Linear Industries, Inc.

# AT725P
# Owner's Manual


August 2009

# Linear AT725P
# 25W UHF 8VSB-ATSC EXCITER/TRANSMITTER

# Owner Manual

## Table of Contents

# User Notices and WARNINGS

## USER NOTICES

IT IS VERY IMPORTANT TO READ THIS MANUAL PRIOR TO OPERATION OF THIS TRANSMITTER!

Notice 1
The transmitter main operating voltage setting is marked on the rear of the AT7350-1 chassis.

Notice 2
The transmitter operating frequency is set from the factory.

Notice 3
For adjusting the RF output power setting a qualified technician should always employ the use of an RF Wattmeter and a calibrated dummy load.

Notice 4
Should accident or injury occur to the personnel engaged in the installation, operation, or service of the equipment, they should seek proper medical attention. It is advisable that such personnel have familiarity with first-aid practices.

Notice 5
For technical support please call the Linear technical support customer service line at 847/428-5793 ext. 105.

Notice 6

**WARNING!**

THE VOLTAGES AND CURRENTS IN THIS EQUIPMENT ARE DANGEROUS. PERSONNEL MUST, AT ALL TIMES, OBSERVE SAFETY WARNINGS, INSTRUCTIONS, AND ANY LOCAL REGULATIONS.

THIS OWNER'S MANUAL IS INTENDED AS A GENERAL GUIDE FOR TRAINED AND QUALIFIED PERSONNEL WHO ARE AWARE OF THE DANGERS THAT ARE INHERENT IN THE HANDLING AND OPERATION OF POTENTIALLY HAZARDOUS ELECTRICAL AND ELECTRONIC CIRCUITS. IT IS NOT THE INTENT OF THIS MANUAL TO PROVIDE A COMPLETE SET OF SAFETY INSTRUCTIONS OR PRECAUTIONS THAT SHOULD ALREADY BE UNDERSTOOD BY TRAINED OR EXPERIENCED PERSONNEL IN USING THIS OR OTHER TYPES AND FORMS OF ELECTRONIC EQUIPMENT.

THE INSTALLATION, OPERATION, AND MAINTENANCE OF THIS EQUIPMENT INVOLVE RISKS TO PERSONNEL AND ALSO TO THE EQUIPMENT. LINEAR, INC. SHALL NOT BE RESPONSIBLE FOR INJURY OR DAMAGE THAT IS THE RESULT OF IMPROPER PROCEDURES OR USE BY INDIVIDUALS IMPROPERLY TRAINED OR LACKING THE KNOWLEDGE TO PERFORM ASSOCIATED TASKS.

ALL LOCAL CODES FOR BUILDING, SAFETY, FIRE, OR RELATED STANDARDS MUST BE OBSERVED. CONSULT LOCAL AUTHORITIES FOR THE STANDARDS FOR THE AREA OR REGION WHERE THE EQUIPMENT WILL BE INSTALLED AND PUT IN USE.

**WARNING!**

AT ALL TIMES DISCONNECT AC/MAIN POWER BEFORE OPENING COVERS, DOORS, ENCLOSURES, PANELS, OR PROTECTIVE SHIELDS THAT EXPOSE LIVE CIRCUITS. NEVER PERFORM MAINTENANCE, MAKE ADJUSTMENTS, OR SERVICE THE EQUIPMENT WHEN ALONE OR FATIGUED.

**WARNING!**

IF ELECTROLYTIC OR OIL FILLED CAPACITORS ARE UTILIZED IN THE EQUIPMENT AND THE COMPONENT APPEARS LEAKY, OR IS BULGING, OR IF THE CASE OR COVERING OF THE COMPONENT APPEARS DAMAGED OR DISTRESSED, ALLOW SUFFICIENT TIME FOR THE UNIT TO COOL OR FULLY DISCHARGE BEFORE SERVICING. SERVICING HOT OR LEAKY CAPACITORS CAN CAUSE A RUPTURE OF THE CASE AND POSSIBLE INJURY.

## Returns and Exchanges

Equipment (Damaged or undamaged) should not be returned unless written approval and a Merchandise Return Authorization (MRA Number) is received from your Linear Sales representative or Linear Customer Service. Special shipping instruction will be provided which will assure proper handling. The circumstances and reasons for the return must be included in the request for return. Equipment that is special or "custom" ordered may be not returnable. In situations where return or exchange is at the request of the customer a restocking fee may be charged. All returns must be sent freight prepaid and properly insured by customer. When communicating with Linear please refer to your Order or Invoice Number.

## Unpacking

Use care when unpacking the equipment. First perform a visual inspection of the item(s) to determine if any damage occurred during shipment. Be sure to retain all the shipping materials (crates and boxes or cartons) until such time that it has been determined that the received equipment arrived undamaged. Find all PACKING LISTS and keep them to assist in locating and identifying any components or assemblies that may have been removed for shipping and might need to be reinstalled in the equipment. Make sure that all shipping straps, supports and packing materials are completely removed from the equipment prior to initialization and use.

# Section 1 – AT725P General Description


## 1. General Description

The ATSC DTV exciter model AT725P is part of the ADVANCED TV line, with modular construction to fit in a 19" EIA standard rack and including the following modules:

- 01 Main Control unit - CIM3297
- 01 Keypad - CIM3003
- 01 Display LCD 20 columns x 02 lines - CIM3004
- 01 Memory interface - CIM3535
- 01 1Mbits memory card - CIM3516
- 01 25W RMS UHF/ATSC - Module 4408
- 01 up-Digital Converter - Module 4492
- 01 Power Supply - Module 4401 (versions M110/M220/B220)
- 01 8VSB Modulator and Master Clock Generator - Module 4549
- 01 DC/DC Converter (+2.5V and +5V)

When an AT725P is installed as a TRANSMITTER, a 6 poles elliptical filter is installed at its RF Output. The additional insertion loss is considered and the unit is pre-corrected and equalized accordingly. In this application, the overall performance of the unit will meet or exceed the FCC requirements for out of the channel spurious emission. Please refer to Annex C.

One will also need to perform an operational software operation, to set the unit as TRANSMITTER. Please refer to Annex A, SET CONFIGURATION at page 64.

- **AT725P Block Diagram:**

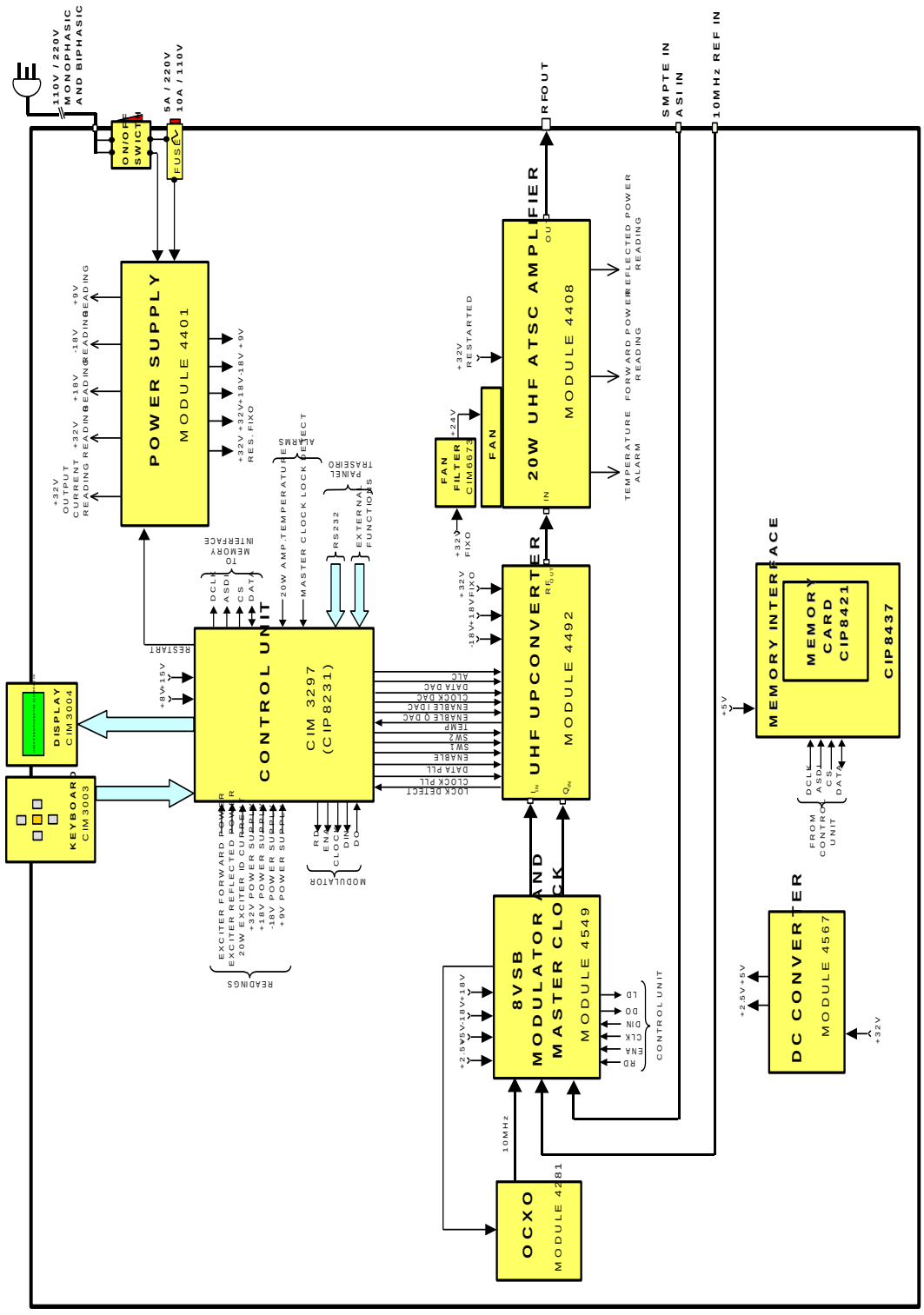



Fig. 1.1: AT725P - Block Diagram

Module 4549

- **8VSB Modulator section**

The 8VSB modulator automatically recognizes the incoming transport stream, either SMPTE310M or ASI. The transport stream input is a BNC connector located on the rear panel of the unit. The modulated output signal of this module is composed by two IF orthogonal carriers termed; signals (I) and (Q). The central frequency of the 8VSB modulated IF signal is 18.83339MHz. The signal processing and modulation performed on this module follows the ATSC recommendation A/53 E.

In this modulator, the in-factory non-linear pre-correction that may be necessary to enhance the equipment's efficiency and meet the FCC's spurious emissions' requirements are performed. If an RF output filter is required (AT275P being set up as a transmitter), the recommended linear equalization is also factory performed in this section.

- **Master Clock section**

The master clock unit generates via PLL and VCO's type oscillator at 172.16MHz. The PLL loop is locked to a 10MHz reference, externally or internally generated. This signal is the time base for the 8VSB modulator

Module 4492

- **IF to UHF up-Converter section**

The IF orthogonal carriers (I) and (Q) are generated on module 4549, (8VSB Modulator section), and are routed to the up-converter module. The output signal of this module is set on the FCC/UHF operational 6MHz channel of the exciter AT725P.

Internally, the modulated IF band mixes with the continuous wave local oscillator LO. As result of this mixing, the IF translation to the UHF band is performed. The LO is a free oscillator, that has its frequency locked via PLL. The LO/PLL use a 10MHz OCXO (oven controlled crystal oscillator) type, or an external reference.

- **10MHz reference automatic switching section**

Both circuits, the 8VSB modulator and the up-converter share the same source of reference signal they need. The use of the same reference allows a perfect synchronization and stability during the DTV transmission process. The internal 10MHz signal is gotten from an OCXO oscillator @ 0.3ppm. The external 10MHz signal can use as reference a GPS signal for instance.

The external reference input is a BNC connector located on the rear panel of the unit. In the absence of this external source, automatically the commutation for the internal source of 10MHz will be made generated by OCXO.

Module 4408

- **25W UHF band multistage amplifier section**

The IF modulated signal already converted into UHF is amplified by an UHF amplifier of 25W. This module uses transistors built with LDMOS technology operating in class AB, with excellent ratio between efficiency and linearity. The RF OUT connector of the unit is the output of this module.

- **RF Output sample section**

The module 4408's RF sample, detects the direct and reverse RF power present on the RF OUT connector of the unit. These two detected samples are then converted on correspondent DC levels before being routed to the master control unit, where they will be processed and displayed on the front panel, LCD screen in unit watts.

CIM3297

- **Control unit card**

The digital management of the transmitter of DTV AT725P is made by the control unit card CIM3297. This control unit utilizes an A128 microcontroller programmed in the assembler language, which makes the process data related with the following parameters:

• Alarm of loss of the lock of the PLL of up-converter.
• Alarm of excess temperature of the 25W amplifier.
• Monitor and exhibit the RF direct and reflected powers, out from the 25W amplifier, muting the transmission in case of extreme levels.
• Exhibits of level electrical current, I1 from the main power supply.
• Process and exhibit the voltages generated by the power supplies.
• Set the Up-converter unit with the operational channel and transmitted power level via ALC.

The control unit is directly connected to a keypad and LCD screen both located on the front panel of the exciter AT725P, from where monitoring and parameters can be set. The same functions can be performed via the RS232 communication connection to a HyperTerminal.

Module 4401

- **Power Supply**

The power supply module is a switching power supply type, running on half-bridge topology. It measures and informs the control unit, the current nominal value of the +32volts DC power supply, and also measures the electrical current demanded by the entire exciter. Both the voltage and the current data are routed to the control unit card to be processed and displayed.

