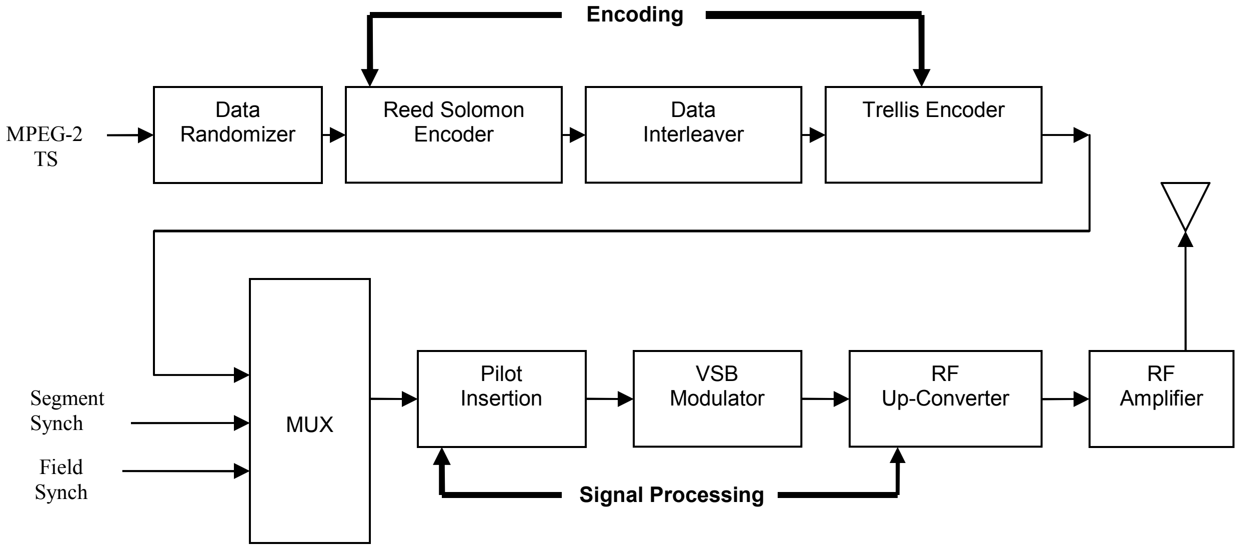
Principle of Operation/ Block Diagram

The input of 8-VSB modulator is a MPEG-2 Transport Stream (TS) based on MPEG-2 at a fixed bit rate of 19.39265846Mbs. The TS has 188 byte packet structure. The 8-VSB spectrum is contained in a 6 MHz channel.



The first byte (sync byte) of the MPEG-2 data packet is stripped and the remaining 187 bytes are randomized using a polynomial generator to prevent long strings of fixed states (1 or 0) that may occur and could increase chances of error.

The Reed Solomon encoder operates on blocks of 187 data bytes to produce blocks of 207 bytes (data plus forward error correction bytes).

The data is then interleaved in order to spread the bits to make it more immune to burst noise.

The trellis encoder converts each byte to four 8-level channel symbols. This is important for the modulation stage.

