digital-synthesis circuitry is simple and stable. The only justification for confirming any of the internal adjustments is out-of-specification operation, and only after all other possible faults have been considered and eliminated. It’s worth a call to the factory to discuss any anomalies before charging-ahead and possibly making things worse.

Equipment Required

- **Dual-Trace Oscilloscope** — 5mV sensitivity, 20Mhz bandwidth, with two matched 10:1 probes.
- **Audio Generator** — 10Hz–1MHz, + 20dBm output capability.
- **AC Voltmeter** — with dB scaling.
- **Digital Multimeter**
- **Frequency Counter** — capable of accurate frequency measurement from 1kHz to 2Mhz.
- **“Precision” FM-Stereo Demodulator** — station Mod-Monitor with input for composite baseband signal.
- **Spectrum Analyzer** (optional*) — must have good resolution in the 100Hz to 100kHz (FM composite baseband) display range.
 - * The Spectrum Analyzer is *not* required if the “Precision” FM-Stereo Demodulator is capable of resolving crosstalk, stereo separation and 38kHz “residual” measurements to a value of -70dB or better.

Power Supply Check

1. Apply power to the 708.
2. Check that the positive and negative 9-volt regulated supplies are between 8.5V and 9.0V. You can check these on pin 8 (positive) and pin 4 (negative) of any 8-pin IC.

Clock Set

1. Use one of the low-capacitance ‘scope probes to connect to the input of the frequency counter. Check the clock frequency at the right-hand end of R59, between IC15 and IC16.
2. Adjust C34, the trimmer capacitor just below the SUBCARRIER 1 input connector, for exactly 1,216,000Hz.

Input Level Set

1. Preset the 708 front-panel switches as follows:
POWER — ON
MODE — MONO
PILOT — OFF
O'SHOOT COMP. — OUT
PRE-EMPHASIS — OUT
1. The input gain range should be jumpered for high-level inputs; this is the H position on jumpers strips JMP2 and JMP3. Apply the output of the Audio Generator to both the right- and the left-channel PROGRAM LINE INPUTS. Feed these two inputs in parallel, and in phase, by connecting the test signal "hot" lead to both + terminals, and the test ground lead to G. Both - terminals also should be connected to the G ground terminal.
2. Set the Audio Generator frequency to 400Hz, output level to +10dBu.
3. Clip the two 'scope probes to the output of the filter buffer amplifier, IC34. The most convenient monitor points are the right-hand ends of R128 and R135, for the left and right channels, respectively. The monitor points are identified in the circuit board legend with L and R designations next to the right-hand end of the two resistors.
4. Adjust both front-panel L and R INPUT GAIN controls for a scope display of approximately 9 volts peak-to-peak. Position the left channel waveform slightly above the right to keep track of which is which.

Low-Pass Filter Matching

The low-pass filter for the right program channel is not adjustable; rather, it employs close-tolerance components to meet design requirements. Since close frequency and phase response matching between stereo channels is essential to good Stereo Generator crosstalk performance, trim controls have been included in the left-channel filter so that it may be tuned to match right channel response.

1. Confirm that the PRE-EMPHASIS and O'SHOOT COMP switches are in their OUT positions. Frequency and phase response matching is optimized with these circuits inactive. The scope should continue to monitor the output of the filter buffer stage.
2. Increase the Audio Generator frequency to the first filter null, approximately 19.1kHz. Observing the lower (right channel) trace, down-range both oscilloscope vertical attenuators and fine-tune the Audio Generator frequency for the deepest null in the right channel signal.

HINT: When properly nulled, the signal waveform will be very close to the noise floor. If you find the nulled signal difficult to resolve, try triggering the 'scope timebase directly from the Audio Generator. This will make the waveform "hold still" and stand out from the (random) noise.

3. When the Audio Generator has been fine-tuned to null the right channel, adjust R116 (next to IC31) for a null in the left channel filter. Both channels should null to the same relative amplitude.
4. Increase the Audio Generator frequency to the second filter null, approximately 21.8kHz. Again, fine-tune the Audio Generator frequency for the deepest null in the right channel signal.
5. Adjust R122 (next to IC33) for a left-channel null.
6. Increase the Audio Generator frequency to the third filter null, approximately 34.6kHz. Once again, fine-tune the Audio Generator frequency for the deepest null in the right channel signal.
7. Adjust R141 (next to IC37) for a left-channel null.

