SECTION 1 - THEORY OF OPERATION

1-1 GENERAL

The 2975 digital radio test platform integrates over 20 radio-testing instruments into a single user-friendly instrument that offers the interconnectivity normally expected from a personal computer.

The 2975 digital test platform, created with modular design, is simple to support and upgrade. The 2975 provides comprehensive transmitter and receiver testing, while the full-range spectrum analyzer and tracking generator make possible base site component testing. The dual channel oscilloscope and internal DEMOD scope provide comprehensive viewing of signals.

This following sections, System Overview and Module Overview, provide the maintenance technician with a concept of how the 2975 operates.

1-2 SYSTEM OVERVIEW

RECEIVE SYSTEM OVERVIEW

The 2975 is capable of receiving modulated or unmodulated signals ranging form 1 MHz to 2.7 GHz. Signals are received through the Power Termination Assy at the ANT Connector (low power signals, <-10 dBm) or T/R Connector (high power signals, >-10 to +50 dBm). A diode detector serves to measure RF power applied to the T/R Connector. The ANT Connector and GEN Connector are protected from high power levels by a limiter circuit. Refer to the Generate System Overview for more details on the GEN Connector. The RF signal is routed to the Receiver Assy.

The Receiver Assy has selectable attenuators and provides reference signals of 10, 40, 80 and 400 MHz to the system. External 10 MHz I/O is routed from the Receiver Assy to the Rear Panel Assy. In the Receiver Assy, the incoming signal is converted to an IF (immediate frequency) of 10.7 MHz and signal conditioning is started. The 10.7 MHz IF signal is passed on to the Video/IF PCB Assy.

The IF/Video PCB Assy has selectable 10.7 MHz IF filtering of 30 kHz, 300 kHz and 6 MHz. Both the CAI (Common Air Interface) PCB Assy and the IF/Video PCB Assy work together to provide the AGC (automatic gain control) for the Receiver Assy. The CAI PCB Assy sends data to the IF/Video PCB Assy to increase or decrease the gain automatically, providing the correct level to the CAI PCB Assy. The IF/Video PCB Assy also is responsible for Analyzer resolution bandwidth filters in the “Look and Listen” mode of 300 Hz, 3 kHz and 60 kHz. When the dedicated Analyzer mode is selected, all combinations of IF filtering are used to provide a fully functional Spectrum Analyzer. Additional functions of the IF/Video PCB Assy are: 10.7 MHz IF output to the Rear Panel Assy, Video output to the Rear Panel Assy and IF Count to the Multifunction PCB Assy. The final destination of the 10.7 MHz IF signal is routed to the CAI PCB Assy.

The CAI PCB Assy receives the 10.7 MHz IF signal and digitally performs the demodulation process. Demodulation types include FM, AM, P25 and P25Encr. During the demodulation process, the signal is measured for correct power strength. If the incoming power is incorrect, data is provided back to the IF/Video PCB Assy for AGC control as previously discussed in the IF/Video PCB section above. The CAI PCB Assy provides digitally demodulated signals to the system for meter functions such as: Receiver Level Meter, Deviation Meter, C4FM Meter, Demod Output, Internal Demod Scope and Speaker. Other CAI PCB Assy functions are discussed in the Generate System Overview.

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GENERATE SYSTEM OVERVIEW

The Generate System path starts with the CAI PCB Assy. The CAI PCB Assy digitally modulates an 11.4 MHz IF signal. The Modulation sources are M1, M2, Mic and Audio. The Modulation types include FM, AM, P25 and P25Encr.

Primarily Digital audio sources begin in the Multifunction PCB Assy and are transferred to the CAI PCB Assy, however; the CAI PCB Assy provides P25 and P25Encr (encrypted) digital audio sources. The 11.4 MHz IF signal is routed to the Generator Assy.

The Generator Assy is designed to convert the 11.4 MHz IF signal to the desired output frequency between 1 MHz to 2.7 GHz. The variable attenuator in the Generator Assy provides 9.9 dB attenuation in 0.1 dB steps between the 10 dB steps of the Attenuator Assy. The signal is amplified to a level high enough to overcome the losses of the Attenuator Assy and Power Termination Assy and to meet the specified maximum output power level. The desired RF signal is then routed to the Attenuator Assy.

The Attenuator Assy consists of six relay-attenuator sections and a driver board. One relay-attenuator section is 10 dB and the other five relay-attenuator sections are 20 dB for a total attenuation of 110 dB. After the Attenuator Assy, the RF signal goes to the Power Termination Assy.

The RF signal can be routed out the GEN Connector or the T/R Connector in the Power Termination Assy. The GEN Connector provides a maximum output signal of +10 dBm and the T/R Connector provides a maximum output signal of -30 dBm over the 1 MHz to 2.7 GHz range.

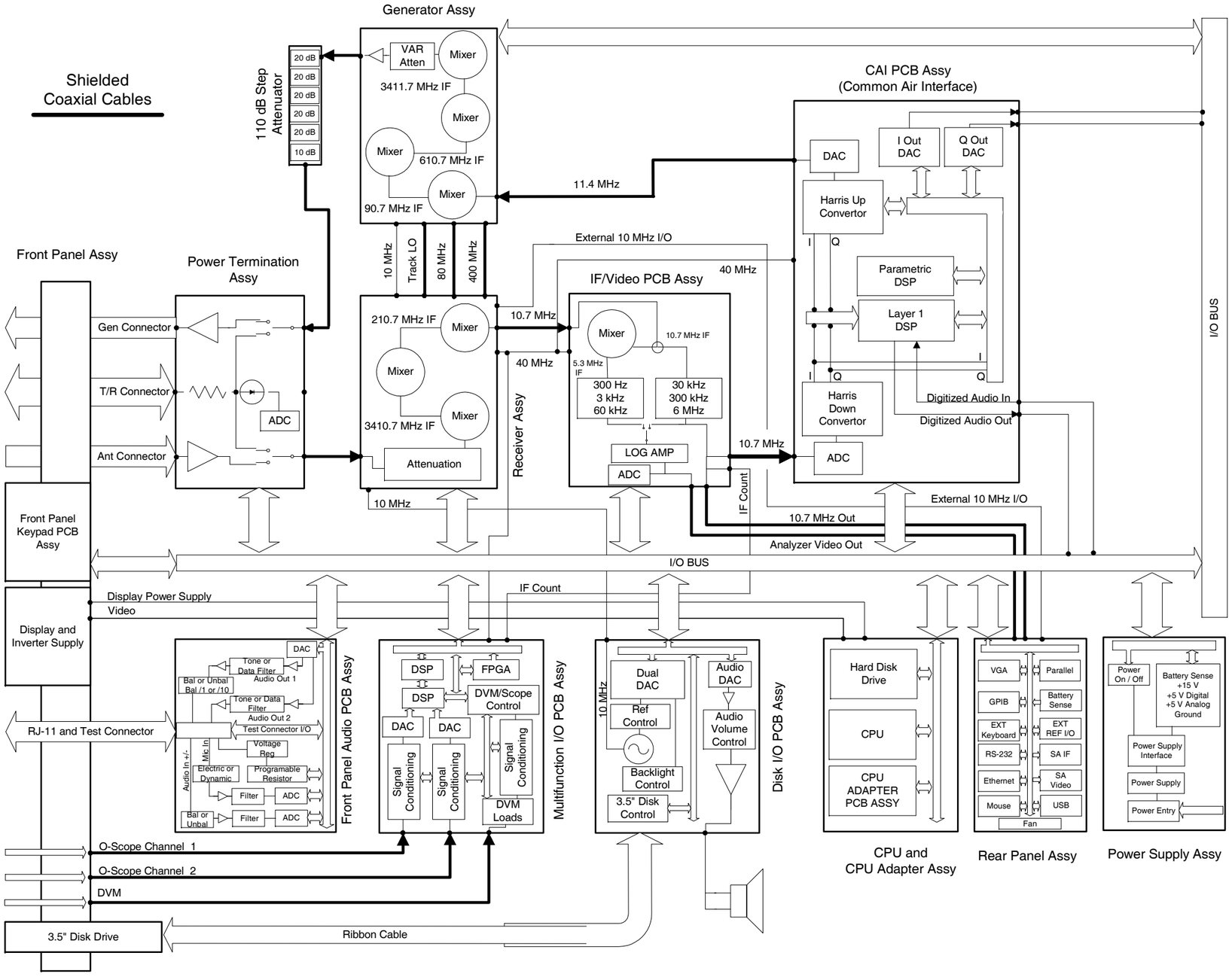

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Figure 1-1 2975 System Overview

