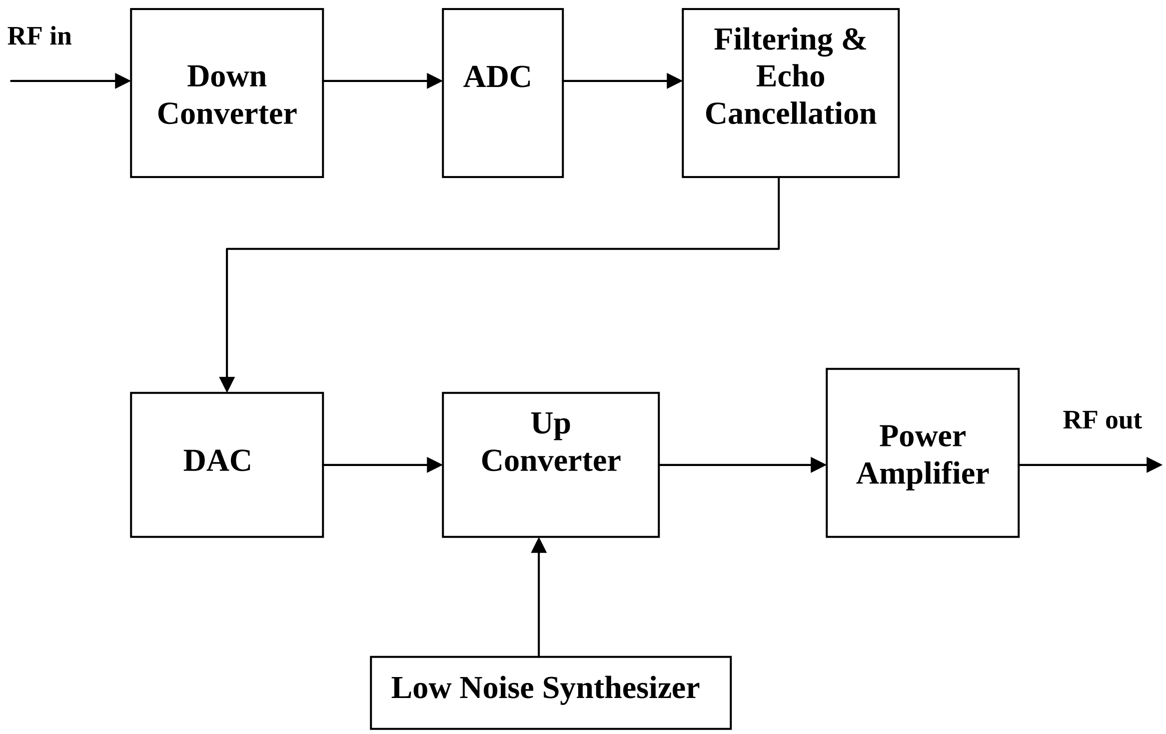
Principle of Operation/ Block Diagram

The input to the TLUD-30 system enters into the processor where the signal gets transferred onto a different frequency and then amplified by the power amplifier stage.

The processor input is typically an off-air digital television signal or a digitally modulated RF signal from an 8-VSB modulator. The 8-VSB input spectrum is contained in a 6 MHz channel. The nominal input level for best performance is -55 dBm, but it accepts a range of -10 dBm to -75 dBm.



The first stage is the Down-Converter and it brings the frequency down to an IF signal which enters the Analog-to-Digital Converter (ADC) block. At this stage, the MPEG data is extracted from the signal. The next stage is the filtering and echo cancellation. After filtering, the processor re-modulates the signal to the desired RF channel. This is being done by converting digital data stream to analog signal and up-converting it to 44 MHz IF and then desired RF channel.