Crosstalk Trim

If your station Mod-Monitor includes a true “precision” FM-stereo demod (crosstalk/separation resolution of 70dB or better), it may be used in lieu of a Spectrum Analyzer for this part of the Calibration Procedure. If a Mod-Monitor of *insufficient precision* is used, final Calibration (and performance!) of the 708 will reflect the inaccuracy.

1. Connect the COMPOSITE OUTPUT of the 708 to the input of the Spectrum Analyzer (or directly to the Composite Input of the Mod-Monitor).
2. Next, re-apply the Audio Generator test signal to the left and right PROGRAM LINE INPUTS of the 708 as described under the Input Level Set section at the beginning of this Procedure. The Audio Generator frequency should be 400Hz, but the level should be reduced for a peak-to-peak waveform amplitude of 6 volts on the right-hand ends of R128 and R135.
3. Monitor the “sub channel.” This is the 38kHz double-sideband, suppressed-carrier component on the Spectrum Analyzer (or an “L-R” Mod-Monitor reading).
4. Carefully adjust the front-panel INPUT GAIN L control for a null in the sub channel.
5. Adjust R156 (to the left of IC41) to further null the sub channel.
NOTE: Because the effect of the two preceding adjustments will appear to interact, it will be necessary to repeat Steps 4 and 5 until no further improvement in the sub-channel null can be achieved.
6. Increase the Audio Generator frequency to 15kHz. Adjust R141 (to the left of IC37) for the best null in the sub channel at 15kHz.
7. Repeat Steps 4, 5 (at 400Hz) and 6 (at 15kHz) until the sub-channel null at both frequencies is at maximum.

Because the Inovonics 708 utilizes digital techniques (instead of analog multiplication) to generate the subcarrier, crosstalk is symmetrical; that is, sub-to-main crosstalk will be identical to the main-to-sub which was optimized in the foregoing Procedure.

**Input Level
Calibration**

NOTE: This portion of 708 calibration must follow the preceding Crosstalk Trim procedure directly.

1. Re-apply 400Hz to both channels and monitor the filter buffer stage at R128 and R135, just as described at the beginning of this Procedure.
2. Turn the O'SHOOT COMP. switch to the IN position.
3. Make no changes to the 708 INPUT GAIN controls. Note that as the output level of the Audio Generator is increased, the 9-volt p-p waveforms will clip, or flatten, top and bottom. Carefully, adjust the output level of the Audio Generator to a point where the flattening is scarcely visible. As the O'SHOOT COMP. switch is switched between IN and OUT, there should be a just-perceptible change in the amplitude of the waveform(s) as the clipping circuit is biased into, and out of, operation. This Audio Generator output level setting represents the 100%-modulation level as applied to the 708 PROGRAM LINE INPUT terminals.
4. With the front-panel meter monitoring the left-channel input, L, adjust R45 for a *half-brightness* indication of the 0dB, LED.
5. Step the meter to monitor the right-channel input, R, and adjust R46 for a half-brightness indication of the 0dB LED.
6. Verify that L+R metering indicates 0dB with the LED at full brightness, and that nothing shows in the L-R position.

**Output Level
Calibration**

NOTE: This portion of 708 calibration must follow the preceding Input Level Calibration procedure directly.

1. Set the MODE switch to STEREO and turn the PILOT switch ON.
2. With the 400Hz, 100%-modulation input signals applied, turn the front-panel COMPOSITE PROCESSING control fully clockwise to the +3dB marking.
3. With the Modulation Monitor connected to the COMPOSITE OUTPUT of the 708, and with the Mod-Monitor set to read Total Modulation in its peak-responding mode, adjust the OUTPUT LEVEL control of the 708 for a 100% Mod-Monitor reading.
4. Switch the Mod-Monitor to measure the 19kHz stereo pilot injection level, and adjust the 708 front-panel PILOT INJ. control for a 10% reading.
5. If necessary, repeat Steps 3 and 4 to secure simultaneous 100% Total Mod. and 10% Pilot readings.
6. With 708 front-panel metering switched to MPX, adjust R47 for a 0dB indication.
7. With 708 metering switched to PILOT, adjust R48 for a 0dB indication.