- **AT725P External Interfaces**

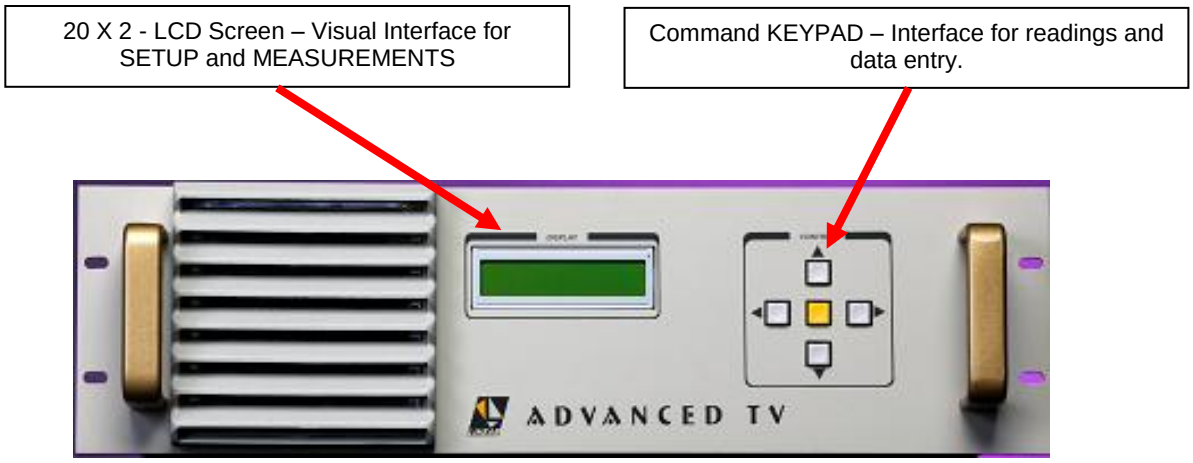



Fig.1.2: AT725P Front View

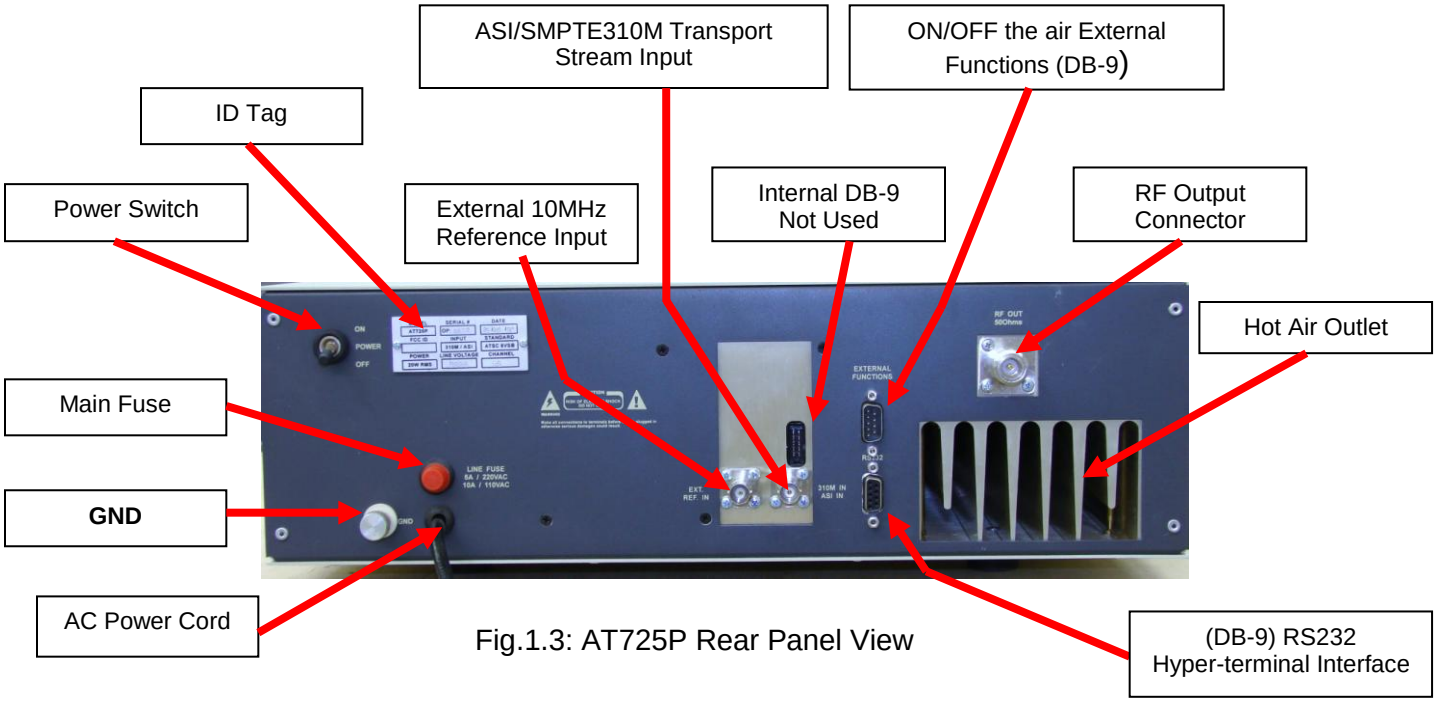



Fig.1.3: AT725P Rear Panel View

- **AT725P - Modules and Parts Displacement**

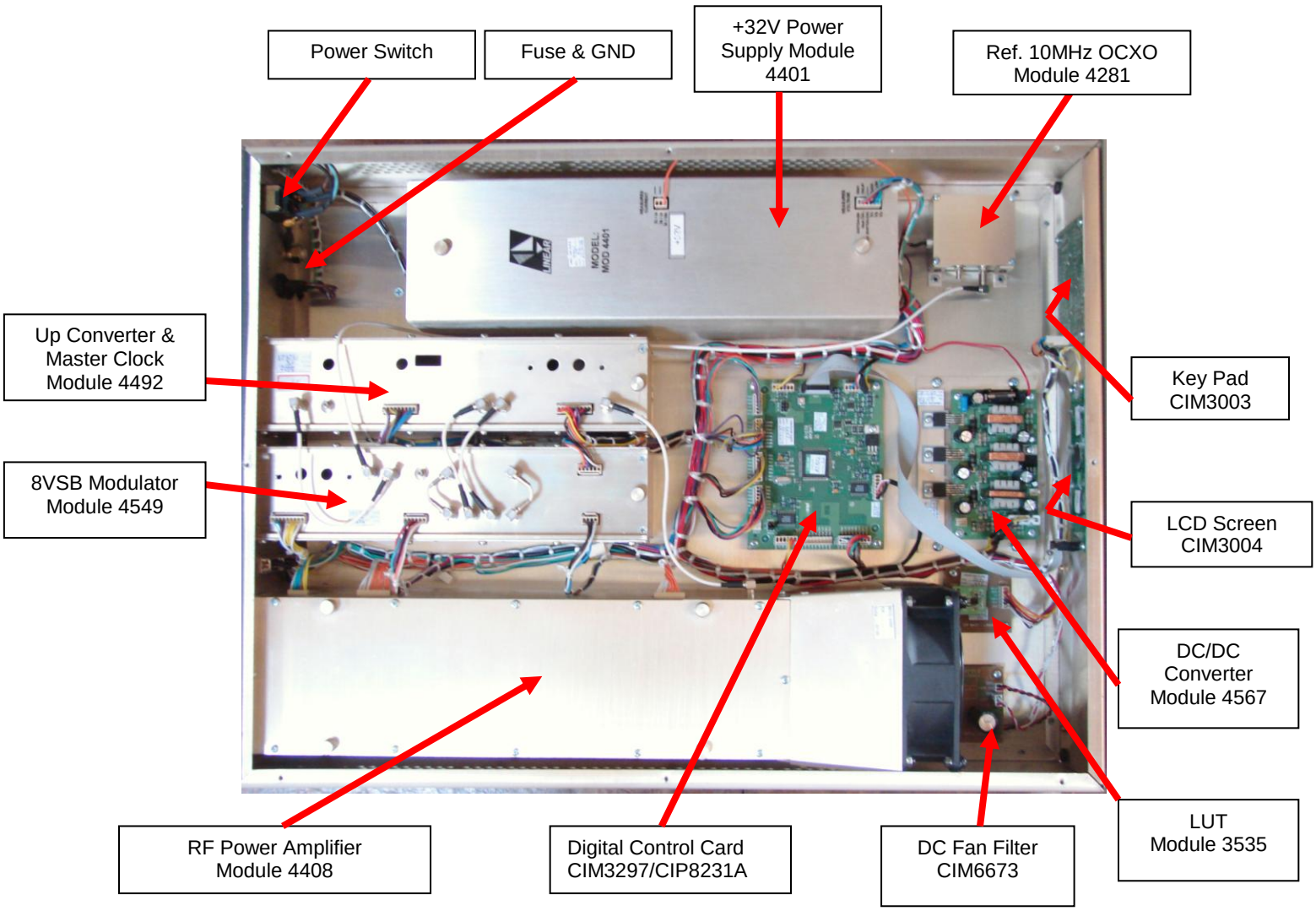



Fig.1.4: AT725P Modules and Parts displacement

- **AT725P - 25W UHF ATSC/8VSB Exciter- Transmitter - Technical Specifications**

| **Electrical** | |
|---|---|
| Main | 110/220 VAC, bi phase, 50-60 Hz. |
| Consumption | 400W. |
| Power Factor Correction, FPC. | Included |
| **Signal Input** | |
| Transport Stream Input | ATSC/MPEG2, compliant to SMPTE310M |
| Input Data Rate | 19.39 Mbps |
| External Reference Signal | 10MHz. (0 to +10 dBm). |
| Input Connector | 75Ω (BNC), |
| Reference Input Connector | 50Ω (BNC), |
| **RF** | |
| Modulation Mode | 8VSB. |
| IF | 18.833916 MHz. |
| Channel Bandwidth | 6MHz. |
| Test Signal | PRBS |
| Frequency Range | UHF. C14 to Ch59, (3 bands). |
| Frequency Step | 1 Hz. ± 220kHz |
| Symbol Rate | 10.76 MSymbol/sec. |
| Digital/Analog Converter | 16 bit |
| Linearization Pre-Correction | Included |
| Pilot frequency stability overall | ± 4.6 ppm. |
| Initial tolerance | ± 1.0 ppm. |
| Vs. temperature in operating temperature range (steady state) | ± 10 ppb. |
| Holdover 24 hours, full temp. range | ± 12 ppb. |
| 24 hours drift (after 30 days) | ± 1.0 ppb. |
| Long term stability over 15 years | ± 3.5 ppm. |
| Peak to peak frequency response | 0.15 dB. |
| Peak to peak group delay response | 10 ns. |
| Phase noise | ≦ -104 dBc/Hz @ 20kHz offset. |
| Conducted spurious and harmonics | < -60 dBc, FCC 47 Part 74. |
| Radiated spourious and harmonics | < -80 dBc, FCC 47 Part 74. |
| MER (Modulation Error Rate) | ≥ 29 dB (transmitter output) typical. |
| RF output connector | N |
| **Communication** | |
| Hyper-terminal | RS232 (DB-9) |
| External Command – ON/OFF | (DB-9) |
| **Mechanical** | |
| Air speed over drawers | 25 ft/minute. |
| Dimensions | 3UR (H), 19"(W), 26"(D) |
| Weight | Gross: 11 Kg |

# Section 2 – Control Unit

- **General Functional Description**

The DIGITAL CONTROL UNIT is responsible for all the digital management of AT725P exciter-transmitter. Management and operability of the transmission is performed via key pad access located on the front panel or via the RS232 through the hyper-terminal.

Its main attributes include:

- Management of the alarm of loss of the Lock of the PLL of Up-Converter.
- Management of the alarm of excess of temperature of the 25W amplifier.
- Monitor and exhibit the direct and reverse RF power at 25W level. In case of extreme levels, the transmission will shut down.
- Display the main electrical current value, I1, drained from the main power supply.
- To process and show the power supply voltages.
- Perform the IF/RF Up-conversion control and transmitted power level control, (ALC).

- **Control unit block diagram**

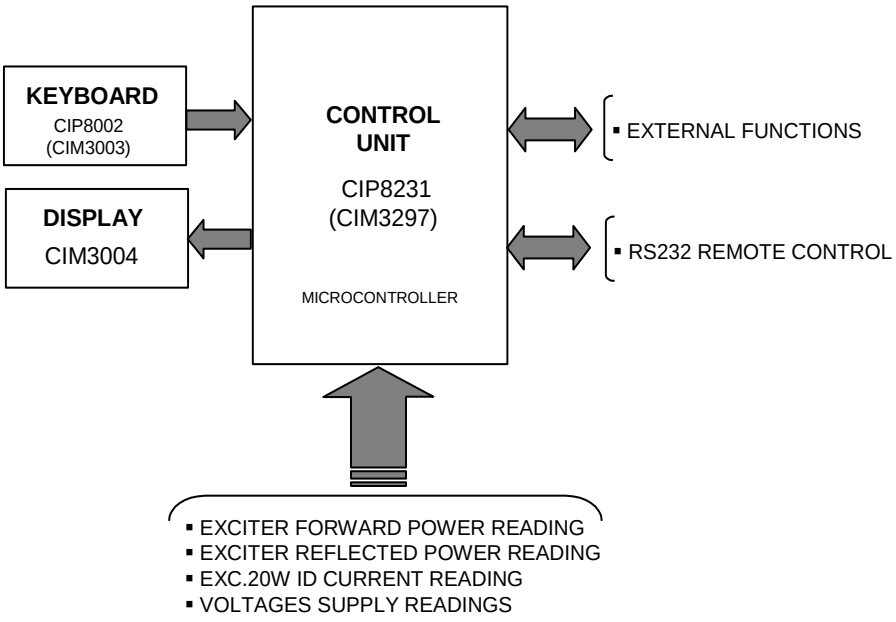



Fig.2.1: Control unit general block diagram

The PCB board CIP8231 is called generically the CONTROL UNIT, as it is the main component of the DIGITAL CONTROL UNIT within the AT725P.

Fig.2.1, profiles the main components and connections of the Control Unit.

Fig.2.1 control unit board - CIP8231 (CIM3297)

Fig.2.2. Keypad board - CIP8002 (CIM3003)

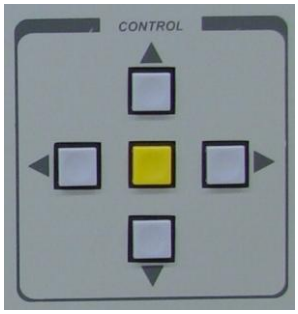
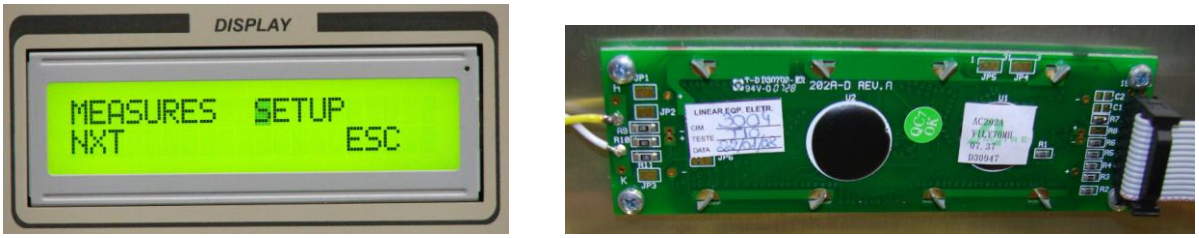



Fig.2.3 20 x 2 LCD display board - CIM3004




- **CIP8231 Connections**

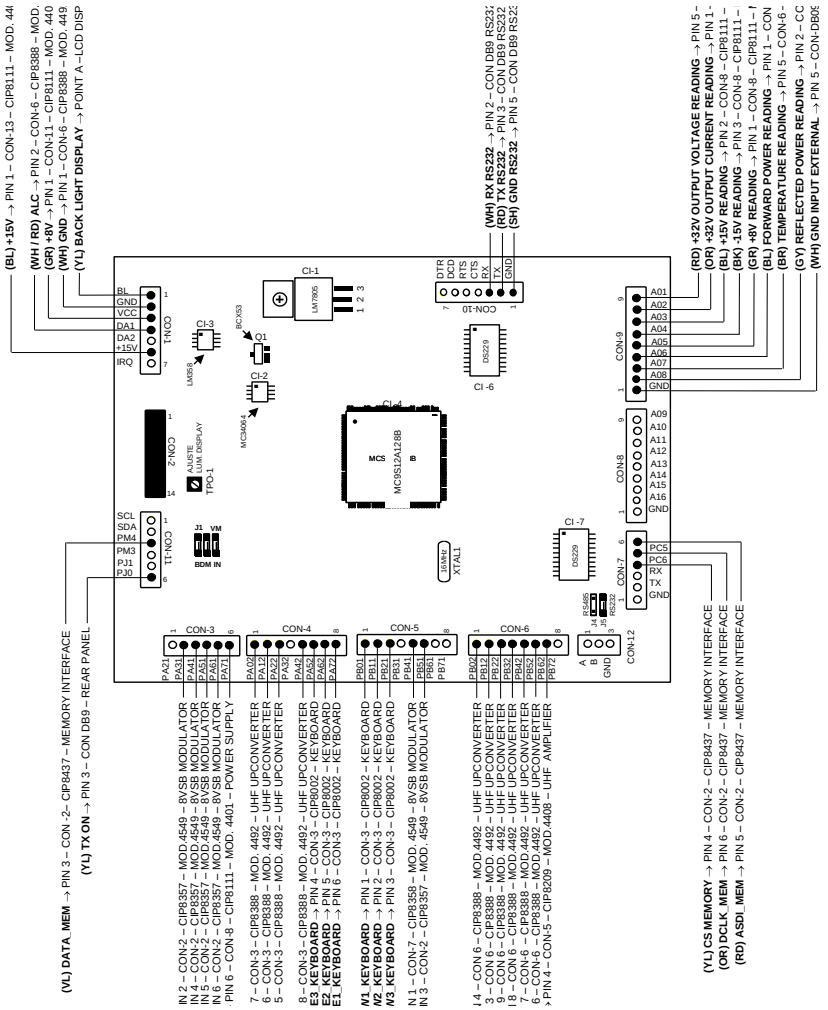



Fig.2.4: CIP8231- the control unit board - components and connections.

The function of the CIP8231 board can be described in the following parts:

➢ The integrated circuit CI-4 (A128) is a 16 bit microcontroller programmed to perform the total management functions of the equipment. This component is programmed in the factory by a numeral designation and its current associated software version. The software version corresponds to any updates that the control software may receive in the future for the CIP8231 board.

→ ***In case of substitution of the CI-4 or even the entire PCB CIP8231, it is mandatory to inform the factory prior replacement, the programming identification number that is clearly indicated at the CI-4 body.***

➢ The analogical readings function: All available analogical readings are sent via the connector CON-9 on the CIP8231 board. Analogical readings include the following parameters:

• Direct power – 25W Amplifier.
• Reverse power - 25W Amplifier.
• (+9V) - Power supply.
• (+18V) - Power supply.
• (-18V) - Power supply.
• (+32V) - Power supply.
• (I1) – the main power supply drain electrical current.

All these seven analogical information are sent to microcontroller CI-4, where they are first digitalized and then processed. The software of this microcontroller establishes that the nominal value of the readings is 4Volts, that is, in connector CON-9 the reading information will have to be of 4V in the way to express nominal values of each readings at the LCD display located at the front panel of the equipment.

On each module of the equipment that generates some type of control-analogical information, there is an associated test point. When during the calibration process external instruments measurements indicate the correct nominal value for that function, a trimmer is adjusted in such way that the voltage on the test point is set on +4Volts.

On the test point associated with reflected power, if the voltage becomes higher than +4Volts, the control unit will process this event as an alarm. This will occur every time that the reverse power exceeds 10% of the direct power.

- **Alarm detection**

For the listed alarms below, the CIP8231 control unit board shuts down the transmission by making the ALC voltage 0Volts at the up-converter module, 4492. For more details see the power control description on the next page.

The possible alarms to be interpreted by the CIP8231 are:

- Lack of lock voltage of the PLL at the Up-converter - Module 4492.
- Excessive temperature of the 25W UHF amplifier - Module 4408 – (above 65ºC).
- Excessive reverse power (above +4V at CON-9).
- Overflow of the FIFO in the 8VSB modulator (informing for communication between microcontroller and modulator).
- Lack of synchronism of the transport stream, MPEG.
- Presence of not programmed hardware (it can appear in the warm-up phase of the equipment).
- Imperfections associated with the generation of the master clock signal in the modulator 8VSB - Module 4549.

The alarms above reach the connectors CON-4, CON-5 and CON-6 at the CIP8231 board as digital information.

The microcontroller (CI-4) receives the alarm(s) information, processes them into the system, and the software makes the decision to incapacitate the transmission or not.

The presence of +5V in the pins of alarm of connectors CON-4 and CON-6 and, therefore, in connector CON-5 means that the status of alarms is empty and the transmitter operates normally. In the event of one of these points of alarm falls for a value below of +5V, being generally the zero, the microcontroller inhibits the transmission.

The alarms generated in the system are displayed as - alarms - in the Master Control Unit window (MCU) on the front of the AT650P. The corresponding identification symbol of alarms is "*" for current alarms - CURRENT - or "#" for old alarms - PAST. In the occurrence of an alarm "*" in Alarms the transmission automatically will be inhibited. When the causing problem of the identified alarm "*" is resolved, the "#" symbol will appear and the transmission will return (slowly) to its full power. To erase old alarm records, key "CLR.ALL" in the MCU panel of the AT725P, or in the hyper-terminal (keyboard key "1").

- **Communication with 8VSB modulator**

The CIP8231 board makes the communication with the 8VSB modulator - Module 4549 - through a set of serial interface gates, (SPI). These connections are present on the pins 2 to 5 on the connector CON-3 and also on pins 5 and 6 of CON-5 connector.

The communication between the CIP8231 board and the 8VSB modulator module 4549 has the objective to make the reading and the configuration of determined parameters of this module, as for example, the adjustment of the pilot programming stream, or the 8VSB signal, and adjustment of the rejection of superior lateral band.

- **Setting the FCC/UHF operational channel**

The programming of operational channel of the equipment is made on the CIP8231board. Out from this board the generated channel code will program the up-converter - Module 4492 - for one determined UHF canal of/ATSC. This stream of information is composed by data, clock, and enabling code, and are present at pins 1, 2 and 3 of CON-4 connector on CIP8231 board.

The control board sends the right channel operational information to program de fraction-base PLL circuit at CIP8388, which will synthesize the local oscillator frequency suitable for the desired channel.

All time that the equipment is turned on, the CIP8231 board automatically makes the programming of the PLL at the module 4492.

It is important to remember that the initial programming that CIP8231board sets for the exciter AT725P is made in the up converter is factory procedures. These programming procedures are made in the act of the configuration of the equipment and although to be done it saw panel frontal (keypad and display), they are not accessible to the end user.

In turn, the module 4492 sends to CIP8231 board, the lock detected information, as response that the PLL circuitry is in lock and ready for operation. This information is packaged as voltage level of approximately of +3,6V and is routed to the pin 5 of CON-4 connector CON-4 on the CIP8231 board. The absence of this voltage will trigger the lock alarm that will cause the reduction to 0 of the RF power of the module and at the same time will be signaled in the LCD display located in the front panel of the exciter.

- **RF power control**

The programming of transmitted power made by the end user, and can be made via the front panel. The CIP8231 board converts this digital input programming information into analogical level of voltage. This voltage is then sent to the up converter of the exciter. This specific voltage level is called as ALC REFERENCE VOLTAGE or trellis voltage, being shown in the LCD digital display as V.P. Adj.

The trellis voltage is directly proportional to the RF power level at the output the exciter, that is, higher the trellis voltage higher the exciter RF power level. The typical value of trellis voltage when the transmission is under the normal rated power is between 3V and 4V.

For some failures, or malfunctions, the power control is responsible for the immediate action to reduce to zero the RF power level of transmission that is, zeroing the trellis voltage, in the following situations:

• Lack of Lock of the PLL of the UP Converter - Module 4492.
• Temperature of the UHF Amplifier of - Module 4408 - above 65°C
• Imperfection in the generation of master clock in the 8VSB modulator - Module 4549.

When the equipment is turned on and the warm up period starts, around 5 seconds, the exciter reaches the nominal RF power value. This period of time, is also known as SLOPE UP time, it is the time necessary for the trellis voltage increases from its initial 0V up to its the corresponding value to set the programmed RF power level at the output of the exciter.

- **Programming the off-set operational frequency**

The AT725P exciter is factory adjusted in a given FCC/UHF operational channel, under ATSC standard 8VSB modulation process, and no off-set is set. This channel can or not suffers change in its off-set frequency, under the end user discretion. The offset can shift the RF channel band up to 30 kHz, in 1Hz increments. The shift of frequency can increase or decrease the start frequency of the band of the UHF channel. The offset is programmed at the CIP8231 board, and acts at the up-converter module 4492, on the pins 1, 2, 3 at CON-4 connector.

All time that the equipment is turned on, the CIP8231 board automatically re-confirms the last set of programmed data at the 4492 up-converter module. It is important to say that programming instructions generated by the CIP8231 board of the exciter are initially set via the keypad/LCD screen located on the front panel of the exciter. However, those are procedures set on the factory and, therefore, not accessible to the user.

- **+32V power supply ON/OFF control.**

The CIP8231 board sends to the power supply, module 4401, a command to switch it ON. It is a +5V level command. It is present at pin 6 on CON-3 connector.

The absence of this command voltage will make that the power supply module 4401 stops to supply the switched +32V line, which feeds the 25W UHF amplifier module 4408. The others voltages generated by other power supplies are always present during the exciter operation.

- **Serial communication RS232**

The access to CIP8231 board is possible made through a PC that has the Windows Hyper Terminal. Located on the rear panel of the exciter there is a DB9 connector tag as RS232.

This connector is linked to connector printed circuit connector CON-10, located at CIP8231 board.

- **Keypad – CIP8002 board**

  The CIP8002 board contains five key bottoms SW1 to SW5, located on the front panel of the exciter. This board is a matrix of electrical ON/OFF contacts. The responses are made available at the CON-3 connector.

- **LCD - CIM3004 board**

  CIM3004 board is a LCD - Liquid Crystal Display - of 20 columns for 02 lines. The luminosity of deep (back light) of this display is made by CIP8231 board that sends +5V between the test point termed A+ (yellow wire) and ground test point termed K- (white wire). The multi-way connector CON-2 receives the pin-to-pin from the CIP8231 board. The trimmer TPO-1 present at CIP8231 board controls the intensity of the characters of the display and the jumper J1, also present at CIP8231 board, must be set on the R61 position, if is desirable that the LCD back light stays ON all time.

