ADVANCED TV LINE

Model AT7400

400W ATSC UHF Transmitter

OWNERS MANUAL

Linear Industries Incorporation
www.linear-tv.com
Made in USA

AT7400
400W ATSC DTV TRANSMITTER
ADVANCED TV LINE

Owner Manual

Table of Contents

User Notices and WARNINGS

USER NOTICES

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

Notice 1
The transmitter main operating voltage setting is marked on the rear of the AT7250 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 should seek proper medical attention. It is advisable that such personnel have familiarity with first-aid practices.

Notice 5
To call our technical support center or for other customer service issues at Linear Inc, refer to the following number: 630 346 6698.

Notice 6
If you experience some specific difficulty and the technical information available in this manual is not enough to help you, do not hesitate to call LINEAR technical support center.

Notice 7

WARNING!

THE VOLTAGES AND CURRENTS IN THIS EQUIPMENT ARE DANGEROUS. PERSONEL MUST, AT ALL TIMES, OBSERVE SAFETY WARNINGS, INSTRUCTIONS, AND ANY 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 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 PERSONS 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 DISCONECT AC/MAINS 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 – AT7400 Technical Specifications

1. Introduction

The AT7400 is a 400W UHF ATSC/8VSB transmitter assembled and tested in United States by LINEAR INDUSTRIES INC. (www.linear-tv.com).

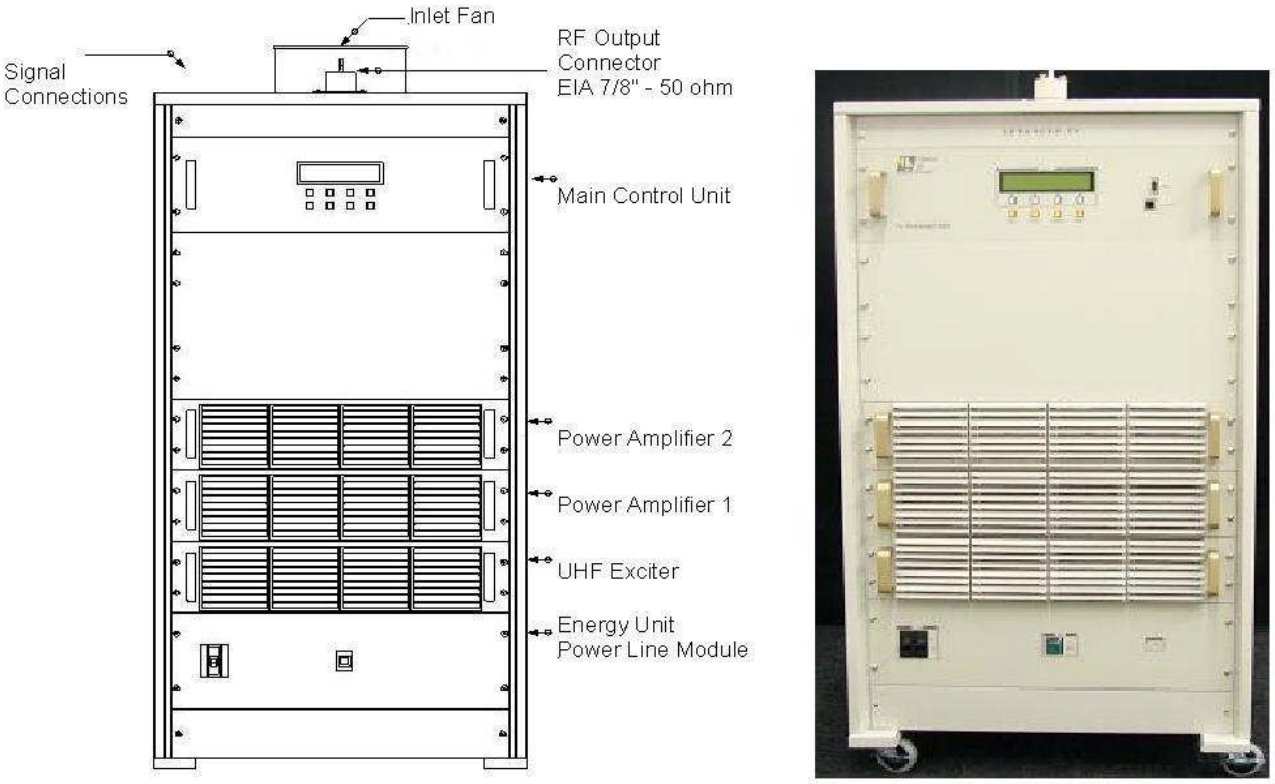
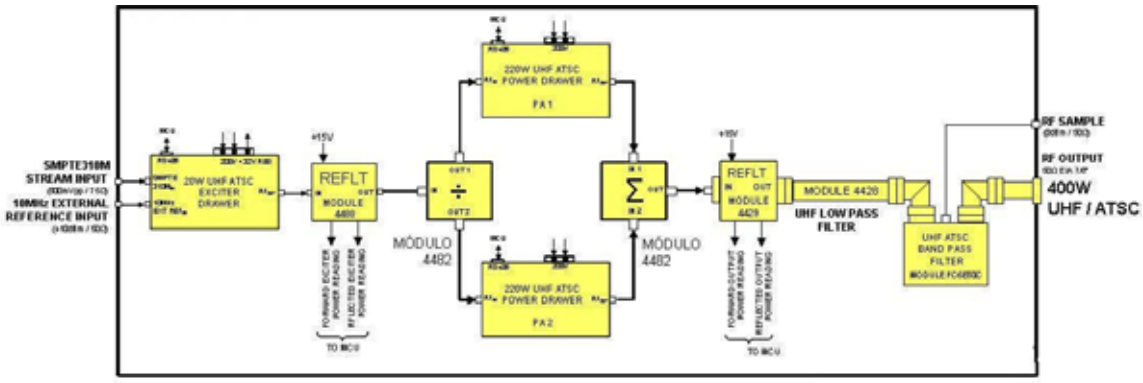


Fig1.1: AT7400 Front View, cabinet wheels are optional.

2. AT7400 RF line Up



3. AT7400 Cabinet Air Flux: 0.25m^3/sec. - 21ft^3/sec.

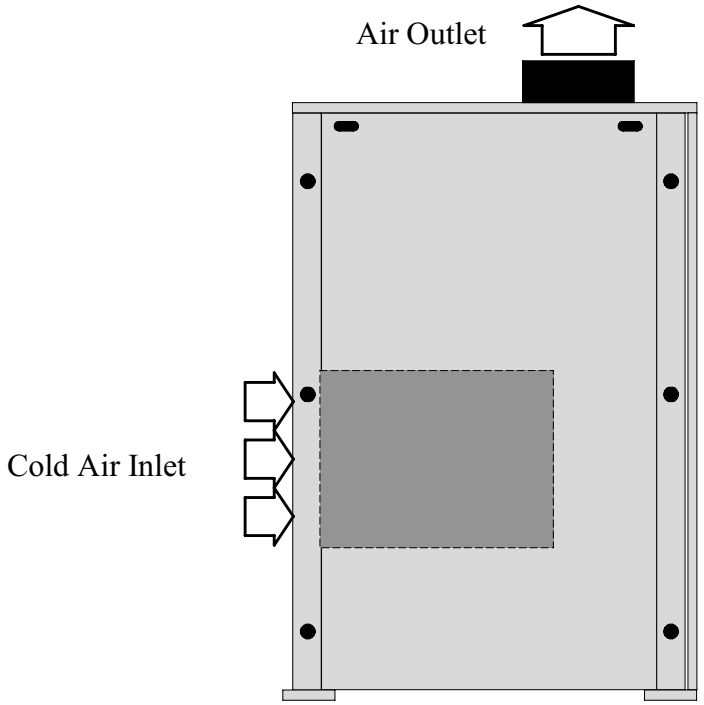


Fig. 1.4: Air flux path at AT4700 cabinet, (lateral view). Darker area denotes the internal heat source, or the RF drawers, (1) Exciter and (2) PA's.

4. AT7400 – 400W UHF ATSC/8VSB Transmitter - Technical Specifications

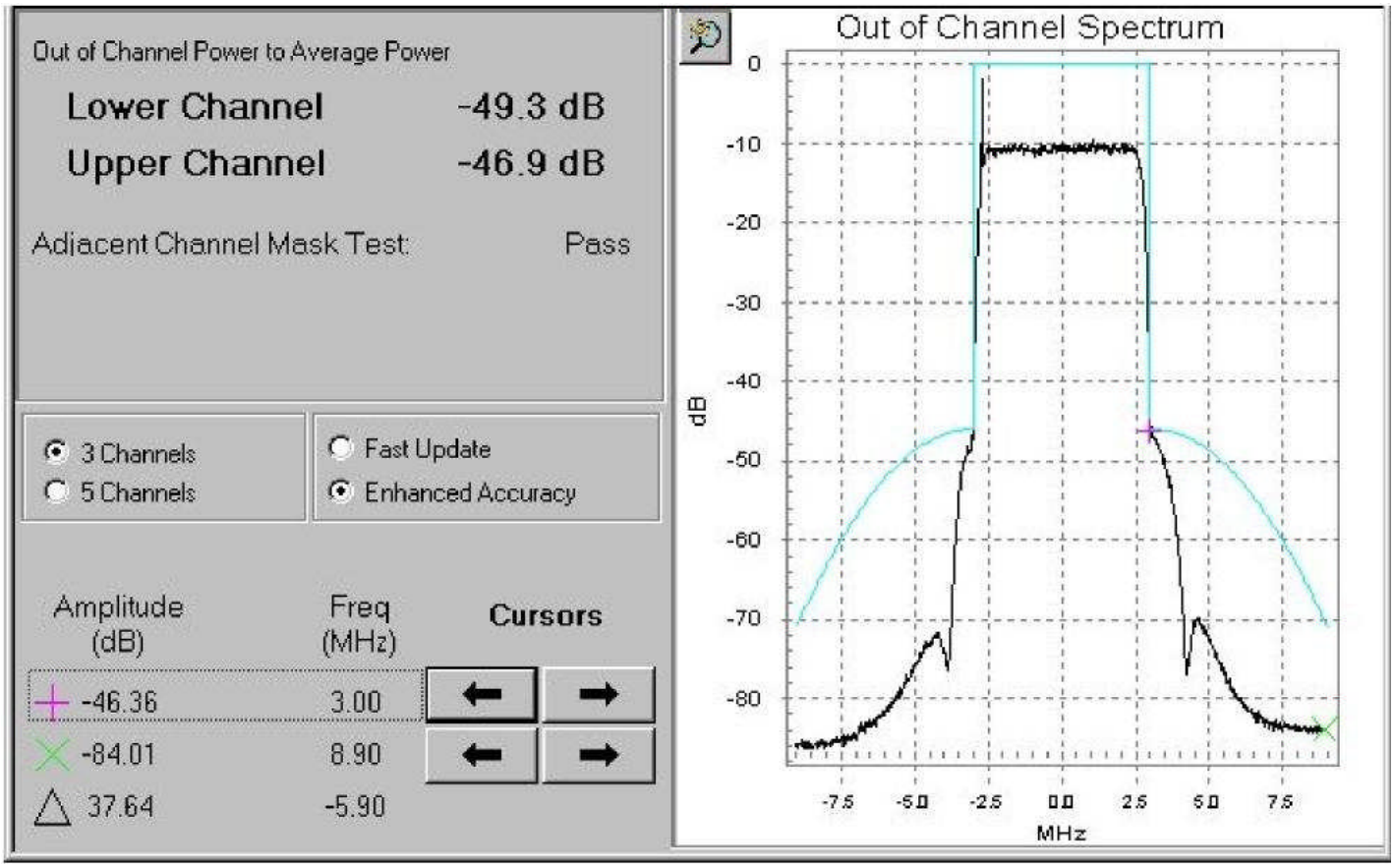
Electrical	
Main	220/240 VAC, bi phase, 50-60 Hz. 3w.
Consumption	3200W.
PFC	Included
Signal Input	
Transport Stream Input	ATSC/MPEG2, compliant to SMPTE310M
Input Data Rate	19.39 Mbps
External Reference Signal	10MHz. (0 to +10 dBm).
Input Connector	75Ω (BNC),
Reference Input Connector	50Ω (BNC),
RF	
RF Output Power	400w (rms)
Modulation Mode	8VSB. All-Digital Complex IF modulation
IF	18.833916 MHz.
Channel Bandwidth	6MHz.
Test Signal	PRBS. Pseudo Random Bit Sequence
Frequency Range	UHF. Ch14 to Ch69, (4 bands).
Frequency Step	1 Hz. ± 220kHz
Symbol Rate	10.76 MSymbol/sec.
Digital/Analog Converter	16 bit
All –Digital Linear. Pre-Correction	Included
Pilot frequency stability overall	± 0.3 ppm.
Peak to peak frequency response	≤ 0.15 dB.
Peak to peak group delay response	≤ 15 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)	≥ 39dB (modulator output) typical.
	≥ 39 dB (exciter output) typical.
	≥ 29 dB (transmitter output) typical.
RF output connector	EIA 7/8” Flanged.
Output sample connector	N
Remote Control	
RS-232	Dial-up network interface via hyper-terminal
Ethernet	SNMP. IP network interface via Web Browser.
Mechanical	
Air Refrigeration	Internal drawer’s air speed: 400 ft/minute.
	Overall Air flow: 21ft^3/sec.
Dimensions	58”(H), 28”(W), 43”(D)
Weight	Gross: 286.7 Kg | NET: 236.70 Kg
Foot print	28”(W), 7’(D)

