8. OPERATIONAL DESCRIPTION - MODEL Axcera-5724

8.1 General Description

The 5724 transmitter is a complete 12-watt solid-state, digital transmitter. It operates at a nominal output power of 12 watts (average).

8.2 Technical Specifications

Type of Emission 6M00D7W

Frequency Range.. 2572 to 2614 MHz

Output Power Rating .... 12 watts average

8.3 Performance Specifications

Operating Frequency Range .... 2572 MHz to 2614 MHz

RF output - Nominal:
- Power .... 12 watts average
- Impedance .... 50 ohms
- Connector .... Type N

Modulation.. QAM, MPEG-2 Transport Stream
Phase Noise [1].................... < or = 110 dBc (single sideband measurement)
Frequency Response ....± 0.25 dB
Group Delay .... 40 nsec peak-peak (Measured with 1 MHz delay aperture)
Gain Linearity (AM-AM [2]) .... 0.2 dB /dB
Phase Linearity (AM-PM [2]) .... 1°/dB
IF Input Frequency .... 41-47 MHz or 32-40 MHz
IF Input Impedance .... 75 or 50 Ohms (specify)
IF Input Level ....+20 to +40 dBmV (-28 to –8 dBm) average
Frequency Stability [3] .... ± 500 Hz (standard)
- w/Precise Frequency Option.................................± 1 Hz (optional)

<u>Electrical Requirements</u>

Power Line Voltage .... 110 volts, 60 Hz
220 volts, 50/60 Hz
Power Consumption .... 520 watts

<u>Environmental</u>

Maximum Altitude .... 12,000 feet
Operational Temperature Range ....0°C to +45°C

<u>Mechanical</u>

Dimensions:

Width ....19 inches
Depth ....21 inches
Height...8.75 inches
Weight...45 lbs

[1] Measure with optional LPN oscillator.
[2] Specified at 6dB above digital average power.
[3] When interfaced with 5060 10 MHz system reference or GPS precise reference.

8.4. System Overview

The 5724 transmitter is made up of the trays listed in Table 8-1.

Table 8-1. 5724 Major Trays and Assemblies

MAJOR ASSEMBLY DESIGNATOR	TRAY/ASSEMBLY NAME	DRAWING NUMBER
A1	QAM Modulator	Model PQM2100
A2	Upconverter/Amplifier Tray	1584-1004

8.4.1 QAM Modulator Tray, Upconverter/Amplifier Tray

The 5724 is a complete digital transmitter capable of operating at an output power of 12 watts (average). Functionally, the 5724 transmitter is comprised of an external QAM modulator and Upconverter/Amplifier tray. The IF signal from the modulator is applied to the input of the Upconverter/Amplifier, which provides spectral shaping of the IF signal in accordance with occupied bandwidth requirements of the Rules and Regulations. The modulator receives a serial bit stream, translates the signal to a Quadrature Amplitude Modulated (QAM) format and converts the digital information to analog, and modulates the signal to IF. The modulator tray's IF output is routed to the driver/amplifier tray for IF signal processing, upconversion to the RBS/EBS band, and final amplification. The Upconverter/Amplifier tray utilizes ALC circuitry for automatic level control of the output signal to maintain a constant power level. Both modulator and Upconverter/Amplifier trays are 19-inch rack mount assemblies and can be supplied with or without a cabinet. Both trays are supplied complete with cables and cabinet slides.

8.4.1.1 IF Processor Assembly (Upconverter/Amplifier Tray)

The input to the Upconverter/Amplifier tray is the IF output from the QAM modulator tray. The QAM IF output signal from the modulator is applied to the IF input jack (J1) on the rear of the tray. This IF input signal is then fed to the IF Processing Card (1585-3108).

The IF signal enters the card at J1 and is transformer coupled for impedance matching of the IF signal (75Ω to 50Ω). The signal is then applied to an adjustable resistor pad network, which allows for three IF input level ranges of 10 dB each. The signal is amplified and applied to a 6 dB transformer directional coupler, which provides a sample to a peak detector in the ALC portion of the circuit. The main output of the coupler is fed to frequency response correction circuitry, which consists of four adjustable notch filters. The frequency response correction circuit may be removed using on board jumpers. The output of the frequency response corrector is amplified and applied to a PIN diode attenuator. The ALC circuitry takes a peak-detected sample of the IF signal and generates an ALC voltage, which biases the PIN diode attenuator. The ALC circuit senses any change in the IF level and automatically adjust the loss through the PIN attenuator to compensate, thereby maintaining a constant IF output regardless of minor changes in the input signal.