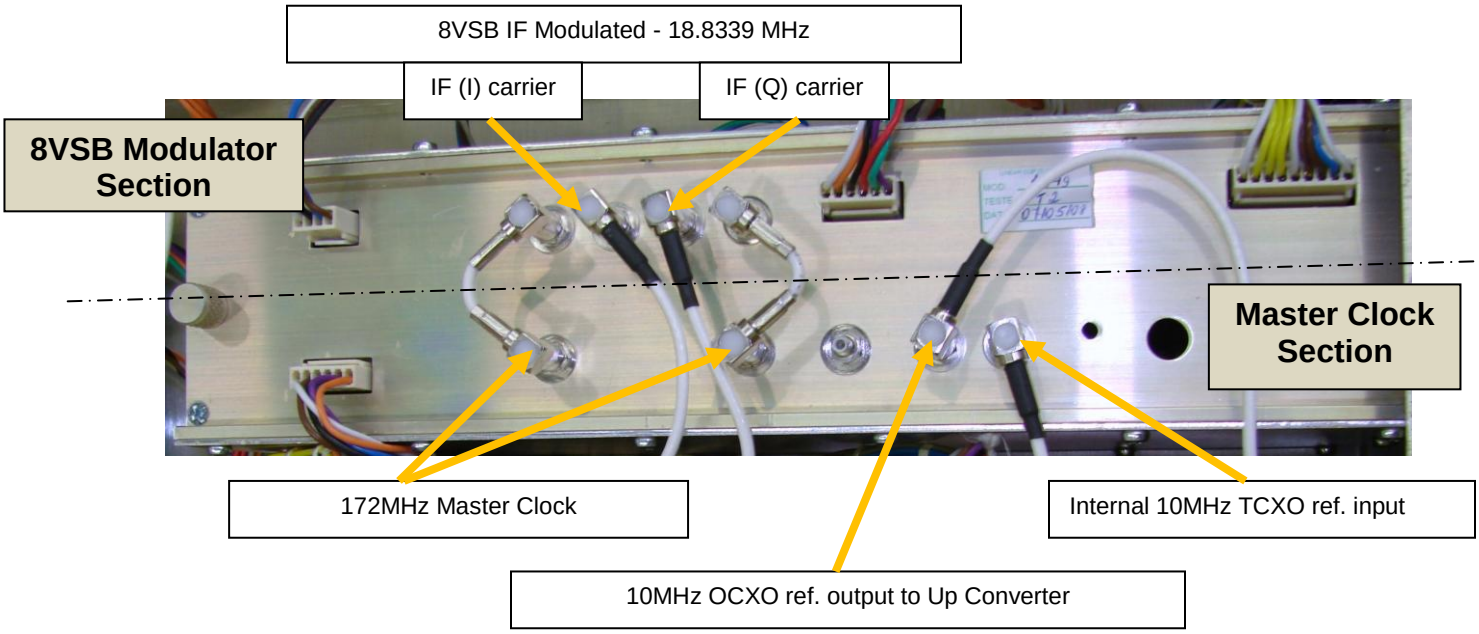
# Section 3 – 8VSB Modulator and Master Clock

Module 4549

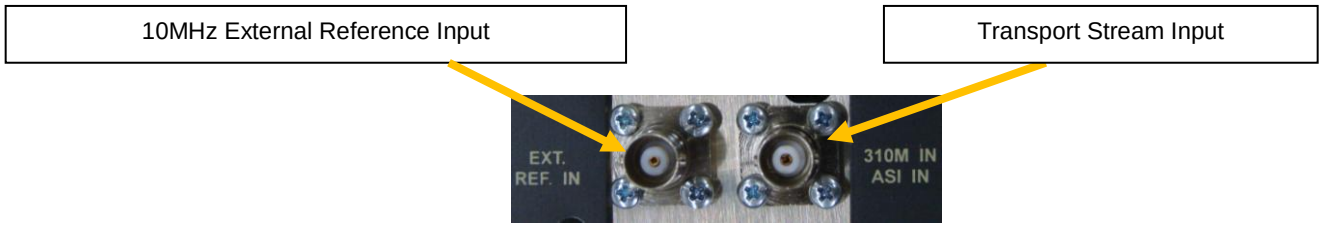
- **Introduction**

The Module 4549 is composed by an 8VSB MODULATOR including an IF pre-correction circuitry CIP8357 board (CIM3510) and also a MASTER CLOCK UNIT, CIP8358.

Each one of these printed circuit boards are located below of one out of the two lateral covers of module 4549, as it shows the drawing of external connections of this module.




(a)




(b)

Fig.3.1: Module 4549, (a) top view, (b) connectors, from rear panel

- **General Functional Description**

The module 4549 can be break down in 2 printed circuit boards. This section describes the 8VSB modulator only. These boards are physically located below of each side of the top covers, as shown on the figure below:

- **CIP8412 board - 8VSB Modulator/Pre-corrector.**

The CIP8412 is part of the Module 4549. It is the 8VSB modulator that process the transport stream (TS) that carries up to 4 broadcast programming including, audio, video and data. All information compressed and multiplexed in a MPEG2 format.

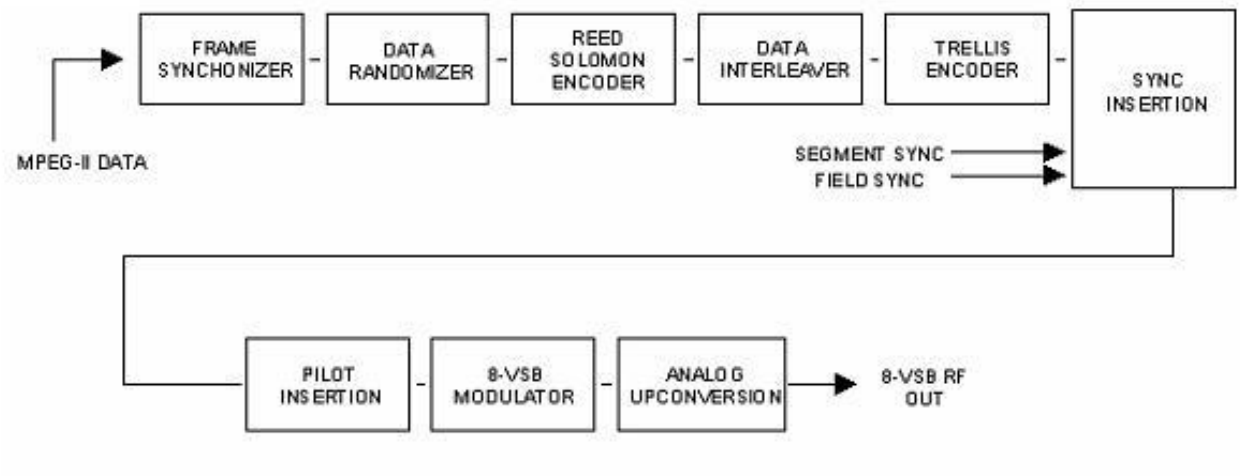



Fig.3.2: CIP8412 – 8VSB Modulator Block Diagram

The 8VSB channel modulator inserts the forward error correction, (FEC), into the transport stream MPEG2. The modulator follows the ATSC standard A/53 annex D.

- **CIP8412 board - general functional description**

The input transport stream signal to be modulated must be either ASI or SMPTE310M format at with 19.39Mbps of bit rate, and with 800mVpp @ 75 ohms. The ASI/SMPTE 310M input is located on the rear panel by a BNC connector.

First the circuit to recover the clock rate is used to perform the protocol interface. After that there is a rate equalization of the transport stream, TS, performed by the insertion or delete of the null packets, at the end the symbol rate is ready to be stabilized and locked with a external/local reference of 10MHz and no longer with the TS stream that is limited to 2.8ppm accuracy. During this processing is also used the re-stamping for multiple programs, termed as PCR.

The entire 8VSB modulation process is digital. This process includes the FIR filters, and do not uses SAW filters to create the VSB band. Digital modulation increase the quality of the modulated signal measured via a proportional increase of the MER, (Modulation Error Rate). The modulation process generates 2 identical but orthogonal signals, termed signals; I and Q. The frequency of the IF carrier is 21.52MHz, and the center of the channel is 18.8MHz.

The value for the system when working with 2 orthogonal carriers is because it is possible to implement corrections on non-linear distortions, or simply implement digital pre-distortion. The digital pre-correction is possible using LUT, (Look up Tables) refer to Section 7. This table synthesizes inverted responses regarding the RF power amplifier transfer function, reducing the IMD products.

The digital processing generates I and Q distorted, and these 2 signals are then converted to the analog format via a 16 bits DAC, with 2 balanced outputs, on a total of 4 output analog signals. These signals are termed; I, I', Q and Q', and are respectively present at the CN9, CN8, CN6, and CN5 connectors at CIM3444.

These 4 signals will become the UHF Up-Converter input signals, Module 4453.
After the data processing as described below, the data stream is ready to receive the channel coding, that is break down on the following steps:

- **Frame synchronization:**

For each 188 bytes on the MPEG2 package, this circuit identifies and removes the 47th byte.

- **Randomizer:**

This circuit equally spread the modulated signal energy over the channel band. The final energy density is similar to a AWGN noise, with this technique, it is possible to achieve a higher bandwidth usage efficiency.

- **Reed-Solomom:**

Reed-Solomon is a block coder, (207,187) that adds 20 redundant bytes on each 187 bytes of the MPEG2 package. With this method it is possible to correct on the reception site, some possible data errors that may had occurred during the transmission of the RF signal.

- **Interleaving:**

The interleaving technique helps to spread the errors around the time line, making them even less susceptible to burst errors.

- **Trellis Code:**

Trellis code is closely related to the channel modulation. It is a convolution coder using 2/3 rate, meaning for each 2 bits at the input, there are 3 coded bits at the output creating the 8 symbols used on the 8VSB modulation process, (-7, -5, -3, -1, +1, +3, +5, +7), having as ultimate goal improve the threshold on the signal-to-noise ratio of the system.

- **Synchronism Insertion:**

The synchronism insertion built the symbol overall structure, creating the fields and frames as specified on the A/53E standard.

- **Pilot Insertion:**

This part of the circuit adds a small DC level into the carrier to allow a safer and robust reception of the signal. This DC level is equivalent to 1.25 CU (Constellation Units).

- **Master Clock – CIP 8358 board – (CIM 3445)**

- **Introduction**

The CIP8358 board, embedded into the module 4549, out from a 10MHz internal/external reference signal, synthesizes a 172.16MHz oscillator that represents 16 times the symbol rate of the modulator 8VSB.

This oscillator signal is squared by a Schmitt-trigger circuit with amplitude equal to 0-3.3 volts. This square wave type signal is the master clock signal that will synchronizes all the digital circuits on this equipment except the control signals.

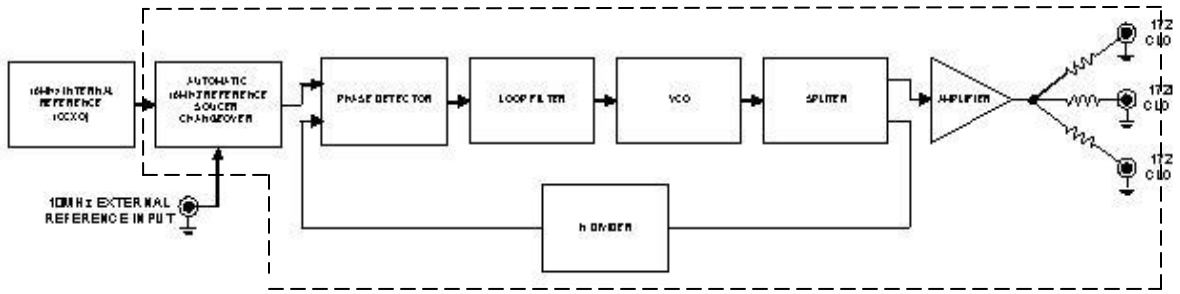



Fig.3.3: CIP8358 master clock – block diagram

- **CIP8358 board – general functional description:**

The 172.16MHz frequency is synthesized via a PLL, a VCO and a DDS circuit. The 10MHz reference is one out of the two inputs of the phase comparator. This signal comes to CIP8358 via a SMB connector, CON-1. The second input is also a 10MHz generated by the DDS circuit out from the free running 172.16MHz oscillator.

The loop filter performs the integration of the phase comparator output, generating the error signal that is feed back to the VCO. On this way the VCO is locked to the external reference signal.
The oscillator signal is delivery via 3 connectors located on the CIP8358 board. Two of those signals are routed to the 8VSB Modulator, CIM3510 board.

# Section 4 – IF/UHF Up-Converter

Module 4492

- **Introduction**

The module 4492 performs the basic functions:

- This module translates the incoming I and Q IF carries, from the 8VSB modulator, to a desirable FCC/UHF operational channel.
- Controls the RF output power of the exciter.

The desirable channel configuration is defined via the keypad and the LCD display on the factory. Channel changes are not allowed to the end user.

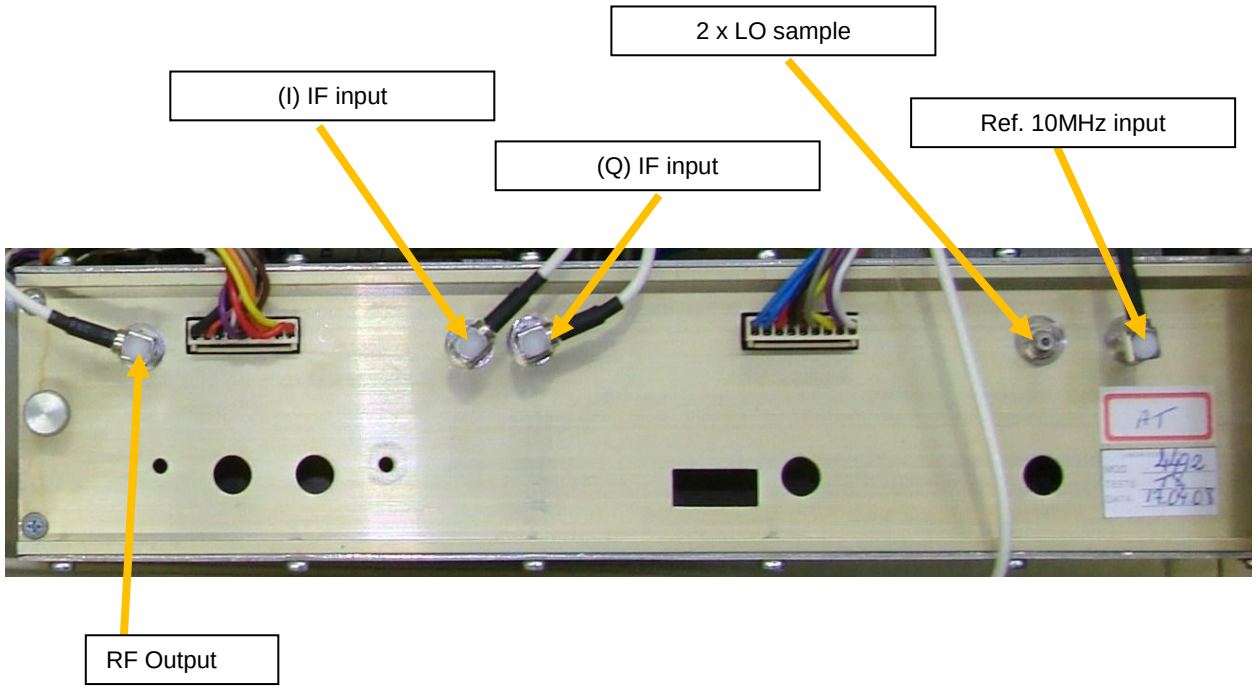



Fig.4.1: Module 4492, RF connections.

The main features associated with this module are:

- Simple conversion.
- Orthogonal mixing, that perform the image rejection, and LO rejection.
- Synthesized local oscillator via PLL, 22 bits serial fractional.
- Allow channel programming @ 1Hz resolution when using GPS reference.
- The LO frequency is divided by 2, that insures 6dB improvement on the LO phase noise.
- 10MHz internal reference oscillator, technology OCXO, (Oven Controlled Crystal Oscillator).
- Uses hybrid amplifiers with high linearity.
- Overdrive protection circuit, acts maintaining the RF power via power reduction.
- Automatically reduces the exciter RF output power in absence of IF signal, either Q or I carriers.
- Stand-by for local oscillator, in case of some failure on the external reference signal.
- Meet or exceed the phase noise requirements for DTV transmission.

**Module 4492 - General functional description -** Refer to Fig.4.2.

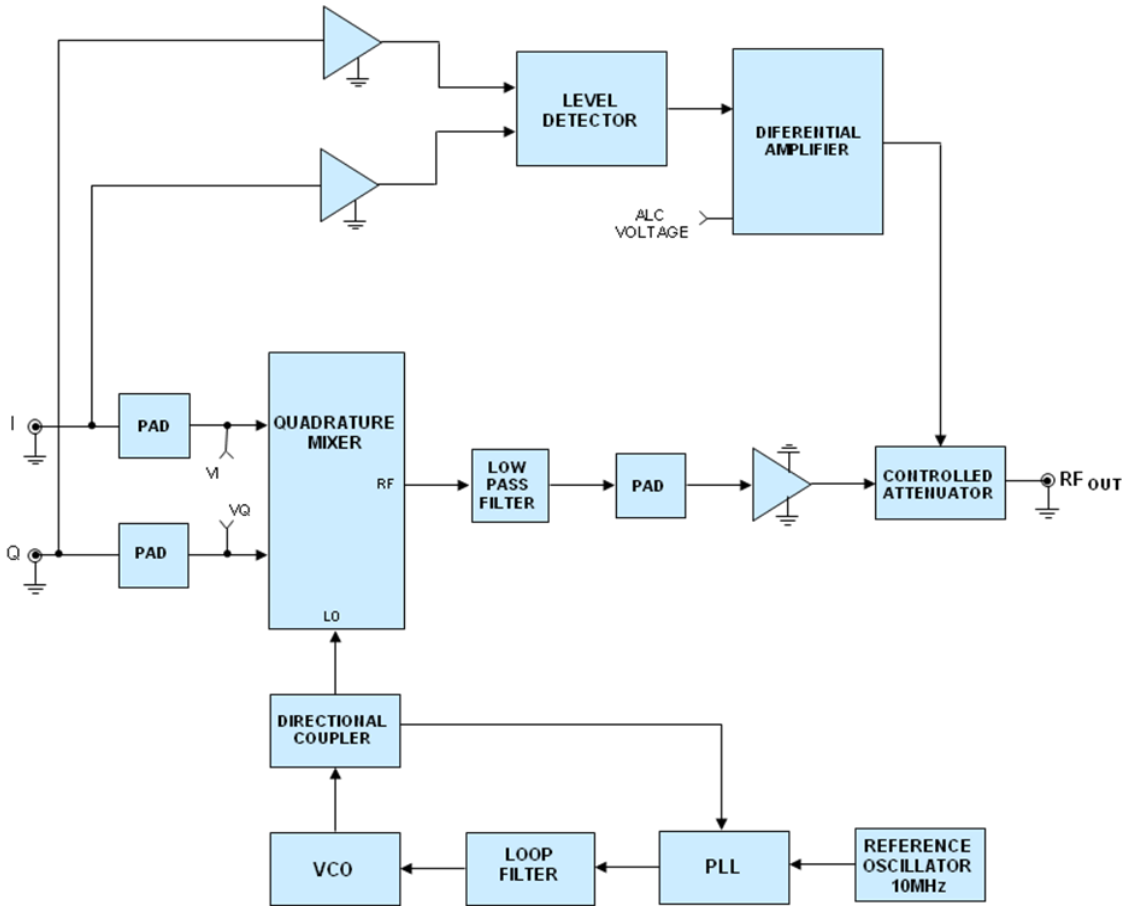



Fig.4.2: Module 4492 – block diagram

The already modulated IF carrier I and Q feed the 2 inputs of the up converter 4492 module. The output signal of this module is a FCC/6MHz/UHF channel (14-69). Besides this main function, it also controls the potential overdrive into the final 25W amplifier.

The up-conversion circuit consists of an orthogonal mixer fed by the 2 orthogonal IF carriers, I and Q fixed center frequency and 6MHz bandwidth. The mixer bit the IF signal with the suitable local oscillator CW signal. The result is two RF lateral bands. The superior lateral band is not desirable and is attenuated by 35dB.

The resultant RF signal is filtered and amplified. The serial data stream that program the PLL circuit are transferred via MICROWIRE interface, composed by 3 high speed transfer lines, 20MHz. The microcontrollers inside the up-converter perform the following function controlling the up-converter:

- **PCB CIM3443 – Local Oscillator:**

The local oscillator is designed based on a PLL circuit. This oscillator is able to synthesize frequencies within the band from 450MHz up to 900MHz. To guarantee a high quality signal generation out from the local oscillator, 4 VCO's (voltage controlled oscillator) were implemented with a shift frequency range of 125MHz each. Just one VCO works at the time to avoid interferences. On this arrangement, a 102dBc@20Hz phase noise is achieved. The synthesizer on the feedback loop select the desired frequency inside the choose VCO band.

The VCO's signal outputs are isolated among them via a sum and inverted circuits. The reference frequency generated by a DDS circuitry complete the Up-conversion frequency process. The output local oscillator signal power is +5dBm.