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1-3 MODULE OVERVIEW

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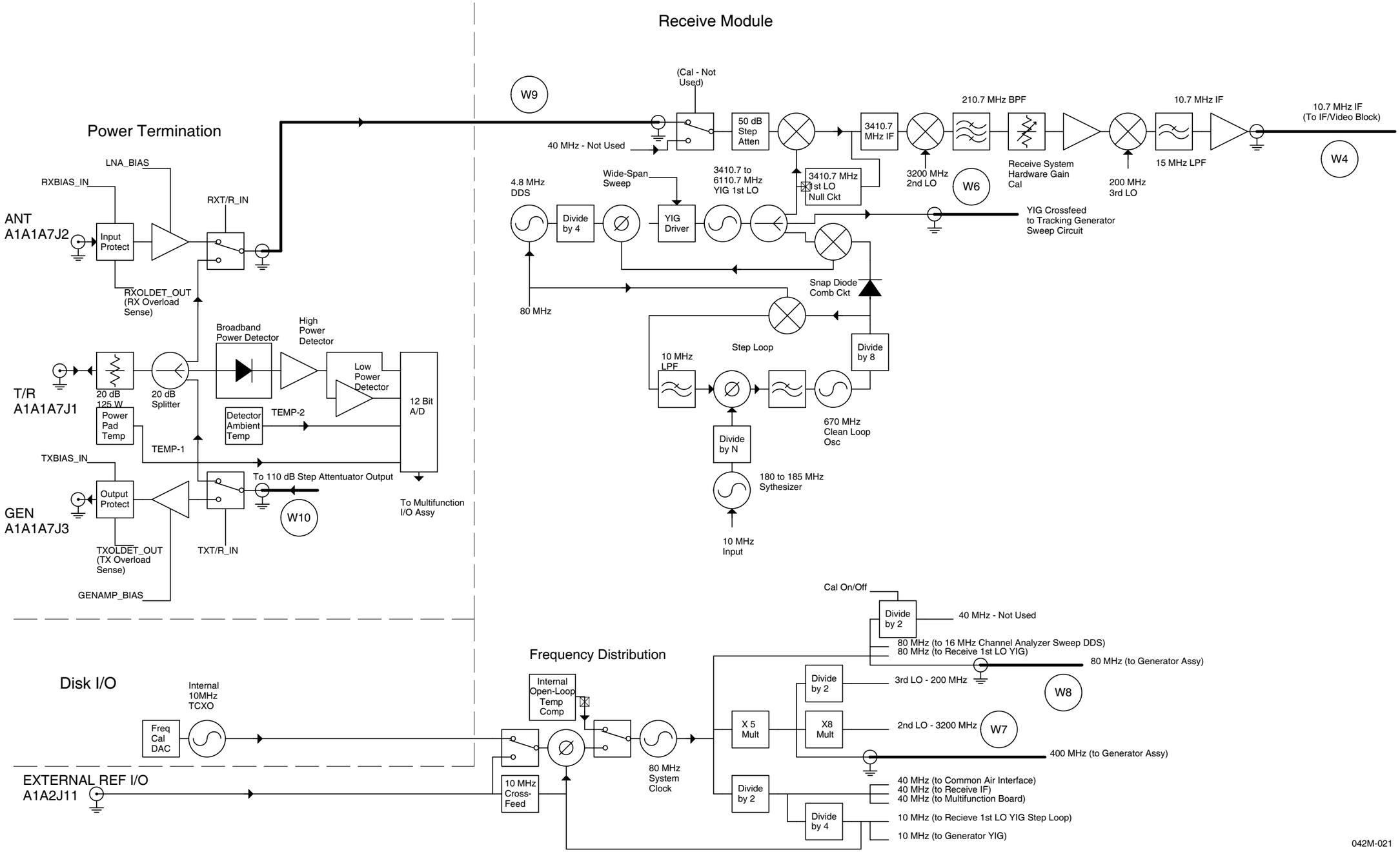

Figure 1-2 2975 Module Overview

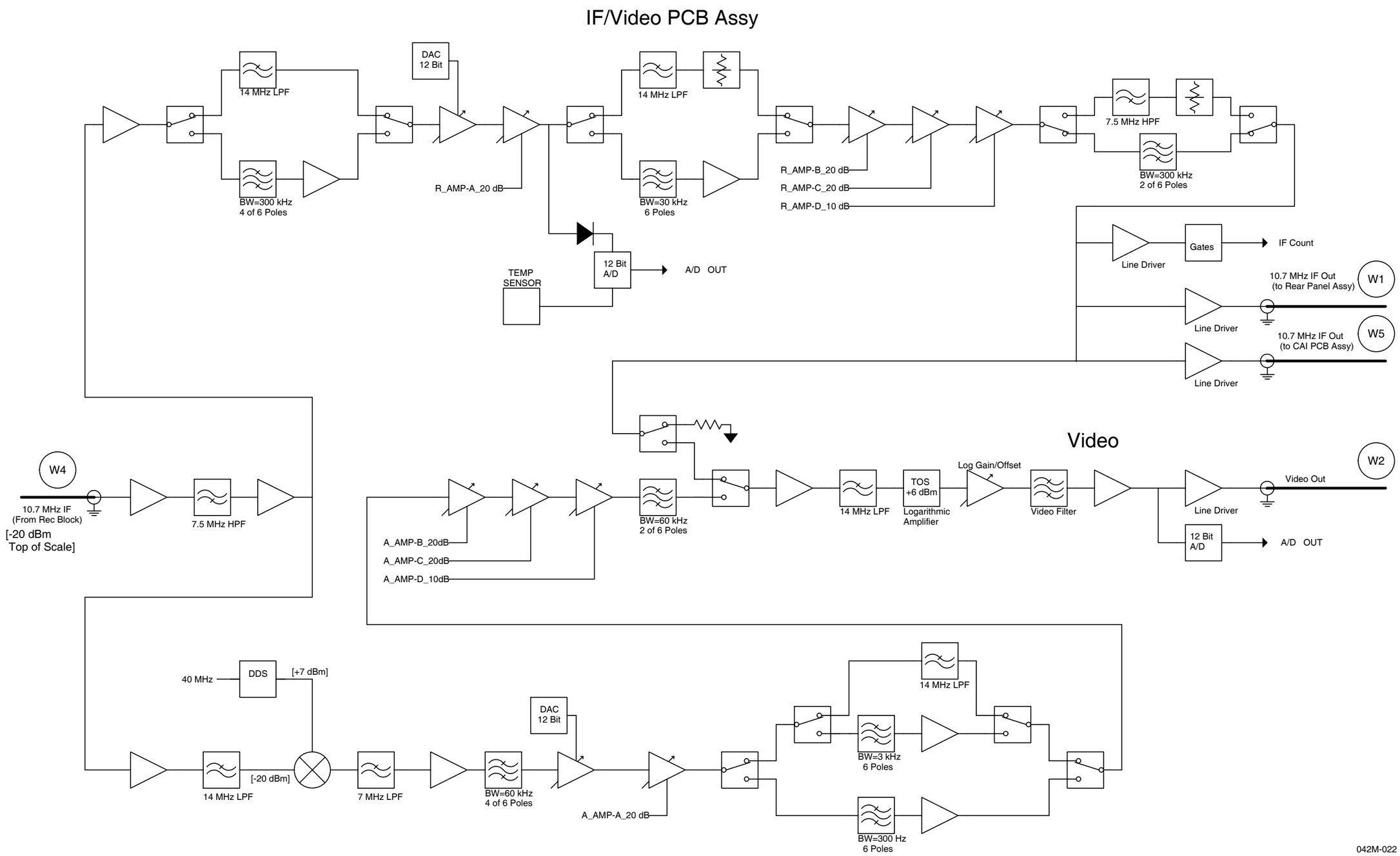

Figure 1-2 2975 Module Overview (cont)