8. Reset the COMPOSITE PROCESSING control to the full-counterclockwise OUT position. NOTE: when composite clipping is turned off, front-panel MPX metering will read -1dB when a steady-state, 100%-modulation input signal is applied.

**Stereo Pilot
Distortion Null**

NOTE: This portion of 708 calibration must follow the preceding Output Level Calibration procedure directly. At this point the Modulation Monitor should indicate 90% Total Modulation of the 400Hz Audio Generator test signal, and 10% pilot injection.

1. Disconnect the Audio Generator from the PROGRAM LINE INPUT of the 708 Stereo Generator.
2. Switch the Mod-Monitor to show 38kHz residual subcarrier.
3. Adjust R85 (to the right of the clock trimmer cap) to null the 38kHz second-harmonic-distortion component of the stereo pilot. The Mod-Monitor should indicate a 38kHz “residual” reading at the bottom of its most sensitive scale (-70dB or better).

**Subcarrier
Calibration**

NOTE: This portion of 708 calibration must follow the preceding Stereo Pilot Distortion Null procedure directly.

1. Downrange the Mod-Monitor display to verify that the 19kHz stereo pilot reads 10% in the Total Modulation measurement mode.
2. Switch the PILOT switch OFF.
3. Connect the output of the Audio Generator to SUBCARRIER INPUT 1 of the 708. Reset the Audio Generator frequency to 80kHz, output level to 0dBu.
4. Adjust the 708 front-panel SUB 1 INJ. control for a Mod-Monitor indication of 10% Total Modulation.
5. Switch the 708 metering to SUB 1 and adjust R49 for a 0dB reading.
6. Disconnect the Audio Generator from SUBCARRIER INPUT 1 and connect it to SUBCARRIER INPUT 2.
7. Adjust the SUB 2 INJ. control for a Mod-Monitor indication of 10% Total Modulation.
8. Switch the 708 metering to SUB 2 and adjust R50 for a 0dB reading.

Separation Trim

The traditional method of adjusting and verifying stereo separation is to visually monitor an oscilloscope display of the composite multiplex signal (one channel driven and stereo pilot off), and adjust for the straightest baseline of the DSB waveform. Although this technique does permit a rough separation calculation, even today’s best ‘scopes will show baseline distortion when overdriven to the extent necessary to resolve stereo separation of 40dB or more. For the high figures of separation which modern stereo generators can achieve, a precision stereo demodulator will give much greater measurement and, consequently, adjustment accuracy.

It is entirely feasible to trim the equalization and phase adjustments in the 708 output circuitry to correct for shortcomings elsewhere in the

transmission system; for instance, in a “composite” STL, or even in a long run of coax cable. The following procedure leaves the 708 adjusted for *its own* best stereo separation. Nevertheless, the front-panel MPX EQUAL. control will give a user the option of optimizing the entire transmission system, though he should keep in mind that a chain is only as strong as its weakest link. It’s far wiser to fix the weak link than to accommodate for it at another point.

1. The COMPOSITE OUTPUT of the 708 should be cabled directly to the composite input connection of the Mod-Monitor using a short cable of known characteristics, preferably 50-ohm or 75-ohm coax.