- **PCB CIM3443 – Local Oscillator – block diagram:**

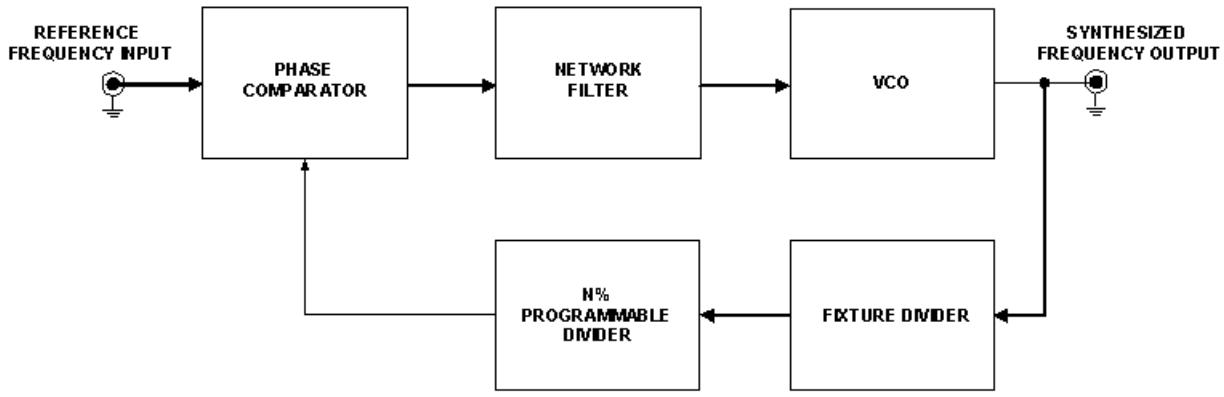



Fig.4.3: CIM3443 local oscillator – block diagram

- **PCB CIM3442 – UHF Mixer**

The mixing operation translates the IF modulated signal frequency up to the assigned UHF broadcasting channel, the operation utilizes the complex approach considering the orthogonal pair of signals (I-, I+) and (Q-,Q+) allowing rejection of one side band, and the oscillator itself. The rejection is around 40dB, facilitating the post filtering steps.

Right after the mixing operation, the now RF signal is 10dB broadband (VHF and UHF) amplified under a typical 2dB roll-off characteristic. The RF output pass through a 25dB dynamic range variable attenuator. The control of this attenuator is related with the DC level generated by the ALC (Automatic Level Control). In case of absence of a IF signal or valid IF signal (locked via PLL) of any of the 4 possible IF signals, the attenuator assumes it higher level of attenuation, and shutting down the RF chain of amplification.

- **PCB CIM3442 – UHF Mixer – block diagram**

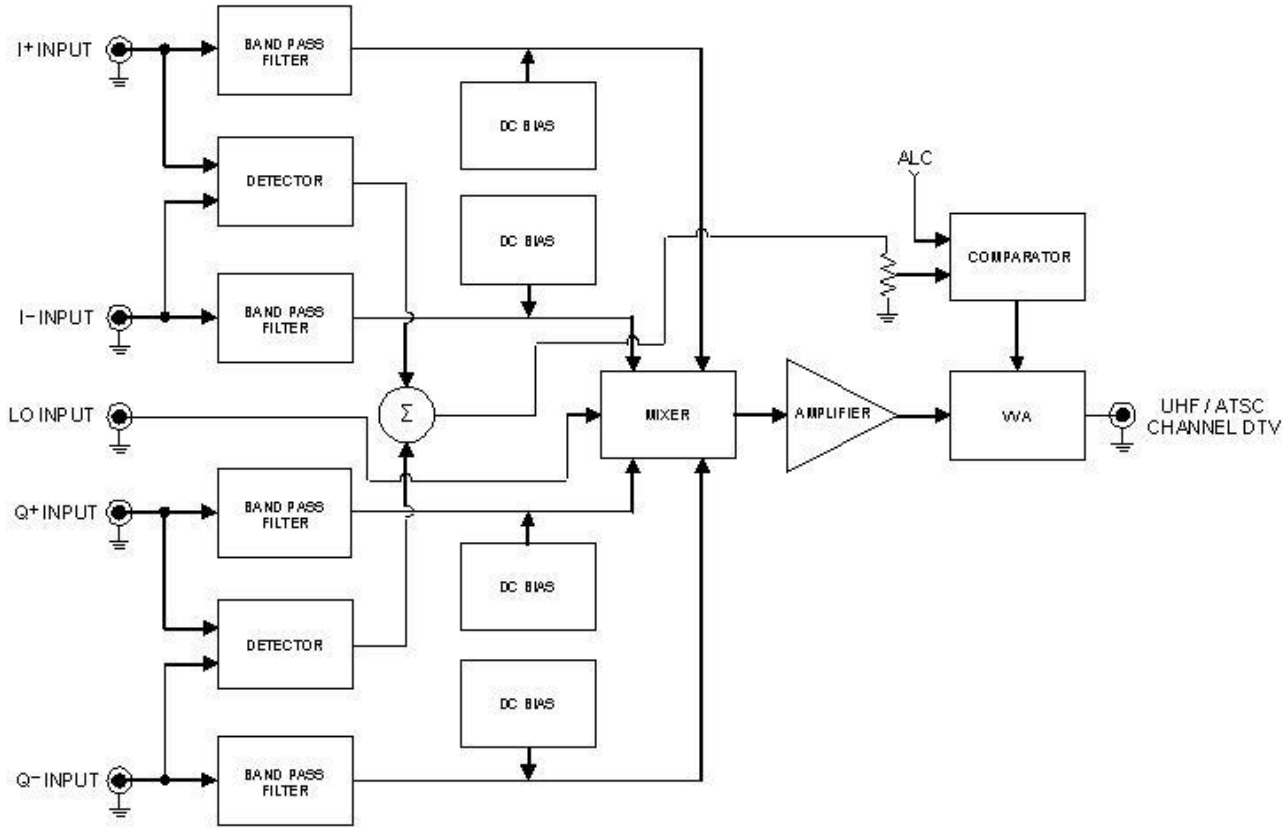



Fig.4.4: CIM3442 UHF mixer – block diagram

- **PCB CIM3442 – UHF Mixer – adjustment procedures:**

The mixer-ALC circuitries have 2 types of adjustments. The first one is a DC level that polarizes each branch of the input of the complex mixer. Each one of the DC levels must be adjusted seeking for the max rejection on the un-desired vestigial side band, in conjunction with the LO rejection as well. The level adjustments are performed by the trim pots: TPO-1, TPO-2, TPO-3, and TPO-4. Voltage range of +1.4V to +1.6V should be present on the following test points.

- TPO-1: readings on L17
- TPO-2: readings on L18
- TPO-3: readings on L19
- TPO-4: readings on L20

The second set of adjustments follows the first one. Once the first set is completed, the fine tuning adjustment should be performed. It is necessary to connect the spectrum analyzer to the UHF RF output of the sub-module 4453. At this point, either the LO signal, as the superior RF spectral image of the UHF/ATSC RF channel, must be attenuated by 40dBc.

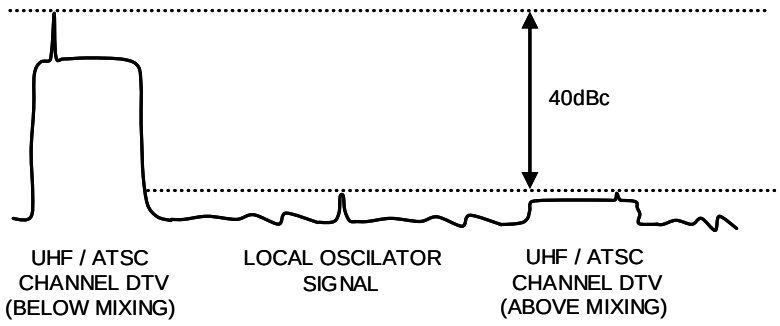



Fig.4.4: Level references for mixer-ALC fine tuning

The second adjust detects the protection signal at the center of the band. In absence of 1 out of 4 controls IF signals, this DC level exceed the min threshold and shut down the RF output signal. The DC threshold adjust is performed by TPO-5, and should be set for +2.5V.

- **Module 4466 – Direct Digital Synthesizer (DDS)**

The module 4466 is a signal reference generator based on a DDS circuit. This module is able to synthesize frequencies up to 50MHz under mHertz precision range. The signal is used as PLL reference on the UHF Up-Converter module 4453 – PCB CIM3442. The RF channel 10kHz off-set if necessary, is pre-set on the DDS circuitry. The phase noise on the reference signal generated on this module is better than 110dBc/Hz.

The SCU unit – PCB CIM3297 – configures the DDS's circuitry parameters via a serial communication port. The DDS module receives a signal out from the master clock module 4454 - PCB CIM3445; perform the programming operation for the RF output channel as required under mHertz precision. At the end, is expected a frequency error around 1Hz max., when measured at the output of the UHF mixer circuit. Before leaves the module, the DDS signal is amplified and filtered.

# Section 5 – 25W UHF Multistage Amplifier

Module 4408

- **General Functional Description**

- **Introduction**

The module 4408 was developed to act as driver of DTV in standard ATSC in all the band of UHF. It is composed by three stages of amplification. The module 4408 has high linearity with a satisfactory performance for TV signals. This module was developed to operate in three bands of UHF, which are:

• LOW BAND (LB): channels 14 to 44
• HIGH BAND (MB): channels 45 to 59

For the two bands of UHF described above, the same PCB is used.

| 25W UHF / ATSC AMPLIFIER - MODULE 4408 | | |
|---|---|---|
| CIRCUIT | CIM | CIP |
| DRIVER | 3392B | 8209 |

What defines which one UHF band the module 4408 must operate, are determined by the PCB's components.

Module 4408 is divided in the following parts:

- 3dB input attenuator, (3dB PAD)

This attenuator is composed by 3 resistors connected as type π topology, R1, R2 and R3, this attenuation guarantee 6 dB isolation. The input matching circuit also has 4dB isolation. The total isolation between the PCB input and gate of the transistor T1, is at least 10dB.

- **First amplifier on class A**

This section uses the transistor LDMOS, T1 (PD57006) with operating with a power gain close to 22dB. The class A polarization insures a high linearity amplification behavior.

The transistor T1 is connected to the +32V power supply, module 4401. This voltage is available at the pins 2, 3, 4 and 5 at the connector CON-2 – module 4408. The trimmer TPO-1 adjusts the VGS voltage of the transistor T1 and, consequently, the drain bias current (ID) of this same transistor. By trimmer C15 the gain of T1 is optimized for the highest value.

- **Second amplifier on class A**

The transistor LDMOS T2 (MRF-373) is the main device of the second amplifier on the module 4408. This transistor also is polarized on class A. The drain voltage is gotten from +32V main power supply. This voltage is available at pins 2, 3, 4 and 5 of connector CON-2 of module 4408. The trimmer TPO-2 adjusts VGS voltage of T2 and, consequently, the drain bias current of (ID) of this transistor.

To trimmers C32 and C33 adjust the gain associate with T2, being optimized for the highest value.

- **Third amplifier on class AB**

This final amplifier device is the LDMOS transistor T3 (BLF-861A) type GEMINI, that is, in the same die it has two transistors. The polarization of T3 is made in class AB, what it guarantees higher efficiency without a significant loss of linearity.

The +32V power supply for this amplifier is also gotten from the main power supply. This voltage is available at the pins 1, 2, 3, 4, 5 and 6 out of the CON-3 connector of the module 4408. The trimmer TPO-3 simultaneously adjusts the VGS voltage for each one of the gates of transistor T3 and, consequently, the drain bias current of T3.

- **LDMOS's VGS voltage soft start circuit**

Module 4408 is endowed with a protection system that approximately delays in 2.2 seconds the release time of the polarization voltage VGS of the LDMOS transistors. On doing that it is guaranteeing protection against potential undesirable voltage spikes during the transient turn on period.

The +12V voltage regulator CI-8 sees from pin 1 of the connector CON-2, the +18V voltage originated on the main power supply module 4401. The +12V at the output of CI-8 suffers the 2.2 seconds delay caused by the circuitry composed by the operational CI-7B, D5 diode and the soft started time constant caused by R73 and C91 . This voltage is presented to the (+) non-inverting input (pin 3) of the op-amp CI-7A that compares that it with the +6V threshold voltage on the (-) inverting input (pin 2). At the moment that pin 3 voltage is higher than pin 2, the op-amps changes its state and deliver at its pin 1 +10.8V approximately. This voltage will energize the VGS's polarization circuits.

- **Temperature alarm**

The module 4408 is protected against risk of over temperature operation. If the temperature raises and exceeds 65˚C (140˚F) the protection circuit acts and disconnect the module.
The protection circuit is composed basically for the thermal sensor S1 and the CI-5. The temperature of the module converted into a DC voltage can be measured at pin 4 at CON-5 connector. This voltage is routed to pin 7 of CON-6 connector at the control unit PCB. The lack of this voltage means that the temperature of

module 4408 exceeded the 650 C. Under this occurrence, the control unit will no longer allow to the +32V power supply to feed the module.

- **RF Power Measurements**

Through a PCB type directional coupler at CIP8209 board, a RF output sampling is collected. This RF sampling is sent to the circuits of direct and reversed power readings. The detector circuit for direct power is basically composed by the diode D1B, the operational amplifier CI-3B and the trimmer TPO-5 that fine adjusts the detected DC level. The detected voltage will be displayed as RF power level on the LCD screen on the front panel. The reverse RF power reading is performed by diode D1A, the operational CI-3A and for trimmer TPO-4, which adjusts the level of reading measured in pin 2 of CON-5 connector.

- **Protection against high reverse power**

In an event of reverse power at the RF output, meaning reading of RF equal or above 20% of the direct power the reflected protection circuit will act. The action with no longer provide VGS for the LDMOS transistors, enforcing the 0 current condition. The diode D1A detects the reversed RF power converting it into a DC voltage. This voltage is amplified by the CI-3A op-amp, and sent to the non-inverting input (pin 5) of comparator CI-4B where is compared with the +6V fixed voltage at the inverting input (pin 6) of this comparator. Any time that the reverse power spike up the voltage at pin 5 above +6V the CI-4B output (pin7) will assume a +Vcc level enforcing T5 to the saturation point. Once saturated T5, it will no longer provide any positive voltage to pin 3 of CI-7A op-amp so, consequently, the +10.8V will no longer be present and the VGS voltage will not be available for the transistors LDMOS. On this case the RF power is not present.

- **RF balancing monitor**

Module 4408 has a error detector circuit for phase and amplitude unbalancing. This circuit constantly monitors the RF output of the pair of transistors part of T3. If the phase and amplitude are not correct, the power combination will not happen as desirable at max efficiency, excess of heating will be generated then. Two monolithic LED will go off according with the current operational condition. If the RF power combination is running correctly the green LED will be ON, if not than the red LED will be ON.

R30 is the dummy load for the hybrid H2. On ideal conditions, there is no RF power present on it. Under unbalance condition, some RF power will start to be present on R30. The unbalance condition is consequence of a less than ideal tuning of the RF network surrounding T3. In this situation D3 diode detects this power converting it into level DC in the not inverting entrance (pin3) of the DC amplifier CI-4A, causing saturation into transistor T4 and, consequently, the red LED LED1 will be lighted. An ideal tuning correctly achieved via trimmers C50, C54, C64 and C68, it will not allow any unbalanced RF power by R30 and the T4 transistor will remain cut, what it makes with that the green LED - LED2 be lighted.

- **Technical specifications**

| PARAMETERS | SPECS |
|---|---|
| **INPUT** | |
| FREQUENCY | 470 to 860MHz |
| IMPEDANCE | 50□ |
| CONNECTOR | SMB MALE |
| RETURN LOSS | ≥ 10dB |
| **RF OUTPUT** | |
| GAIN | 43dB ≤ ±2dB |
| ATSC RMS POWER | Up to 23W |
| HARMONICS 2nd | ≤ -30dBc |
| **GENERAL** | |
| CONSUMPTION | 324VA |

- **Module 4492 block diagram**

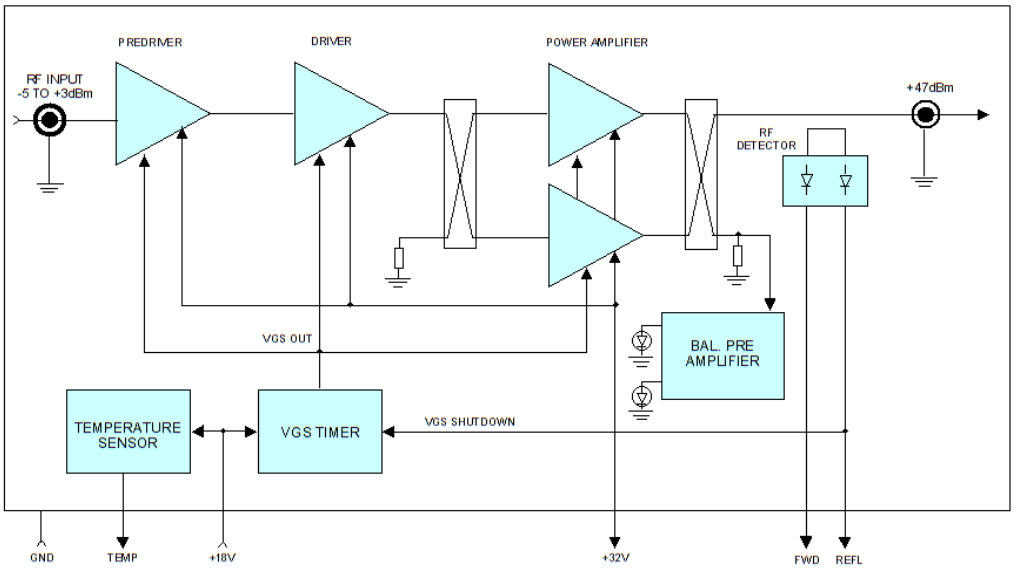



Fig.5.1: 25W UHF ATSC Multistage Amplifier

- **Module 4492 external connections**

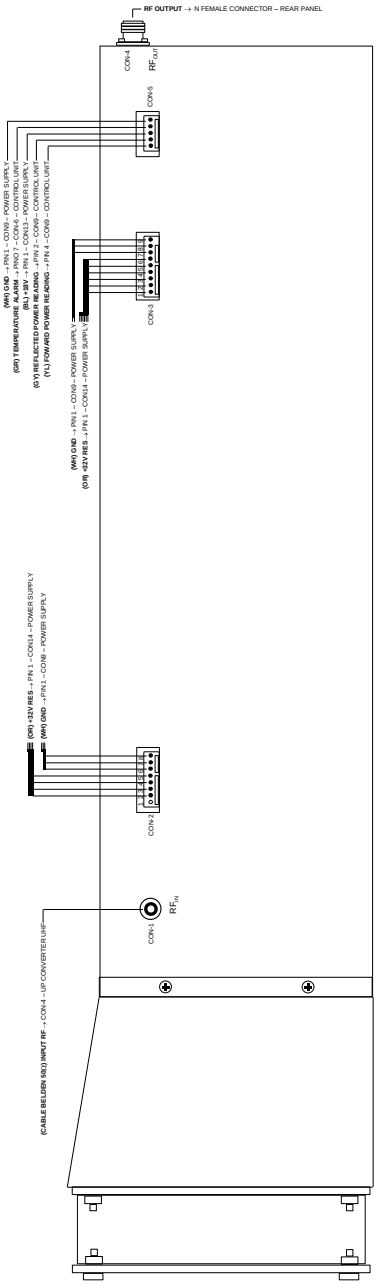



Fig. 5.2: 25W Amplifier – The Module

- **CIP8209 card**

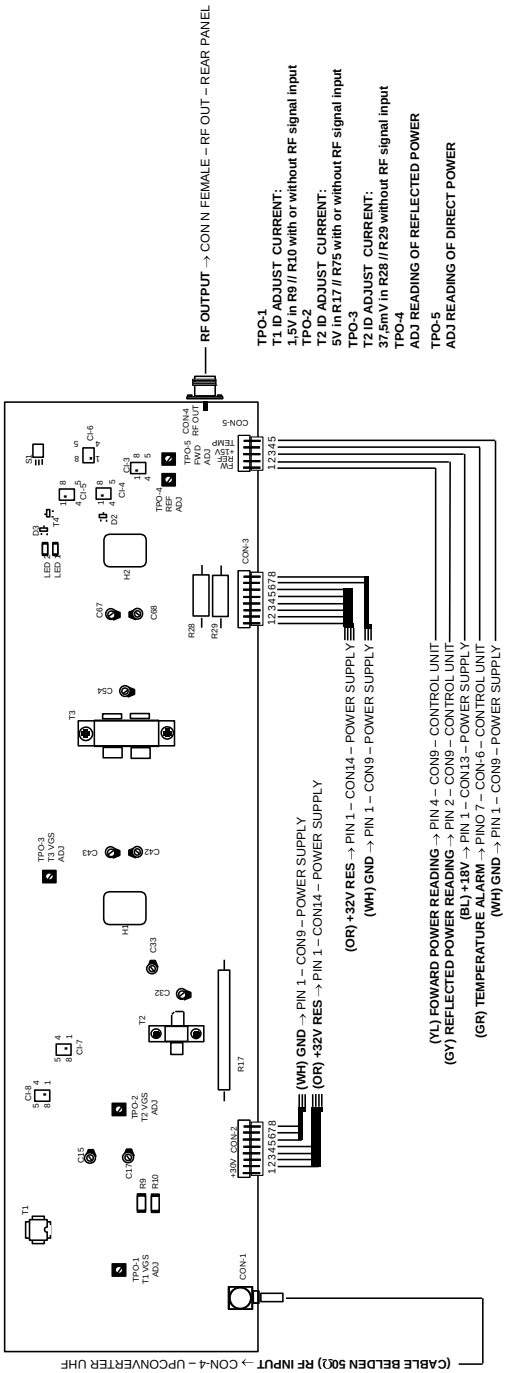



Fig. 5.3: 25W Amplifier – DC & RF connections diagram

- **CIP8209 card – adjustment procedures**

Connect a coaxial load 50Ω/100W (minimum) at RF output having a good frequency response (470MHz 860MHz).