5. AT4700 Available Models and Options

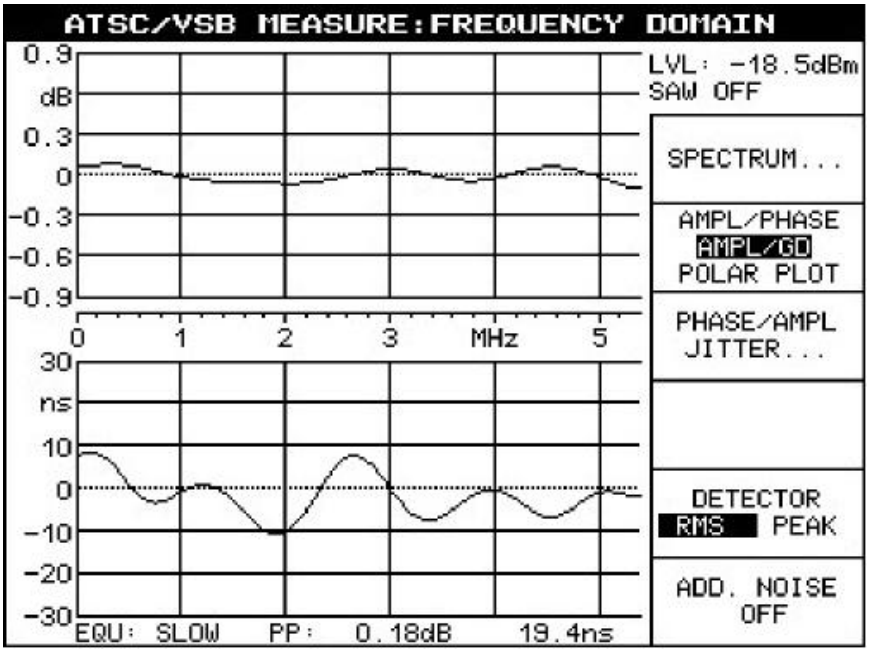
Models	
A	Mono-phase; 220Vac.
B	3-phase; 220Vac – 380Vac; 3 wires.
C	3-phase; 220Vac – 380Vac; 4 wires.
Options:	
01	Integrated GPS receiver
02	Adaptive digital pre-correction
03	Dual Exciter
04	Analog Transmission Mode
05	Cabinet 4 wheels