2. Preset the 708 as follows:

MODE — STEREO
PILOT — ON
O’SHOOT COMP. — OUT
PRE-EMPHASIS — OUT
COMPOSITE PROCESSING — OUT

1. Apply a 1.5kHz sinewave signal from the Audio Generator to the 708 *left* channel PROGRAM LINE INPUT *only*. Set the signal level for a 0dB indication on the 708 meter in the L position.
2. Check the Mod-Monitor reading of Total Peak Modulation. It should read between 90% and 100%.
3. Also check the Mod-Monitor indication of Pilot Injection Level. If necessary, adjust the 708 PILOT INJ. control for a 10% reading.
4. Switch the Mod-Monitor to display left and right channel levels. The left channel should measure about -1dB. Ideally, the right channel should read -70dB or below.
5. Adjust the front-panel MPX EQUAL. control for best stereo separation.
6. Change the Audio Generator frequency to 15kHz. Adjust R44 for best stereo separation at this higher frequency. R44 is located behind the COMPOSITE OUTPUT connector.
7. Repeat steps 5 and 6 to secure greatest separation at 1.5kHz and 15kHz, respectively. These two adjustments interact, but there will be only one final setting of each which will yield best separation at the two test frequencies. The optimum adjustment should yield > 65dB separation at all frequencies between 20Hz and 15kHz, left-into-right and right-into-left.

Section V

CIRCUIT DESCRIPTIONS

This section details the circuitry of the Inovonics Model 708 FM Stereo Generator. Circuit descriptions refer to the three pages of Schematic Diagrams contained in the Appendix, Section VI, Pages 38, 39 and 40.

Component Annotation The schematics may appear to be annotated in a somewhat haphazard manner, insofar as component reference designations are concerned. Rather than annotate the *schematic* in a logical sequence, we have instead chosen to designate the *components on the circuit board*, top-to-bottom, left-to-right, following the physical placement of the parts in their vertical rows. It is our expectation that this practice will aid any required troubleshooting, making it easier to locate the physical part or test point from an analysis of the circuit diagram.

Left and right program channel circuits are identical, so only the left channel will be described here. A skilled technician will be able to extrapolate for right channel operation with little effort.

INPUT CIRCUITRY

Line Input Balancing IC42B is an “active-balancing” stage for the left channel program line input, affording rejection of unwanted common-mode signals. When jumper JMP3 connects R202 *into* the network (H), the Line Input accepts “High” program levels between +5dBu and +20dBu. With R202 jumpered *out* (L), “Low” program levels from -10dBu to +5dBu are accommodated. Input range setup is described on Page 9.

The left channel INPUT GAIN control, R198, is in the feedback path of voltage-amplifier stage IC43B. This affords the 15dB variable gain adjustment within each jumpered range.

Pre-Emphasis IC45B provides the additional gain required for transmission pre-emphasis. C77 or C78, jumper-selected to parallel the input resistor to this stage impart the 50 μ s or 75 μ s characteristic, respectively. CMOS switch IC44D, controlled by the front-panel PRE-EMPHASIS switch, S6, turns the pre-emphasis on and off.

FILTER OVERSHOOT COMPENSATOR

Sources of Overshoot All low-pass filters exhibit a certain amount of overshoot and ringing when presented with complex input waveforms. Generally, the sharper the cutoff, the more pronounced the effect. Overshoots result from the elimination of higher-order input signal components which, prior to

filtering, helped define the signal peak amplitude. Even a fully phase-corrected filter will exhibit overshoots, and a 7-pole “elliptic” filter, as used in 708, can overshoot 3dB or more!

Other systems of overshoot control permit the primary low-pass filter to overshoot, then isolate and re-introduce the overshoots to cancel themselves in the signal path. The patented overshoot compensator in the 708, on the other hand, pre-conditions the limited program signal *ahead* of the filter so there is little or no tendency for the filter to *generate* overshoots in the first place.

Input Clipper Diodes CR26 and CR27 form a “hard” clipper at the compensator input and are biased to a point which represents 100%-modulation. Presumably, the program signal has already been limited to this same value, thus the two diodes rarely clip *legitimate* program waveshapes. Clipping at this point is limited to those fast transients which somehow elude the processing peak controller.

Phase-Lag and Recombining IC41A includes a phase-lag network which time-displaces the fast leading and trailing edges of steep waveforms. This means that the primary characteristic of a program waveform which would normally *excite* filter overshoots is instead added to the waveform *amplitude*. CR20 and CR21, also biased to the 100%-modulation level, “strip” these displaced-and-added components from the program signal. IC39A compares the “stripper” input and output, recovering the stripped-off components. As these contain much of the program harmonic (high frequency) information, we cannot afford simply to throw them away. By recombining these stripped-off program components with the stripped program signal *in opposite phase*, the spectral integrity of the program is maintained. This 180-degree displacement of certain program overtones is not discernible to the listener, but is quite effective in inhibiting filter overshoots.