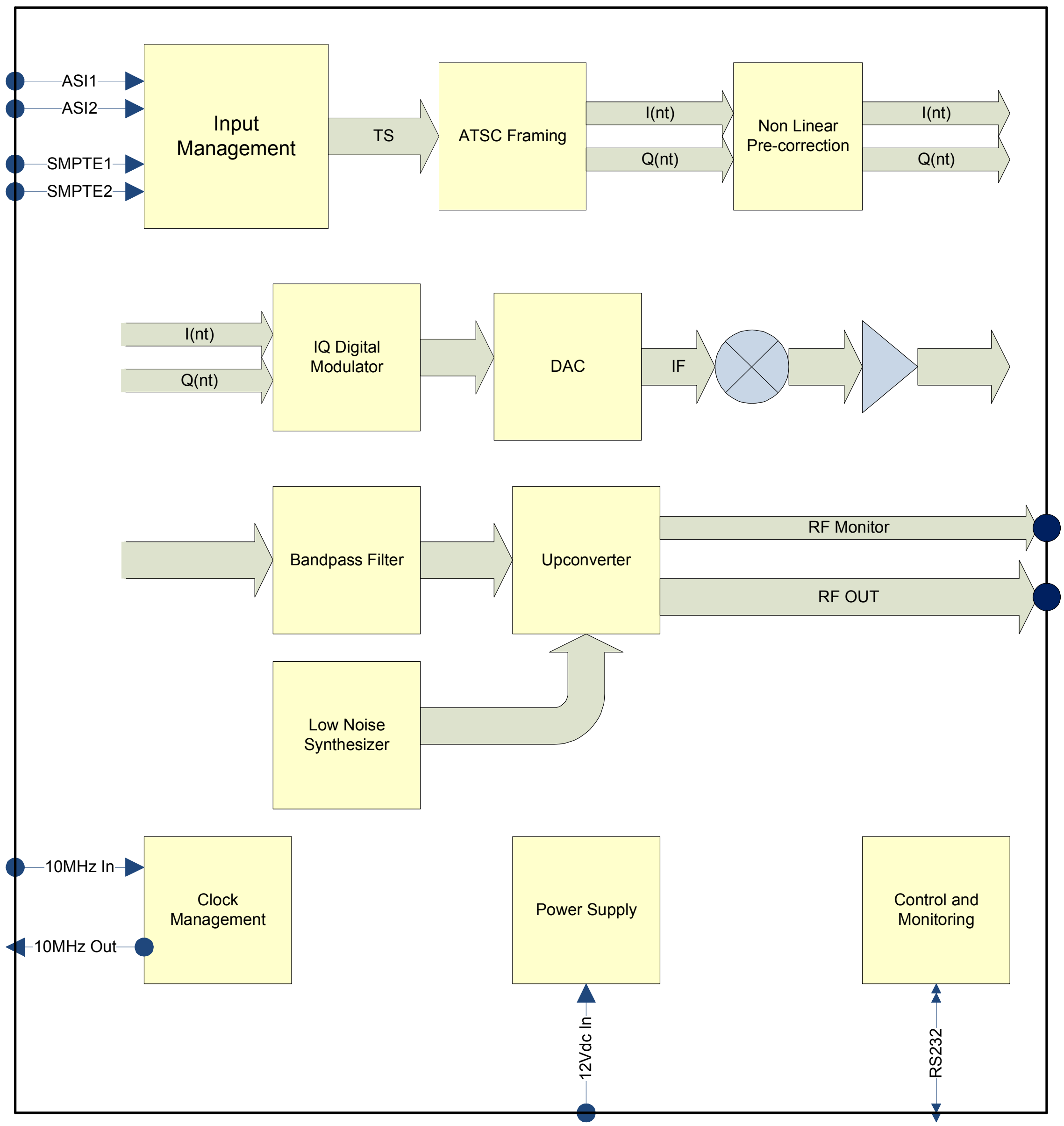
The Mux inserts a sync byte after each 828 symbols. This is inserted to recover synchronization of the MPEG packets as the MPEG sync bytes are removed.

The low level pilot is added to the baseband data. The low level pilot is 11.3 dB below the average data signal power. The pilot is inserted 310 KHz from the lower band edge. The low level pilot aids carrier recovery and is independent of data.

The VSB modulator processes symbols to produce a very short pulse occurring at exactly the center of the symbol times but still maintains their proper 8-levels of amplitude. These short pulses are then applied to a raised cosine filter (Nyquist Filter).

The signal is then up-converted to 44 MHz IF and then to the desired RF channel.
The output of RF channel coming from the modulator is amplified by the power amplifier.

Modulator Components



Data Input Interfaces

The module accepts a MPEG2-Transport Stream dedicated to ATSC transmission as specified in SMPTE-310 and ATSC Standard A/53. It also supports an ASI-320 stream format. Two data inputs are implemented to allow for an input data stream redundancy (Primary input / Secondary input).