6. AT7400 Typical Test Report

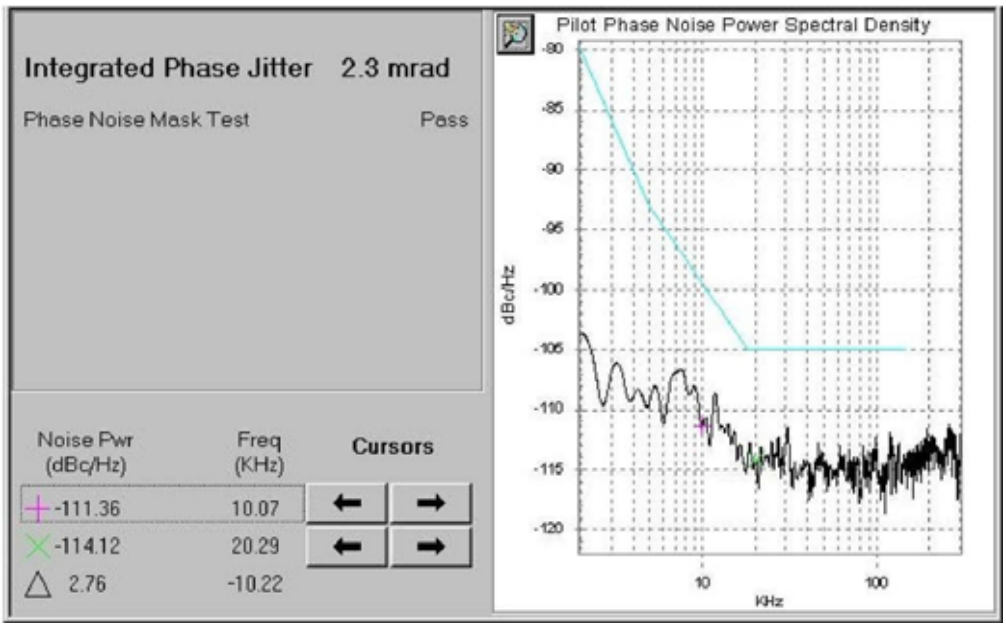
6.1. Out of Channel Emissions



6.2. Frequency Response and Group Delay



6.3. Carrier Phase Noise



6.4. Digital Modulation Error Rate

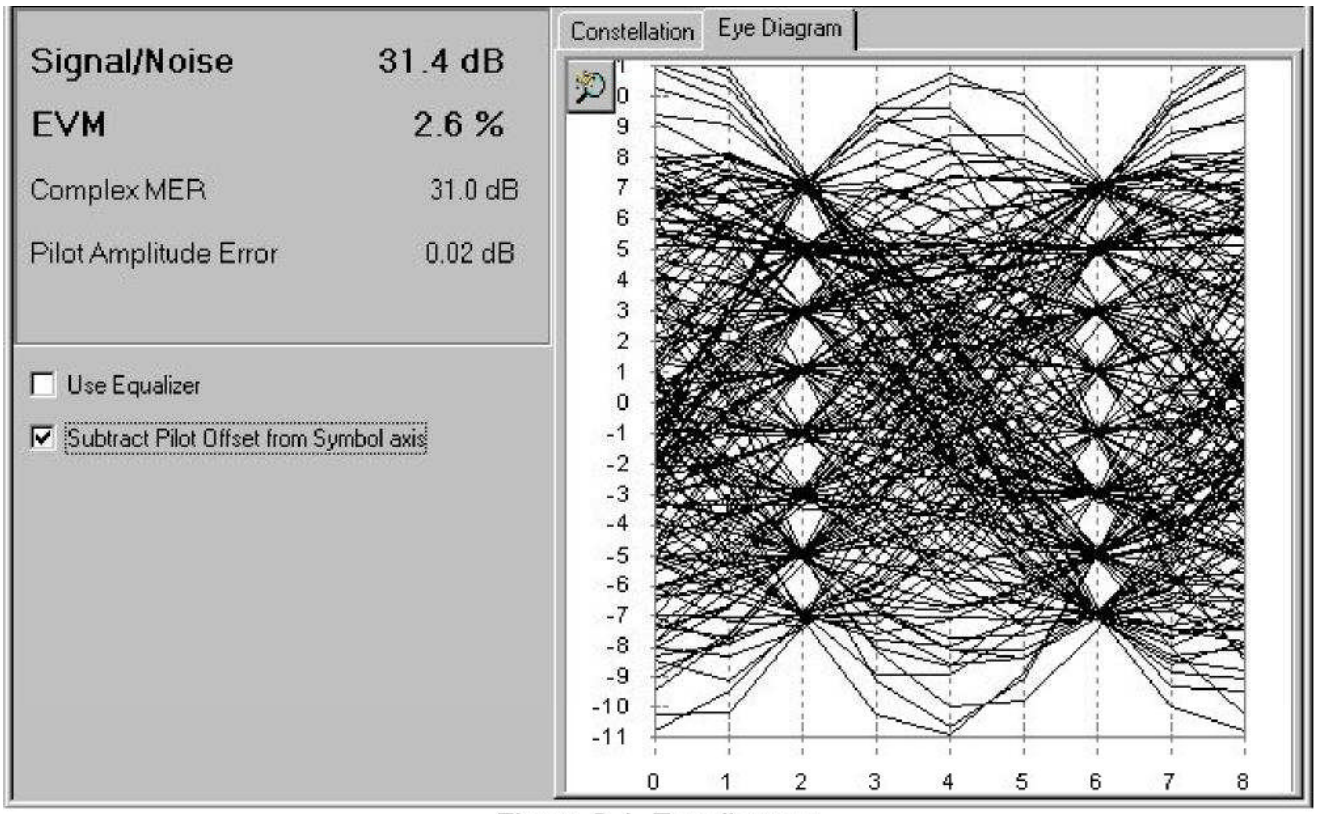


Figure 2-4. Eye diagram

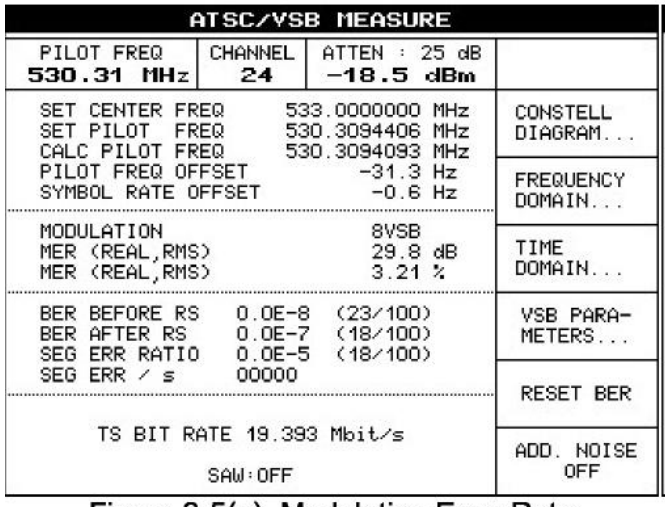


Figure 2-5(a). Modulation Error Rate

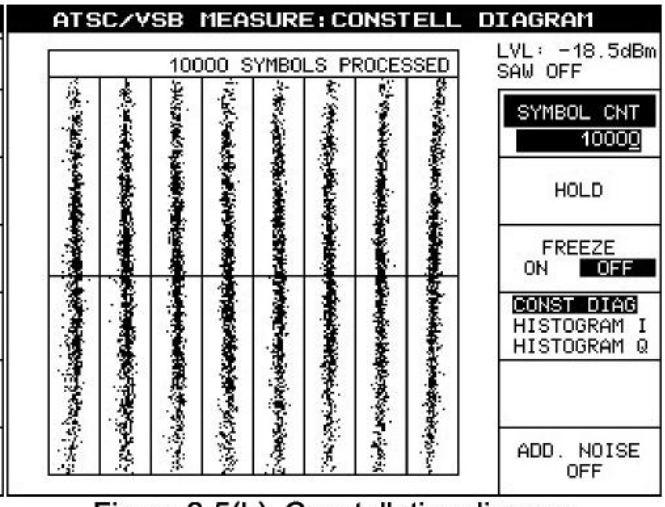
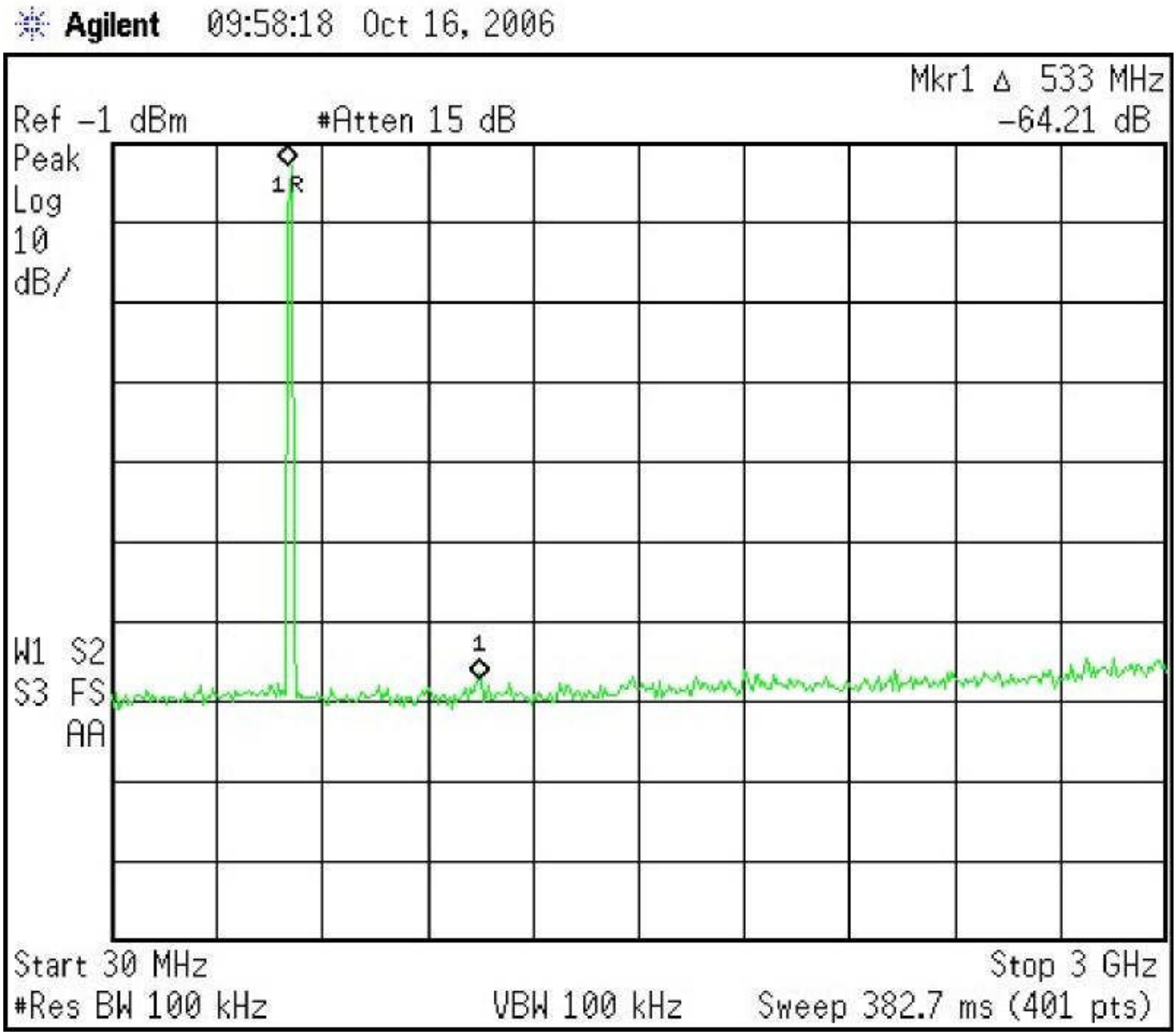


Figure 2-5(b). Constellation diagram

6.5. Conducted Spurious Emissions



Section 2 – Master Control Unit

Module 4459

1. General Description

The main control unit, MCU, is the logical master unit acting all over the transmitter operational functions. The MCU is constantly connected and exchanging information via RS485 with the UHF power amplifiers units and the UHF exciter unit. External keyboard allows local changing on parameters and monitoring, displayed on a LCD screen. Via a RS232, it is also possible to implement telemetry using either the Windows Hype Terminal, or via Ethernet Web Server.

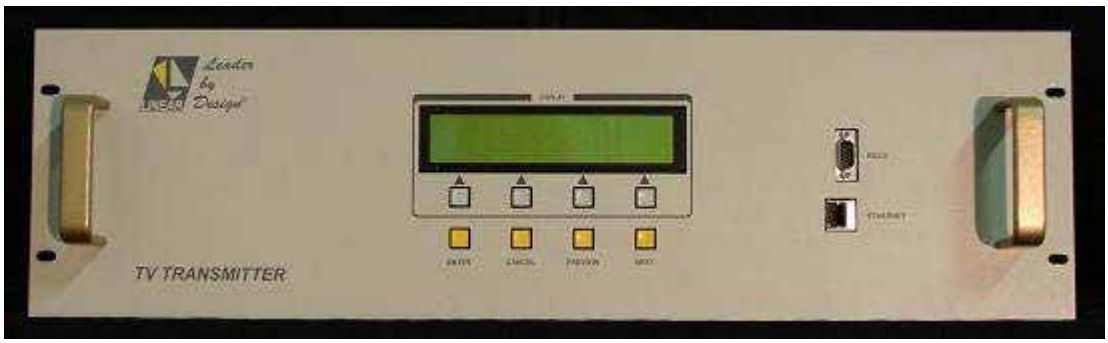


Fig.2.1: – Front View MCU module 4459

2. Following, the main functions of MCU

2.1. Monitor and display the alarm status on each of the transmitter units.
2.2. Monitor the direct and reverse RF power, out from the intermediate directional coupler, module 4488, avoiding a potential over driver to the power amplifiers.
2.3. Monitor the direct and reverse RF power, out from the output directional coupler, module 4429, and inhibiting excessive RF power level on either direction.
2.4. Send to the exciter driver local control unit, via RS485 protocol, the set of programmed software instructions related with the broadcasting channel, and the associated power level.
2.5. MCU is composed by the following printed circuit boards:

2.5.1. 01 control unit; CIM3297.
2.5.2. 01 SNMP interface; CIM3453.
2.5.3. 01 Keyboard; CIM3112.
2.5.4. 01 LCD Display; CIM3108.

2.6. Module 4459 Block Diagram

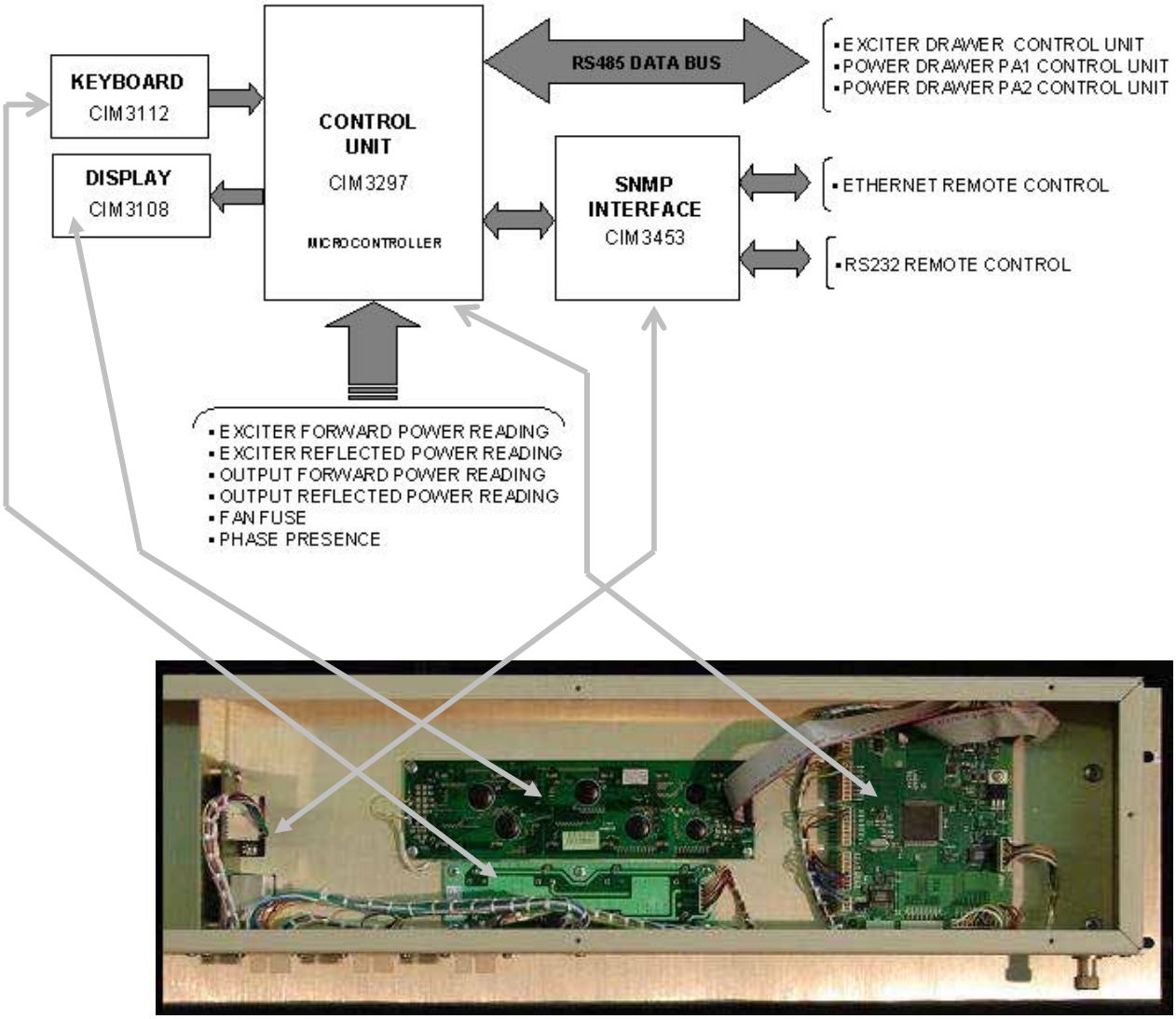


Fig.2.2: – Module 4459 block diagram and PCBs displacement.