IC48A combines the stripped-off signal components from both the right and the left channels. This is full-wave rectified by Q8 and Q9 to flash the front-panel O'SHOOT COMP. indicator whenever filter compensator action takes place.

LOW-PASS FILTER

The 7-pole, elliptic-function (Cauer) low-pass filter is an active version of the classic L-C designs worked-out in Germany during the late 1940s (probably with a slide rule!). The particular active configuration used in the 708 is sometimes called the “FDNR” because each of the legs to ground simulates a Frequency-Dependent Negative Resistance. Referring back to the classic L-C design, resistors in series with the signal replace series inductors, and each of the active circuits to ground replaces an inductor/capacitor series-resonant element.

Components in the right channel filter have fixed values. The resonant frequency of each of the left channel legs is variable over a small range so that the two channels may be precisely matched in amplitude and phase response.

A great “cookbook,” with this and other filter circuits which might prove valuable to the broadcaster, is the *Electronic Filter Design Handbook* by Arthur B. Williams, published by McGraw-Hill. The reader is kindly directed to this source for a more informed discussion of how the FDNR circuit works than we could possibly muddle-through here.

IC34B buffers the output of the low-pass filter and includes gain, both to compensate for the 6dB filter loss and to present the proper amplitude to the digital synthesis circuitry.

PILOT AND SUBCARRIER GENERATION

| | |
|------------------------------|---|
| Clock | IC18D is a crystal-controlled oscillator at 1.216Mhz. IC18A buffers the clock, and binary divider IC15A furnishes the 608kHz digital synthesis sampling frequency. |
| Pilot Generation | IC19 is an up/down BCD counter clocked at the 608kHz sampling rate. 1-of-10 decoder IC24, OR gate IC20D, and binary divider IC17B work together to keep IC19 continually counting from zero to 8, back down to zero, etc. Counting logic is decoded by a 1-of-9 de-multiplexer (IC23 and IC28B) which samples a resistor string with sine-weighted values. This generates <i>one-half</i> a sinewave for each counting cycle. IC15B reverses the DC polarity applied to the top of the resistor string for <i>every-other</i> up/down count, forming the complete 19kHz pilot sinewave from 32 discrete steps. R85 introduces an offset to compensate for any difference between the power supply rails, and is adjusted to null the 38kHz second harmonic component. The segmented Stereo Pilot is buffered by IC27A |
| Center-Sampling | Analog switch IC28A is controlled directly by the 1.216MHz clock, turning on for one-half of one clock period precisely at the <i>center</i> of each stepped pilot waveform sample. This charges C36 to the sample voltage value, which is held by buffer stage IC27B until the next center sample is taken. Center-sampling eliminates integration of switching noise which is concurrent with leading and trailing edges of the waveform steps. |
| PILOT Switch | In its OFF position, the front-panel PILOT switch, S4, presets IC6 to a zero count. This holds the stereo pilot at its zero crossing. |
| Subcarrier Generation | The FM-multiplex “composite” waveform consists of a “main” channel, conveying the L+R stereo sum in its normal audible frequency range, and a “sub” channel with L-R stereo difference information in the form of a 38kHz double-sideband, suppressed-carrier subcarrier. The 19kHz pilot is added to enable stereo receivers to reconstruct and re-introduce the 38kHz carrier for difference signal demodulation. |

Digital synthesis of the composite waveform is similar to the generation of the Stereo Pilot previously discussed, but with sinusoidal *commutation* between the left and the right stereo program channels at a 38kHz rate.

Up/down counter IC26 is clocked at the 608kHz sampling rate. The output is decoded by IC25. With gating provided by IC20C and CR19, IC26 counts continuously from zero to 8, back to zero, etc. A Pulse from IC16C presets the counter to its center position (count of 4) each time the pilot reaches the proper phase relationship. This ensures proper and constant synchronization between pilot and subcarrier.