The ALC circuit uses a DC level generated externally to control the output power level. There are two possible bias voltage inputs. The first, Inner Loop, is generated form a peak-detected sample of the output amplifier. The second, Outer Loop, is used only if an external final amplifier tray is connected to the system. If both Inner Loop and Outer Loop inputs are used, the signal that is the largest in level controls the ALC circuit.

The ALC circuit may be bypassed by placing switch SW2 in the manual position. When the ALC circuit is disabled, the loss through the PIN attenuator is adjusted by a manual gain potentiometer, which then directly controls the output in a manual fashion.

The ALC circuit also contains a average detector which detects the average level of the IF signal. This average level is compared to the output of the peak detector and if the average level approaches the peak level, indicating a loss of modulation on the IF signal, a mute signal will be generated muting the IF. This prevents against overpower conditions in situations where the modulating signal is interrupted. The ALC circuit provides several front panel LED indicators including: Peak Vs. Average Fault, I/P Fault, Mute, and ALC Fault.

The output of the PIN diode attenuator is amplified an applied to three sections of group delay equalization which compensate for group delay created by external filters. Each section of group delay may be removed from the circuit using on board jumpers. For non-adjacent analog applications, Delay Equalizer 1 is removed from the circuit. For adjacent analog applications, all three sections are used. For adjacent and non-adjacent digital applications, Delay Equalizer 3 is removed from the circuit. The output of the delay equalizer circuit is fed to a 6 MHz lumped element band-pass filter. The band-pass filter may be removed from the circuit using on board jumpers. The band-pass filter may also be bypassed through a SAW filter when tight filtering of the IF is required.

The output of the band-pass filter is applied to a linearity correction circuit, which compensates for compression in later stages of the system. The output of the linearity correction circuit is fed to a 6 dB transformer directional coupler which provides a front panel sample of the IF signal. The main output of the coupler is connected to the output of the IF Processing Card (J1B).

8.4.1.2 L.O. / Upconverter Assembly (Upconverter/Amplifier Tray)

The L.O./Upconverter Assembly consists of a L.O./Upconverter Board (1585-1117), Inter-digital Filter (2140-1006), and a Single stage Amplifier Board (1585-1101).

The L.O./Upconverter Board generates a UHF L.O. frequency using a voltage-controlled oscillator (VCO) IC (V804ME01). The VCO is locked to an external precise 10 MHz reference using a frequency synthesizer PLL IC (LMX2325TM) in a phase lock loop configuration. The LMX2325TM is a high performance frequency synthesizer with integrated pre-scalers and uses a proprietary digital phase lock loop technique to produce a very stable low noise signal that is used to control the VCO frequency. The desired L.O. frequency is selected using the front panel LCD display/keypad. The Control Monitoring Assembly detects the keyboard input and routs the serial data to the serial data input of the PLL IC.

Under normal operating conditions, the external 10 MHz precise reference input will be routed to the oscillator input of the PLL IC through a magnetic latching relay (K1). IF the external precise reference is removed the relay will open and an internal 10 MHz reference oscillator IC will be routed to the oscillator input of the PLL IC.

The L.O. signal from the VCO is buffered to an internal micro-strip coupler, which provides an L.O. sample that is routed to a rear panel jack. The L.O. signal is then amplified by an IC amplifier (U8) to a sufficient level to drive the L.O. input of an IC mixer (U10). An IF input to the mixer, is provided via the IF Processor Assembly. The output of the mixer is amplified by an IC amplifier (U12) and fed to the RF output jack of the board (J8).

The RF signal is then fed to a 6 MHz band-pass inter-digital filter (2140-1006), which selects the desired conversion frequency (L.O. - IF) and attenuates any undesired signals generated during the mixing process.

The RF output of the filter is then fed to the Single Stage Amplifier Board (1585-3101), which consist of a single IC amplifier (VNA-25) with a gain of 14 dB. An RF sample is obtained using a micro-strip coupler (J2). The main RF output is connected to the output jack of the module (J8).