2.7. Unit Control Board CIM3297 at Module 4459

This is the principal board on the MCU module. See Fig.2.5 for the PCB CIM3297 connections. The logic functions performed by the PCB CIM3297 are as follows:

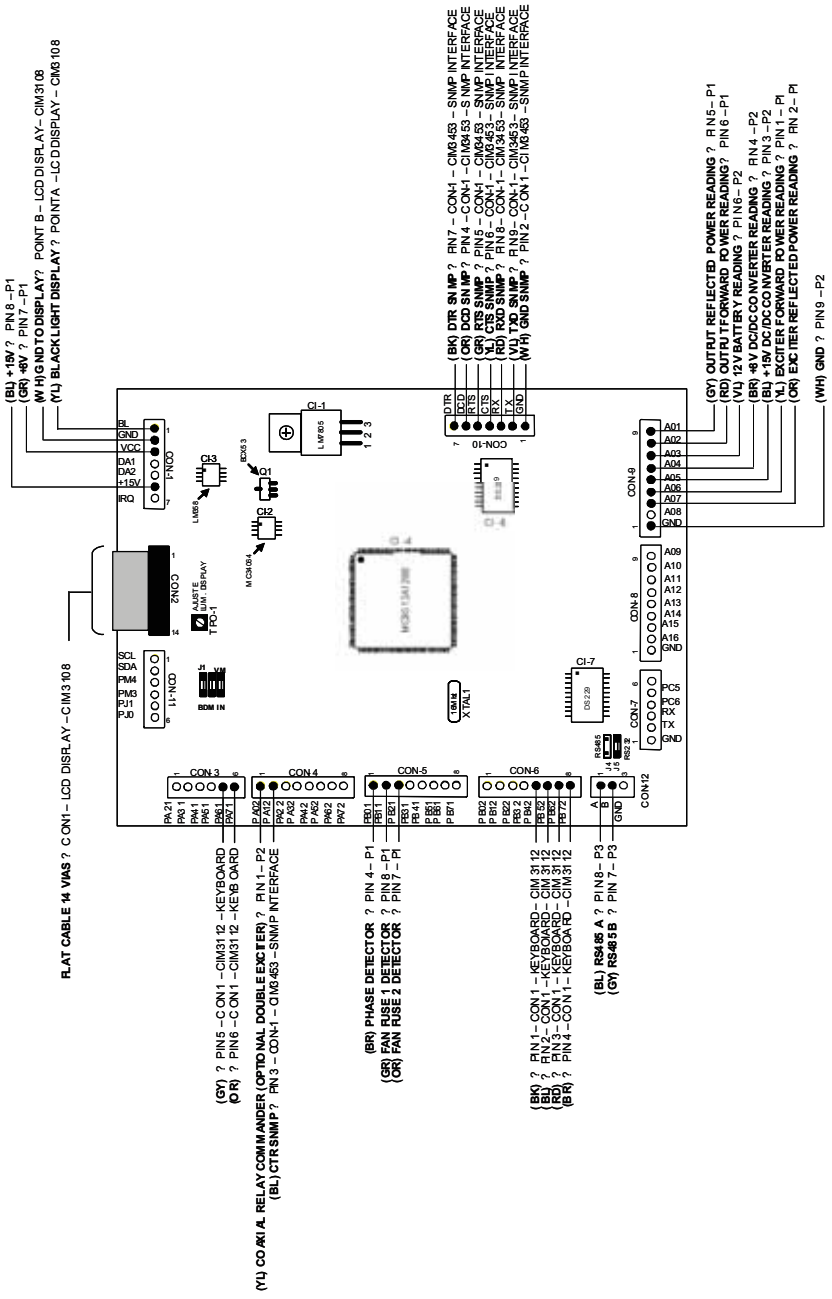


Fig. 2.3: - Module 4459 connection diagram for PCB CIM3297.

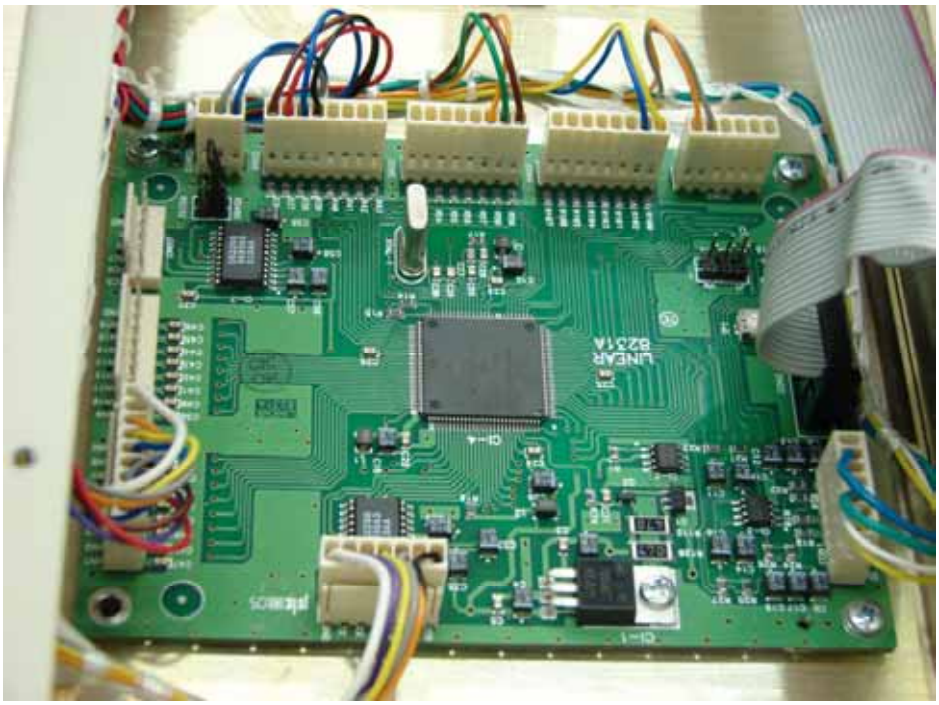


Fig.2.4: – Module 4459, CIM 3297 the transmitter main microcontroller.

2.7.1. Digital Control

○ The integrated circuit CI-4 (A128) is a 16 bit microcontroller, programmed on assembler language. This integrated circuit controls this module, 4459, and also the entire transmitter. This IC carries a controlled software version, and is programmed on factory.

→ ***In case of substitution of the CI-4 or even the entire PCB CIM3297, it is mandatory to inform the factory prior replacement, the programming identification number that is clearly indicated at the CI-4 body.***

2.7.2. Analog Readings

Information on analog format is available at the connectors P1 and P2 on the module 4459's panel, which are routed to CON-9 at the PCB CIM3297. On P1-P2 connectors are available the following analog reading from external measurements:

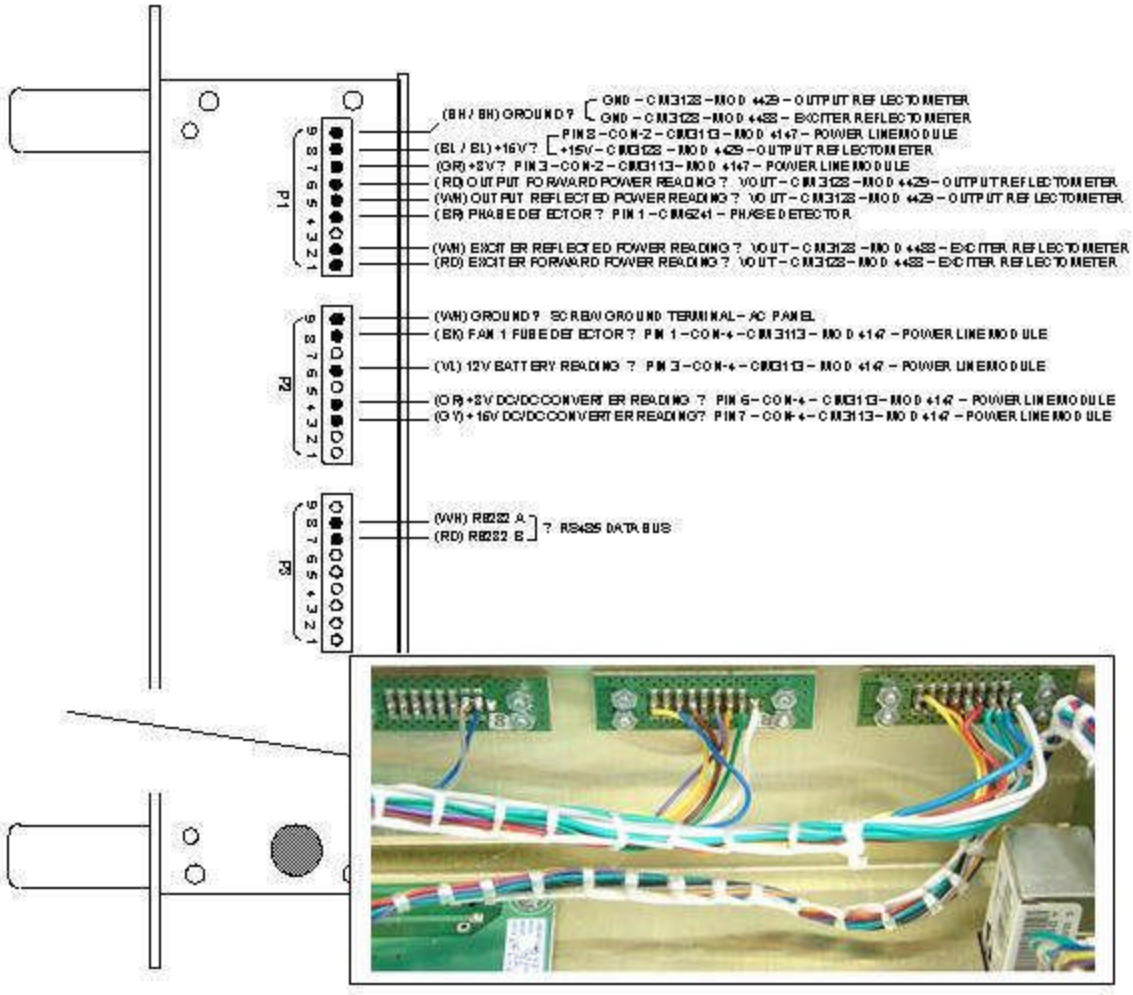


Fig. 2.5: - Module 4459 external connections and internal connections view.

2.7.2.1 Direct RF power, and reverse RF power. From the RF output directional coupler, module 4429.

2.7.2.2 Direct RF driver power, and reverse RF driver power. From the RF intermediate directional coupler, module 4429.

2.7.2.3 +8V, from the DC/DC converter; module 4147.

2.7.2.4 +15V, from the DC/DC converter; module 4147.