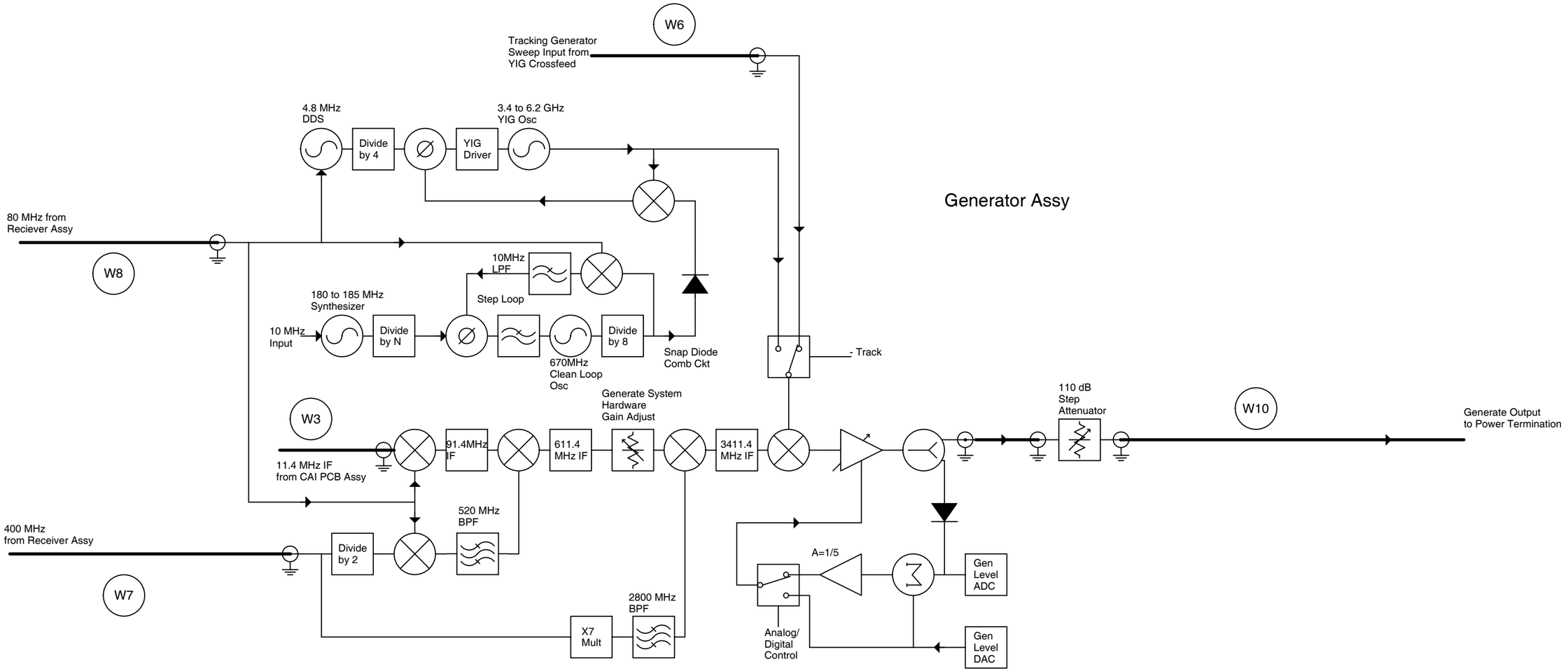

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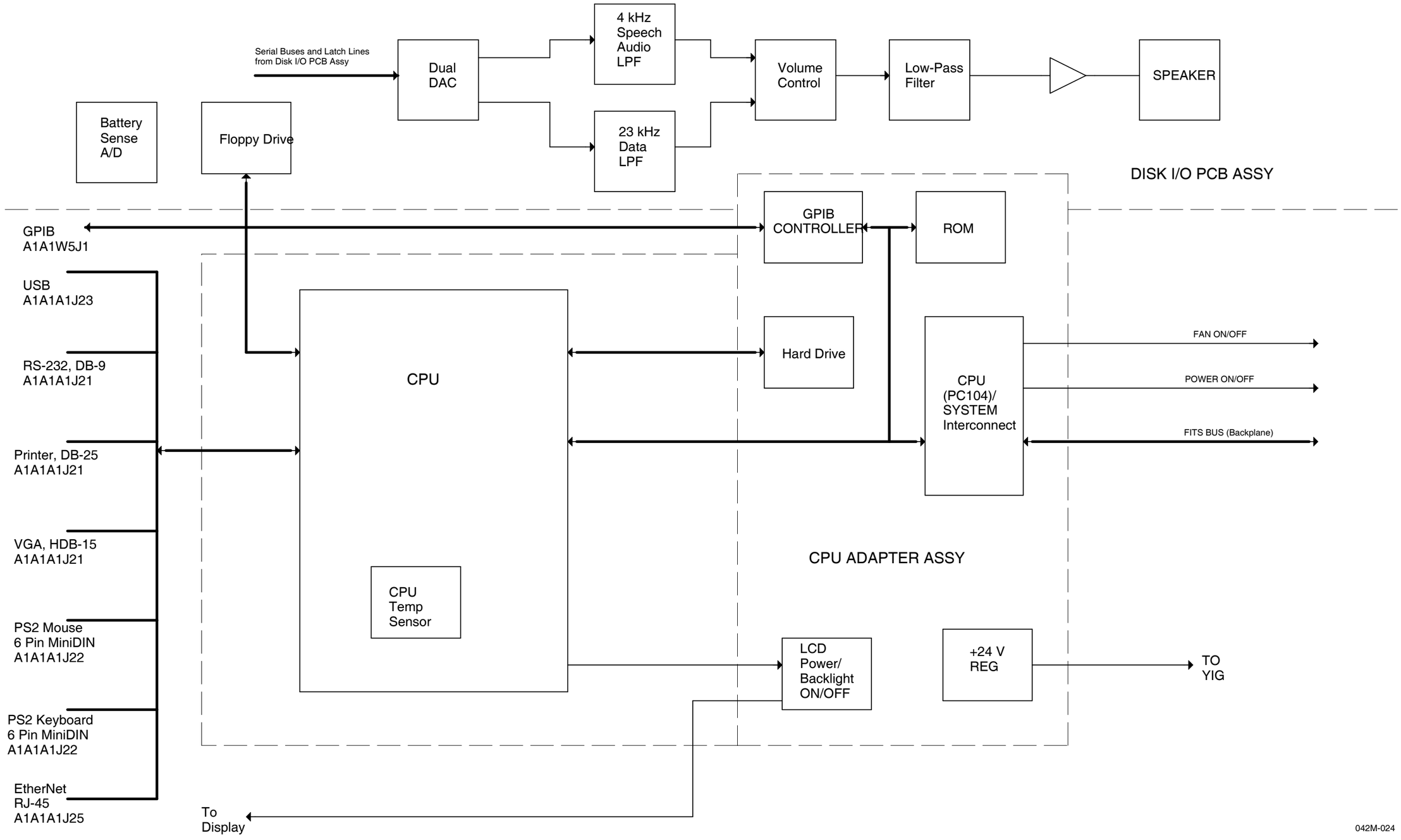
Figure 1-2 2975 Module Overview (cont)



042M-024

Figure 1-2 2975 Module Overview (cont)

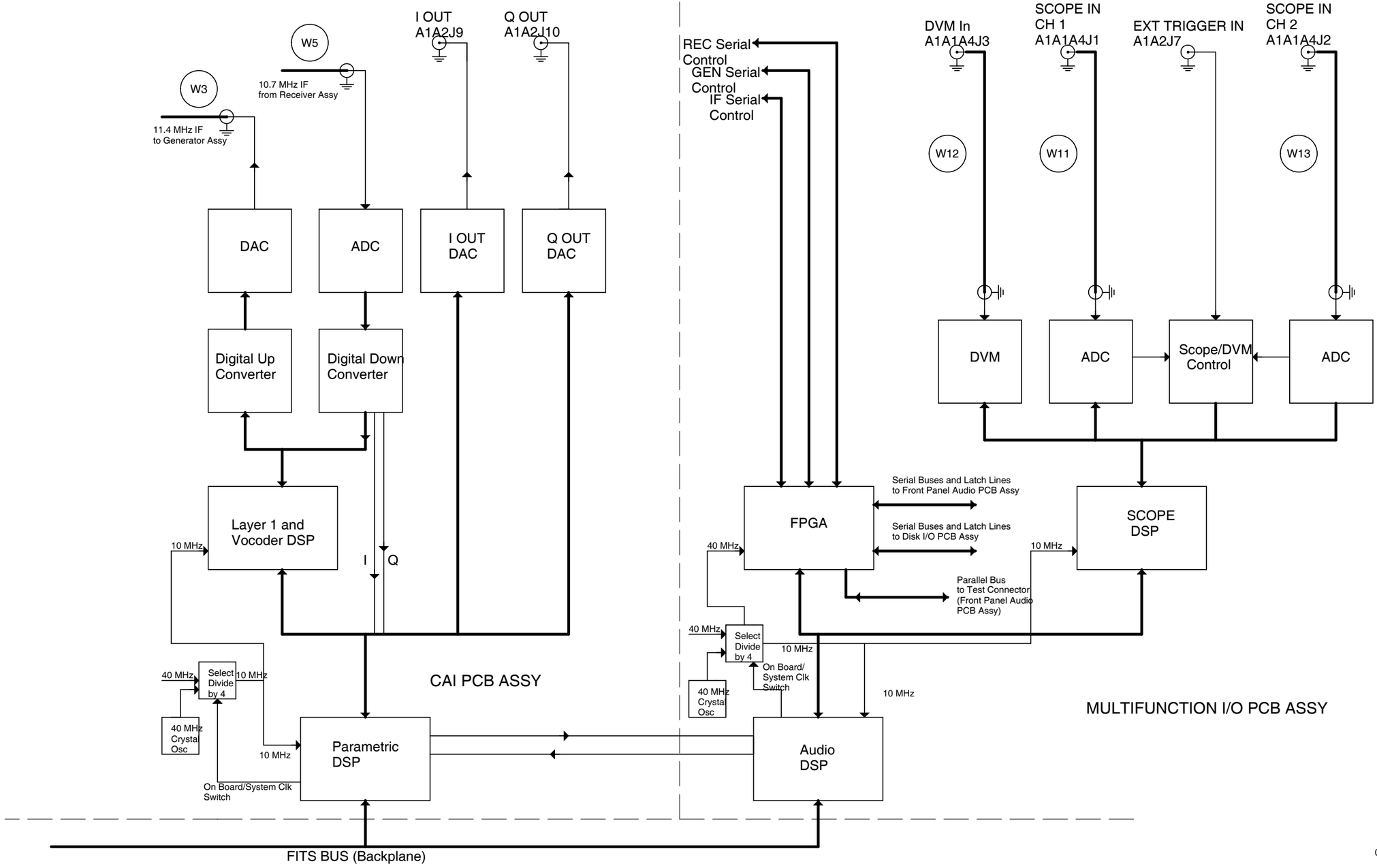
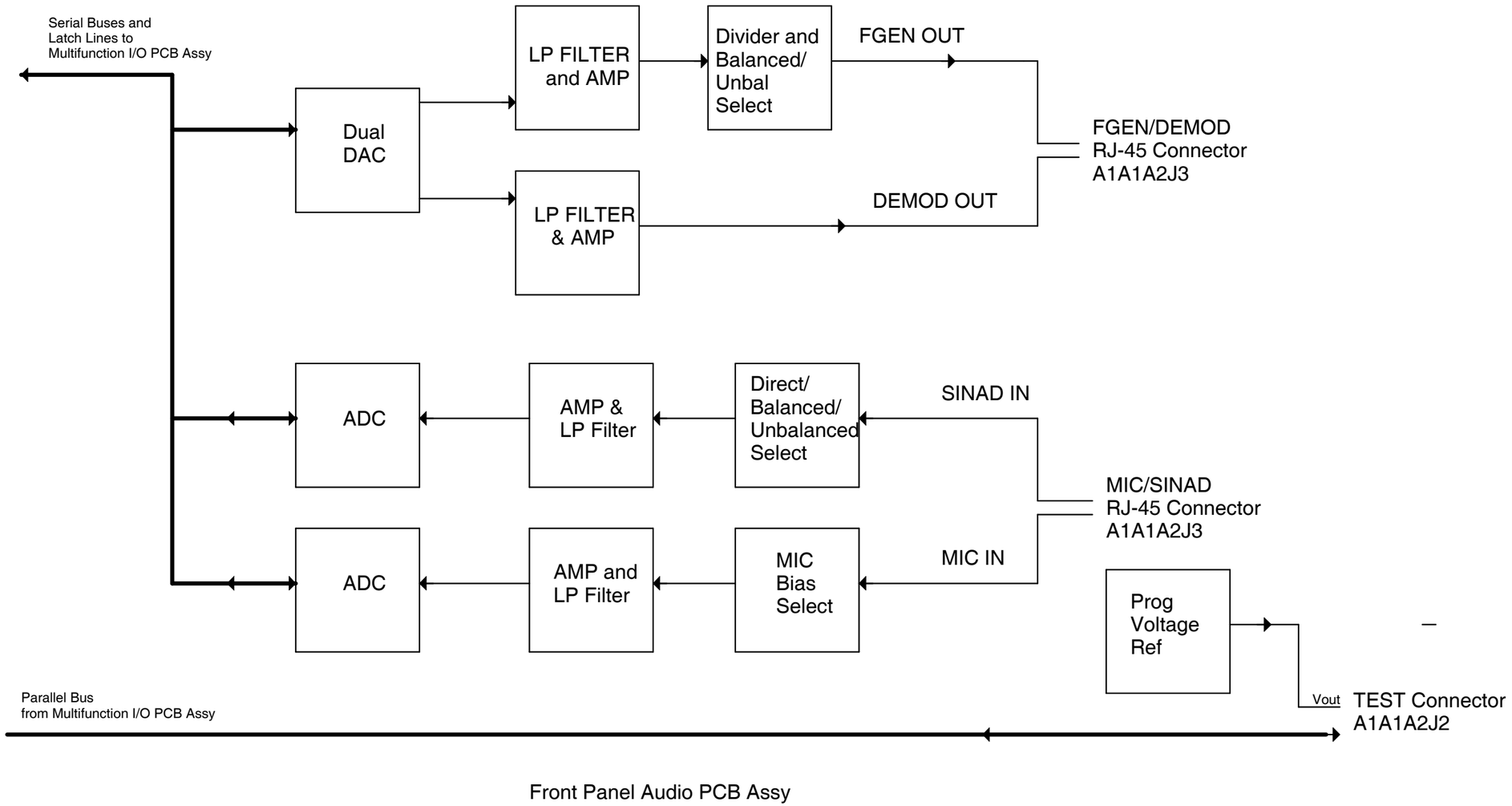