Data Input Management

The data input management consists of several processes:

- Bit rate adaptation and PCR (Program Clock Reference) re-stamping:
  The ATSC transmission scheme relies on a very stable and accurate data stream clock. The SMPTE-310 data clock will be at the exact standardized clock frequency. At the same time, the modulator will synchronize with this input data stream to be able to recover the same clock. In the case of using an external clock reference (10 MHz), the global clock synchronization might be plesiochronous (i.e. a small clock deviance between the multiplexer clock and the modulator reference clock). In that case, it is recommended to enable the “bit rate adaptation” on the modulator. When this mode of operation is enabled, the unit discards or inserts Null packets to adapt the MPEG-TS input bit rate to the precise bit rate defined by the ATSC mode. PCR re-stamping is then executed accordingly.
- Switching performance:
  The switching is not expected to be seamless. However, in the case of feeding the exact same data stream on both inputs (Primary & Secondary), the modulator will perform seamless switching from one input to the other. Switching is made on a per packet basis.
- Automatic mute:
  The user can enable or disable the automatic mute for when an error on either the SMPTE-310 or the ASI-320 input is detected. The delay for the detection of the loss of the SMPTE-310 input is 1 second. In case the user disables the automatic mute, null packets are inserted to reach the required bit rate.
- Test mode:
  Test modes available:
    - 23 bits of random data sequence
    - Single tone insertion

Output Interface Management

- Channel Encoding:
  The modulator performs channel encoding according to the ATSC standard:
    - Randomization (energy dispersal)
    - Reed Solomon coding (RS coding)
    - Data field interleaving
    - Trellis coding (constellation building)

- Channel modulation:
  The modulator performs channel modulation according to the ATSC standard:
  - Frame building
  - Pilot insertion
  - Constellation mapping
  - Nyquist filter
- Output processes:
  - Linear pre-correction.

    The modulator can perform linear pre-correction adjustment. It is possible to configure the amplitude and group delay values. The group delay correction is from -2 to +2µs while the amplitude adjustment is +/-3dB. A Tilt function has been implemented to correct for up-converter distortions. It uses a set of 64 coefficients that are computed by the control software.

    Using the software, the user will define their linear pre-correction curve. Then the points will be used to compute complex coefficients to be sent to the module. It needs 64 complex coefficients and these coefficients are used in the module to configure the filter.

  - Non Linear pre-correction.

    The modulator can perform non linear pre-correction over a 20 MHz bandwidth. The modulator can also perform amplitude and phase correction over the full spectrum of the signal. For these purpose two tables (AM-AM and AM-PM) of a maximum of 16 points (abscissa and ordinate values for each point) are downloaded in the modulator ("1S mode"). In "2S mode", the user sets and downloads two groups of 16 points for each table. The first group corrects the "left" side of the spectrum and the second group corrects the "right" side of the spectrum. The "2S" mode provides more pre-correction adjustment accuracy and allows the opportunity to perform different pre-corrections that will have a corresponding impact on the left and right sides of the spectrum. This has been developed particularly to correct asymmetric shoulder levels. Each table defines the amplitude and the phase pre-correction that will be applied on the spectrum.

    The AM-AM pre-correction table defines the AM/AM curve that will be applied across the channel spectrum. For each point, the abscissa can be defined from -12 dB to +12 dB in 0.05 dB steps and the ordinate can be defined from -6 dB to +6 dB in 0.05 dB steps.