**Adjusting bias ID of T1, T2 and T3**

For T1:
TPO-1 makes the adjustment of the chain of drain (ID) of T1. This adjustment is made measuring the drop of tension in the resistive parallel set formed by R9 and R10 (2 x 10Ω /1W), being the adjusted one for 1.5V, what it corresponds 300Ma of ID. This is a class A polarization adjustment.

For T2:
TPO-2 adjusts the voltage VGS of the T2 and, consequently, the bias drain (ID). This adjustment is made measuring the voltage drop in the resistive parallel set R17 and R75 (2 x 10Ω)/10W), being adjusted for 5V, what it corresponds to a bias current of drain ID equal 1.0A. This is a class A polarization adjustment.

For T3:
TPO-3 adjusts the voltage VGS of transistor T3 and, consequently, the chain of drain (ID). This adjustment is made measuring the voltage drop in the resistive parallel set R28 and R29 (2 x 0.12Ω)/10W), being adjusted for 3.7Mv, what it corresponds to a bias current of drain ID equal 600Ma, or 300Ma for each branch of T3. This is a class AB polarization adjustment.

- **CIP8209 card – frequency response adjustment**

Module 4408 is a UHF broadband amplifier that must have its frequency response optimized for higher gain focused on the operational transmission channel. The factory adjustments must stay even when a LDMOS transistor replacement becomes is necessary.

The capacitors trimmers present at the module 4408 are the tuning elements to be set for higher possible gain, at the same time achieving flatness response at the desired UHF operational channel. Below we see one possible set up suitable for the adjustment of frequency response.

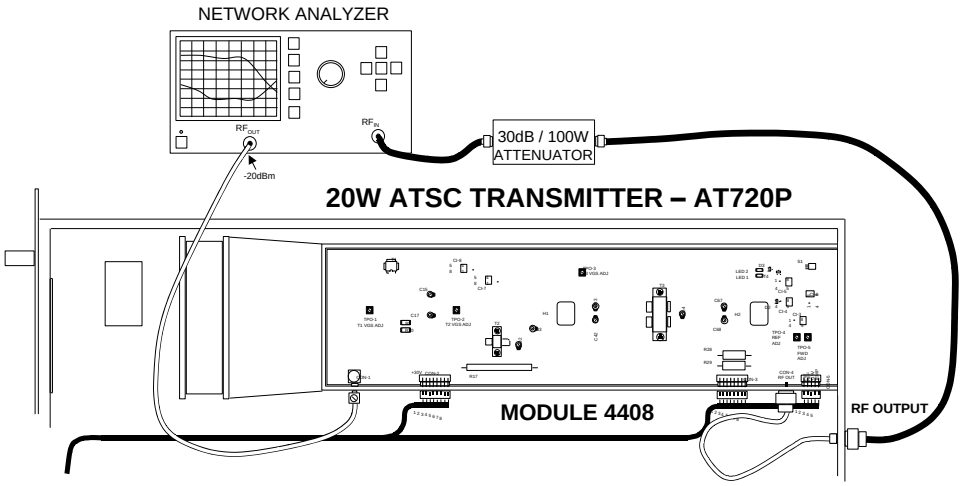



Fig.5.3: Frequency Response Adjustment Factory Set Up

Set the network analyzer output level at -20dBm, and connect it at the module 4408 RF input. Tune the capacitor trimmer for the most flat frequency response over the operational channel. The overall gain should be 44dB ± 2dB. Remember the bands which the amplifier was designed for:

- LOW BAND (LB): channels 14 to 44
- HIGH BAND (MB): channels 45 to 59

# Section 6 – Power Supply

Module 4401

- **General Functional Description**

The Power supply - Module 4401 - is of the switching type configured in the topology half bridge, having overall efficiency above 80%. The module 4401 is responsible for the generation and distribution of following voltage DC:

- +32V FIXED
- +32V RE-CONNECTABLE
- +18V
- -18V
- +9V

The module 4401 can be connected to the electric AC network of 120Vac or 240Vac, according with internal jump positions.

The module 4401 is self-protected against DC short-circuit. The protection acts inhibiting the generation of the switching pulses, shutting down the power supply; 0 volts at the DC's outputs. The output +32V RE-CONNECTABLE is commanded by the Control unit.

The re-connection command is sent to the power supply, to turn the +32V RE-CONNECTABLE on.
This voltage is responsible for the feeding of the 25W amplifier - module 4408. The consumption in Amps out from the +32V RE-CONNECTABLE is basically the consumption associated with the drain electrical current of the LDMOS transistors of the amplifier. Because of this configuration, the LDMOS currents are measured at the power supply module 4401.

These currents measurements are routed to the control unit. In case of extremes measured values the control unit inhibits the +32 RE-CONNECTABLE. Power supply.

- Module 4401 – Block Diagram
- Input AC filter

The C1, C6 and TF-1 components together assemble the line filter. This filter minimizes the noise generated by the power supply into the AC network.

The varistors V1, V2 and V3 prevent over-voltage damages potentially caused by occurrences on the AC network.
The group of diodes D1/D4 rectifies the AC voltage from the AC network and delivers this rectified voltage to the capacitors C9 and C10 for filtering.
These capacitors could be connected in parallel or in series, according with the set of the jumps for 120/240Vac.

The resistances R1 and R2 are the loads for the capacitors C9 and C10 at the time that the power supply is powered ON. R3 and R4 provoke a fast discharge of C9 and C10 when the power supply is OFF.
The control of the switching function over the PWM modulator is performed by the components TF-3, D5, D6, D7, R9, T3, C20, C18 and C46.

- **Switch and Power**

The switching function over the DC input voltage is performed by the Mosfets, T1 and T2. The trigger pulses are generated by control integrated circuit CI-1, through the transformer TF-4 that also isolates the modulation circuit from the AC network.

The switching voltage in the transistors is applied in the transformer TF-5 that through the convenient turn's ratio, it will generate the voltages in its secondary.
The capacitors C15 and C16 divide the entrance voltage, reducing the voltage over the transistors. C14 prevents the direct-current flow towards TF-5.

The "Snubbers" formed by R7, C17, R34, C31, R37, C35, R43 and C42, help to reduce high frequency noise generated by the fast and short time switching pulses present on the mosfet transistors as in TF-4.

- **Rectification and Filtering**

The pulses delivered by the several switching and power devices, will be than rectified by D8 to the D14 and filtered by C32 the C47.
The inductor L2 in its multiple sections, stores the transfer energy that help to filter the signal.
The resistors at the output act as bleeders avoiding undesirables' transients and oscillations.

- **Pulse Width Modulation**

This block is composed basically by the integrated circuit CI-1 that performs the PWM switching process control.

CI-1 output (pins 11 and 14) supply the switching pulses that are applied to the transformer TF-4. The "Soft-Start" system prevents a fast rise of the exit voltage. In this circuit, this function is carried through by C23.

- **Feedback**

The resistors R10, R13, R12 and TPO-1 form a voltage divider that take a sample of +32V output of the power supply and delivery to the comparator CI-1, compares that it with its reference of +5V via R39.
As the value of this sample, the modulation circuit will create a variation in the width of the switching pulses, having compensating voltage variations in the output voltages.

- **Protection and Readings**

The set of protection acts in case of over-current in the outputs.
In the event of over-current, in any one of the outputs, the voltage in the inverting input of comparators CI-3 and CI-4, transferred by the electrical current readings, will be greater that the voltage of reference in the not inverting entrance.

This event take the output of the comparator to a low level will trigger a timer formed by CI-2, R26 and C28 that will a voltage at pin 10 of the CI-1 inhibiting the switching process. The electrical current readings are detected over the power resistors (R44, R45, R36, R40, and R38) and amplified by op-amps getting deep of scale (4V) proportional the nominal current of each output. All the electrical current readings possess its proper adjustment:

- TPO-2: +32V/10A
- TPO-3: +18V/1A
- TPO-4: +9V/1A

The readings of output voltage are constituted by operational amplifiers (CI-8, CI-9, CI-10) and each one with a TPO for full scale adjustment (4V) proportional to the nominal the output voltage.

- TPO-5: +32V
- TPO-6: +32V RECONNECTED.
- TPO-7: -18V
- TPO-8: +18V
- TPO-9: +9V

* NOTES:
1) The current reading is only for the exit of +32V.
2) It does not have reading for the voltage of +32V RECONNECTED.

- **Reconnection Process**

The output of +32V RECONNECTED power supply of the Module 4401 is used to exclusively feed the UHF amplifier - Module 4408.

The +32V RECONNECTED output is a derivation of the +32V FIXED output. This exit is enabled or disabled by control unit - CIP8231 card board - through the reconnect command. In normal conditions this command sends +5V to pin 6 of connector CON-8 of CIM3388 (CIP8111) card board of module 4401. Having this voltage, the switch transistor will be saturated and, consequently, the exit of +32V RECONNECTED will be enabled.

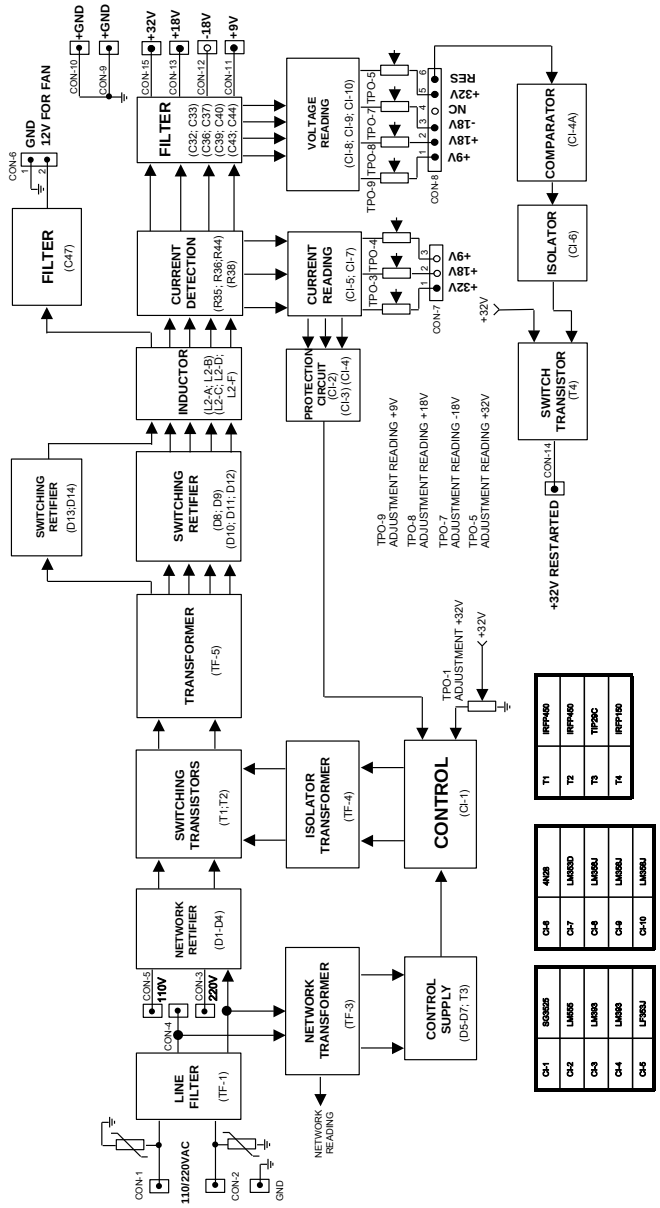



Fig.6.1: Module 4401 Block Diagram

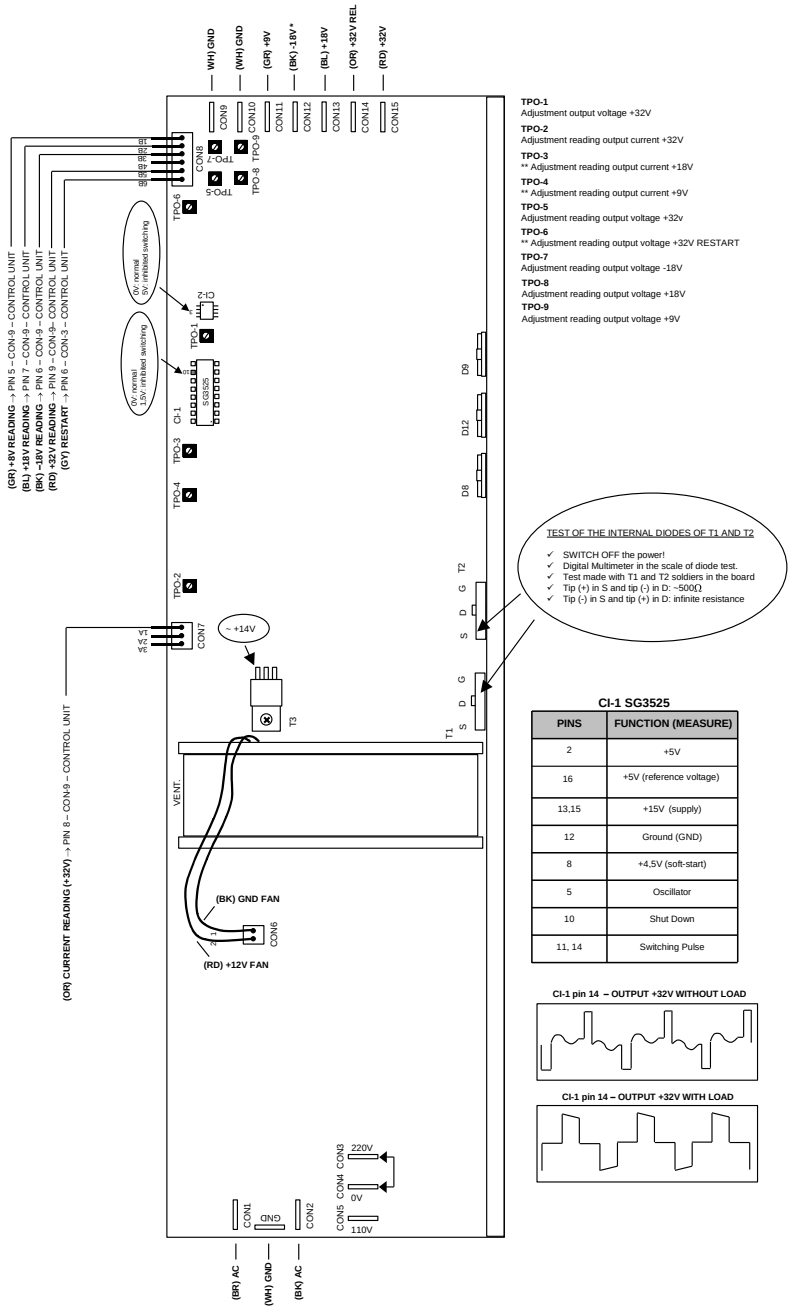



Fig.6.2: Module 4401 – Main components board displacement

- **MODULE 4401 – Technical Specifications**

| FEATURE | SPECIFICATION |
|---|---|
| INPUT AC VOLTAGE | 90 TO 140VAC / 180 TO 250VAC |
| SWITCHING FREQUENCY | 50kHz |
| LINE REGULATION | BETTER THAN 2% FOR ALL OUTPUTS |
| OUTPUTS NOMINAL VOLTAGES AND CURRENTS | +32V / 10A<br>+18V / 1A<br>-18V / 1A<br>+9V / 1A |
| RIPPLE | 300mV (+32V)<br>120mV (+18V / +9V)<br>80mV (-18V) |
| LOAD REGULATION | BETTER THAN 2% FOR +32V<br>BETTER THAN 25% FOR +18V, -18V, +9V |
| EFFICIENCY | BETTER THAN 80% |
| OUTPUT OVER CURRENT LIMIT | 30% UPPER NOMINAL VALUE |
| RESTART VOLTAGE | HIGH LEVEL: > 3.5 TO 5Vdc<br>LOW LEVEL: < 3.3Vdc |
| SHUTDOWN VOLTAGE | HIGH LEVEL: > 0.7 TO 5Vdc<br>LOW LEVEL: < 0.7Vdc |

| POWER SUPPLY | | |
|---|---|---|
| **CIRCUIT** | **CIM** | **CIP** |
| POWER | 3388A | 8111A |

- **MODULE 4401 – Changing the Mains Voltage Operation**

The module 4401, on its rear side, is built in such way that it is possible access the 110/220Vac switching voltage jump. The figures below illustrate the position for the jump for each desired operational voltage. This is the only required maneuver to change the voltage operation on the AT725P unit.

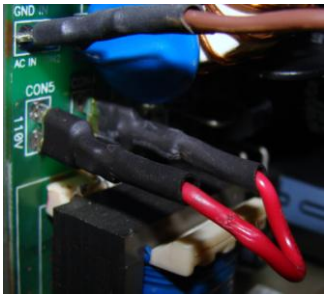



Fig.6.3: Jump connection for 110Vac operation, (CON5-CON4)


Fig.6.4: Jump connection for 110Vac operation, (CON4-CON3)


Fig.6.5: Module 4401 - +32V Switching Power Supply

# Section 7 – DC/DC Converter

Module 4567

- **General Functional Description**

This module has as function to generate specific voltages not present at the main power supply - module 4401. The module 4567 generates +2.5V and +5V, via standard IC regulators, see below:

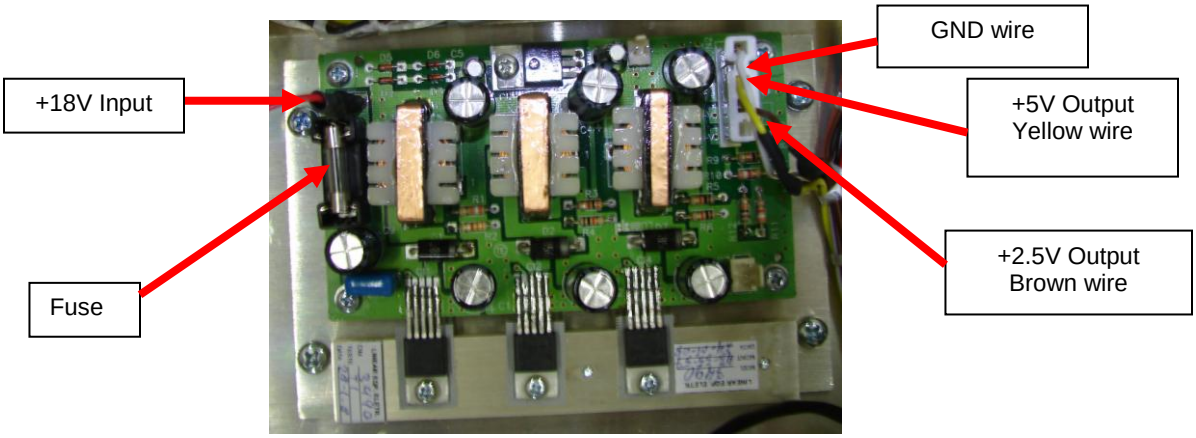



Fig.7.1: DC/DC Converter Board

| CIM3490 (CIP8390) | |
|---|---|
| **INPUT** | **OUTPUT** |
| +18V | +2.5V (CON-2/2) |
| | +5.0V (CON-2/3) |

# Section 8 – Memory Interface

Module 3535

- **General Functional Description**

The connectors CON-4 and CON-10 at the modulator – module CIM3510 – are the communication connectors with the memory interface CIM3535 mother printed circuit board.