8.4.1.3 Power Amplifier Assembly (Upconverter/Amplifier Tray)

The Power Amplifier Assembly consist of a 70W PEP Amplifier Module (1585-1102), 5 Section Bias Board (1585-1109), and Dual Power Detector Board (1585-1125).

The 70W pep Amplifier provides both amplification and Feed Forward distortion cancellation. This module is subdivided into 5 functional sections: preamplifier section, power amplifier section, feed forward cancellation section, correction signal amplifier section, and RF output section.

The RF input signal from the L.O./Upconverter/Assembly enters the module at J1 and is fed to the preamplifier section. The preamplifier consists of three cascaded GaAs FET amplifiers (FLL 101ME driving a FLL 351ME driving a FLL 200IB-3) with an overall gain of approximately 24 dB. The output of the final FET is applied to a 3.0 dB micro-strip hybrid coupler, which splits the signal providing an output sample at J2. This sample is used in the feed forward distortion cancellation section of the module, which the correction signal that will be amplified and coupled with the RF output signal to cancel the distortion created in the power amplifier. The main output of the coupler is fed to the power amplifier section of the module.

The power amplifier consist of three GaAs FET amplifiers (FLL 200IB-3 driving two parallel S45V2527-51's) with an overall gain of approximately 21 dB. A 20 dB micro-strip coupler provides an uncorrected (distorted) sample of the RF signal at J4. This uncorrected sample is fed to the correction signal input (J10) of the feed forward distortion cancellation section of the module.

The preamplifier (undistorted) sample is phase shifted 180° through a delay line and fed to the feed forward distortion cancellation section where it is coupled with the uncorrected signal from the output amplifier. Combining these two signals (the phase shifted (180°) input signal, and the distorted RF output signal) cancels the information-carrying component of the signal, leaving only the distortion of the output amplifier.

This correction signal is fed to the correction signal amplifier section of the module where it is amplified to a sufficient level to cancel the distortion created by the output amplifier. The correction signal amplifier consist of three cascaded GaAs FET amplifiers (FLL101ME driving a FLL351ME driving a S45V2527-51) with an overall gain of approximately 36 dB.

The amplified correction signal and the phase shifted (180°) output of the power amplifier are applied to a hybrid micro-strip coupler in the RF output section of the module where the signals are coupled together, effectively canceling the distortion in the output signal. The main output of the module (J8) is connected to the RF output jack (J8) on the rear of the tray. A 20 dB forward power sample is obtained using an internal micro-strip coupler. The circulator provides a reflected power sample.

The DC biasing of the FET amplifiers in each section of the module is controlled and filtered by corresponding daughter boards (daughter boards D6 and D7 for the preamplifier, daughter boards D1, D2, and D3 for the power amplifier, and daughter boards D4 and D5 for the correction signal amplifier), which are soldered directly to the main board. The DC bias drain to source currents are set by adjusting the negative gate to source voltages which are adjusted by potentiometers on the daughter boards.

The -5V bias voltage is generated on board using a voltage regulator (LM377T). This bias voltage is also used as an interlock, which is fed to the Transmitter's Control and Monitoring Assembly. IF the bias voltage is lost, the control circuitry will immediately shut down the switching supply, thereby removing the drain voltages from the amplifier modules and protecting the GaAs FET devices.

Differential amplifier OP Amp circuits are used to monitor the drain currents of the FET devices. The OP Amp outputs drive LED indicators as well as an opto-isolated O/P amplifier status line.

The Dual Power Detector Board inputs forward and reflective power signals from the Amplifier Module and detects the levels using peak detector circuits. These circuits provide voltage levels proportional to the power level of the sampled signal, which is used for metering and ALC purposes. Metering adjustment is provided with on board potentiometers.

The Dual Power Detector Board also contains a gating pulse timing circuit that serves to maintain the proper power level when sync suppression scrambling systems are used.