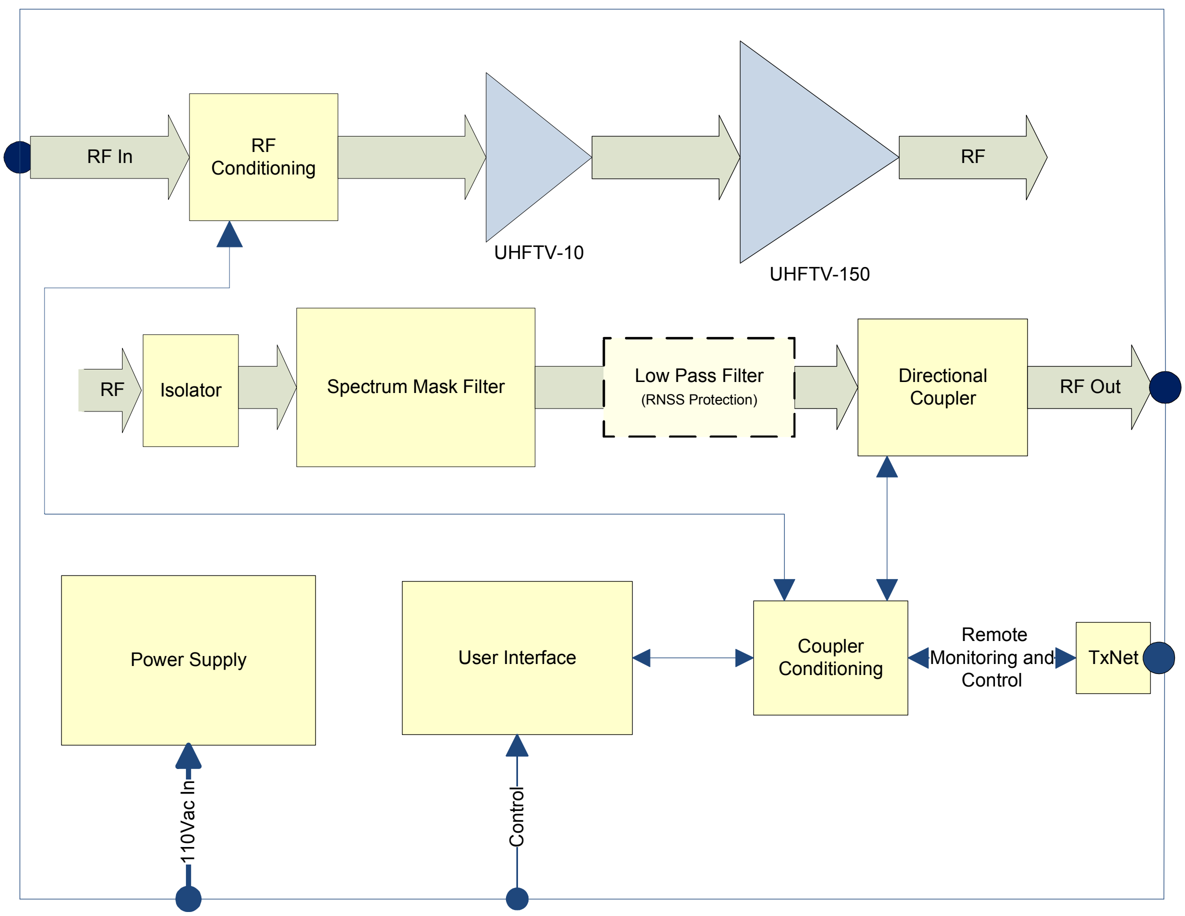
    The AM-PM pre-correction table defines the AM/PM curve that will be applied to the spectrum. For each point, the abscissa can be defined from -12 dB to +12 dB in 0.05 dB steps and the ordinate can be defined from -25° to +25° in 0.2° steps. All 16 points are equally spaced over the useful spectrum in 1S mode and over each left/right segment of the spectrum in 2S mode. These tables can easily be defined by using the control software.

- RF Output signal:
  The main signal is available on the “RF Out”.
  The centre frequency of the signal can be set from:
    - 470 MHz to 860 MHz with a step of 1 Hz.

  The user will be able to setup attenuation between 0 to 10 dB in 0.1 dB steps. An offset gain is also available from -2 to +2 dB in 0.1 dB increments if finer adjustment is desired. The output can be muted either by the user or by pre-determined conditions. The mute can be direct (abrupt muting) or progressive.

  A sample of the signal is available at the test point at an attenuated level of -20 dB.

Power Amplifier Components



Amplifier Pallet

The UHFTV-10 pallet is a two stage ultra linear class-A linear pallet. It has a minimum gain of 38dB and draws no more than 2.75Adc total drain current (the exact bias and drain currents of your system are found in the spec sheet supplied with each manual). The quiescent and drain currents can be measured on the UHFTV-10 pallet by measuring the voltage drop across the current sense resistor found directly at the DC power supply lead input to the pallet. This resistance is 0.01-ohms, providing a 10mV per ampere ratio.