- **Module CIM3516 – General Functional Description**

The 1Mbit LUT memory card – module CIM3516 - is connected to the memory interface - module 3535. This module holds all the non-volatile parameters data related with the digital linear and non-linear pre-correction.

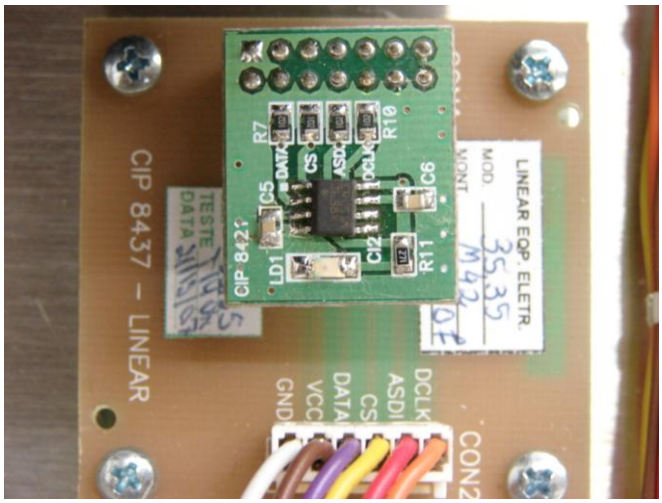



Fig.8.1: LUT Memory card & module 3535

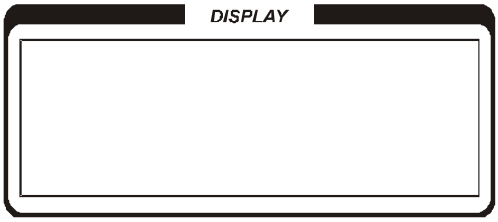
# Annex A – AT725P Operational Software

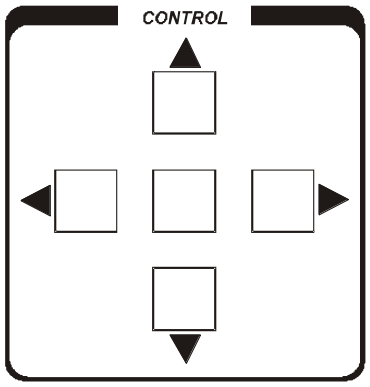
# AT1012_ASM version 1.2

## 1. Introduction

The LINEAR family of ADVANCED TV transmitter/Exciter equipment possesses a system for measurement (measures), configuration (SETUP) and alarms (alarms) all controlled by a microprocessor controlled system. This document will demonstrate the navigation, operation and configuration of these functions.

## 2. Navigation and Signals




### 2.1 Keypad and Display

#### 2.1.1 Keypad

Moves the cursor up

Moves the cursor right

Moves the cursor left

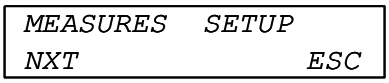
Moves the cursor down

Yellow Key "ENTER"

## 2.2 Display

The display navigation is made by the following:

The cursor must be located on the first character of each function to access that function.




It is then activated by pressing the yellow "ENTER" key

During the navigation there will appear in the display special functions that assist navigation, these are:

ESC – Used to return to the previous menu
NXT – Used to access the next screen
CLEAR – Used to clear old alarms

## 2.3 Signals

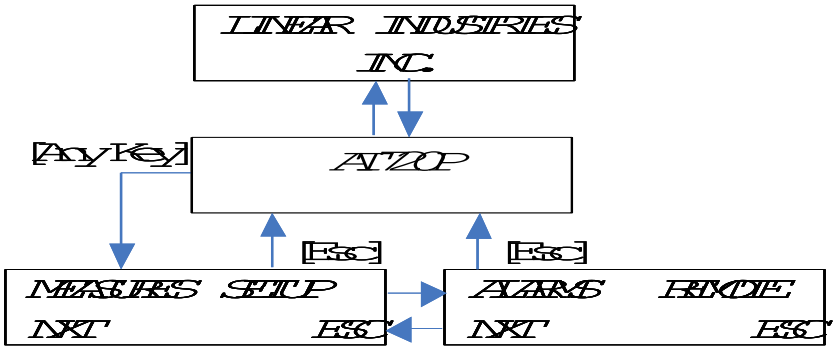
During the navigation there will appear in the display signal characters these are:

| | |
|---|---|
| * | – Indicates the presence of a current alarm |
| # | – Indicates the presence of an old alarm |
| (LOCK) | – Indicates that the equipment is configured with password, and that to have access to that part of the menu the password must be entered. |

 – The UP and DOWN arrows assist in the movement between screens. When they appear the UP or DOWN key must be used to move between screens. If in a measurement screen, to return to the previous menu, any key can be pressed.

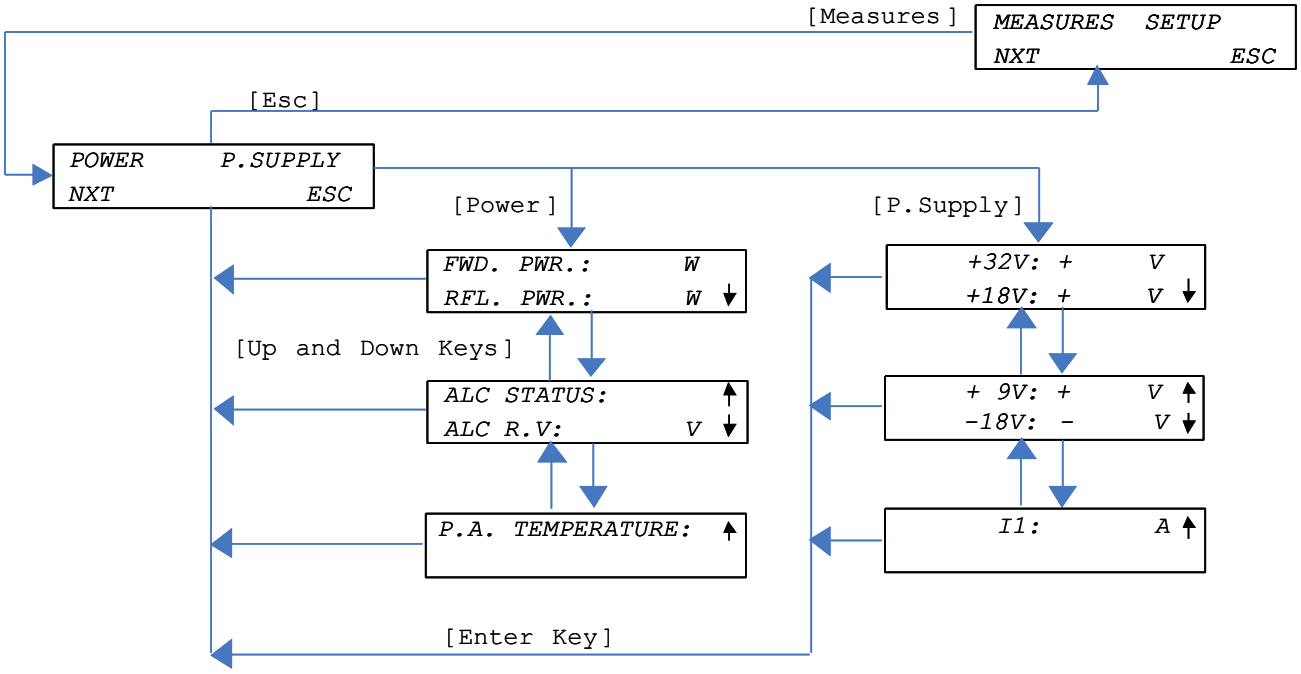
## 3. Screen Flow Charts

### 3.1 Main screens

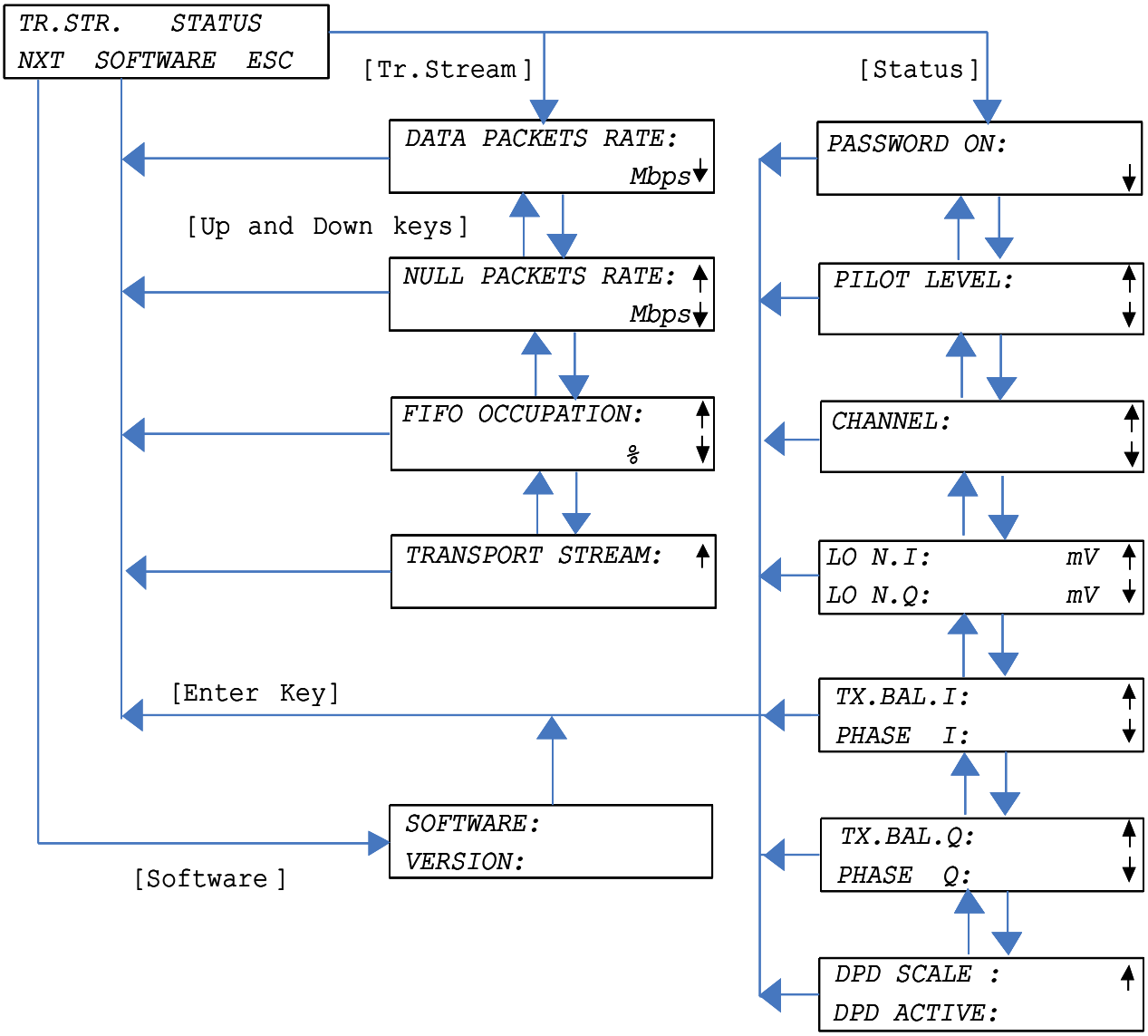



**Main screens**

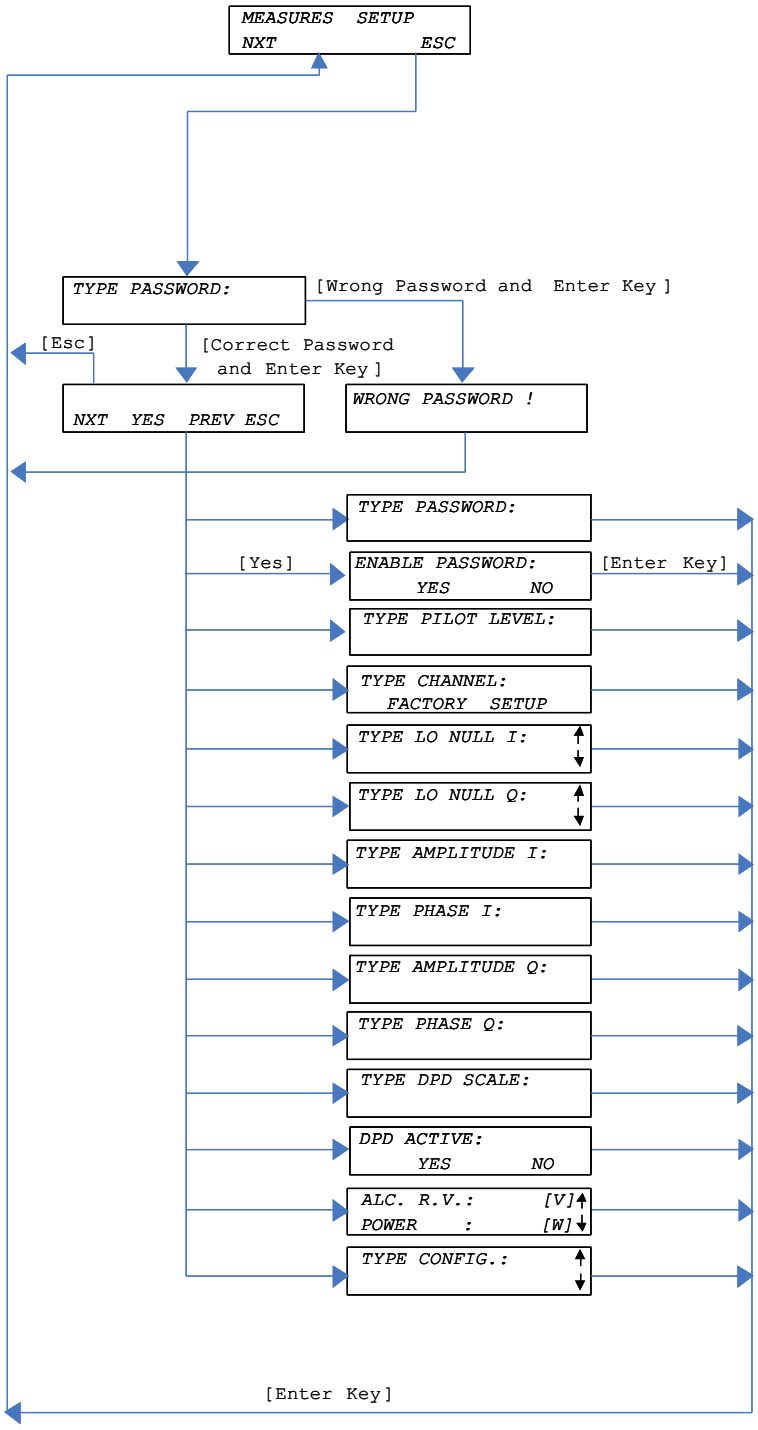
### 3.2 Measurement Screen 1



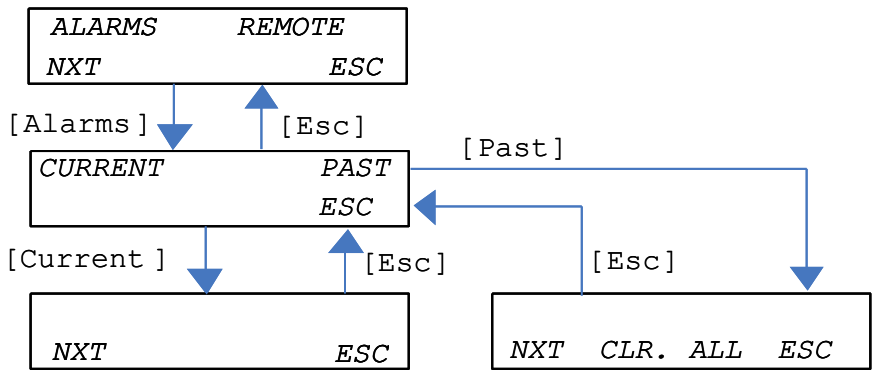
### 3.3 Measurement Screen 2



## 3.4 Configuration Screen

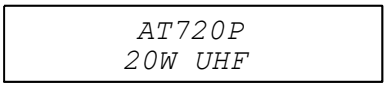


### 3.5 Alarm Screen




## 4. Initialization

When the equipment is initially switched on the screen backlight lights automatically and the message "LOADING"… is displayed, indicating the load process of the modulator has begun. In the unlikely case that the equipment continues showing this message, the possibility of software error has occurred in the load process of the modulator and the equipment may not enter into correct operation. Please report this status to Linear Industries Inc for the necessary steps of action. Following the LOADING message, the name of the manufacturer, the type number of the equipment, normal rated RMS power and the operating channel are displayed.


This information alternates approximately every 2 seconds. The backlight switches off after approximately 20 seconds. After this initialization of the equipment these indications will remain indefinitely until another key is pressed. When pressing another key the backlight will light again. Depending on the type of screen the cursor will automatically locate itself in one of the options. To execute some of these options, after the backlight has extinguished it may be necessary to press any key again. If no option is chosen, the backlight will switch off in approximately 20 seconds and then after approximately five minutes the screen returns to the initial display.

### 4.1 MEASURE MENU

The measure menu allows access to the general equipment configuration parameters; power levels, TS feed and status, qualification of passwords, cancellation of the L.O signal., rejection of image frequency signal, level of scale, activation of look up tables (LUTs) for pre-distortion and the name and version of the installed software on the central microcontroller.

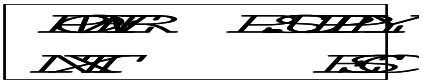
Navigation through these screens is made with the keys UP and DOWN. When these are displayed it is not possible to configure any parameters. The "ENTER" key must be pressed to return to the main screen.

#### 4.1.1 POWER MENU

The power menu displays the forward and reflected power at the output of the equipment, measured at the output power reflectometer. Also displayed are the ALC reference voltage and the temperature of the final RF output amplifier.

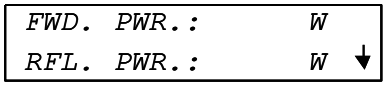
To have access to the POWER screen, the following sequence of screens is necessary:

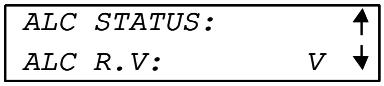
Access MEASURES



Access POWER

Use the key "DOWN" to see the next set of screens.



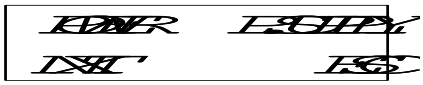

To return to the previous screen, press the UP key. To return the POWER option presses "ENTER". NOTE: The screens above are a rolling type, allowing access to all of the voltage measurements by using the UP and DOWN keys.

### 4.1.2 POWER SUPPLY MENU

This screen displays the voltages and currents of the principal equipment power supplies.

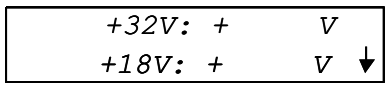
To have access to the P.SUPPLY screen the sequence of screens are:

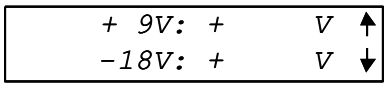
Access MEASURES

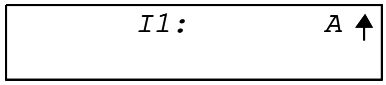


Access P.SUPPLY

Use the key "UP and DOWN" to move between screens.




To return to the previous screen press the key UP. To return to the option P.SUPPLY press "ENTER".

### 4.1.3 MENU ESC

Pressing ESC returns the cursor to the previous screen.

### 4.1.4 MENU NXT

Selecting the "NXT" option provides access to more options of measurement. The sequence for access of these measurements is shown below:

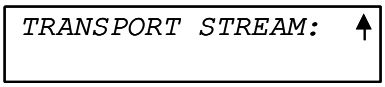
### 4.1.5 MENU TR.STR.

TR STR shows information about the input digital signal.

Select **NXT** and press **ENTER**

Select **TR.STR** and press **ENTER**




To return to the previous screen press the UP key. To return to the TR.STR options press ENTER.

### 4.1.6 MENU STATUS

#### 4.1.6.1 Password qualification state

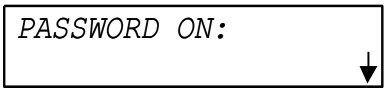
This screen shows the information on the configured parameters:

**PASSWORD ON: YES -** indicates that a password is required to enter into the SETUP MENU, and will be asked for to each attempt of access this menu.