8.4.1.4 Control/Monitoring Assembly (Upconverter/Amplifier Assembly)

The Control/Monitoring Assembly (1585-1129) consist of an 8-bit microcontroller (MC68HC705B`6) and associated control circuitry and provides the capability to control and monitor the operating status o the transmitter. The interconnection between the Transmitter Control and Monitoring Module, IF Processing Module, and Local Oscillator/Upconverter Module is accomplished through the Backplane Board. The interconnection between the Transmitter Control and Monitoring Module, Power Supply Module, and Power Amplifier Module is accomplished through interconnect cables. A detailed listing of all the interfaces between the Transmitter Control and Monitoring Module and the various modules, which make up the ITS-5724 transmitter is given below.

8.4.1.5 Power Supply Assembly (Upconverter/Amplifier Assembly)

The transmitter may be powered by either a 115 VAC/60 Hz or 230 VAC/50/60 Hz source. The AC source enters the tray at jack J1and passes through the Power Entry Module. The Power Entry Module contains a switch, for selecting 115V or 230 V input, a line filter and fuse protection. The output of the Power Entry Module is distributed to a terminal block (TB1).

Varistors VR1, VR2, VR3 and VR4 provide transient and over voltage protection to the transmitter. The rear panel circuit breaker applies AC voltage to the input of the 530 W Switching Power Supply (MP6-2K-4ll-00-415-CE) located on the Power Supply Module.

The Switching Supply provides three outputs. The first output is a +11 VDC/31A line used to power the GaAs FET amplifiers with power. The remaining outputs are +12 VDC lines used to supply the modules within the transmitter. The +12 VDC line is also used to power the 12 VDC cooling fan via the Backplane Board.

8.5 Control and Status

8.5.1 Upconverter/Amplifier Tray

Table 8-2. IF Processor Assembly Panel Samples

SMA CONNECTOR	DESCRIPTION
IF SAMPLE	Provides a sample of the IF frequency.

Table 8-3. IF Processor Assembly Front Panel Control Adjustments

POTENTIOMETERS	DESCRIPTION
FREQ RESP EQ	Provides adjustments for frequency response equalization.
ALC	Sets the reference level of the ALC circuit.
MAN	Adjusts the gain when ALC is disabled.
MAG	Sets the linear equalization of the system.
CUT-IN	Sets the reference power level the linearity equalization is active.
SWITCHES	**DESCRIPTION**
LIN EQ OUT/IN	Allows linearity equalization to be switched in or out.
MAN / ALC	Allows the selection between ALC or Manual mode.

Table 8-4. IF Processor Assembly Front Panel Status Indicators

LED	FUNCTION
Input Fault (Red)	Illumination indicates when no IF input is present.
P/A (Red)	Illumination indicates a PA fault (peak to ave).
ALC (Red)	Illumination indicates an ALC fault.
MUTE (Red)	Illumination indicates the IF signal is muted.

Table 8-5. LO/Upconverter Front Panel Samples

SMA CONNECTOR	DESCRIPTION
LO SAMPLE	Sample of the LO Frequency.
RF SAMPLE	Sample of the On Channel RF Output of the Upconverter.

Table 8-6. Control/Monitoring Assembly Control Adjustments

POTENTIOMETERS	DESCRIPTION
CTRS LCD	Adjusts the contrast of the front panel LCD.
FWD	Calibrates forward output power.
REFL	Calibrates reflected output power.
EXT F	Calibrates forward output power of the external amplifier.
EXT R	Calibrates reflected output power of the external amplifier.
NORM	Not used.
AUX	Not used.
SWITCH	**DESCRIPTION**
RST	Microprocessor reset.
DIP SWITCH 1	Set to “on” position when an external amplifier is present.
DIP SWITCH 2	Set to “on” when an internal modulator is used.

DIP SWITCH 3	Set to “on” when using an external IF carrier option.
DIP SWITCH 4-6	Not used.
DIP SWITCH 7-8	Selects languages to the LCD display.

Table 8-7. Controller/Monitoring Assembly Front Panel Status Indicators

DISPLAY	FUNCTION
ACTV (Green)	Illumination indicates that the microprocessor is active.

Table 8-8. Power Amplifier Assembly Control Adjustments

POTENTIOMETERS	DESCRIPTION
FWD LEV	Calibrates the forward power metering level.
REFL LEV	Calibrates the reflected power metering level.
FWD ZERO	Calibrates the zero level for the forward power metering.
REFL ZERO	Calibrates the zero level for the reflected power metering.
GATE LEVEL	Sets the detected forward power level in conjunction with an external gating pulse provided by certain video scrambling systems to properly reference the peak power level.
GATE TMG	Sets the trigger timing of an external gating pulse provided by certain video scrambling systems to properly reference the peak power level.