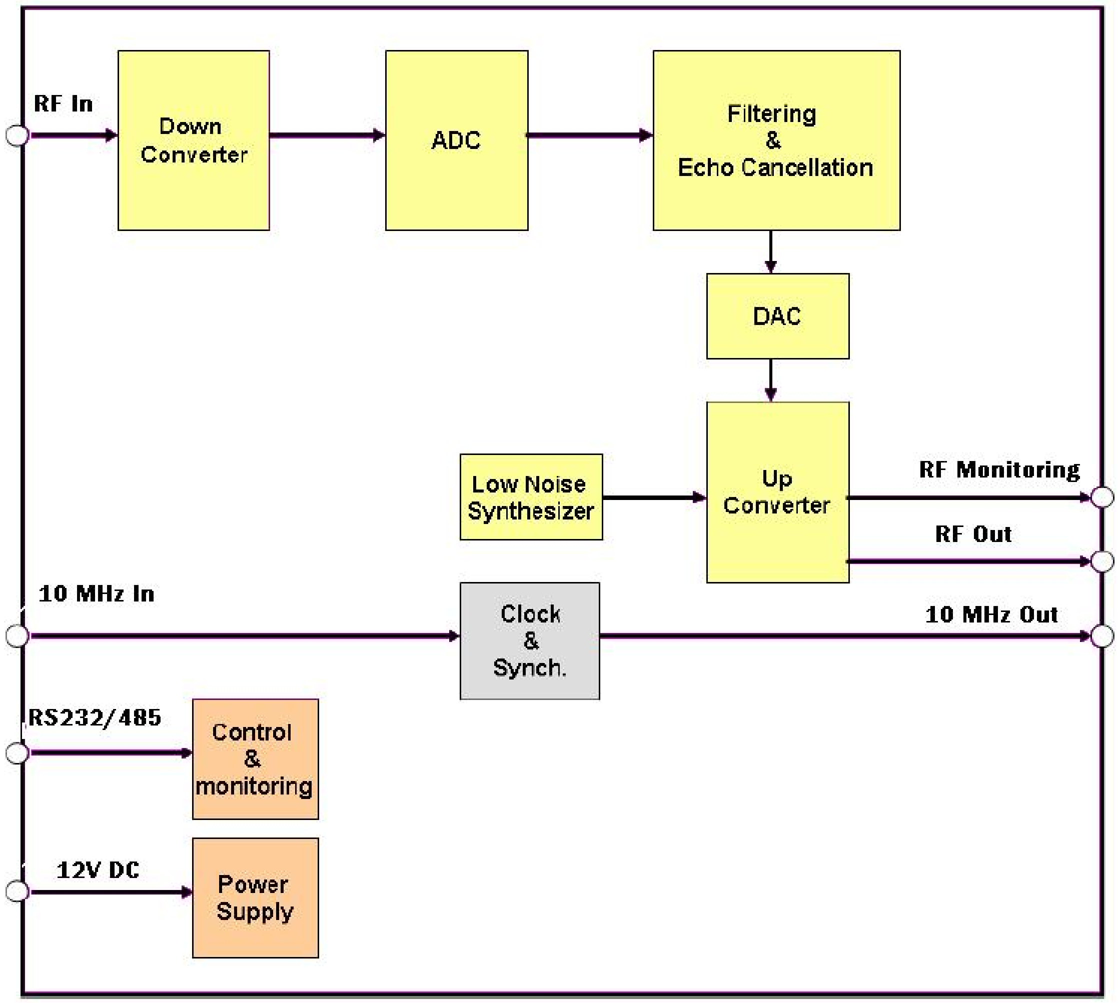
The digital RF signal output of processor enters the power amplifier input which consists of 2 stages of amplification.

The specific description of the TP600-8VSB processor and the power amplifier are described in the following sections.

Processor Components

GENERAL DESCRIPTION

TP600-8VSB modules include, within a single package, a RF down-converter, a digital processing platform and an up-converter.



TP600-8VSB Block Diagram

The system can retransmit either on the same frequency (Gap-Filler mode), or on a different channel (Transposer mode). When used in the Gap-Filler mode, a low transit delay enables Single Frequency Network (SFN) coverage to be expanded efficiently. All signal processing is done digitally at an intermediate frequency level. An integrated digital echo cancellation algorithm enhances the overall system stability and performance. An additional benefit is the embedded digital shaping filter which gives higher frequency selectivity (i.e. higher robustness against adjacent channel interference).

Simple to use linear and non-linear pre-correction circuits are incorporated to compensate for output filter and power amplifier characteristics.

FEATURES

Input Features

- **RF Input**

The RF input accepts a digital RF signal in the UHF band with a supported channel bandwidth of 6 MHz.

- **AGC**

The AGC allows dynamically adjusting the power level of the module.
The nominal input level is -55 dBm for best performance, but accepts a range of -10 dBm to -75 dBm.

The maximum output power level of the TP600-8VSB is equal to 0dBm (others available on request). The output power adjustment has latency in response to input power variations.

- **Mute & Demute Thresholds (squelch)**

The user has the possibility to control the mute of the RF output as a function of the RF Input level. The Mute Threshold defines the minimum input level before the RF output is disabled. The Demute Threshold defines the power level for the processor to demute. It is possible to disable this function by entering the value of -75 dBm in the MuteThreshold field.

DTV Gap-Filler/transposer setting

- **Echo Canceller for DVB-T/H, FLO™, DTMB, ISDB-T, DAB**

The Gap Filler embeds a state of the art echo canceller algorithm. There are two types of echoes to define:

Multi-path echoes:
The multi-path echoes are signal echoes that take part of the incoming signal. The Multi-path echoes are due to signal reflections or from SFN transmission (multiple received transmitters).