2.7.2.5 The 12V/7Ah battery voltage.

From the connector CON-9 these readings feed the microcontroller CI-4, from where those are digitalized and processed. By software decision, the microcontroller sets the nominal value for these readings always +4V, meaning, to all nominal values the +4V will be assigned, and will be available at the CON-9. These values are transferred to the main LCD display on the MCU.
On the intermediate and final directional couplers, module 4488 and 4429, as well on the mains module, 4147, there are test points where the +4V nominal reference voltage are set. For instance:

- *Once on operation and at the time the transmitter is set for its nominal RF output power, the trim pot TP01 at PCB CIM3128A located at the module 4429 should be adjust on such way that the +4V is measured at pin 8, on the connector CON-9 located at PCB CIM3297. More details will be shown on specific sections of this manual.*

2.7.3. Alarm Detection

The system alarms are routed to MCU module 4459 via P1 and P2 connectors. These alarms are routed to CON-5 at PCB CIM3297. These alarms are:

2.7.3.1 Lack of AC phase on mains, detected at module 4147.
2.7.3.2 Open fuse for fan #1, detected at module 4147.
2.7.3.3 Open fuse for fan #2, detected at module 4147. *(For 2 racks systems only).*

At the time when the system is on normal operation, no alarms, a +5V voltage is sent to the CON-5 via P1-P2 connectors. When an abnormal condition happens, that requires attention and generates an alarm status; a lower voltage is than sent, usually 0V. When a lower voltage is detected by the microcontroller, the transmission is halted.

2.7.3.4 The alarm status is shown at the LCD screen on the front panel of the MCU. The alarms events are classified in two categories regarding the time line occurrence:
2.7.3.4.1. On going alarm situation, noted by the sign “!”.
2.7.3.4.2. Old alarm situation, noted by the sign “#”.

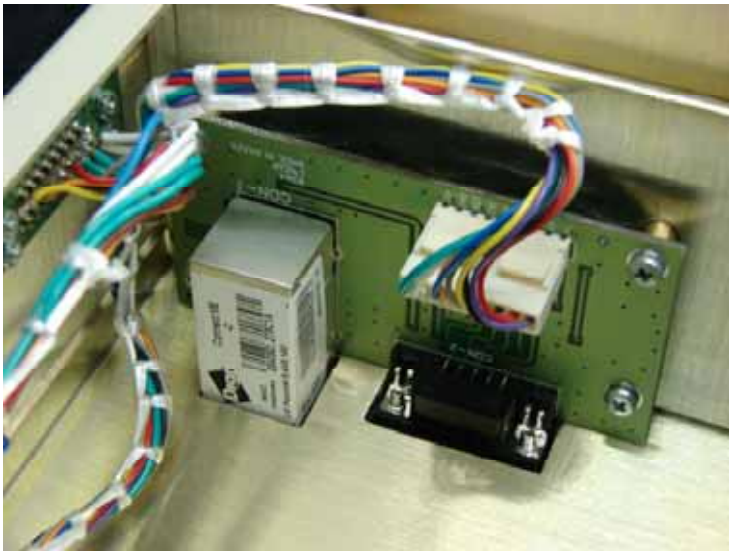
At the time when an alarm source cease, the transmission is reestablished, and the “!” sign is switched to a “#” sign, and registered. Old records can be manually erased by pressing the key “CLEAR” on the MCU front panel keyboard.

2.7.4. RS485 Communication bus

On the PCB CIM3297, pin 1 and pin 2, at the CON-12 perform the RS485 communication link among the MCU, the UHF exciter driver drawer and the UHF power amplifier drawers.

2.7.5. Interface SNMP

The interface SNMP is the PCB CIM3453. The connectors CON-4 and CON-10 located at the PCB CIM 3297 links the 2 PCBs.



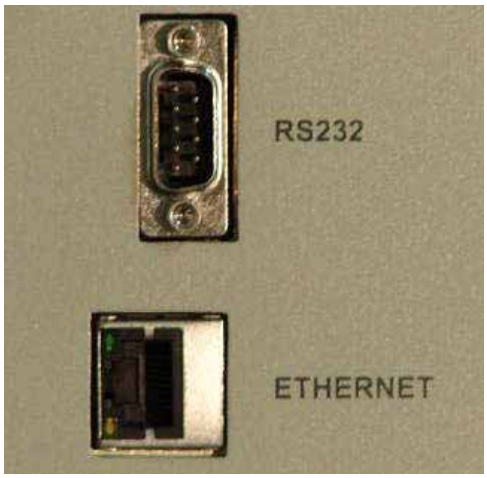


Fig. 2.6: - Module 4459 SNPM interface, PCB CIM3453, internal and external view.

2.7.6. Displaying the Exciter and Power Amplifier Drawers Alarms

Each drawer has its own local control units. The local processed data is link to the MCU via RS485 protocol. The MCU unit analyze, command actions and display at the LCD, the overall system status.
Alarms from the drawers, are displayed as *drawers alarms*, followed by one of each signs "!", or "#". Any alarm originated on any internal module belonging to the UHF exciter drawer, that is followed by the sign "!", (on going alarm), will cease the transmission. On other hand, any alarm originated on the UHF power amplifier drawer, also followed by the sign "!", will cause a proportional RF power reduction, implemented by the MCU logic control.

2.7.7. Keyboard, PCB CIM3112

This PCB holds the 8 key pads, which externally allows local manual interface with the transmitter MCU. This PCB is a switch matrix. CON-1 transfers the CH1-CH8 keyboard ON/OFF operations to the MCU main board.

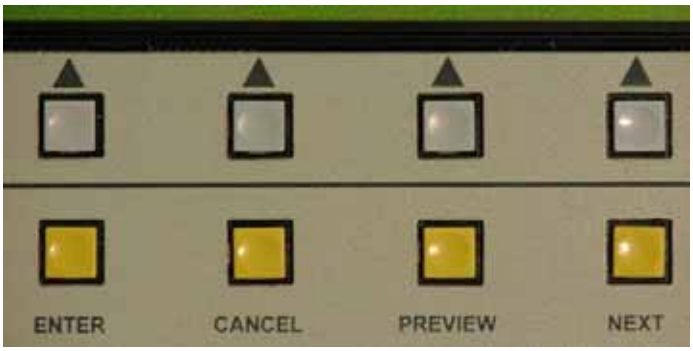


Fig. 2.7: - Module 4459 local command keyboard, external view.

2.7.8. LCD board, PCB CIM3108

This board is 4 rows, 40 columns liquid crystal display, LCD. The board is DC powered by the PCB CIM 3297, a +5V feed into the point A, (yellow wire) and ground at point K (white wire). A multi-via connector receive a pin-to-pin data out from CON-2 at PCB CIM 3297, exception for the pin 13 and pin 14 that have each other exchanged its positions by the flat cable.

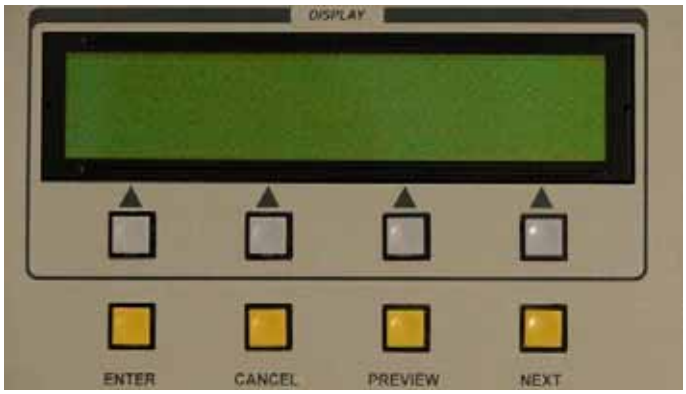


Fig. 2.8: - Module 4459 local command keyboard and LCD panel external view.

2.7.9. Module 4459 Internal Wiring

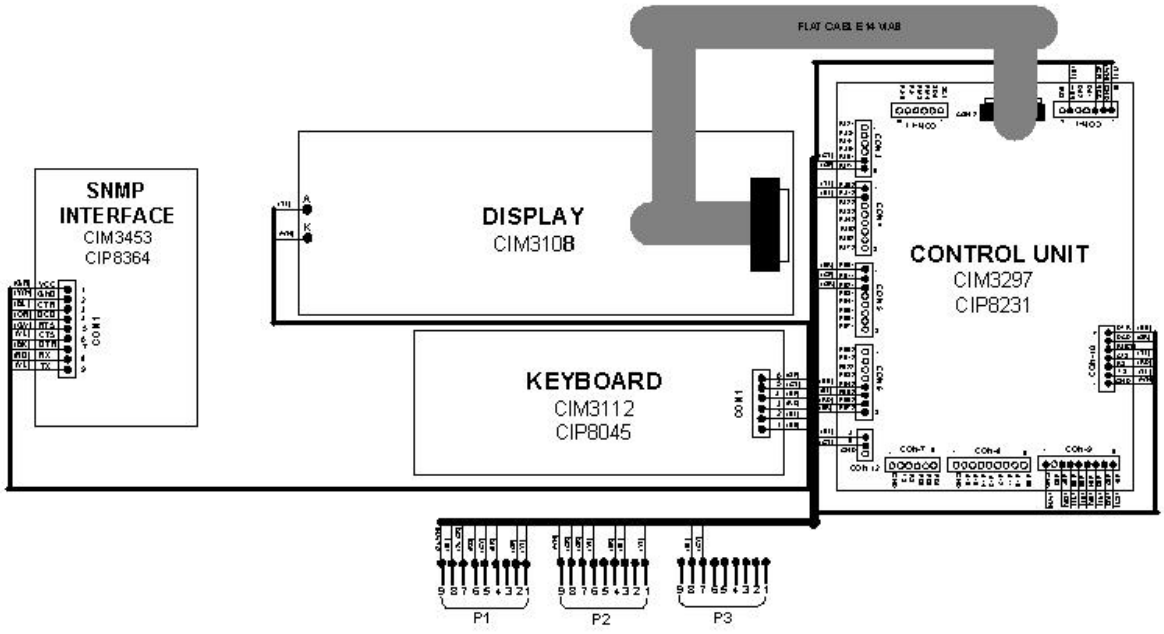


Fig. 29: - Module 4459 wiring diagram.

2.7.10. Module 4459 Schematic Diagrams: SEE ANNEX A

2.7.10.1 - PCB CIM3297
2.7.10.2 - PCB CIM3112
2.7.10.3 - PCB CIM3108
2.7.10.4 - PCB CIM3453

Section 3 – 20W UHF ATSC Exciter

Unit/Drawer GAV4452

1.General Description

The 20W UHF ATSC exciter drawer performs several important functions, as follows:

a. The 8VSB modulation. Incoming SMPTE310 data stream, over an IF carrier, 21.52MHz.
b. Insert the pre-distortion function over the modulated IF signal.

Fig.3.1: Top GAV4452 front view, bottom GAV4452 rear view.

c. Up-convert the IF signal on UHF ATSC broadcast channel.
d. The output RF power control.
e. Generates the 172MHz Master Clock signal, out from a 10MHz stable reference internally originated, OCXO/0.3ppm oscillator, or externally originated like a GPS source. Automatically switch from INT/EXT master clock signal source in presence or absence or the EXT signal.
f. Via a DDS circuitry, generates 1Hz steps over the UHF channel frequency.
g. Generates DC voltages for all internal modules, and the +32V externally to the DC/DC converter, module 4147.
h. The 30W/47dB gain UHF/ATSC power amplifier.