IC35 and IC28C also decode the count, sequentially sampling each tap of the resistor divider string which bridges the left and right program audio signals. Sampled program audio is buffered by IC29B, center-sampled by IC28D, and held between samples by C38 and buffer IC29A. The stereo multiplex signal consists of 16 discrete, sinusoidally-weighted steps.

When the front-panel MODE switch, S3, is set to MONO, the counting sequence is halted with the counter preset at the center position (count of 4). This stops the subcarrier generation, and L+R audio appears at the 708 output. In the MONO position, S3 also stops the stereo pilot, regardless of how S4 is switched.

Composite Processor

The emitters of transistors Q5 and Q6 are biased to the same 100%-modulation level as the clipper diodes in the overshoot compensation circuit. The transistor base/emitter junctions comprise the composite clipping network. The buffered composite signal, less the stereo pilot, is presented to this clipper through front-panel COMPOSITE PROCESSING control R57. When R57 is set to its fully-counterclockwise OUT position, the clipper is essentially a “safety” clipper, catching only those occasional program peaks which somehow have evaded the earlier overshoot protection circuitry. As R57 is cautiously turned clockwise, program peaks at the 100%-modulation value may be subjected to as much as 3dB of clipping.

Even though the composite waveform is clipped prior to pilot injection, good broadcasting practice demands judicious use of this feature. (See Page 17.)

Q5 and Q6 also function in the common-collector mode to flash the indicator adjacent to the COMPOSITE PROCESSING control. Additional gain is provided by IC14 to light the LED, which gives a visual indication of circuit action.

Combining Amplifier

IC22B is a combining stage for the main/sub portion of the composite signal, the stereo pilot, and any optional RDS or SCA subcarriers applied to the rear-panel SUBCARRIER INPUT connectors. Adjustment over the composite level delivered to the exciter is afforded by R58, the front-panel OUTPUT LEVEL control in the feedback path of IC22A.

Output Filter Since all components of the composite output are digitally synthesized at a 608kHz rate, only a simple filter is required to eliminate the sampling frequency from the Stereo Generator output. L2, L1, C25 and C26 form a 4-pole filter with quasi-Butterworth response. This filter is exceptionally flat to about 100kHz, but effectively prevents any higher-order digital noise components from appearing at the 708 output.

Output Phase and Equalization Trimmers The output amplifier consists of IC21A, IC10B, and transistors Q3 and Q4. R71 is the front-panel MPX EQUAL. control, affording variable high frequency tip-up and an opportunity to optimize stereo separation of the overall transmission system. R56 is an internal trim control to calibrate multiplex signal phase response.

BARGRAPH METER

Display Selector Front-panel “up/down” selector switch S2 cycles the display among its various internal monitoring functions. Three sections of IC13 de-bounce the switch contacts; the fourth section, IC13A, presets the counter to the default MPX display when power is first applied. The BCD output of up/down counter IC12 is decoded by two, 8-channel CMOS multiplexers. IC1 lights the appropriate identifier LED below the bargraph display, and IC11 routes the selected signal to the metering circuit.

Left- and right-channel program signals, taken just after pre-emphasis amplifier IC45, are presented, independently, to two inputs of multiplexer IC11. Left and right audio is also matrixed: IC6A derives the L+R stereo sum, IC6A the L-R stereo difference. Sum and difference signals are scaled to give a reading of 0dB when both channels are driven to the 0dB point, in- and out-of-phase, respectively.

The combined composite multiplex signal, the stereo pilot, and the two subcarrier input signals are also routed to multiplexer IC11. All monitored signals may be trimmed by appropriate meter calibration controls, except for the stereo sum and difference which are based on trimmed left and right values.

Meter Rectifier Voltage-gain stage IC10A feeds the full-wave, peak-responding rectifier circuit. The value of positive-going waveform peaks is buffered by IC4B and rectified by diodes CR8 and CR9. Negative-going values are inverted by IC4A and rectified by CR6 and CR7. The absolute value is held by C9, IC5A buffers the feedback around the rectifiers.