Multi-echoes:
Multi-echos come from the feed-back contribution of the Gap Filler RF output. Their delays and levels depends on the input and output antennas coupling and of the installation configuration.

The algorithm first identifies the MAIN incoming signal as the one with the highest level within the received signal. It then examines a given time window relative to the main signal in which to cancel the echoes.
The echo cancelling window has a fixed duration of 5 us. The starting point of the window can be offset 1.5 us to 448 us from the main signal position.

The echoes that are out of the window are not taken in account by the algorithm and are passed through. The algorithm efficiency depends on the gain margin figure. The gap filler gain margin is the ratio in Decibels (dB), at the RF input, between the in-band input power measured without any multi-echoes (RF output muted) and the global input power (echoes included) contained in the echo cancellation window. The maximum gain margin is -12 dB, meaning that the total power of the echoes, in the echo cancelling window, is 12 dB higher than the RF level of the incoming signal.

- **Echo Canceller Limitations**

As with any complex algorithm, the echo canceller has some limitations. Although the echo canceller has been initially optimized to reduce the multi-echoes, it also has the capability to attenuate incoming multi-path echoes. This can operate properly as soon as the multi-path echoes are located within the echo cancelling processing window, and for multi-path echoes with levels that are lower than the main path signal (echoes < Main Signal - 2dB). We recommend installing this product in an environment that provides the lowest multi-echoes signal level. Please consider that the echo canceller might not operate correctly in the presence of significant pre-echos. The echo canceller includes a gain margin estimation tool. This allows monitoring of the multi-path and multi-echoes signal levels that are to be compensated. Note that the indicated gain margin level corresponds to the echo levels measured inside the EC processing window.

- **VSB Echo-Canceller Differences**

The echo-canceller for VSB modulation has some differences. The echo canceling window is fixed in length. The starting time of the window is a function of the shaping filter to ensure the main multi-echo falls within the window. The algorithm cancels the echo with the highest magnitude, which should be main multi-echo.

The maximum allowed gain margin is 0dB. This means the maximum amplitude of the main echo in the echo canceling window cannot be larger in magnitude than the main signal.

- **Static delay**

The user has the possibility to add a static delay from 0 us to 400 us in steps of 100 ns. Adding a static delay shifts the output signal as well as the starting point of the echo canceller window.

- **On-Channel Gap-Filler (Iso-Frequency)**

The On-channel Gap-Filler option enables setting the TP600-8VSB in iso-frequency state, meaning that the output frequency is always the same as the input frequency.

Output Features

- **Output Frequency**

The RF output can be set in VHF band III and UHF band IV & V. The User has the option to set the output frequency independently from the input frequency.

If the output frequency is the same as the input frequency, the unit works as a Iso-Frequency Gap-filler.

If the output frequency is different from the input frequency, the unit works as a DTV transposer.

- **Output Level Setting**

The output power level of the TP600-8VSB is 0dBm. The user has the possibility to adjust the output power level using two options:

  - Attenuation: the output signal can be attenuated from 0 dB to 10 dB in increments of 0.1 dB

  - Gain offset: the output signal can be increased from 0 dB to 2 dB in increments of 0.1 dB.

Please note that these two values are applied simultaneously and added.

- **Enhanced Input Loss Detector**

If the incoming signal is suddenly lost, the squelch function (mute threshold) might not be sufficient to mute the output of the Gap-Filler. If some multi-echoes are present, the TP600-8VSB could enter into a Larsen loop condition. The enhanced input loss detector function detects a sudden increase of the gain margin at the input and helps detect the loss of the correct incoming signal. Enabling this function helps the user mute the output correctly to protect the downstream amplifier.

- **Linear Filter Pre Correction (Tilt)**

In order to compensate for output linear distortion, the user can set a TILT compensation of +/-2 dB in increments of 0.2 dB step.

- **Non Linear Pre Correction**

The processor can perform non-linear pre correction over a 20 MHz bandwidth and amplitude and phase correction over the full spectrum of the signal. For this purpose, two tables (AM-AM and AM-PM) with a maximum of 16 points (with x and y coordinate values for each point) are downloaded in the processor ("1S mode").
In "2S mode", the user sets and downloads two groups of 16 points for each table. The first group belongs to the "low band" of the spectrum side and the second one corrects the "high band" spectrum side. The "2S" mode provides more pre-correction adjustment accuracy and gives the opportunity to perform different pre-corrections for the right and left sides of the spectrum. This has been developed to correct asymmetric shoulder levels.

Each table defines the amplitude and phase pre-correction that will be applied to 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. The 16 points are equally spaced over the useful spectrum in 1S mode or over each spectrum left/right segment in 2S mode.

A flag is available to express whether the system has loaded the table and is ready to accept a new table. Please refer to register 0xAF.