The UHFTV-150 pallet used in the driver and final amplification stages use LDMOS (Laterally Diffused Metal Oxide Semiconductor) technology. LDMOS technology offers higher gain, efficiency and linearity over standard MOSFET and Bipolar devices. LDMOS transistors have the added advantage of not having BEO (Beryllium Oxide) in their construction. The UHFTV-150 amplifier pallets have a typical gain of 13dB and draw no more than 14Adc (again, the exact bias and drain currents of your system are found in the spec sheet supplied with each manual). Currents for these pallets must be measured with an ammeter in series with the power supply lead. Temperature compensated biasing helps ensure steady operating levels over wide temperature ranges.

Isolator

The power amplifier pallets are protected in part by the isolator located in the filter enclosure. It is actually made up of a circulator and 50-ohm dump resistor. The circulators' specifications include an insertion loss of less than 0.2dB with an isolation rating better than 20dB. Any reflected power gets dumped into the flanged power resistor. This way, there is instantaneous protection due to the isolator setup and long term protection due to the software.

Directional Coupler

The Technalogix dual directional couplers provide DC voltages proportional to forward and reflected RF power monitoring. These analog voltages are converted for processing using analog-to-digital converters and provide the control system with valuable data for monitoring purposes. The directional couplers installed in the power amplifier and filter enclosures have a state of the art detection circuitry for measuring forward and reflected power. Hence the readings on the displays in the power amplifier system are digital 8VSB power. Output power should be set following the operating procedure found elsewhere in the manual.

The directional coupler has a typical insertion loss of 0.5dB and its Type N connectors can handle 1,500 watts peak. The coupler requires 5Vdc to power the internal electronics of the coupler and is supplied from the control printed circuit board at the front of each enclosure.

Monitor and Control System

Control System Overview (Insight)

The Insight control system is used for a variety of functions, the most important of which is ensuring that the transmitter continues to operate in a safe manner. The control system also allows the user to monitor and control the transmitter from both the front panel and the remote access port.

Five modules comprise the Insight control system. These modules work together to provide all the functions of the control system. The modules are: the user interface module, the coupler condition module, the RF conditioning module, the temperature sensor module, and the TX NET module. The operation of each module is outlined in the following sections.

User Interface Module

The primary function of the user interface module is, as the name suggests, providing the user interface for the control system. This circuit board is mounted to the front panel of the transmitter, directly behind the LCD display. The membrane switch on the front panel is also connected to the user interface module. These components together provide the user with the ability to monitor the transmitter from the front panel.

The following parameters can be monitored from the front panel:

- Forward (incident) power at the transmitter output.
- Reflected (reverse) power at the transmitter output.
- DC voltage of the transmitter power supply.
- DC current for each pallet in the transmitter.
- Temperature of the heat sink of the transmitter.
- The time since the transmitter was last shut down.

The hardware of the user interface module is based around a microcontroller (U112). This microcontroller interfaces directly with the LCD and the membrane switch to provide output and receive input from the user. The microcontroller also communicates with the coupler conditioning board over a controller area network (CAN) bus. This communication is facilitated be two ICs, U113 and U114, and passes through a CAT5 cable attached to connector J105. The communication link with the coupler conditioning module allows the user interface module to receive information about the forward power, reflected power, and temperature of the transmitter, as well as relay commands from the user to the rest of the system. If the transmitter includes more than on amplifier module, a second CAN connection will be present between the user interface module (J106) and the TX NET board to facilitate communication between enclosures.

Other elements of the user interface module are also controlled by the microcontroller. A buzzer (BZ101), a status LED (D113), and a relay to control the backlight of the LCD (RL101), are all controlled through a buffer (U116). In order for the user interface module to monitor the current draw of each pallet in the system, the DC supply wires pass through the user interface module on their way from the power supply to the pallets. The DC enters through connector J101 from the power supply, and exits through J102 to go to the pallets. As the current passes through shunt resistors (R117, R118, R120, R121, R123, R124, R126, R127, R129, R130), the voltage drop is monitored by U101 to U105, buffered by U106 to U108, and sent to the analog to digital converter integrated into the microcontroller. There are five circuits for which the current is monitored by this system.