Buffer stage IC5B drives the three cascaded LED driver ICs. A small amount of mains-frequency “dither” is added to the DC level to provide a smooth fade from one LED display segment to the next.

Each of the LED drivers contains ten voltage comparators and a resistive voltage-divider reference. When the three are “stacked,” this creates a 30-step voltage-linear readout, though only 29 segments

comprise the Model 708 display. The front-panel meter is scaled both in percent-modulation and in dB. This is similar to a standard VU meter except for the peak-response ballistics.

Each of the three LED bargraph modules is *series*-connected. This is a power-saving technique since each *module*, rather than each individual *segment*, draws only 5 milliamps. This technique does demand more than the bipolar 9-volt regulated supply, however, so the LEDs and their associated driver ICs use a separate ± 12 -volt supply taken prior to the 9-volt regulators.

POWER SUPPLY

Stereo Generator circuitry operates from a bipolar 9-volt supply. The two supplies are regulated by linear “three-terminal” IC voltage regulators: IC2 for the +9-volt supply, IC3 for the -9-volt supply. The power transformer has dual primary windings which may be switched in parallel or in series for 115V or 230V mains, respectively.

The rectified raw DC from the input filter capacitors runs the front-panel LED bargraph display. Emitter-followers Q1 and Q2, clamped by zener diode CR10, prevent the LED supply from exceeding a total of 24 volts, overall.

Section VI

APPENDIX

The following section of this Manual contains Parts Lists for the Inovonics 708 Stereo Generator, Schematic Diagrams of all electronic circuitry, and an explanation of Inovonics' Warranty Policy.

PARTS LIST

EXPLANATION OF PARTS LISTINGS

This section contains listings of component parts used in the Inovonics 708 FM-Stereo Generator. These are listed either *en-masse*, or by schematic component reference designation, and may, or may not, specify a particular manufacturer. When no manufacturer is called-out, the term “open mfrg.” advises that any manufacturer’s product is acceptable.

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 and we’ll do our best to figure out what you need and get it on its way to you.

PARTS LISTING

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

- a) **Under 100pF** are “dipped mica” type, DM-15 (or CM-05 military series) size designation; “P” value is picofarads, $\pm 5\%$, 200VDC; (open mfrg.).
- b) **100pF to 0.47 μ F** are of the metalized mylar or polyester variety; whole number “P” values are picofarads, decimal values are microfarads, $\pm 5\%$, 50VDC or better. The style used in the 708 is the “minibox” package with lead spacing of 0.2 inch. **Preferred mfrg.:** Wima MKS-2 or FKC-2 series. **Alternates:** CSF-Thompson IRD series or Roederstein KT-1808 or KT-1817 series.
- c) **1.0 μ F and above** are radial-lead electrolytics, value per schematic, 25VDC; (open mfrg.).

| | |
|--|--|
| C1,2 | Capacitor, Ceramic Disc “Safety” Mains Bypass, .0047 μ F, 440VAC; Murata/Erie DE7150 F 472M VA1-KC (preferred) |
| C5,6 | Capacitor, Electrolytic, axial leads, 1000 μ F, 35VDC; (open mfrg.) |
| C31 | Capacitor, Monolithic Ceramic, 0.1 μ F, 50VDC; (open mfrg.) |
| C34 | Capacitor, Variable, 5-50pF; Mouser 24AA024 |
| C39-43,48-51, 54-57,59-61, 67,78 | Capacitor, “High-Q,” .0033 μ F, 2.5%, 100VDC; Wima FKC-2 (Polycarbonate) preferred, any equivalent <i>must</i> have identical characteristics. |
| CR1-5,11 | Diode, Silicon Rectifier; (open mfrg.) 1N4005 |
| CR6-9,12-27 | Diode, Silicon Signal; (open mfrg.) 1N4151 or equiv. |