The modules assembled into the GAV4452 are:

- 01 Module 4454 - 8VSB Modulator and MASTER Clock Generator
- 01 Module 4453 - IF/UHF Up-Converter
- 01 Module 4466 - DDS
- 01 Module 4464 - 20W UHF / ATSC
- 01 Module 4456 - Power Supply
- 01 Subordinate Control Unit (SCU) – CIM3297

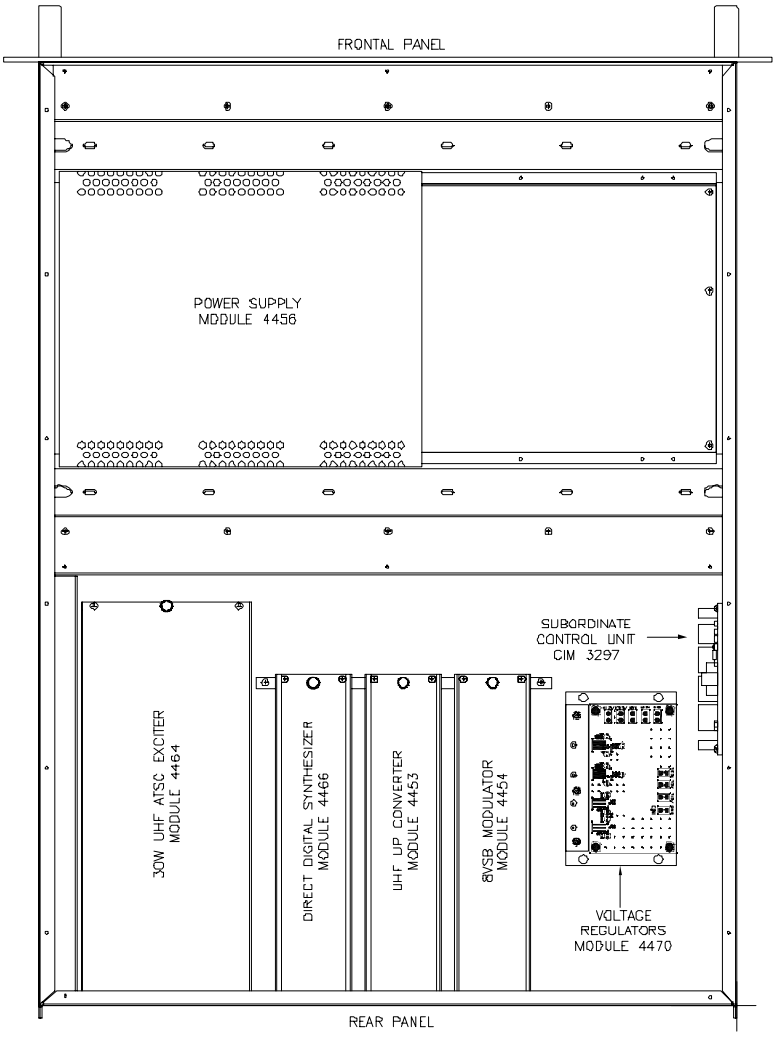
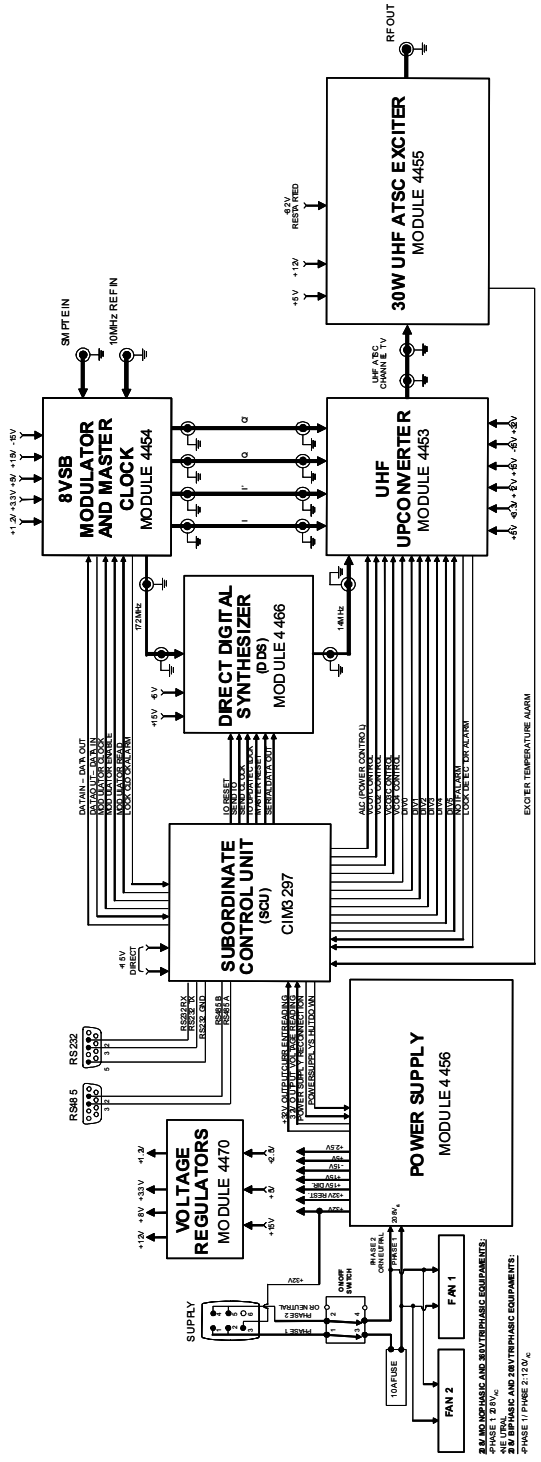


Fig.3.2: GAV4452 modules displacement, top view.

2.GAV4452 – 30W UHF/ATSC Exciter – Block Diagram



3.GAV4452 - Module 4454 – 8VSB Modulators and Master Clock

3.1. General Functional Description

The module 4454 can be break down in 2 printed circuit boards. These boards are physically located as the figure below:

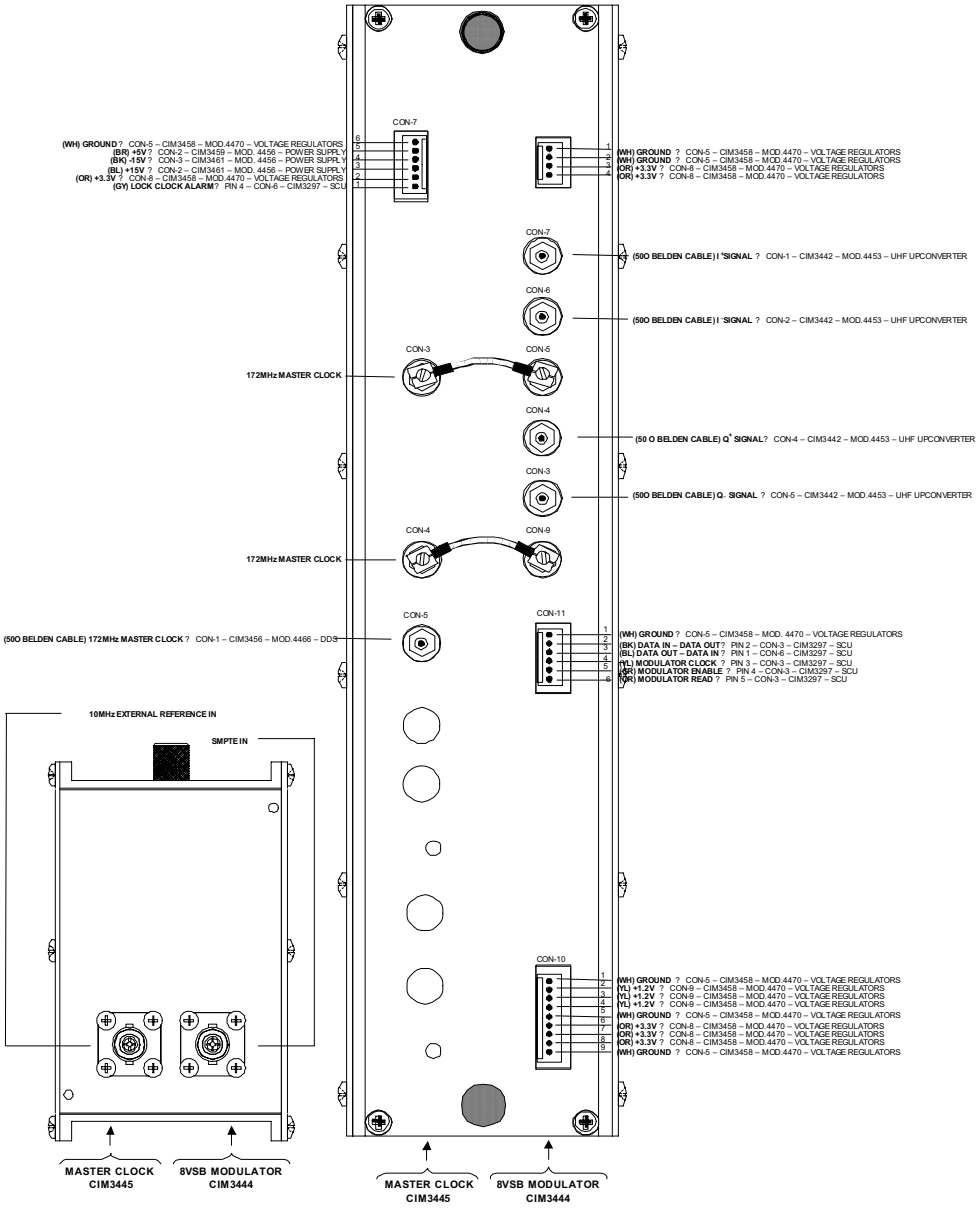


Fig.3.3: Module 4454 – Left: Front View, Right: Top View.

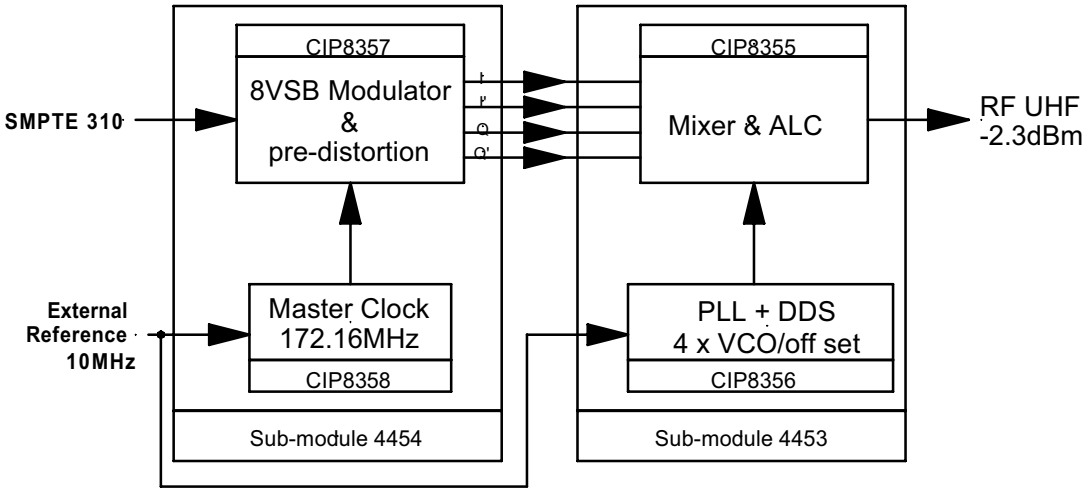


Fig.3.4: Module 4454- 8VSB Modulation and IF/UHF up-conversion structure

3.1.1. Module 4454 - PCB CIM3444: 8VSB Modulator/Pre-Corrector

The PCB CIM3444, is part of the Module 4454. It is the 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

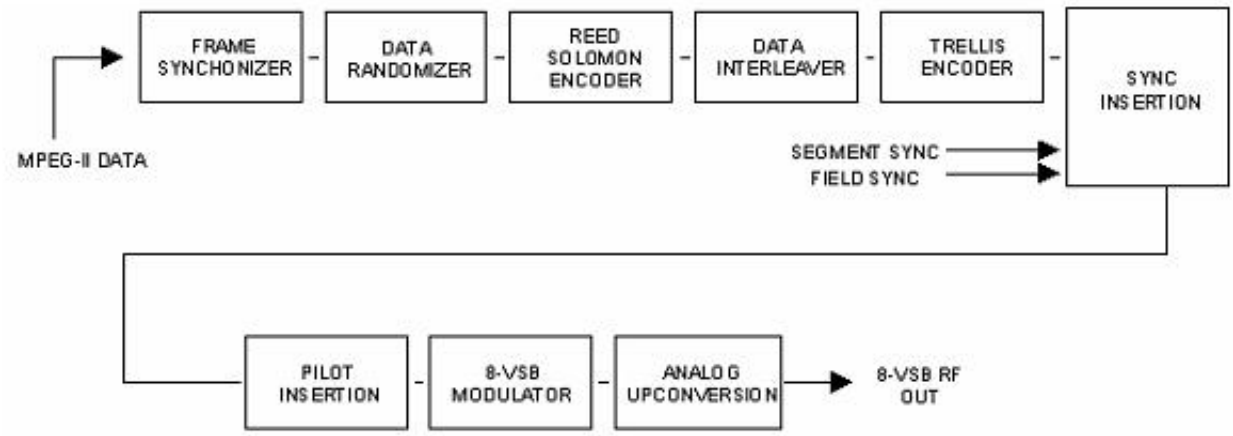


Fig.3.5: CIM3444 – Block Diagram

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.