Figure 1-2 2975 Module Overview (cont)



Front Panel Audio PCB Assy

042M-026

Figure 1-2 2975 Module Overview (cont)

1-3-1 BACKPLANE PCB ASSY (42A1A1A1)

Refer to Figure 1-2.

The Backplane PCB Assy provides the mechanism that routes electrical signals between the various system assemblies:

- 32-Pin Connector provides connection to the Power Termination Assy
- 10 Pin Header provides ribbon cable connection to the Front Panel Assy
- 10 Pin Header provides ribbon cable connection to the Attenuator Assy
- 24 Pin Header provides ribbon cable connection to the GPIB Connector
- 40 Pin Header provides ribbon cable connection to the CRYPTION Connector
- 44 Pin Header provides connection to the Front Panel Audio PCB Assy
- 48 Pin DIN Connectors for:
  - Disk I/O PCB Assy
  - Rear Panel PCB Assy
  - IF/Video PCB Assy
  - Generator Assy
  - Receiver Assy
- 96 Pin DIN Connectors for:
  - Power Supply Assy
  - CAI PCB Assy
  - CPU Adapter Assy (3)
  - Multifunction IO PCB Assy (3)

The Backplane PCB Assy layout utilizes RF techniques on all signals >33 MHz and on all low level signals.

1-3-2 FRONT PANEL AUDIO PCB ASSY (42A1A1A2)

Refer to Figures 1-2 and 1-3.

The Front Panel Audio PCB Assy plugs into the Backplane PCB Assy and supports the RJ-11 and Test Connector of the 2975 Front Panel. The Front Panel Audio PCB Assy converts analog audio signals from the RJ-11 Connector (Audio Input) to digital signals for the system. The Front Panel Audio PCB Assy also provides output analog audio signals to the RJ-11 Connector (Audio Output) by converting digital signals from the system. Signal Tone or Data filtering, in addition to the balanced or unbalanced switches, are preformed by the Front Panel Audio PCB Assy. Output signals from the Front Panel Audio PCB Assy are the audio function generator signals and the demodulated audio signal (Demod). Audio Input signals to the Front Panel Audio PCB Assy are the microphone and Sinad In signals.

The Front Panel Audio PCB Assy generates a digitally controlled output voltage for the Test Connector and routes input/output signals to/from the Test Connector.

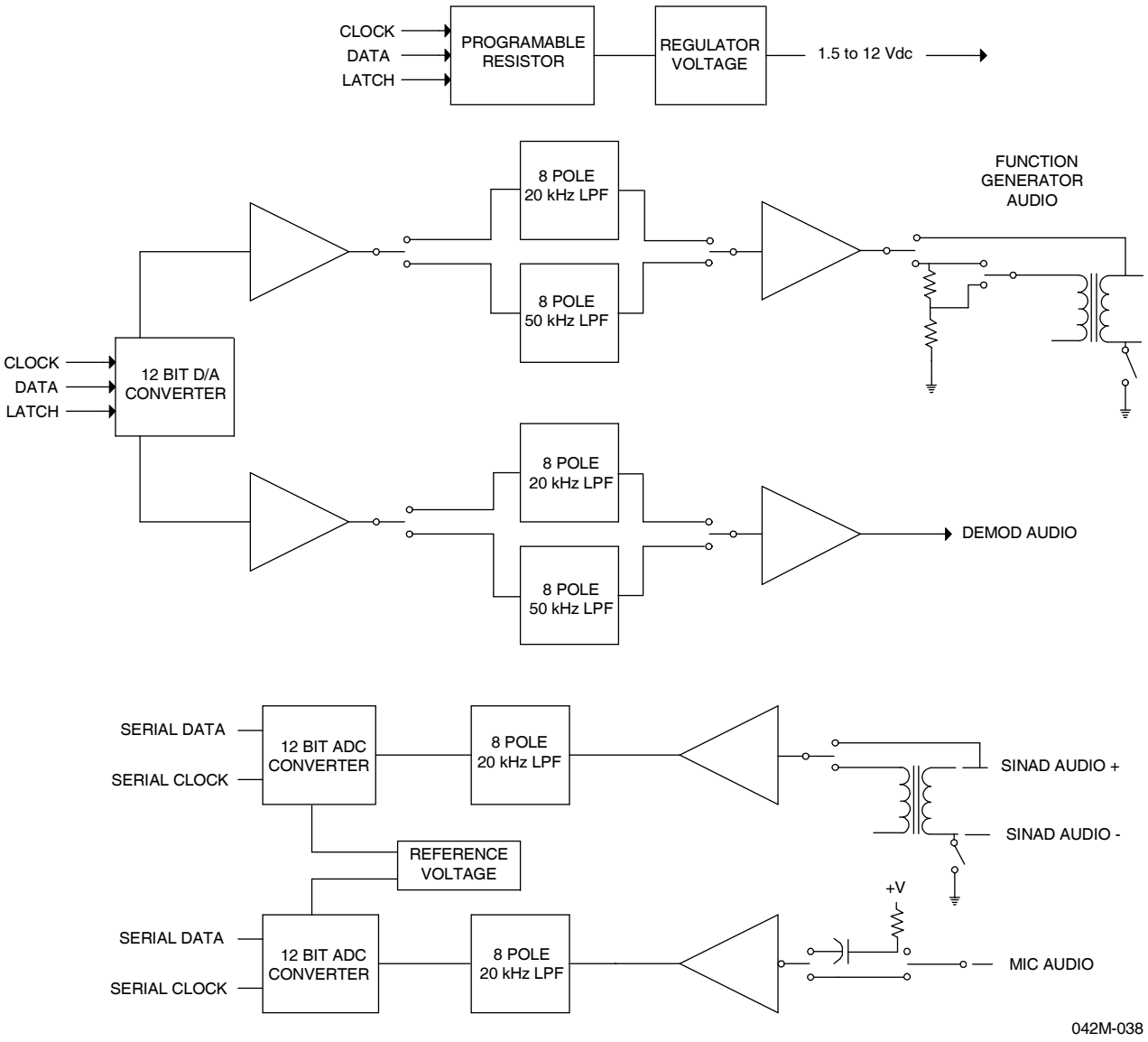


Figure 1-3 Front Panel Audio PCB Assy Block Diagram

1-3-3 CPU ADAPTER ASSY (42A1A1A5)

Refer to Figure 1-2.