| | |
|---|---|
| CR10 | Diode, Zener, 22V; (open mfr.) 1N5251 |
| 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.) |
| FB1 | Ferrite Bead; Amidon 73-801 |
| I1-9,16 | LED Indicator, diffused yellow, T-1 package; Stanley MAY 3378S |
| I10,12,14,17, | LED Indicator, diffused pastel red, T-1 package; Stanley MVR 3378S |
| I11,13,15,18 | LED Indicator, diffused pastel green, T-1 package; Stanley MPG 3878S |
| BAR1,2 | 10-Segment LED-bar display module, green; Kingbright DC-10GWA |
| BAR3 | 10-segment LED-bar display module, yellow; Kingbright DC-10YWA |
| — | Right-angle socket for BAR1-3 (708 requires two, 14-pin and two, 16-pin.); Circuit Assembly Corp. CA-14SE-10RAC3-01 (14-pin), CA-16SE-10RAC3-01 (16-pin) |
| — | Pin-strip sockets for BAR1-3; E-CAM 250-1-2510-1208 (708 requires three, broken into two strips of 30) |
| IC1,11,23,35 | Integrated Cct.; (open mfr.) CMOS 4051B |
| IC2 | Integrated Cct.; (open mfr.) LM317-T (Uses Aavid 574602 B03700 Heat Fin) |
| IC3 | Integrated Cct.; (open mfr.) LM337-T (Uses Aavid 574602 B03700 Heat Fin) |
| IC4,5,27,29 | Integrated Cct.; Motorola MC34082P |
| IC6,10,14,21, 22,30-34, 36-43,45-48 | Integrated Cct.; (open mfr.) LF353N |
| IC7,8,9 | Integrated Cct.; National Semi. LM3914N |
| IC12,19,26 | Integrated Cct.; (open mfr.) CMOS 4029B |
| IC13 | Integrated Cct.; (open mfr.) CMOS 4093B |
| IC15,17 | Integrated Cct.; (open mfr.) CMOS 4013B |
| IC16 | Integrated Cct.; (open mfr.) CMOS 4081B |
| IC18 | Integrated Cct.; (open mfr.) CMOS 4011B |
| IC20 | Integrated Cct.; (open mfr.) CMOS 4071B |
| IC24,25 | Integrated Cct.; (open mfr.) CMOS 4028B |
| IC28,44 | Integrated Cct.; (open mfr.) CMOS 4066B |

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| J1 | AC Mains Connector, PC-mounting; Switchcraft EAC303 |
| J2 | 6-Position Barrier Block; PCD Co. ELFH06210 PC-mounting header with ELFP06210 plug-in screw-terminal block. |
| J601-603 | Connector, BNC chassis-mounting male; Amphenol 31-221 |
| JMP1-4 | Shorting "Shunt" for 0.1-inch header strip (open mfr.) |
| L1 | Inductor, fixed, 560 μ H; ACT Co. PA2-561K |
| L2 | Inductor, fixed, 220 μ H; ACT Co. C4-221K |
| Q1,5,8,9 | Transistor, NPN; (open Mfr.) 2N3904 |
| Q2,6,7 | Transistor, PNP; (open mfr.) 2N3906 |
| Q3 | Transistor, PNP; Motorola MJE350 |
| Q4 | Transistor, NPN; Motorola MJE340 |

Unless specifically noted by component reference designation below, **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 Beckman 89PR series, Tokos RJC097P series, or equivalent "cermet" types.
 - d) **Single-Turn Trimmers** (circuit board) are Beckman 91AR series or Tokos GF06U1 series.
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| R57 | Resistor, Variable, 5K; Piher PT-15-YB-5K with Fig. 3 spindle. Uses Rogan 1R00A110BD001/PT-0-WL knob. |
| S1 | Switch, DPDT Slide, Voltage Selector; C&K V202-12-MS-02-QA |
| S3-6 | Switch, 2-position SPDT Miniature Toggle; C&K 7101-M-D9-A-B-E |
| S2 | Switch, 3-position SPDT "Center Off" Miniature Toggle; C&K 7105-S-D9-A-B-E |
| S501 | Switch, Power Rocker; Carling RA 911-RB-O-N |
| T1 | Power Transformer, PC-mounting; Signal LP-20-600 or direct cross-reference |
| Y1 | Crystal 1.216MHz; <i>SPECIAL - Inovonics Part No. 1242</i> |

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