As the DC supply passes through the user interface module, it undergoes filtering to ensure that the supply to the pallets is as clean as possible. Each of the five circuits passes through a network of transient voltage suppressors, capacitors, and inductors. Each connection is also fused at the input to insure an over-current condition does not persist. The fuses are a replaceable mini blade type fuse with a 42V voltage rating, and a current rating depending on application.

Coupler Conditioning Module

The coupler conditioning module serves to monitor the output of the directional coupler which provides a voltage proportional to the foreword and reflected power at the output of the transmitter. The coupler conditioning module also interfaces with each of the other boards in the control system, acting as the hub of communications for the system. Lastly, the coupler conditioning board sends and receives signals through the remote access port, via the TX NET board.

The analog signals produced by the coupler for forward and reflected power are passed onto the coupler conditioning module by connectors J206 and J207 respectively. Each signal is filtered by CLC networks, and buffered and amplified by the op-amp U214. The level of the forward signal can be adjusted by VR201, and the reflected signal by VR202. These two potentiometers can be used to fine tune the power readings of the transmitter if they go out of calibration. The analog signals are converted to digital by an analog-to-digital converter integrated into the microcontroller U202.

Aside from taking readings from the coupler, the microcontroller on the coupler conditioning module also interfaces with the RF conditioning module (through J201A) and the temperature sensor (through J201B). The microcontroller interfaces with the CAN bus using U203 and U204. Through the CAN bus, the coupler conditioning board is able to communicate with the user interface module, and any other amplifiers that are in the system. The CAN bus is connected through J201C and J201D if there are multiple amplifiers in the transmitter system.

The last task of the coupler conditioning board is to send and receive remote access signals to and from the TX NET board. Two analog outputs, proportional to forward and reflected power and produced by the digital-to-analog converter U212 after it receives input from the microcontroller. The analog outputs are then buffered by U211 before being sent through J203 to the TX NET board. J203, along with J204, also bring the digital inputs and outputs from the TX NET board to the coupler conditioning module. The digital signals are then connected to the microcontroller through the opto-isolators U205, U206, U207, U208, and U209.

RF Conditioning Module

The RF conditioning board is located at the RF input of the amplifier. Its main function is to act as a variable attenuator, so that the control system can add attenuation to the input of the amplifier in order to limit the output power of the transmitter. The RF signal comes in to the RF conditioning module through J302 before it passes through a manually variable attenuator made up of R305, VR303, and R307. The signal then passes through the digitally-controlled variable attenuator U302 before exiting through J303. The input for the digital attenuator comes from the coupler conditioning module through J304. The input signals are passed through the opto-isolators U303, U304, and U305 before being sent to the digital attenuator. In total, five control signals go to the digital attenuator, allowing for attenuations of up to 31dB in 1dB steps.

Temperature Sensor Module

The temperature sensor module is a small board mounted to the main heatsink of the amplifier. The main purpose of the temperature sensor module is to take temperature readings of the heatsink. The temperature sensor IC is U1 which, after it has taken a reading, relays the digital information to the coupler conditioning module through J1. Also passing through J1 is a driver disable signal coming from the coupler conditioning module. The temperature sensor module simply takes this signal and passes it through to J2, where it is connected to the driver pallet.

TX NET Module

The TX NET module is simply a passive board that acts as an interface between the wiring on the inside of the amplifier enclosure and connections on the outside of the enclosure. The DB-25 connector for the remote port (J602) is attached to the TX NET module. The signals travelling through this port are connected to the coupler conditioning module through J601 and J603. The TX NET module also includes up to four straight through RJ45 connections: J604 to J605, J606 to J607, J608 to J609, and J610 to J611. These connections are only used on systems with multiple enclosures, to pass control signals between enclosures.