The CPU Adapter PCB Assy provides a convenient mechanism by which all CPU generated signals are distributed through the Backplane PCB Assy to other system assemblies. A single board computer is mounted to the CPU Adapter PCB Assy. Flat ribbon cables are used to interconnect the PCB assemblies together. The Backplane PCB Assy interface consists of three 96 Pin DIN Connectors.

1-3-4 POWER SUPPLY ASSY (42A1A1A6)

Refer to Figures 1-2 and 1-4.

AC power for the Power Supply Assy is provided by an IEC universal 3-prong power entry module with an integrated power switch, fuses and EMI filter. This feeds the 225 W power supply with an input range of 85 to 264 VAC at a 47 to 63 Hz rate. The Power Supply Assembly is responsible for generating all internal voltages required to operate the 2975.

Four different voltages are generated by the Power Supply Assy and distributed through the Backplane PCB Assy:

+5 V (Analog and Digital)

+12 V

-12 V

+5.1 VA (a 'keep alive' voltage for turn-on circuitry)

The filter array on the V1 (5 V) power supply output isolates the digital and analog +5 V circuitry.

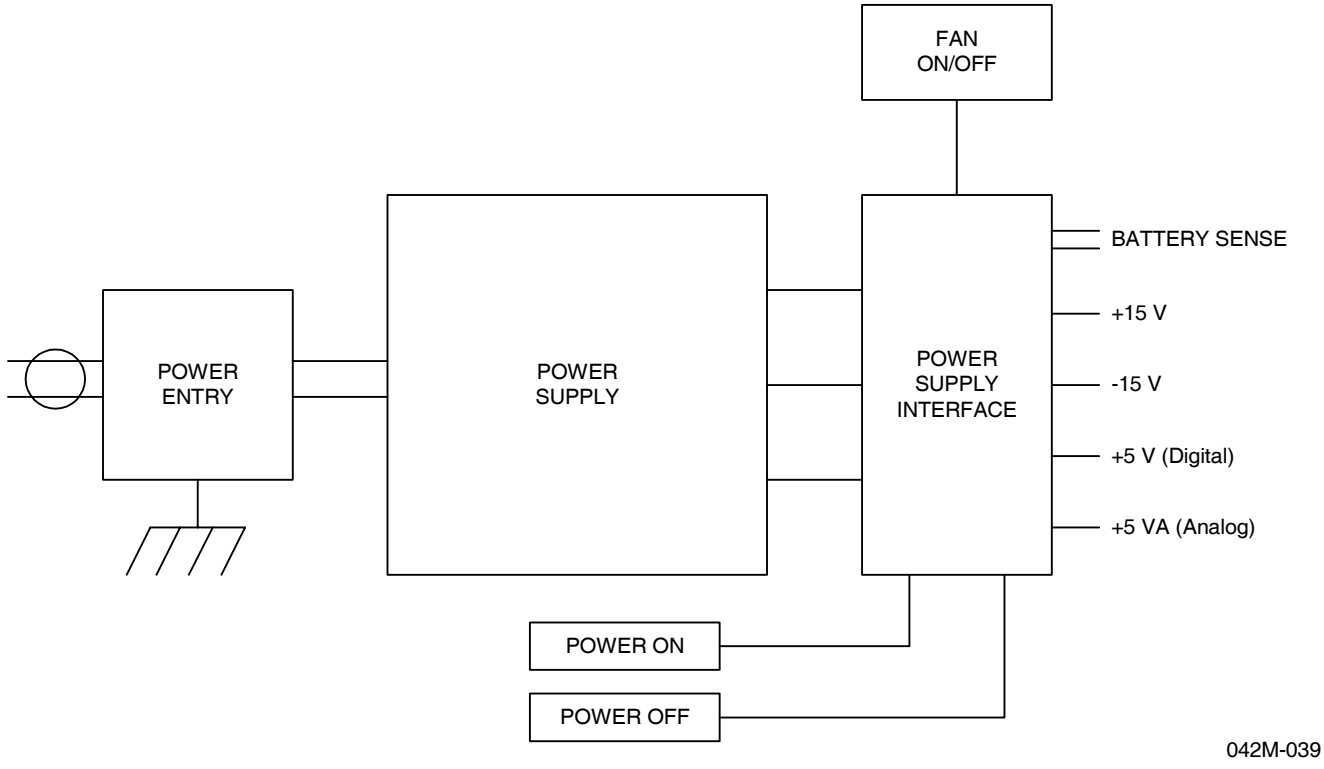


Figure 1-4 Power Supply Assy Block Diagram

1-3-5 POWER TERMINATION ASSY (42A1A1A7)

Refer to Figures 1-2 and 1-5.

The Power Termination Assy consists of four PCB Assemblies: LNA, GEN Buffer, RF Power and Controller. The assembly housing provides circuit isolation, which must be very high for the tracking generator function, as well as providing heat sink cooling for the high power RF input. The cooling fan is turned on and off by the processor control based on the temperature of the Power Termination Assy.

The Power Termination Assy provides the focal point through which RF signals pass between the UUT and the 2975. There are three RF user interface connectors (on the front of the unit) (ANTENNA IN, GEN OUT, T/R) and two internal coaxial cable connections (Receiver Assy and Generator Assy).

POWER TERMINATION RF I/O

The Power Termination Assy has three RF inputs, one output and one bi-directional connector. The main RF T/R (transmit/receive) connector is a type “N” connector which can be used for full duplex operation and is the primary power measurement connector. The ANT (or Antenna) and GEN (or Generator) connectors are TNC connectors. The T/R Connector is designed to accept input RF signals from DC to 2.7 GHz at power levels up to 150 W. At power levels >50 W, the input power must maintain a duty cycle of 20% on and 80% off.

The ANT Connector provides low signal level operation through a LNA (Low Noise Amplifier) which improves the sensitivity and can be used to monitor low level signals with the application of an external antenna. The ANT Connector is protected from high power levels by a limiter circuit.

The GEN Connector provides an output signal of +10 dBm over the 1 to 2700 MHz range, and can be used in conjunction with the ANT Connector to do scalar measurements in the tracking generator operation mode.

The final two RF SSMB connectors are the receive output to the Receive IF Assy and the input from the Generator Assy.

RF POWER DETECTOR

A diode detector on the RF Power PCB Assy at the output of a four-way power splitter serves to measure RF power applied to the T/R Connector.

TEMPERATURE SENSORS

There are two temperature sensors on the RF Power PCB Assy. Sensor 1 is used to monitor the temperature of the 20 dB RF power attenuator. Sensor 2 is used to monitor the ambient temperature of the diode detector to enable temperature correction of the power meter.