**PASSWORD ON: NO** - indicates that the requirement of a password is not necessary to enter into the SETUP MENU and open access is available.

Below is the sequence necessary for this option:

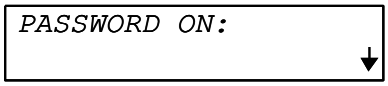
Select **STATUS** and press **ENTER**

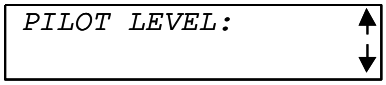



### 4.1.6.2 Amplitude level of the ATSC Pilot carrier:

This is a numerical value relative to the carrier pilot level.

PILOT LEVEL: <+511 TO -2048>
Access to the STATUS menu can be via the far left option or from the PASSWORD ON screen: following viewing the programmed level press the UP and DOWN keys to navigate to other STATUS screens.

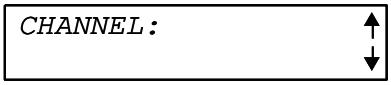



### 4.1.6.3 Transmission channel

This screen displays the factory programmed transmission channel.
CHANNEL <2 to 59>

To have access to this menu navigate via the STATUS option and then select PILOT LEVEL: pressing the UP and DOWN key and then the factory programmed channel can be viewed.

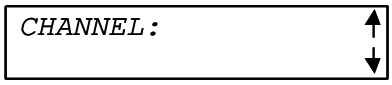




#### 4.1.6.4 DC voltage level adjustment for the cancellation of the L.O signal:

This level indicates the voltage programmed in the Up Converter for the cancellation of the local oscillator signal.

LO N.I.: and LO N.Q. <0.00 to 49.75 mV>:

To have access this menu, select the option STATUS



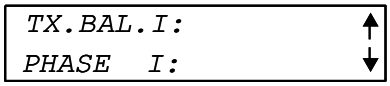


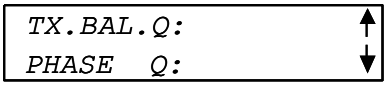
CHANNEL: press UP and DOWN key

#### 4.1.6.5 Rejection of the frequency image:

The following are numerical values related to the amplitude and phase signal for rejection of the image frequency.

TX. BAL. Q: - <00000 to 32767>
PHASE Q: - <-32767 to +32767>
TX. BAL. I: - <00000 to 32767>
PHASE I: - <-32767 to +32767>

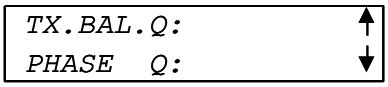



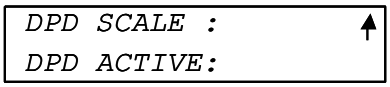



#### 4.1.6.6 Pre-distortion scale level:

This is a scale (or intensity) of the pre-distortion level applied to the transmission signal.

DPD SCALE: < 0000 to 4095>

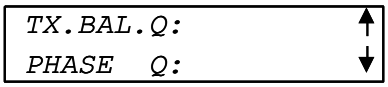


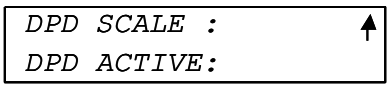




#### 4.1.6.7 Qualification of pre-distortion tables:

DPD ACTIVE: YES – indicates the signal pre-distortion tables are active

DPD ACTIVE: NO - - indicates the signal pre-distortion tables are not active.




#### 4.1.6.8 Name and version of software:

This menu indicates the name and the version of recorded software in the central microcontroller. This information must be provided to the factory in the case of any maintenance request.

SOFTWARE: < ATXXXX >
VERSION: < X.X >

To verify the name and version of software select the option SOFTWARE after that press ENTER.

Select **SOFTWARE** and press **ENTER**

### 4.2 MENU SETUP

This menu allows access to the configuration functions and parameters of operation of the equipment. The RIGTH ARROW and LEFT ARROWkeys locate the cursor in each one of the four possible digits and the "+" and "-" keys and the ENTER and UP and DOWN keys change the digits. The "ENTER" key finalizes the numerical value to the control system. Without pressing the "ENTER" key the value is not remembered. Before the "ENTER" key is pressed the parameter is only adjusted in real time for review of the measured results. If the equipment is switched off during a parameter configuration before pressing the "ENTER" key the configuration will not be saved in the memory and the same values will be as previously stored.

#### 4.2.1 MENU TYPE PASSWORD

This menu is to set the four numerical password digits to have access to the SETUP functions. This menu is active only when option YES in the ENABLE PASSWORD menu is indicated. The RIGTH ARROW and LEFT ARROW keys position the cursor in each one of the four possible digits and the ENTER and UP and DOWN keys edit the digits. The "ENTER" key transmits the value of the password to the control system.
It is only possible to leave this screen after entering the numerical password.
If the correct password is entered access to the SETUP options is available. If the incorrect password is entered the following is message is shown "WRONG PASSWORD" and the equipment returns automatically to the main options menu.

**TYPE PASSWORD: <XXXX>**

Below is the sequence of access for this menu:

Select **SETUP** and press **ENTER**

Type the password number and then press "ENTER"

### 4.2.2 LIST OF MENU OPTIONS:

The following allows navigation in the equipment configuration options:

NXT: executes the navigation option
PREV: returns to the previous menu
YES: indicates access to that particular option
ESC: returns to the main options menu


To see the options select NXT and press "ENTER". When the required option is shown, locate the cursor on the "YES" and press "ENTER".

#### 4.2.2.1 < SET NEW PASSWORD? >

This menu allows the four numerical digits to be configured as a new password for the equipment. The RIGTH ARROW and LEFT ARROW keys locate the cursor on one of the four digits to be changed and the ENTER and UP and DOWN keys change the digits. Pressing "ENTER" key then informs the new password to the control system and returns to the main options menu.

It is only possible to leave this screen after entering the numerical password.

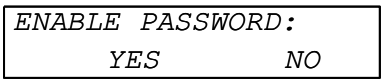

#### 4.2.2.2 < ENABLE PASSWORD? >

This option allows the qualification or not of the password programmed in SET NEW PASSWORD option.

YES: confirms the requirement of the password to have access to the SETUP options menu.

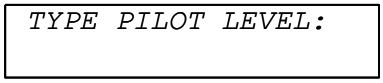
NO: Indicates that no password is required to have access to the SETUP options menu.

.




#### 4.2.2.3 < SET PILOT LEVEL? >

This option allows the configuration of the desired level of the ATSC signal pilot carrier with the following band of values: < +511 TO -2048 >.

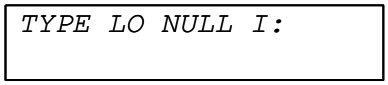



#### 4.2.2.4 < SET CHANNEL? >

For equipment safety reasons changing channel is not allowed in the on-site configuration. This procedure can only be configured in the factory. Changing the channel without the permission of a factory trained engineer can potentially void any warranty on the product.


#### 4.2.2.5 < SET LO NULL I? >

This menu allows the DC voltage adjustment for "nulling" the "I" signal from the local oscillator inter-modulation in the Up Converter. The adjustment has the following potential values: < 0.00 to 49.75 mV >.

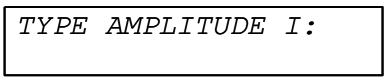


#### 4.2.2.6 < SET LO NULL Q? >

This menu allows the DC voltage adjustment for "nulling" the "Q" signal from the local oscillator inter-modulation in the Up Converter. The adjustment has the following potential values: < 0.00 to 49.75 mV >.

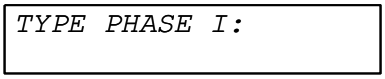

#### 4.2.2.7 < SET TX BAL. AMP. I? >

This menu allows the adjustment of the "I" amplitude of the image rejection signal in the 8VSB modulator with the following band of values: < 00000 to 32767 >.




#### 4.2.2.8 < SET PHASE I? >

This menu allows the adjustment of the "I" phase of the image rejection signal in the 8VSB modulator with the following band of values: < 00000 to 32767 >.

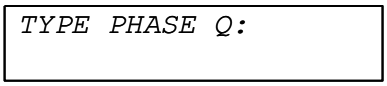



#### 4.2.2.9 < SET TX BAL. AMP. Q? >

This menu allows the adjustment of the "I" balance of the image rejection signal in the 8VSB modulator with the following band of values: < 00000 to 32767 >.


#### 4.2.2.10 < SET PHASE Q? >

This menu allows the adjustment of the "Q" phase signal amplitude of image rejection signal in the 8VSB modulator with the following band of values: < 00000 to 32767 >.



### 4.2.2.11 < SET DPD SCALE? >

This menu allows the configuration of the DPD (Digital Pre-distortion) scale (or intensity) of digital pre-distortion applied to ATSC signal, with the following band of values : < 0000 to 4095 >

```
TYPE DPD SCALE:
```

### 4.2.2.12 < SET DPD ACTIVE? >

This menu allows the activation or not of the digital pre-distortion tables.

YES: activates the use of the digital pre-distortion look up tables (LUT's)

NO: deactivates the use of the digital pre-distortion look up tables (LUT's)

```
DPD ACTIVE:
     YES        NO
```

### 4.2.2.13 < SET POWER? >

This allows the configuration of normal rated power at the output of the equipment. The ENTER and UP and DOWN key increase and decrease the power level. The RIGTH ARROW and LEFT ARROW keys do not possess any function in this screen. The "ENTER" key memorizes the desired value.

```
ALC. R.V.:       [V]
POWER    :       [W]
```

The value of power displayed on this screen is a value fed directly from the output reflectometer and is the same value that is provided to the ALC system (Automatic Level Control) circuit. The system allows a certain flexibility of adjustment by providing at the same time the power level display in order to verify the actual power level. It is not recommended to adjust for very low values of ALC voltage as this may cause the power to become unstable.

For higher ALC values (above 1.3V) the power will vary with the variation of the ALC voltage. In case this simultaneous variation does not occur it is likely that there is a fault in either or both the Up Converter or final RF amplifier. This type of occurrence should be reported to the Linear Industries Inc.

In this screen the ALC is disabled for precise adjustments of the power level and for full manual control of power using the ENTER and UP and DOWN keys. In any another environment or screen the ALC system returns to an enabled mode in order to control the power level.

**WARNING:** It is important not to set the programmed values of the ALC and consequently the final RF power level above the nominal value of the equipment: this may caused damage to the internal modules and may void the warranty on the unit.

#### 4.2.2.14 < SET CONFIGURATION? >

This menu allows the operating mode of the equipment to be configured with regard to including or not an ATSC compliant mask filter.

Key ENTER: TRANSMITTER
Key UP and DOWN: EXCITER

```
TYPE CONFIG.:
```

**Configuration TRANSMITTER**: in this configuration the transmitter provides approximately 15% more power than the normal rated power at the reflectometer output. This amount compensates for the losses of the ATSC compliant mask filter in order that at the output of the filter the correct and nominal rated power level of the equipment is obtained.

Although this compensation is included for the normal rated power, the system still shows the real power level for nominal values, for example, if 23.3W is measured at the output, the display will read 25W. For this configuration the functions in the external connector "External Functions" are disabled.

**Configuration EXCITER**: in this configuration, the transmitter function as a simple Exciter/Driver and it does not take into consideration the use of an output filter. In this mode the transmitter does not compensate for loss of power in the output reflectometer. The nominal output power value can directly measured at the output of the reflectometer; i.e. if the output power is 25W the display will read 25W. For this configuration the functions in the external connector "External Functions" are active. By means of this connector it is possible disconnect the power amplifier and inhibit the transmission signal completely with all the inputs still connected and a completely active control system.

This can be made with the input of a 5V DC level on pin 3 of the male side of the connector DB-9 (external functions), in which pin 5 is at ground level. 5V on pin 3 disconnects the amplifier and 0V keeps the amplifier on. With this function it is possible to externally switch on or off the EXCITER and or TRANSMITTER.

### 4.3 ALARMS MENU

This transmission equipment possesses a system of alarm indications. These are show by symbols at the right side of the display screen: ***** and #. The signal ***** represents the occurrence of a current alarm. The signal # represents an old alarm, i.e. an alarm that has already occurred and has been normalized (cleared). Under normal operating conditions neither of these two symbols will be displayed on the screen.

When the ***** is displayed on the screen access should be made to the current alarm screen to verify which alarm is occurring.

### 4.3.1) CURRENT MENU

This menu displays the current alarm messages i.e. alarms that indicate are still present and have not yet been normalized or cleared.

The current alarm messages are updated when entering the CURRENT MENU.

To update the list, you must leave the menu and then return to the ALARMS using the ESC option and then access the CURRENT menu option again.

Option NXT shows the next alarm message. If there are no alarm messages it will read as follows:

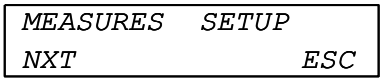
< ALARMS LIST START! >
< ALARMS LIST END! >

Option ESC returns to the previous screen.

The following messages may appear on the current alarms list:

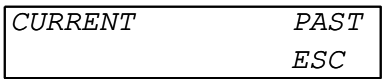
< ALARMS LIST START! >
< OVER FIFO! >
< MPEG LOSS! >
< DWR. NOT PROGRAMMED! >
< TEMPERATURE! >
< LOCK CLOCK! >
< LOCK LO! >
< OUTPUT POWER ZERO! >
< REFLECTED POWER! >
< ALARMS LIST END! >

Below shows the screens necessary to display the CURRENT alarms menu:




Select **NXT** and press **ENTER**

Select **ALARMS** and press **ENTER**




Select **CURRENT** and press **ENTER**


### 4.3.2 PAST MENU

This menu displays the past or old alarm messages, i.e. alarms that indicate some equipment alarm occurrence that has been normalized or cleared.

The current alarm messages are updated when entering the PAST MENU. To update the list, you must leave the menu and then return to the ALARMS menu using the ESC option and then access the PAST menu option again.

Option NXT shows the next alarm message. If there are no alarm messages it will read as follows:

< ALARMS LIST START! >
< ALARMS LIST END! >

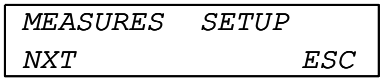
Option CLR. ALL erases all the old alarm messages.

These messages are also erased when the equipment is turned off. Option ESC returns to the previous screen.

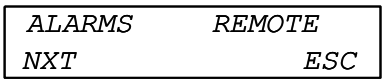
The follow are messages that can appear in the past alarms list:

< ALARMS LIST START! >
< OVER FIFO! >
< MPEG LOSS! >
< DWR. NOT PROGRAMMED! >
< TEMPERATURE! >
< LOCK CLOCK! >
< LOCK LO! >
< OUTPUT POWER ZERO! >
< REFLECTED POWER! >
< ALARMS LIST END! >

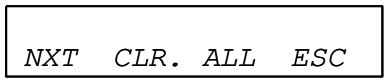
Below shows the screens necessary to display the PAST alarms menu:




Select **NXT** and press ENTER




Select **ALARMS** and press ENTER




Select **PAST** and press ENTER

### 4.4 Remote Menu

It allows the display of the parameters to be configured in the Windows® Hyper-terminal emulator in order to connect a computer with an RS232 port and have access to all the configuration and monitoring of the equipment.

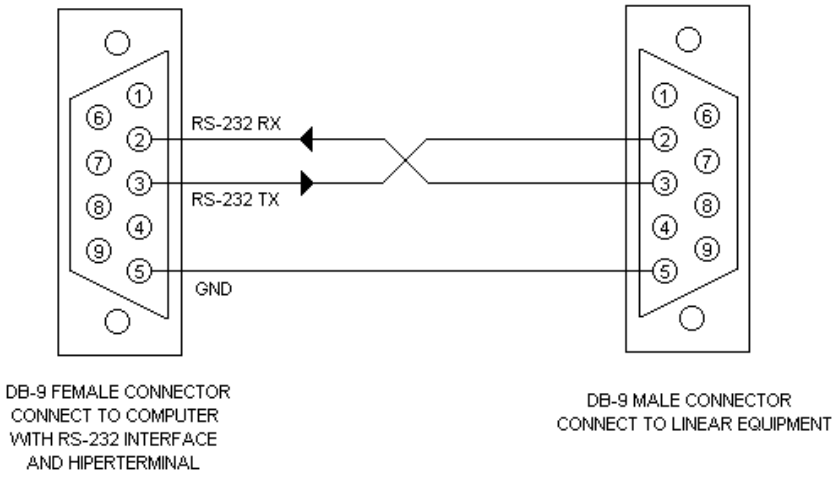
## 5. Operation of the Hyper-terminal

The AT725P transmitter system parameters can be monitored and configured using the Windows® Hyper-terminal. The bands of values are the same as described previously in the equipment front panel operation (LCD display and keys). It is possible to adjust the transmitter power with the Hyper-terminal interface however the ALC system must be first disconnected using the equipment front panel and only within the limits set from the front panel configuration.

The password configuration process is the same as described for the front panel configuration. The password can be qualified or not, and when qualified allows access to the SETUP environment. In the SETUP environment it is possible to qualify or to disable the password and also to define a new password value. The insertion of new values for the password occurs with the cursor automatically moving to the next digit when the highest value has been reached. After reaching the desired number the cursor is moved automatically to the right, and after the last digit is reached the next typed key returns to the first position.

A cable must be connected between the transmitter RS232 output and RS232 input of the computer. The cable end for the computer is a male DB-9 and the cable end for the transmitter is a female DB-9 connector. Only three of the nine pins are used with pins 2 and 3 of the cable crossed. Pins used are TX, RX and GND.

Pin 3 is TX and pin 2 is RX. In the both connectors pin 5 is GND. The figure below illustrates the RS232 cable and connector:



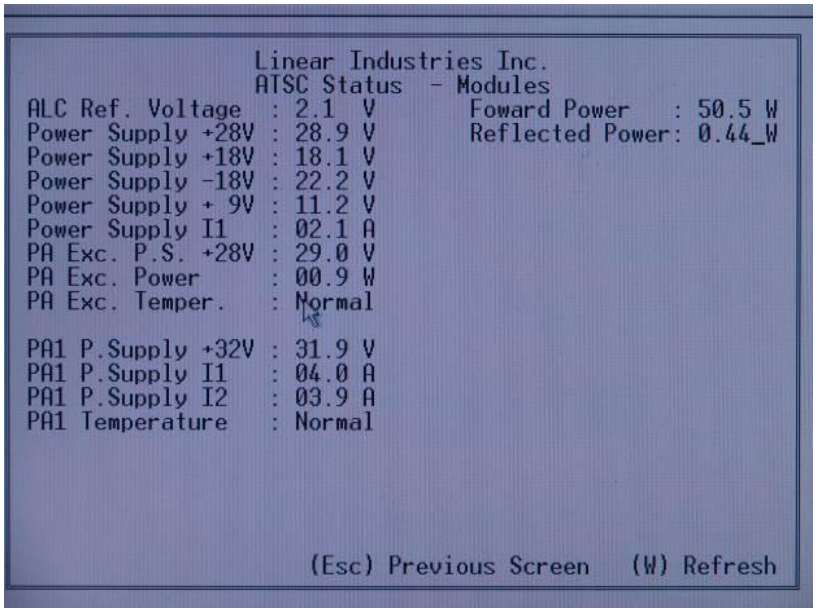

The configuration of the Window® Hyper-terminal must in accordance with following:

PROPERTIES OF COM4

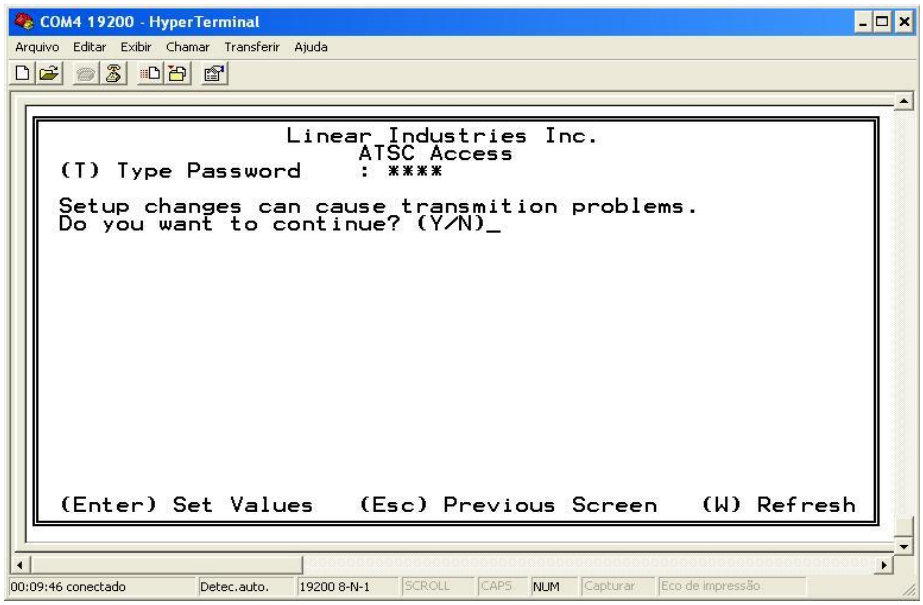
Configuration of Port

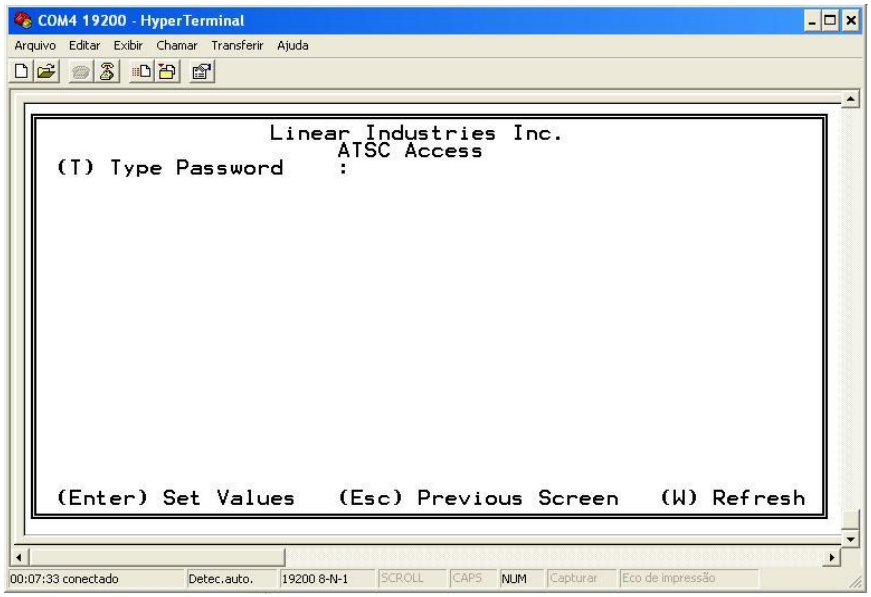
| | |
|---|---|
| Bits per Second | 19200 |
| Bits of data | 8 |
| Parity | None |
| Bits of Parity | 1 |
| Flow Control | None |

To access the data of the equipment and to bring up to date the screens in the Hyper-terminal use ENTER on the keyboard. Screen 1 indicates some measurements, states of the alarms and offers options for access to other functions of the equipment.