8.6 Input Remote Interface Connections

8.6.1 Remote Interface Connections (Upconverter/Amplifier Tray)

Port	Type	Function	Ohm
J1	IEC	AC Input	N/A
J2	BNC	Video Input	75
J3	BNC	Composite Audio Input	75
J4	BNC	Visual IF Output	75
J5	BNC	Visual IF Input	75
J6	BNC	Aural IF O/P	75
J7	BNC	Aural IF Input	75
J8	N	RF Output	50
J9	BNC	Combined IF O/P	75
J10	BNC	IF CW I/P	75
J11	3-Position Terminal Block	Base-band Audio Input	600
J12	37-Position D-Female	Control	N/A
J13	25-Position D-Male	Remote	N/A
J14	BNC	IF Input Signal	75
J15	RJ-45	SCADA Loop-thru	N/A
J16	RJ-45	SCADA Loop-thru	N/A
J17	BNC	Ext. 10 MHz Reference Input	50
CB1	AC	AC Circuit Breaker	N/A

8.7 AC Input

8.7.1 Upconverter/Amplifier Tray

The AC input to the Upconverter/Amplifier Tray is 117 VAC or 230 VAC (factory selectable). The AC input is applied to the tray through Jack J1. MOV's are provided to protect the Tray from transients or surges, which may occur on the AC Input Lines.

8.8 System Operation

When the transmitter is placed in the “operate” mode, as set by the menu screen located on the front panel of the Upconverter/Amplifier assembly, the +10.8 VDC stage of the power supply is enabled, the operate indicator on the front panel is lit and the DC OK on the front of the power supply should also be green.

When the transmitter is in standby, the +10.8 VDC stage of the power supply is disabled, the operate indicator on the front panel and the DC OK on the power supply will be extinguished.

If the transmitter does not switch to "Operate" when the operate menu is switched to Operate, check that all faults are cleared.

The transmitter can be controlled by the presence of input signal. If the input signal to the transmitter is lost, the transmitter will automatically cutback and the input fault indicator will light. When the input signal returns, the transmitter will automatically return to full power and the input fault indicator will be extinguished.

8.8.1 Principles of Operation

Operating Modes

This transmitter is either operating or in standby mode. The sections below discuss the characteristics of each of these modes.

Operate Mode

Operate mode is the normal mode for the transmitter when it is providing RF power output. To provide RF power to the output, the transmitter will not be in mute. Mute is a special case of the operate mode where the +10.8 VDC section of the power supply is enabled but there is no RF output power from the transmitter. This condition is the result of a fault condition that causes the firmware to hold the module in a mute state.

Operate Mode with Mute Condition

The transmitter will remain in the operate mode but will be placed in mute when the following fault conditions exists in the transmitter.

- Upconverter is unlocked
- Upconverter module is not present

Entering Operate Mode

Entering the operate mode can be initiated a few different ways by the transmitter Control/Monitoring board. A list of the actions that cause the operate mode to be entered is given below:

- A low on the Remote Transmitter Operate line.
- User selects "OPR" using switches and menus of the front panel.
- Receipt of an "Operate CMD" over the serial interface.

There are several fault or interlock conditions that may exist in the transmitter that will prevent the transmitter from entering the operate mode. These conditions are:

- Power Amplifier heat sink temperature greater than 78°C.
- Transmitter is muted due to conditions listed above.
- Power Amplifier Interlock is high indicating that the amplifier is not installed.

Standby Mode

The standby mode in the transmitter indicates that the output amplifier of the transmitter is disabled.

Entering Standby Mode

Similar to the operate mode, the standby mode is entered using various means. These are:

- A low on the Remote Transmitter Stand-By line.

Depressing the "STB" key on selected front panel menus.

- Receipt of a "Standby CMD" over the serial interface.

Operating Frequency

The Power detectors in the transmitter have been calibrated at their frequency of use. The detectors for System RF monitoring are also calibrated at the desired frequency of use.