Remote Port

The remote port allows external control of the transmission system via the DB25. The functions of each pin on the remote port are indicated in the following table:

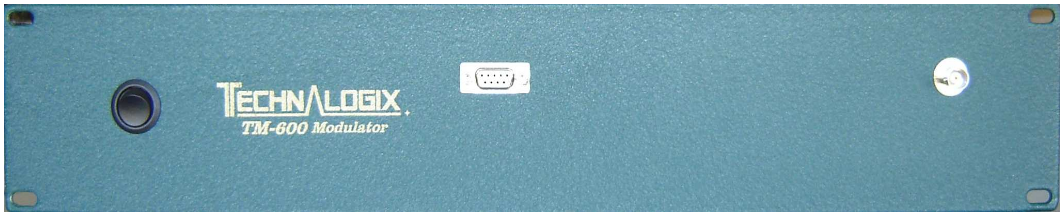
Pin Number	Description
1	Ground
2	Forward power sample[1]
3	Reflected power sample[1]
4	Carrier off[2]
5	Carrier on[2]
6	Increase carrier level (level must have been decreased)[2]
7	Decrease carrier level (1dB increments)[2]
8	Soft reset[2]
9	Reset[2]
10	Power supply fault flag[3]
11	High temperature flag[3]
12	High VSWR flag[3]
13	Amplifier overdriven flag[3]
14	+5Vdc
15	+3.3Vdc
16	Ground
17	Ground
18	N/C
19	N/C
20	N/C
21	N/C
22	N/C
23	N/C
24	N/C
25	N/C

Notes: 1. Analog output with voltage ranging from 0 to 5Vdc.
2. TTL level digital input, active on rising edge.
3. TTL level digital output, active high.

Location and Function of Controls and Connectors (Modulator)

The following illustrations depict the location of the installation connectors when installing the modulator portion of the system.

FRONT



BACK

Front Panel:

Test Point-	Provides a sample of the RF output level. RF test point is only a relative indicator of the actual RF output level and may vary. All RF operating measurements should be made at the RF output of the unit.
RS232 -	Textual low level command interface. User supplies DB9 male to mate to DB9 female on front panel.

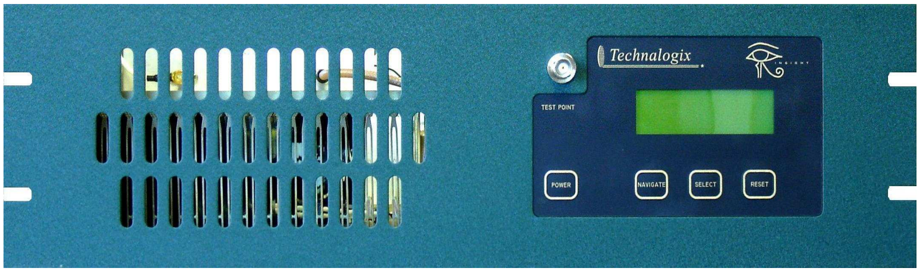
Rear Panel:

ASI In -	ASI-320 MPEG-2 encoded transport stream inputs (BNC).
SSI In -	SMPTE-310 MPEG-2 encoded transport stream inputs (BNC).
10 MHz In -	Accepts external 10 MHz clock reference (BNC).
10 MHz Out –	Provides a 10 MHz clock reference (BNC).
RF Output -	Modulated transport stream, ATSC compliant signal (BNC).

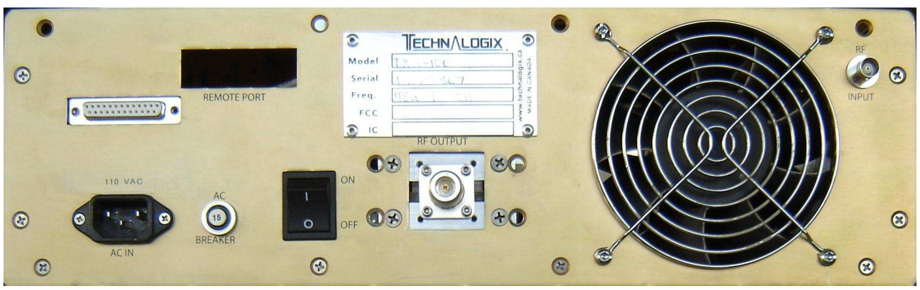
Location and Function of Controls and Connectors (Power Amplifier)

The following illustrations depict the location of the installation connectors when installing the power amplifier.