3.1.1.1 PCB CIM3444 – General Functional Description

The ADVANCE TV series is designed to receive as input signal, programming stream, standard SMPTE310M,with 19.39M bps, amplitude of 800 mVpp, @75Ω. The input BNC connector is located on the top cover of the transmitter rack.

First the circuit to recover the clock rate 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.

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:

3.1.1.1.1. Frame Synchronization

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

3.1.1.1.2. 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.

3.1.1.1.3. 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.

3.1.1.1.4. Interleaving

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

3.1.1.1.5. 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.

3.1.1.1.6. Synchronism Insertion

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

3.1.1.1.7. 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).

The entire 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). 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 than 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.

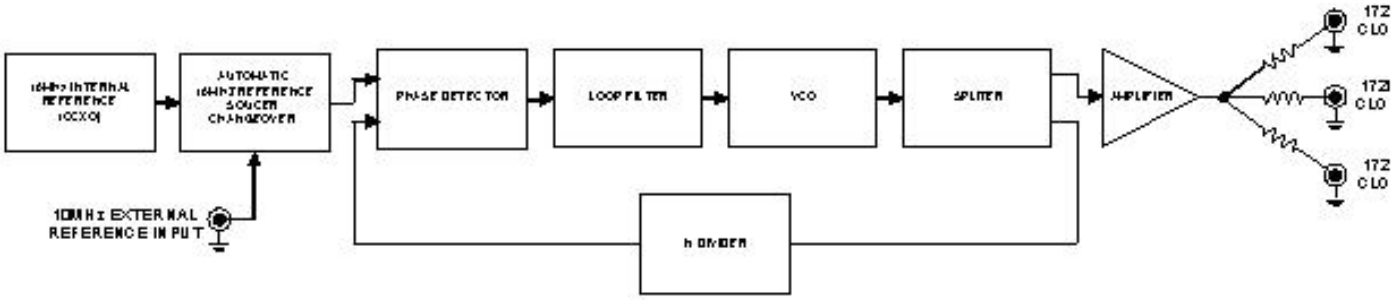
3.1.2. Module 4454 - PCB CIM3445: Master Clock

The Master Clock PCB CIM3445, embedded into the module 4454, 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 schimitt 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.3.6: External Reference input BNC connector

3.1.3. PCB CIM3445 – Master Clock - Block Diagram



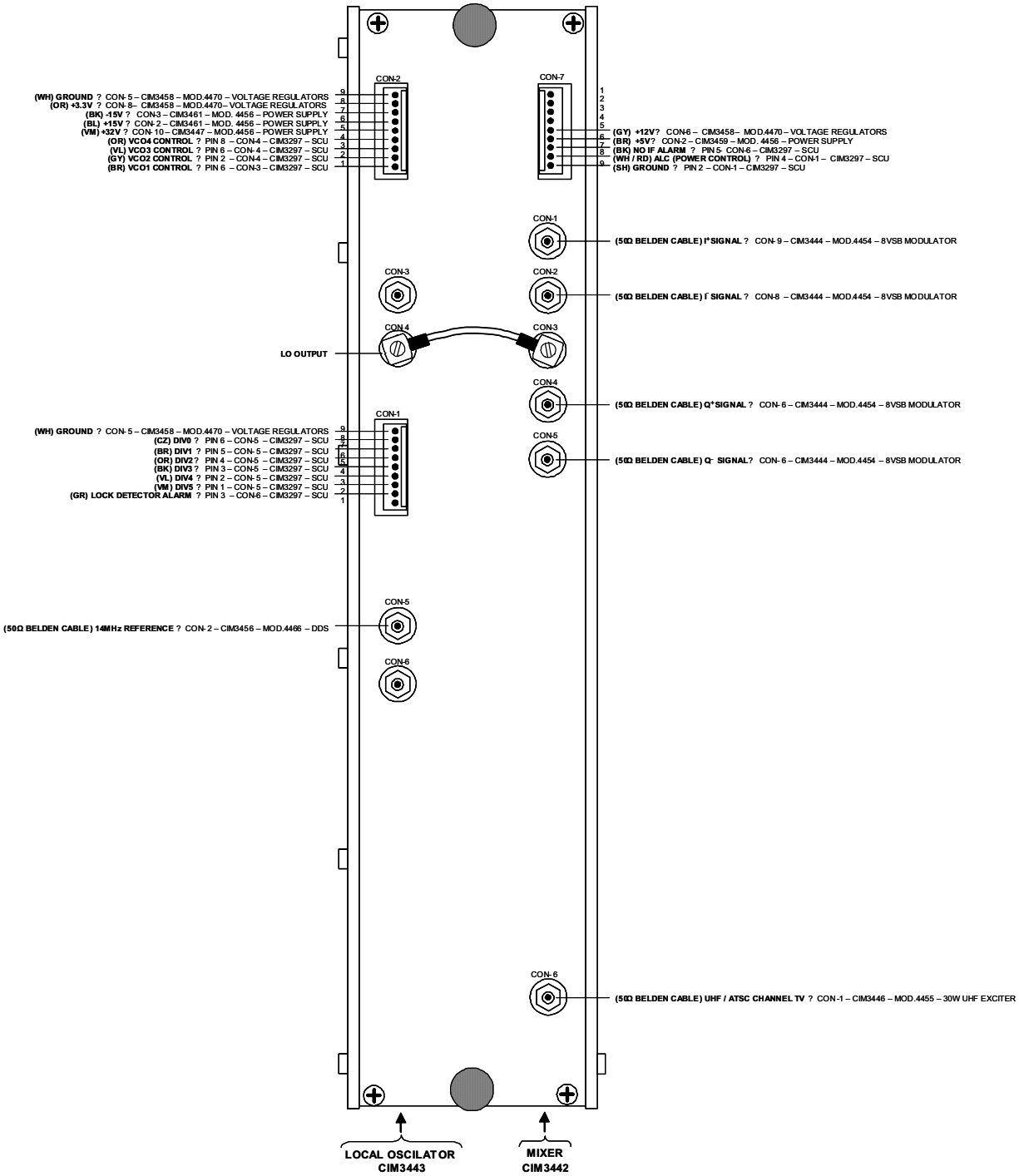
3.1.4. PCB CIM3445 – General Functional Description

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-2. The second one 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 reference signal.
The oscillator signal is delivery via 3 connectors. Two of those are routed to the 8VSB Modulator, PCB CIM3444, and the third one is routed to the DDS circuit, module 4456.

3.2. Module 4453 - UHF ATSC Up-Converter

The Up-Converter module is composed by the mixer circuitry, PCB CIM3442, and a local oscillator, PCB CIM3443.

3.2.1. Module 4453 - External Connections

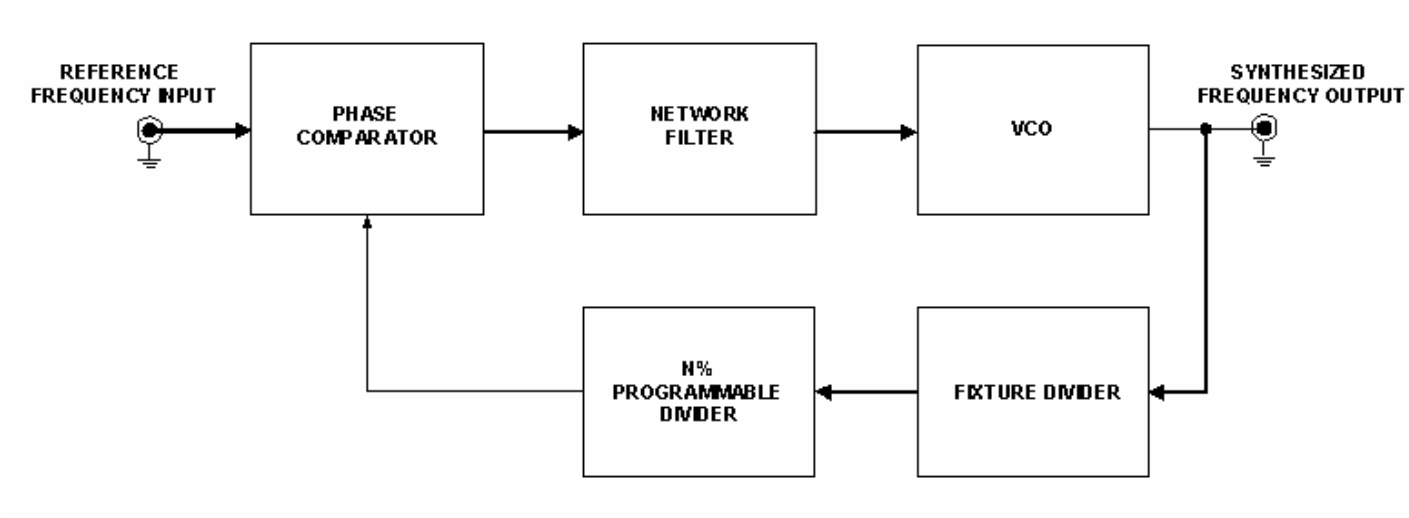


3.2.2. PCB CIM3443 – Local Oscillator

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.