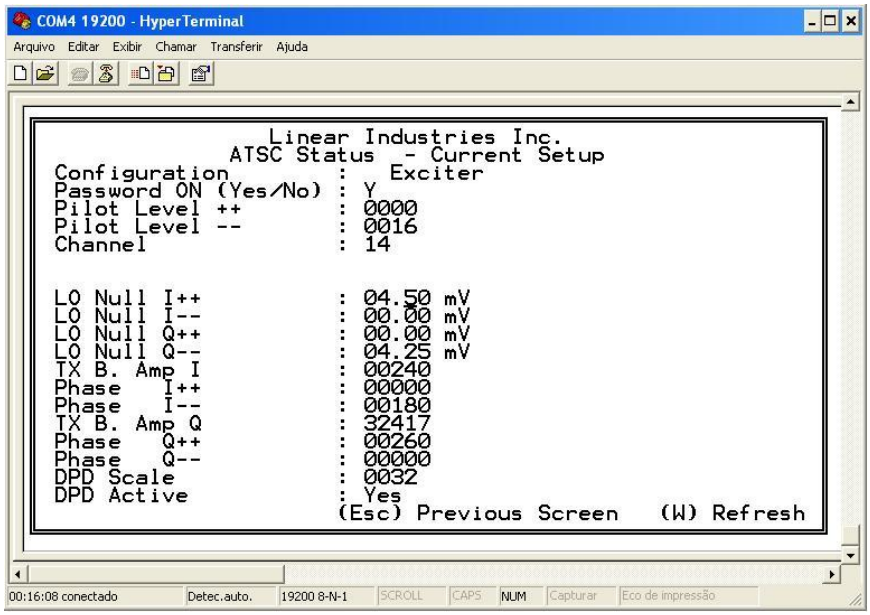



When the password of the equipment is qualified screen 2 will be displayed. A password of 4 digits must be entered to access the SETUP environment. In the case where the entered password is incorrect, the message "WRONG PASSWORD" will be shown. When the password is correct a warning question is asked. Reply YES (y), which then allows access to the SETUP environment. A NO (n) reply will return to the menu to the previous screen 1.






To configure the parameters of screen 3 the characters in the parentheses should be selected by using standard keyboard keys. Select the option desired and then use the keyboard characters U (up) and D (down) or Y (Yes) or N (No) to display the values of configuration. For safety reasons the values entered are only confirmed when exiting from the screen. Exit from the screen by using the ESC key. The W Key will refresh the screen.



# Annex B – Checking the RF Power LDMOS Transistors

All 3 main RF transistors on the module 4408 are LDMOS technology type. The manipulation of these transistors requires some special care, for instance avoiding manual bare finger direct contact with the parts. Instead, prioritize the usage metal parts tools and grounded care procedures.

- **Gate-to-ground conductance test**

With the transistors in place it is possible with a digital multimeter perform this test. Unplug the DC connectors (CON-2 and CON-3) and measure the conductance between the gate terminal and ground.

T1:
Adjust TPO-1 for the minimum of its value; (all counterclockwise) the reading at the multimeter should be close of 380Ω. Adjusting TPO-1 for the maximum of its value, the reading at multimeter should be close of 720Ω.

T2:
Adjust TPO-2 for the minimum of its value; (all counterclockwise) the reading at the multimeter should be close of 370Ω. Adjusting TPO-1 for the maximum of its value, the reading at multimeter should be close of 720Ω.

T3:
Adjust TPO-3 for the minimum of its value; (all counterclockwise) the reading at the multimeter should be close of 550Ω. Adjusting TPO-1 for the maximum of its value, the reading at multimeter should be close of 705Ω. These readings are expected remain the same for both T3 gates.

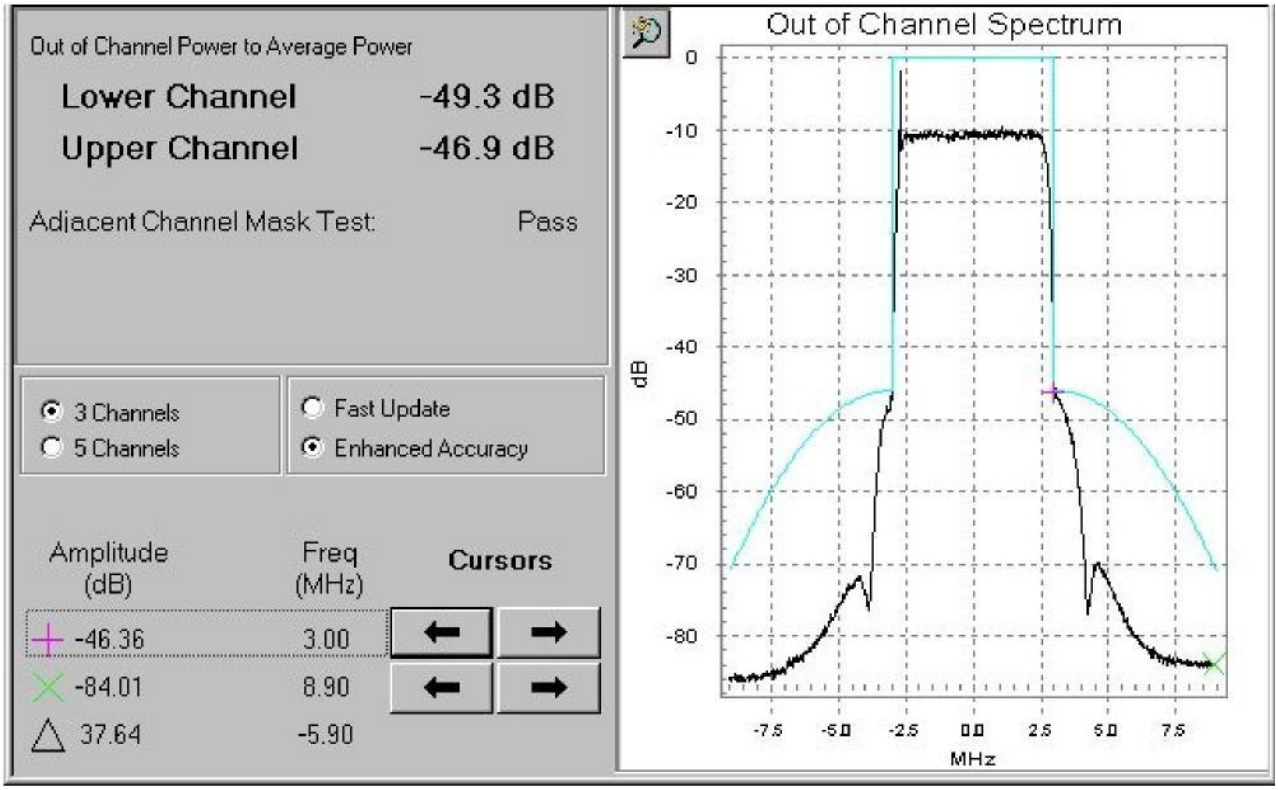
In event that these measurements does not comes true, check the possibility of some surrounding other components be damaged, and/or proceed a careful visual inspection looking for abnormal circumstances . Same tests suggested above could be repeated with the transistors detached out from the PCB board; on this case measurement readings for gate-to-ground should be close of 40MΩ. Also on this situation detect a diode type behavior measuring drain-to-source conductance as follows:

| | | | | | |
|---|---|---|---|---|---|
| (+) | DRAIN | (-) | SOURCE | R= | 580Ω |
| (+) | SOURCE | (-) | DRAIN | R= | ∞ |

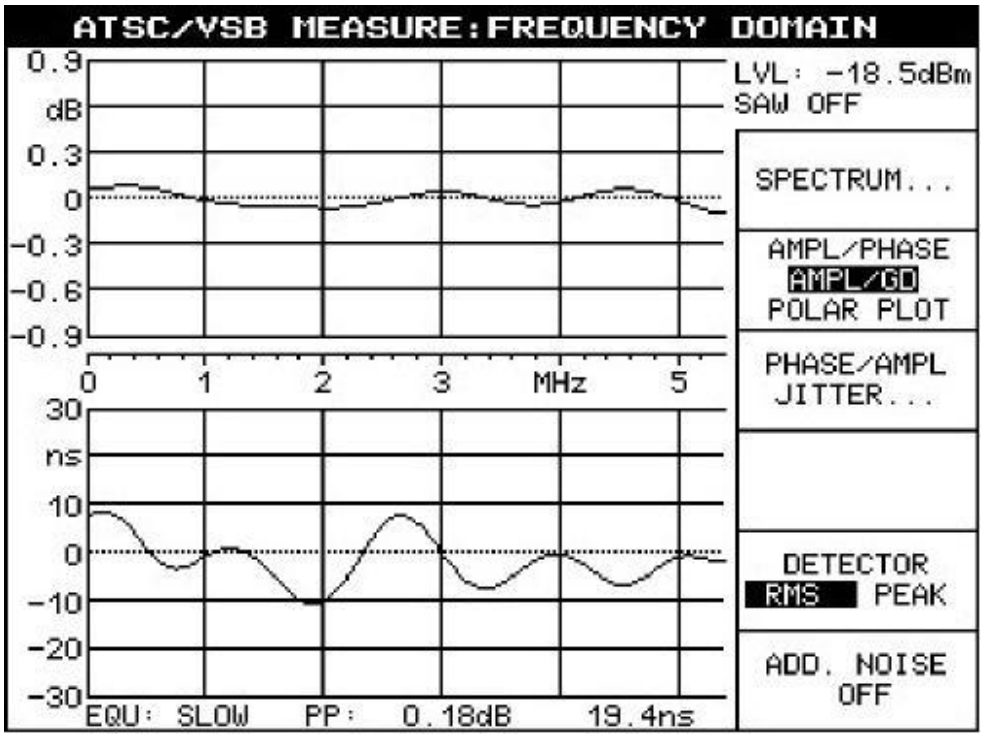
In case these 2 measurements cannot be verified, the transistor must be substituted.

# Annex C – Typical Final Test Reports Results

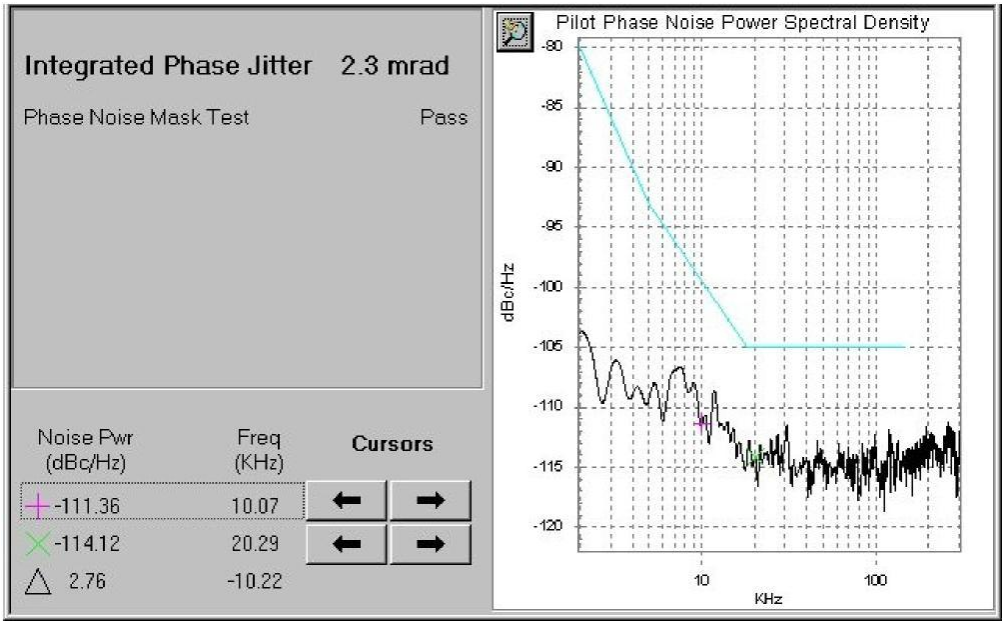
- **Out of Channel Emissions**



- **Frequency Response and Group Delay**




- **Carrier Phase Noise**



- **Digital Modulation Error Rate:**

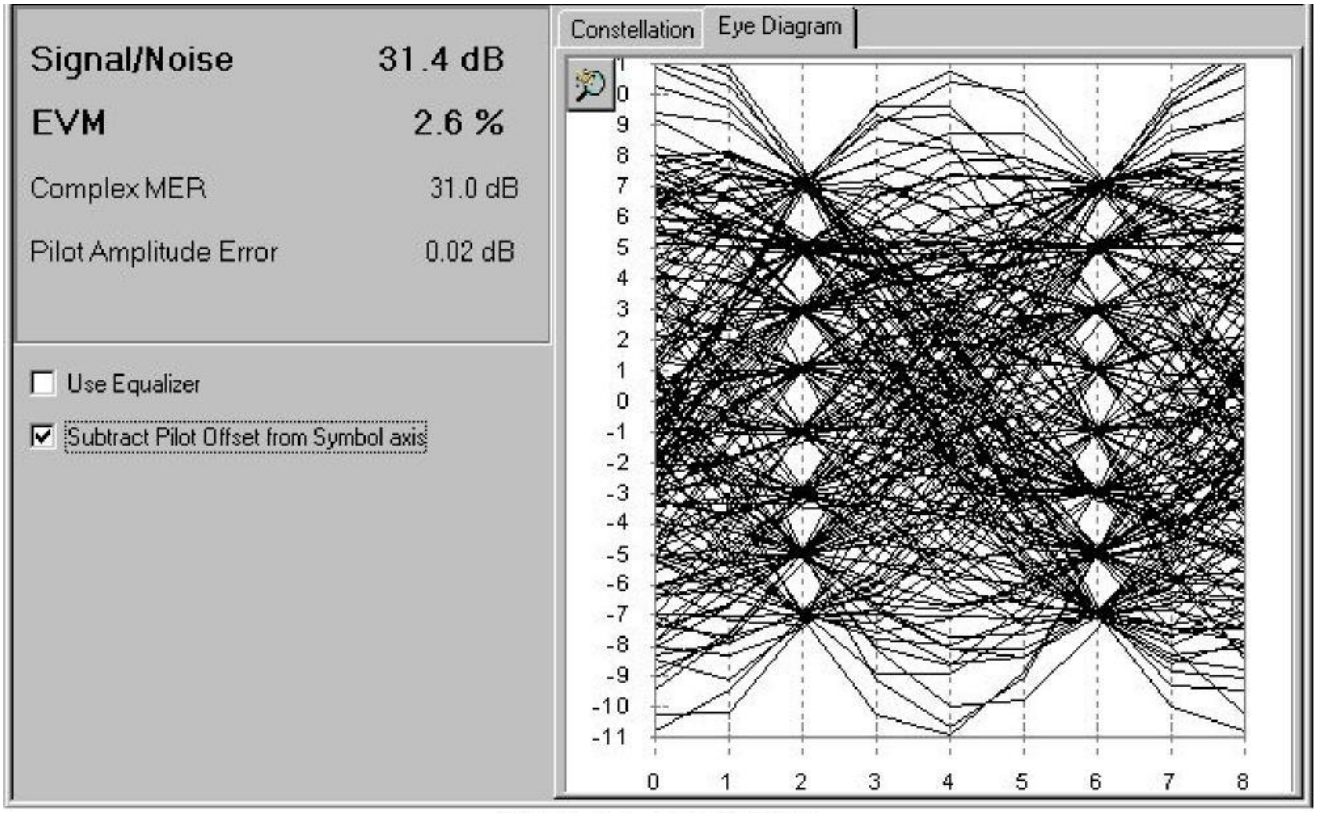



Figure 2-4. Eye diagram

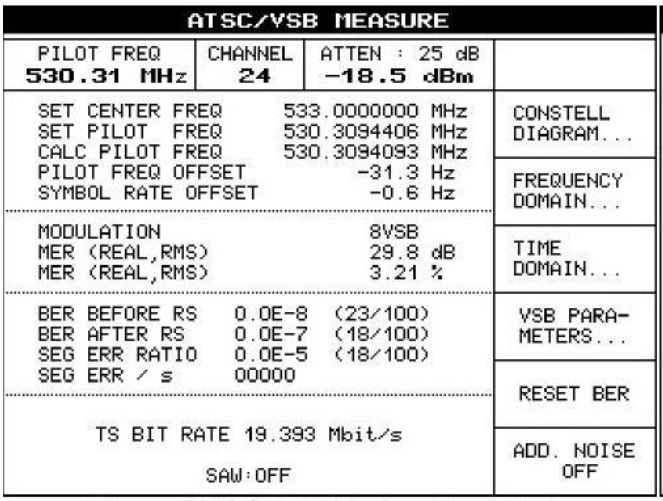



Figure 2-5(a). Modulation Error Rate

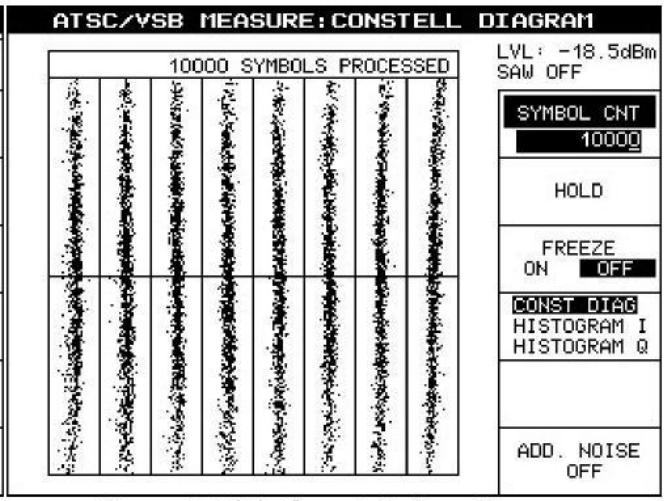



Figure 2-5(b). Constellation diagram

- **Conducted Spurious Emissions**