FRONT



BACK



POWER -	Tactile button to turn carriers on and off.
NAVIGATE -	Tactile button to move between menu items or to refresh the screen after it has timed out.
SELECT-	Tactile button to select menu item, or to refresh the screen after it has timed out.
RESET -	Tactile button to reset microcontroller in control board. Also clears existing faults. The amplifier will come back on with the soft start feature.
RF IN -	RF input from modulator. BNC connector, 50 ohm.
RF OUT –	30 watts 8-VSB RF output. Connects through an inline wattmeter (not supplied) to the antenna. N connector, 50 ohm.
REMOTE PORT -	Port to monitor and control the amplifier externally. See “Monitor and Control” section for pin-out.

Operating Procedure

Modulator Preliminary Setup

1. Terminate modulator into a 50 ohm load before applying power.

2. Connect the power cord of the modulator to a proper electrical source as indicated on the back of the unit.

3. On the front panel, connect the test point to a spectrum analyzer. Make sure that the signal is present, at the correct frequency, and at the proper levels.

   - Allow for 30 seconds delay for the signal to be present after turn on.

4. Connect the RF output to a spectrum analyzer and verify the signal, the frequency, and the levels.

Power Amplifier Preliminary Setup

1. Place the transmitter in its permanent location near a receptacle supplying required AC voltage.

   DO NOT APPLY AC POWER AND TURN ON POWER TO THE TRANSMITTER / TRANSLATOR AT THIS TIME SINCE THE RF OUTPUT MUST BE PROPERLY LOADED BEFORE OPERATION.

2. Place an appropriate AC power line protector, conditioner, and/or surge suppressor across the AC supply line.

3. Hook up the modulator or processor as shown in their respective manuals for a transmitter or translator. ***Do not*** connect the modulated signal from the RF OUT on the modulator or processor to RF IN on the power amplifier at this time. Because of the characteristics of LDMOS devices, the RF drive should not be connected to the power amplifier until after the power supply and bias voltages are present (i.e. soft start is complete).

4. Connect the transmitting antenna cable to the RF OUT N-type connector on the power amplifier.

5. Verify that all signal and RF cables are tight and properly seated in or on the mating connector.

The TXUD-40 transmitter has been factory aligned for channel frequency (per system specification), signal levels and optimum performance.

Operating Procedure

Assuming the above installation instructions have been completed and cautions noted, and the power amplifier is ready to receive a properly modulated digital signal from the modulator, proceed with the following steps to place the system in operation:

1. Ensure that the modulator/processor is turned on and set up according to its instructions.

2. After ensuring the power amplifier is loaded, plug in the power supply and verify that the fan is on.

3. Depress the momentary on/off button after having the power amplifier plugged in for at least ten seconds. The internal soft start circuitry will turn the bias voltages off until the power supply to the amplifier pallet is fully stable. The message on the LCD indicates when the soft start is running. Once complete, the Forward and Reflected Power and Power Supply readings will appear on the LCD.

4. At this time, apply the RF drive signal to the power amplifier. This ensures that the RF drive signal is applied only after the power supply is stable and the bias voltages are applied to the amplifier.

5. The power amplifier Liquid Crystal Display (LCD) shows the user the current status of the amplifier. Verify that the FWD Power reads approximately 30 watts when connected to a digital power meter. The system is set up for 30 watts 8-VSB power and should read 100% FWD Power on the LCD under this condition only. Keep in mind that the system will shut down should the forward RF output power level be exceeded.

THE POWER AMPLIFIER WILL TAKE APPROXIMATELY ONE HOUR TO REACH A STABLE OUTPUT LEVEL DUE TO TEMPERATURE WARM-UP.

6. Ideally, the RFL Power should read zero. However, should a high VSWR be detected, the system will automatically shut down and cycle as previously described. This is also a peak wattage reading.

7. Verify that the power supply reads approximately 30 Volts DC on the LCD.

Look at the transmitted output using a suitable monitor. The picture and sound quality should be clean and sharp. If the output picture and sound quality is unsatisfactory, check the input signals, connections to the antenna system, antenna and transmission line VSWR, and the physical condition of the antenna.

If reception problems are encountered, and the quality of transmission is satisfactory, the difficulty is often with the receiving antenna or with obstructions in the path between the transmitter/translator and receiver.