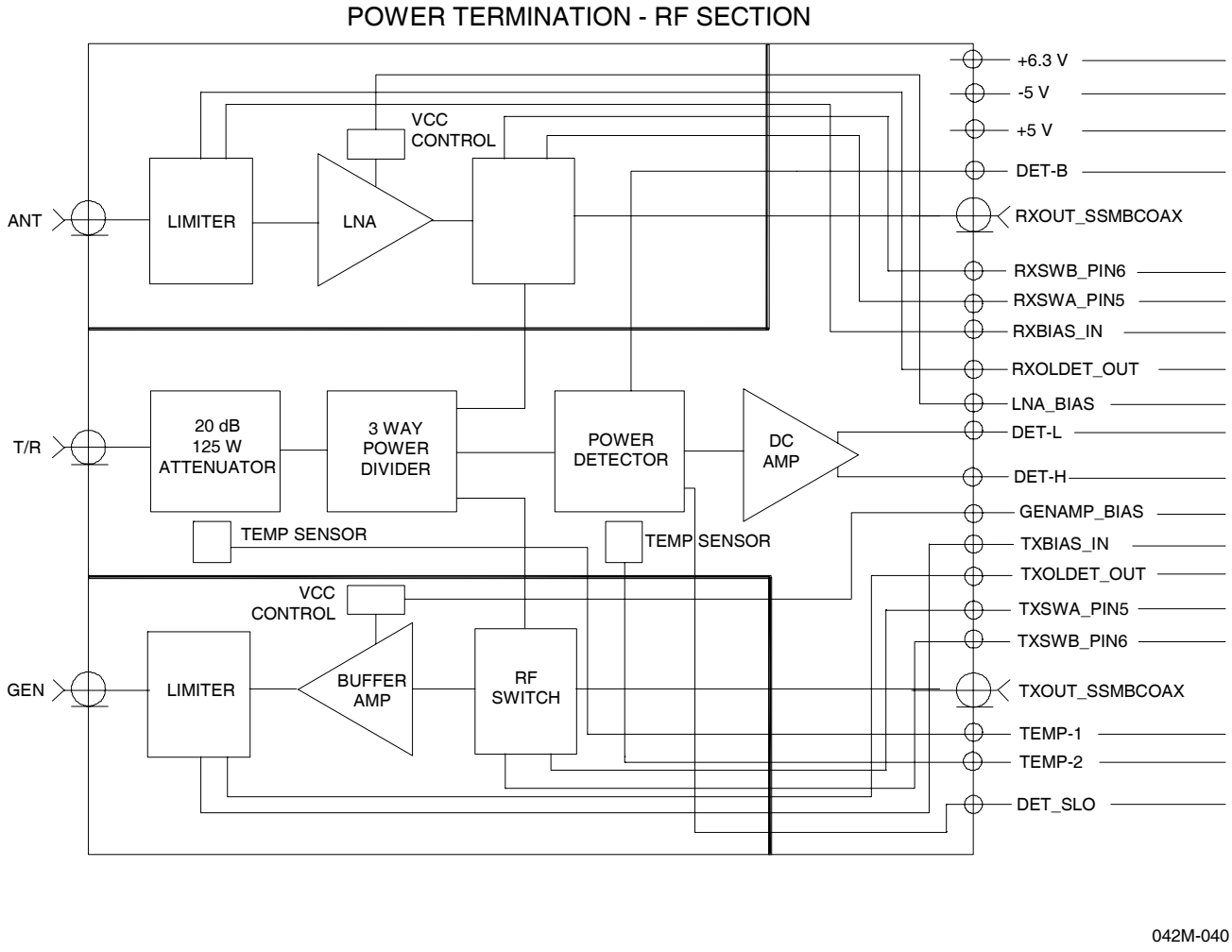


Figure 1-5 Power Termination Assy Block Diagram

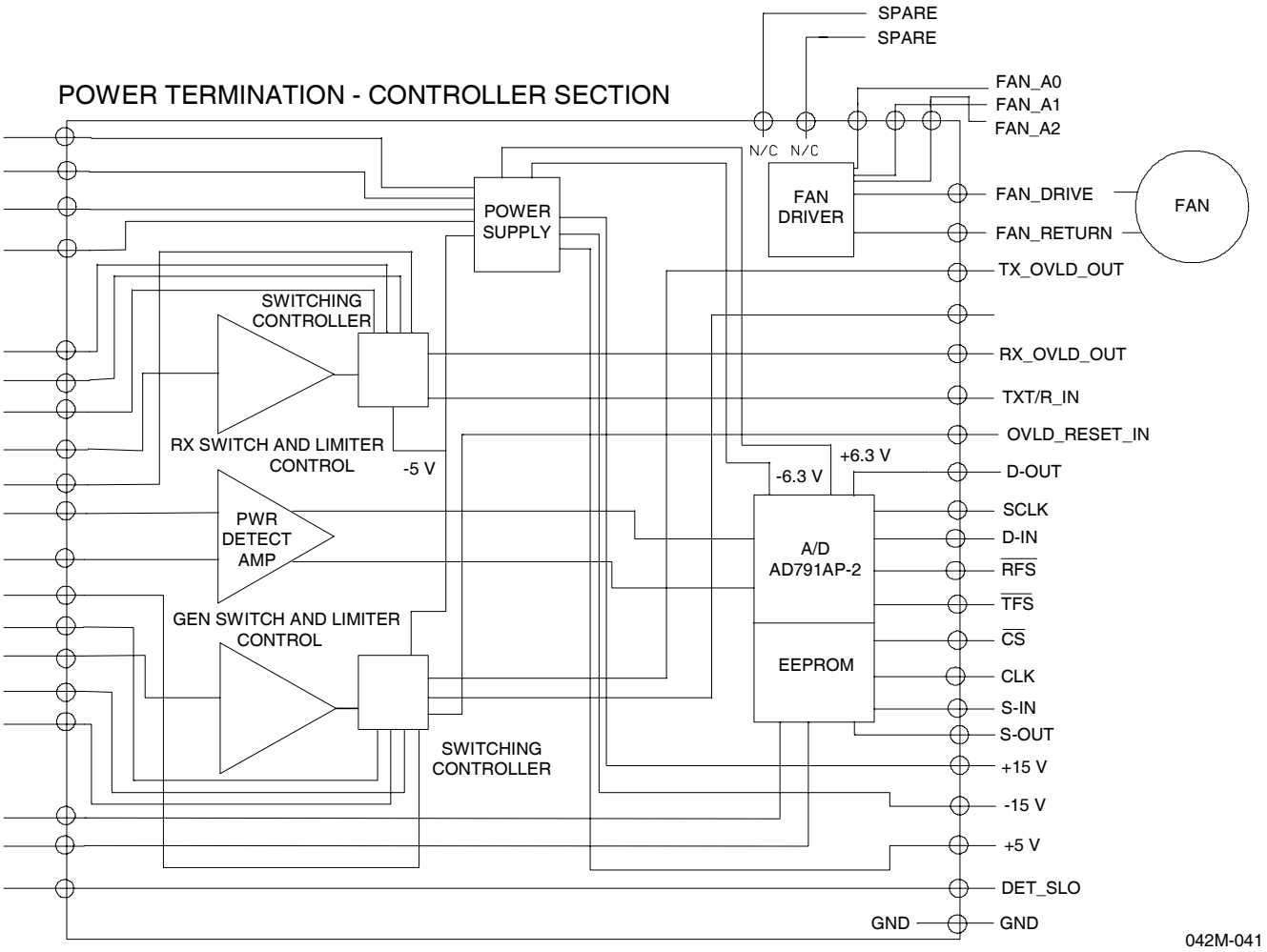


Figure 1-5 Power Termination Assy Block Diagram (cont)

1-3-6 DISK I/O PCB ASSY (42A1A1A9)

Refer to Figures 1-2 and 1-6.

CPU I/O signals are routed to the Disk I/O PCB Assy plug-in slot through the Backplane PCB Assy. The floppy signals go directly to a 26-pin flex cable header, providing a convenient connection to a 3.5" half-height floppy disk drive. Located on the Disk I/O PCB Assy is the OCXO oscillator, providing a very stable and accurate 10 MHz reference frequency for the system. A DAC, driven by the Multifunction I/O PCB Assy provides voltage tuning of the OCXO. A serial EEPROM stores the factory calibrated tuning voltage for the oscillator. A dual DAC drives the speaker amplifier after it is filtered by a 4.6 kHz filter. A differential A-D converter, driven by the Multifunction I/O PCB Assy monitors the battery voltage.

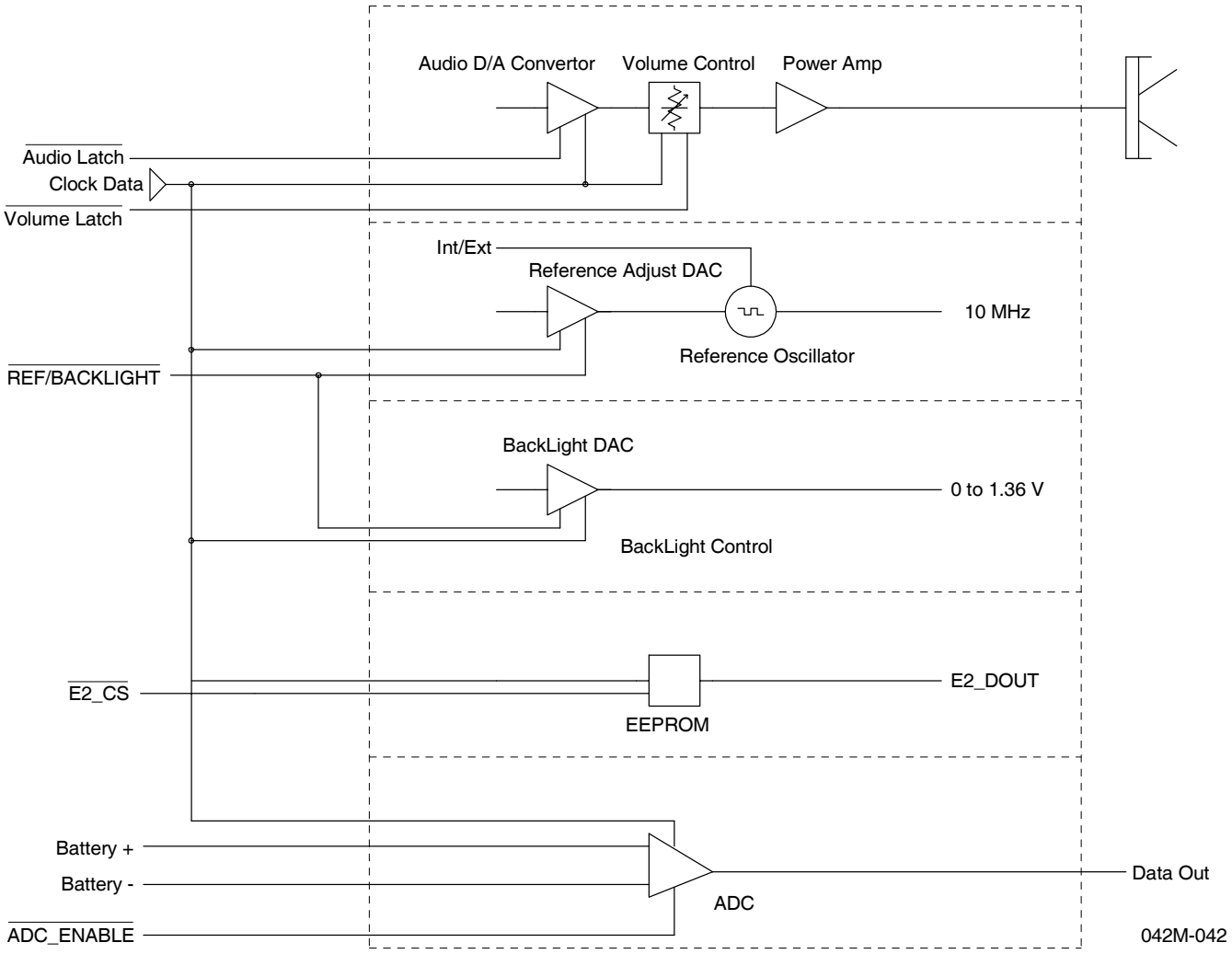


Figure 1-6 Disk I/O PCB Assy Block Diagram

1-3-7 ATTENUATOR ASSY (42A1A3)

Refer to Figures 1-2 and 1-7.