Shaping filter

TP600-8VSB includes an advanced digital shaping filter that produces the cleanest possible output signal spectrum (in particular very low shoulder levels). In ATSC mode the number of taps in the filter can be set. More taps gives greater attenuation, but a longer transit delay through the module.

Synchronization and Clock

The modulator includes its own clock and synchronization generator. A 10 MHz TCXO oscillator provides the internal clock reference to the clock system of the processor.

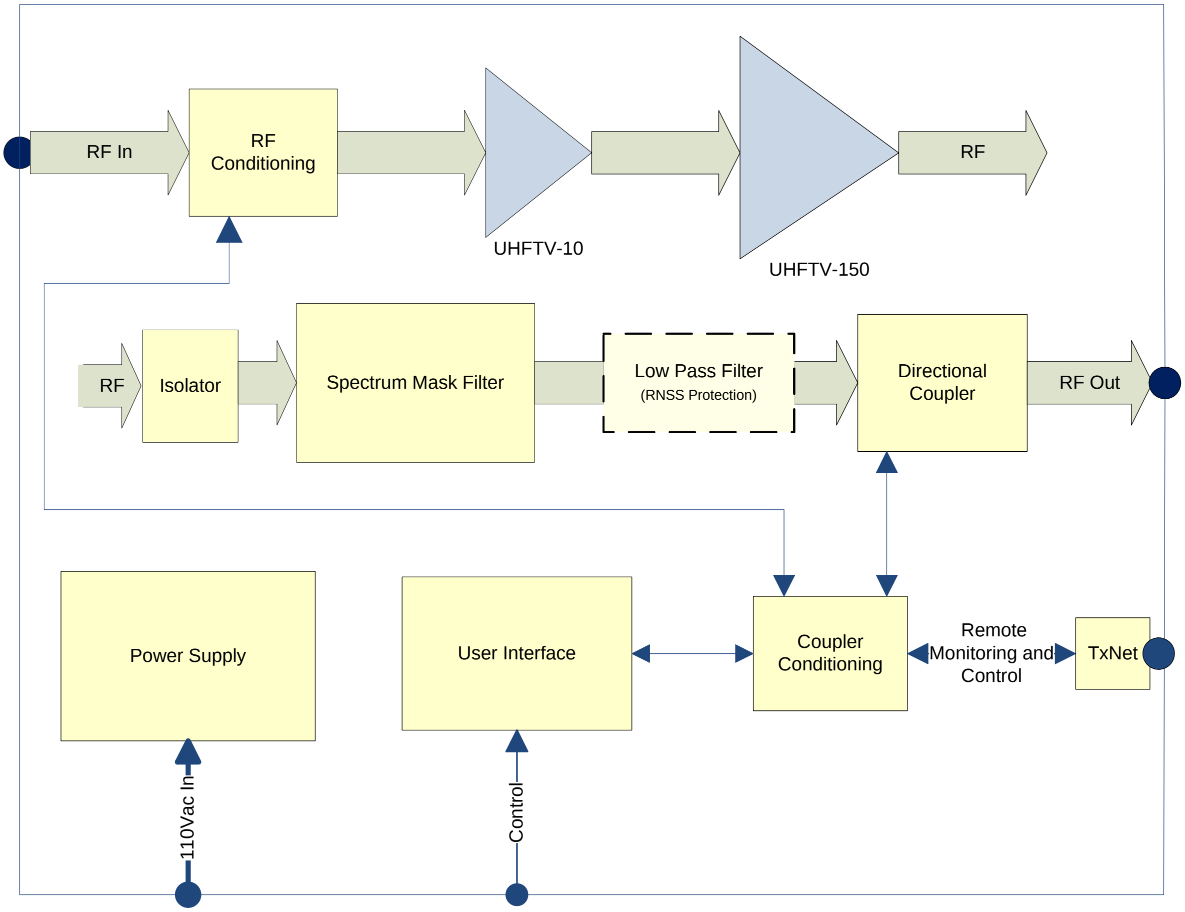
An external 10 MHz reference can be used if a better reference is needed, or if there is a need to lock the processor processing clock to an external reference. This is mandatory for SFN operation.

If the unit is set up to operate with an external reference, it will automatically switch to internal reference if the external reference is lost. The switching is seamless from the external 10 MHz reference to 10 MHz internal clock.

Internal Temperature Management

In order to prevent any damages caused by excessive internal temperature, the processor integrates internal temperature management.

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 (Processor)

The following illustrations depict the location of the installation connectors when installing the processor 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:

RF Input - Digital RF input signal (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

Processor Preliminary Setup

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

2. Connect the power cord of the processor 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 TLUD-30 translator 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/processor, 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.