The attenuator consists of six relay-attenuator sections and a driver board. One relay-attenuator section is 10 dB, and the other five relay-attenuator sections are 20 dB; for a total attenuation of 110 dB. The driver board contains a serial to parallel converter and six transistor driver stages, which drive the attenuator relays with the required current. The module uses 5 V for the supply and relay drives.

Each individual stage has an accuracy (±0.5 dB) to its rated value. The attenuator has a frequency response flatness (slope) from 0 to 2.7 GHz of <3 dB. This slope remains constant (±0.5 dB) with different stages of attenuation on or off. This error is removed when the 2975 is calibrated.

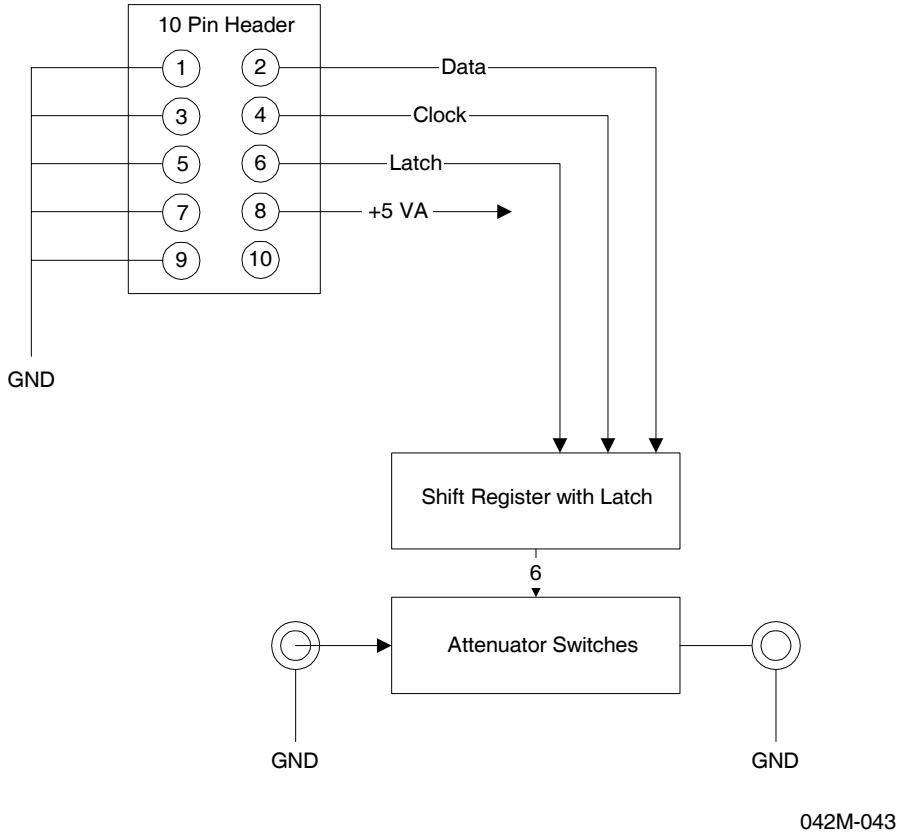


Figure 1-7 Attenuator Assy Block Diagram

1-3-8 GENERATOR ASSY (42A1A4)

Refer to Figure 1-2.

The CAI PCB Assy provides 11.4 MHz IF to the Generator Assy for frequency conversion to the desired output frequency. The Generator Assy provides 0.1 dB steps between the 10 dB steps of the step attenuator attached to the top of the Generator Assy. The Generator Assy is also used as the tracking generator, allowing for swept measurements such as filter response. The Generator Assy consists of two separate PCB Assemblies: RF/Microwave PCB Assy and the Synthesizer/Control PCB Assy. The lower frequency functions reside on the Synthesizer/Control PCB Assy, while the higher frequency functions reside on the RF/Microwave PCB Assy.

RF/MICROWAVE PCB ASSY

The RF/Microwave PCB Assy is designed to convert a 11.4 MHz IF input to any frequency from 1 MHz to 2.7 GHz. The 11.4 MHz IF signal is converted to 3 increasingly higher IF frequencies: 91.4, 611.4 and 3411.4 MHz respectively. At each IF, a considerable amount of filtering is performed in order to remove the images resulting from the previous up-conversion. Finally, the 3411.4 MHz signal is down-converted to the desired frequency. The signal is then leveled and amplified up to a level high enough to overcome the losses of the step attenuator and power termination and still meet the specified maximum output power level.

POWER AMPLIFIER / POWER DETECTION

The output of the ALC gain control element serves as input to the power amplifier. The total gain across the power amplifier strip is approximately 46 dB. Roughly -26 dBm out of the voltage variable attenuator produces full power (+20 dBm) at the output connector of the RF/Microwave PCB Assy.

The resistive tap just before the output attenuator provides the sample point for output power detection. The detected power voltage undergoes an inversion and is passed through a log linearization circuit. The power detect output is passed over to the ALC functions on the Synthesizer/Control PCB Assy for generator output leveling.

SYNTHESIZER/CONTROL PCB ASSY

The Synthesizer/Control PCB Assy consists of 3 major loops: DDS, main and comb driver. This structure locks a YIG oscillator by mixing the output with that of the comb frequency coming from the clean loop. The comb moves in approximately 0.4 MHz steps providing a coarse tune. The DDS, which is tunable in extremely fine steps, drives the main loop, giving the Synthesizer/Control PCB Assy sub-hertz resolution. The comb driver has 2 loops that generate an exceptionally clean signal that is multiplied up to the YIG frequency. The step loop provides all of the step size for the comb driver and is followed by the clean loop which tracks the step loop changes.

The frequencies of 80 and 400 MHz that exist in the Receiver Assy are reused to generate the LOs used for the up-converter block. This is what determined the choice of IF frequencies. In order to convert 11.4 to 91.4 MHz, 11.4 MHz is mixed with 80 MHz and the sum product taken. The 520 MHz LO needed for the 611.4 MHz IF is generated by dividing 400 MHz by 2. This 200 MHz signal is mixed with the 80 MHz in a mixer that has poor third order LO performance. The 3rd LO minus the IF produces 600 MHz. Subtract 80 MHz for a sum of 520 MHz. Finally, the 2800 MHz LO needed to convert 611.4 to 3411.4 MHz is generated by multiplying 400 MHz by 7.

1-3-9 IF/VIDEO PCB ASSY (42A1A5)

Refer to Figure 1-2.

The IF/Video PCB Assy conditions incoming signals from the Receive IF Assy for the CAI PCB Assy and provides a squared IF signal to the Multifunction I/O PCB Assy for frequency counter circuitry. The IF/Video PCB Assy provides the analyzer gain adjustment when adjusting the Reference level dBm on the Spectrum Analyzer, and acts as the receiver Automatic Gain Control (AGC) when in the Receiver mode. As well, providing a digitized logarithmic representation of the incoming signal amplitude for both the “channel” and “widescan” analyzer modes.

The IF/Video PCB Assy also provides a buffered 10.7 MHz IF signal and spectrum analyzer video to the rear of the 2975. Finally, the IF/Video PCB Assy provides a temperature sensor for sensing the internal ambient unit temperature.

IF/VIDEO - 10.7 MHZ IF FILTERS

The 10.7 MHz IF path provides gain adjustment and hardware bandwidth restriction of the incoming signal from the Receive IF Assy to be used by the CAI PCB Assy Digital Signal Processor (DSP). From this path, all signal processing, decoding and metering functions are performed. The IF is also squared up for the IF frequency counter circuitry for the Multifunction I/O PCB Assy. The 10.7 MHz filter bandwidth selections include: 6 MHz, 300 kHz and 30 kHz.

IF/VIDEO - 5.3 MHZ IF FILTERS “CHANNEL” IF

The Spectrum Analyzer 5.3 MHz IF functions to provide a fixed frequency down-conversion of the CAI 10.7 MHz IF signal for the “Look and Listen Mode” in the Channel Analyzer screens. The 5.3 MHz filter bandwidth selections include: 60 kHz, 3 kHz and 300 Hz.

1-3-10 MULTIFUNCTION I/O PCB ASSY (42A1A6)

Refer to Figures 1-2 and 1-8.

The Multifunction I/O PCB Assy consists of two independent subsystems: Scope/DVM Subsystem and Audio Subsystem. The Multifunction I/O PCB Assy performs the following functions:

- Two Channel Scope with external trigger capability
- Digital Voltmeter
- Digital Audio to Front Panel PCB Assy for the Function Generator and DEMOD outputs
- Speaker Driver circuit
- Digital Audio inputs from Front Panel PCB Assy
- RF Subsystem Control I/O
- Digital Function Generator for modulation formats

The main components of the Multifunction I/O module are two Motorola DSP's. One is an Altera FPGA, which performs the actual control of the RF subsystems. The other is a dual channel scope. One DSP functions as the Scope/DVM subsystem and the other performs the Audio and RF control subsystems.

The primary purpose of the master DSP is to control and read the RF subytems. It must also act as the interface to the host CPU for itself and the Scope/DVM DSP. A bi-directional, high speed serial data channel to the CAI PCB Assy is also provided for demodulated audio data input and audio data output that is to be modulated.

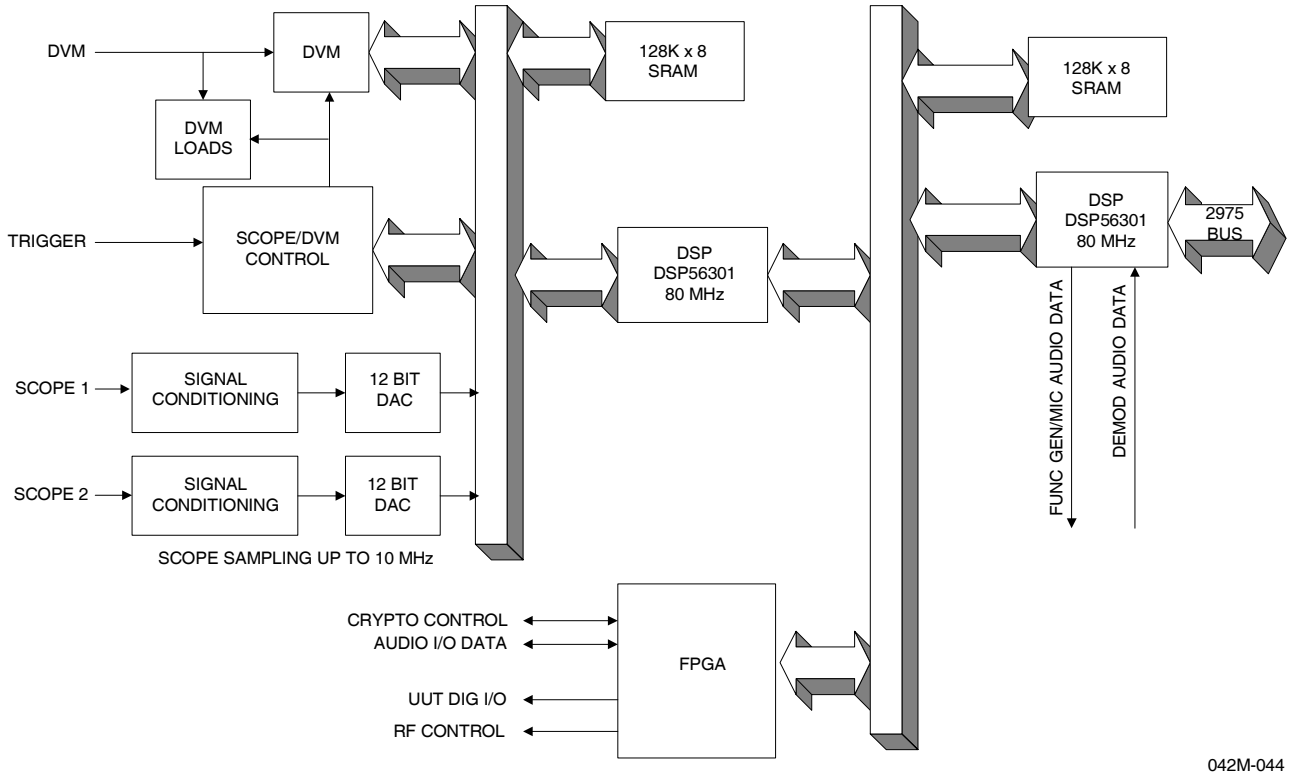


Figure 1-8 Multifunction I/O PCB Assy Block Diagram

1-3-11 RECEIVER ASSY (42A1A7)

Refer to Figure 1-2.

The Receiver Assy is a self contained wideband triple conversion receiver that is designed to convert incoming frequencies (9 kHz to 2.7 GHz) to an output IF frequency of 10.7 MHz. The module consists of two separate PCB Assemblies: Receiver PCB Assy and the Synthesizer PCB Assy.

RECEIVER PCB ASSY

The Receiver PCB Assy converts incoming frequencies (9 kHz to 2.7 GHz) to an output IF frequency of 10.7 MHz. The Receiver PCB Assy provides all the necessary LO's for the conversion to 10.7 MHz IF. The 10.7 MHz IF is routed to the IF/Video PCB Assy for additional filtering and signal conditioning.

SYNTHESIZER PCB ASSY

The Synthesizer PCB Assy consists of 3 major loops: the DDS, main, and comb driver. This structure locks a YIG oscillator by mixing its output with that of the comb frequency coming from the clean loop. The comb itself moves in approximately 0.4 MHz steps providing a coarse tune. The DDS which is tunable in extremely fine steps, drives the main loop gives the synthesizer its sub-hertz resolution. The comb driver has 2 loops that generate an exceptionally clean signal that is multiplied up to the YIG frequency. The step loop provides all of the step size for the comb driver and is followed by the clean loop which tracks the step loop changes. The synthesizer/control board provide both 80 MHz and 400MHz reference for the Generator Module.

1-3-12 CAI PCB ASSY (42A1A8)

Refer to Figures 1-2 and 1-9.

The CAI (Common Air Interface) PCB Assy contains two DSP's and the digital up/down converter chipset. The main responsibility of the CAI PCB Assy is to provide the interface between the IF and the host CPU.

- Digitally perform modulation and demodulation of IF signal using chipset and DSP.
- Perform parametric measurements from the I and Q data that is generated by the chipset.
- Perform voice Encoder/Decoder function in the Motorola DSP.
- Generate received I and Q outputs.
- Controlled by the host CPU over the ISA bus in which part of the address decoding has been performed external to the CAI PCB Assy.

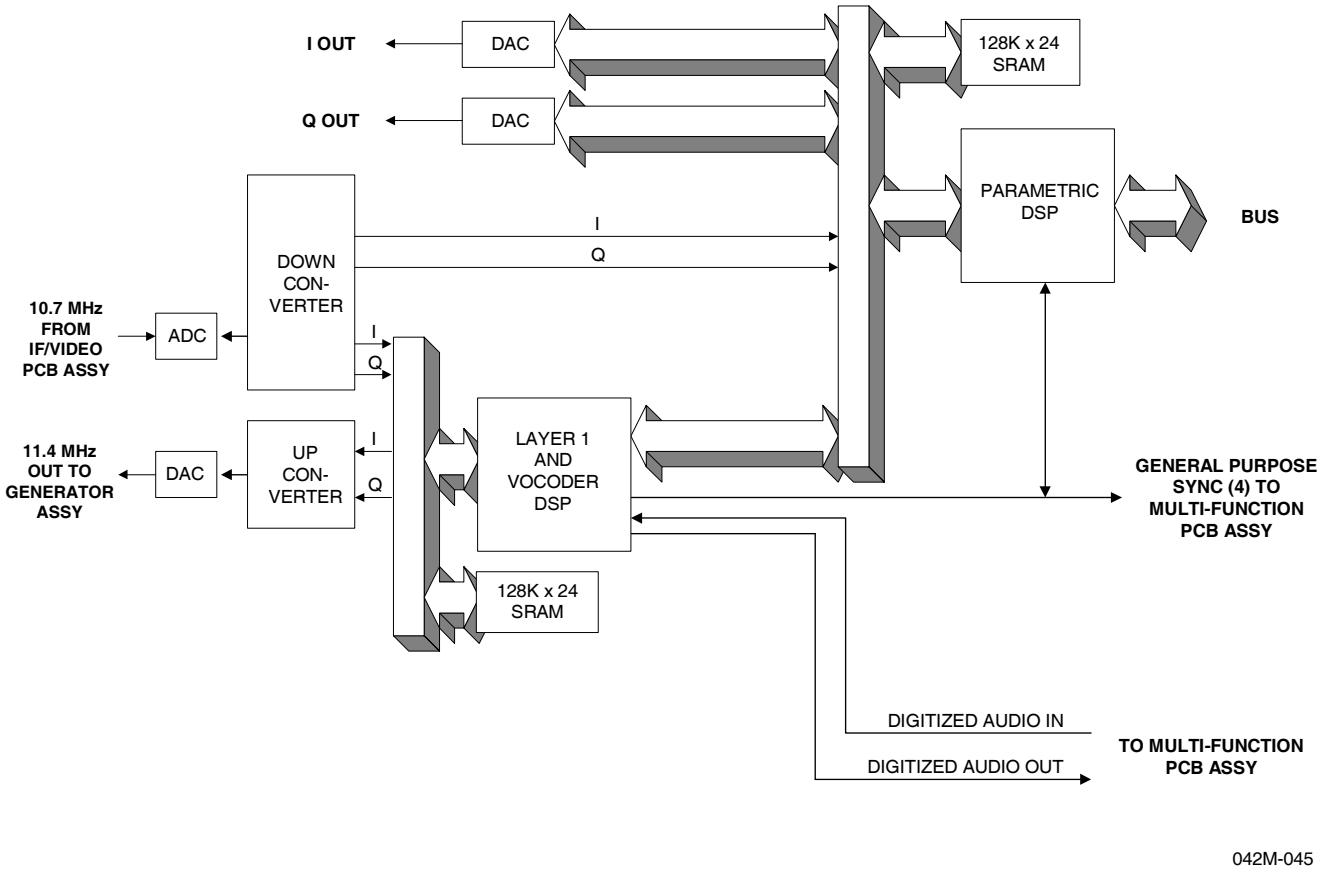


Figure 1-9 CAI PCB Assy Block Diagram