3.2.3. PCB CIM3443 – Local Oscillator – Block Diagram

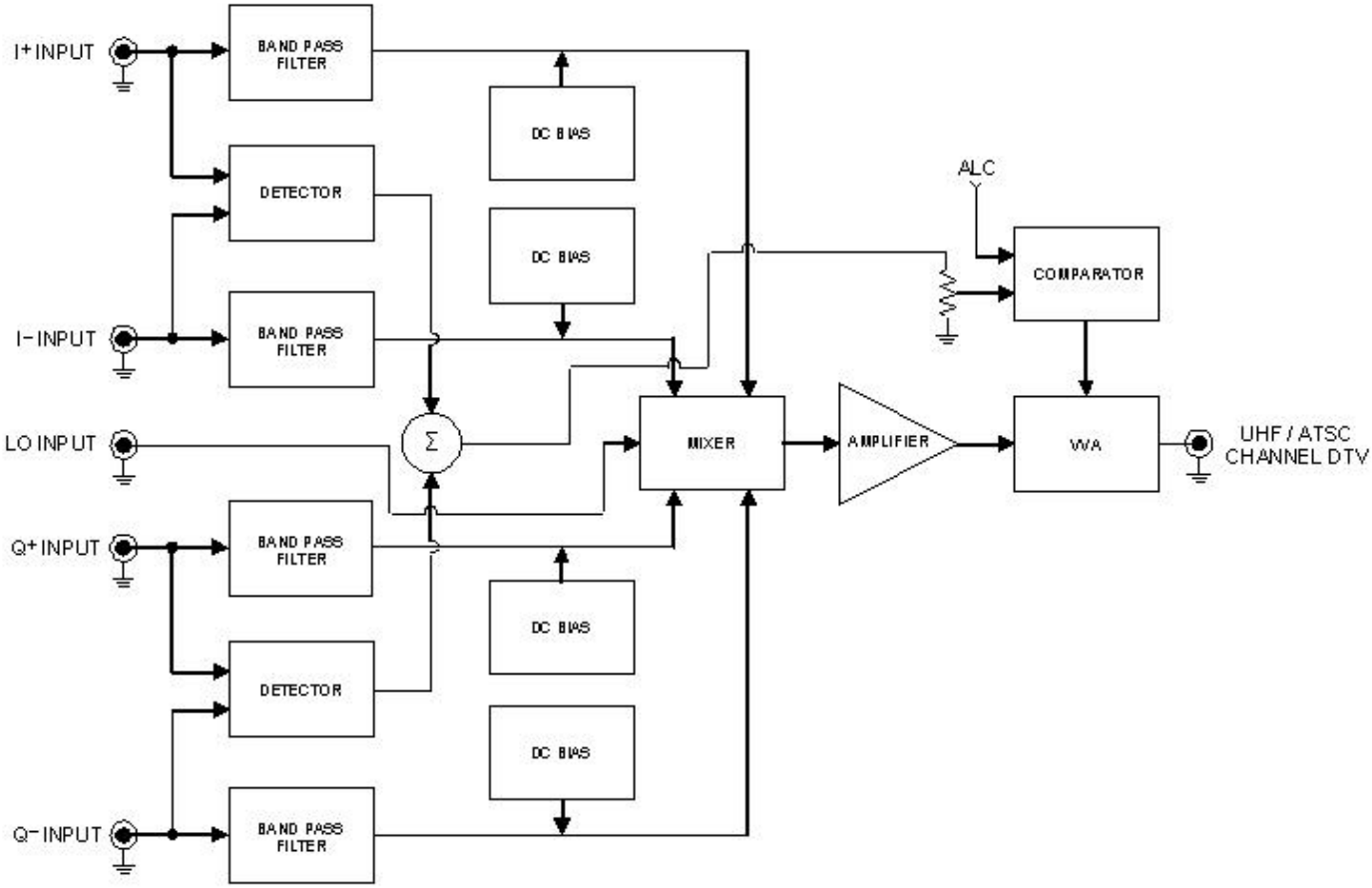


3.3. PCB CIM3442 – UHF Mixer

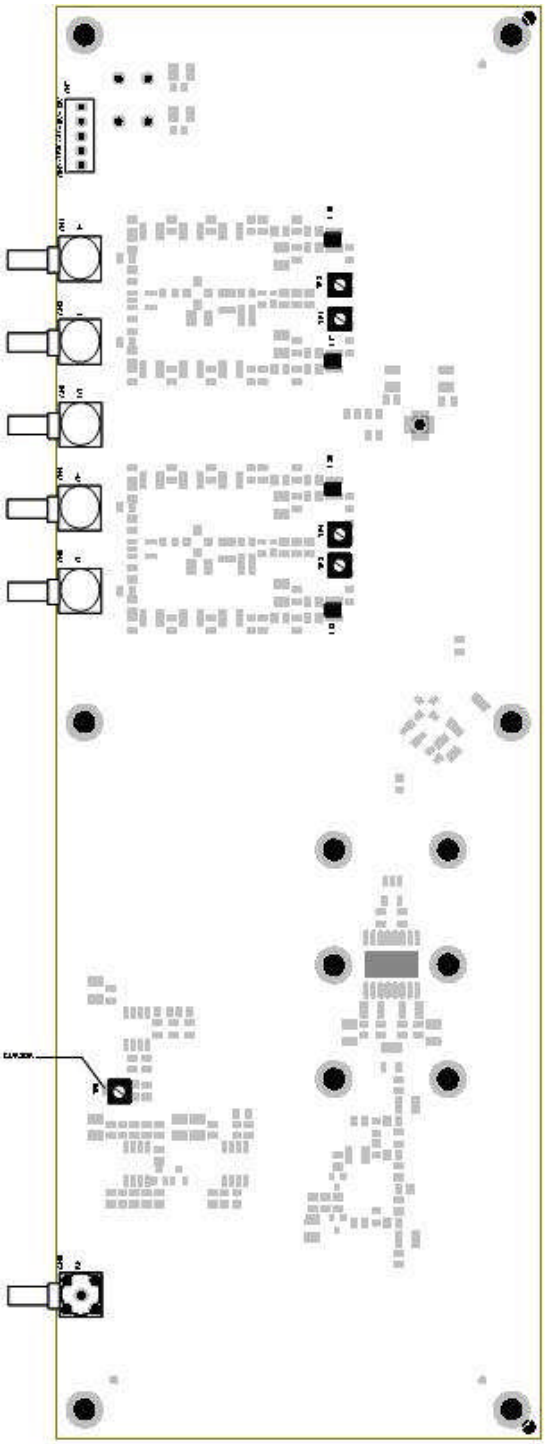
The mixing operation translates the IF modulated signal frequency up to the assigned UHF broadcasting channel, the operation utilizes the complex approach considering the orthogonal pair of signals (I-, I+) and (Q-,Q+) allowing rejection of one side band, and the oscillator itself. The rejection is around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

3.3.1. PCB CIM3442 – UHF Mixer – Block Diagram



3.3.2. PCB CIM3442 – UHF Mixer – Test Points Diagram



3.3.3. 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.

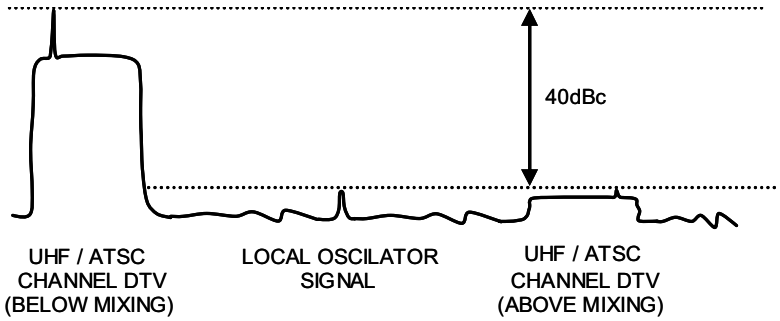


Fig.3.7: Level references for mixer-ALC fine tuning

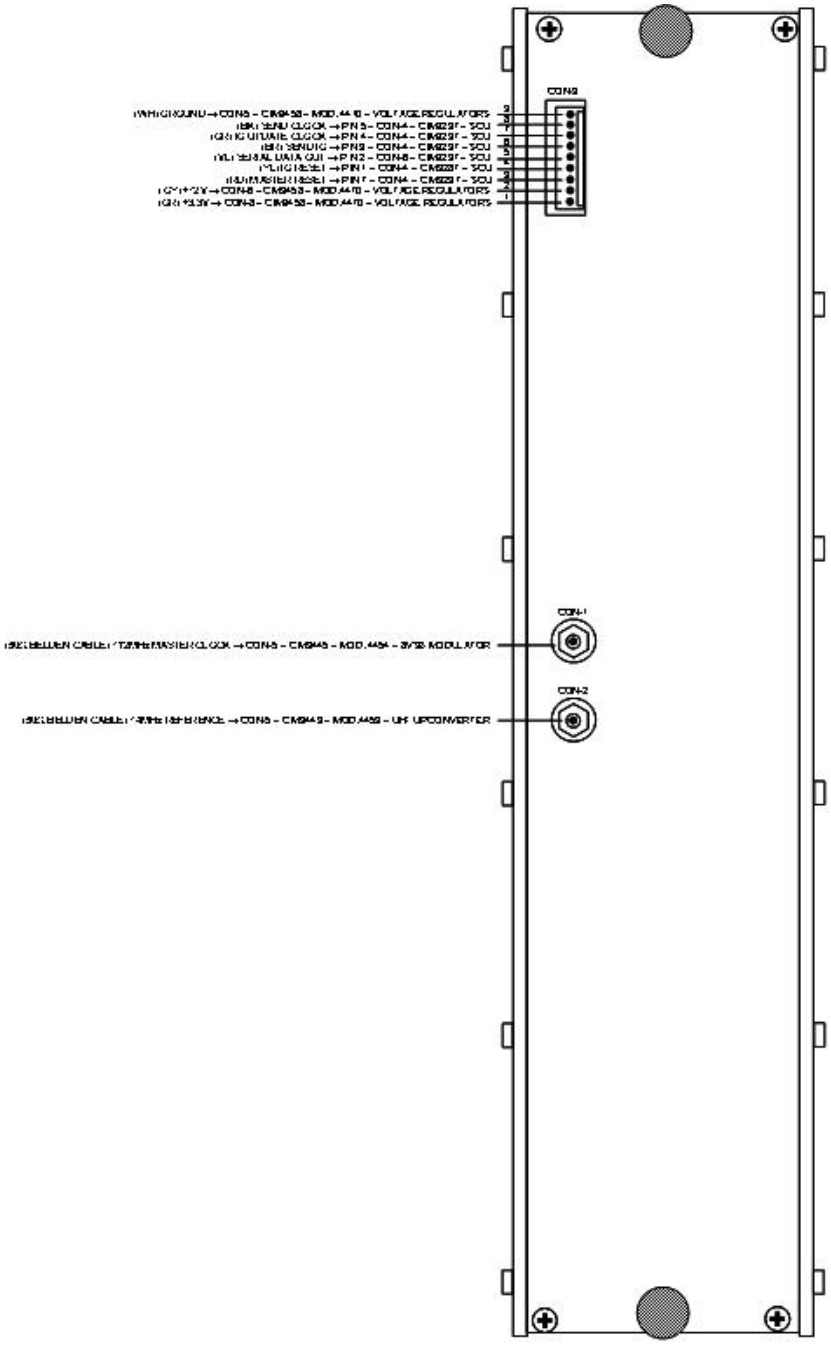
The second adjust detects the protection signal at the center of the band. In absence of 1 out of 4 controls IF signals, this DC level exceed the min threshold and shut down the RF output signal. The DC threshold adjust is performed by TPO-5, and should be set for +2.5V.

3.4. 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.

3.5. Module 4466 – External Connections



3.6. Module 4464 – 20W UHF ATSC Power Amplifier

The RF/UHF signal, already set to the assigned channel, is than power amplified up to 20W. The RF amplifier is type class AB. LDMOS transistors are also used on this amplification stage. Fig.:3.2; illustrates the RF chain of the module 4464.

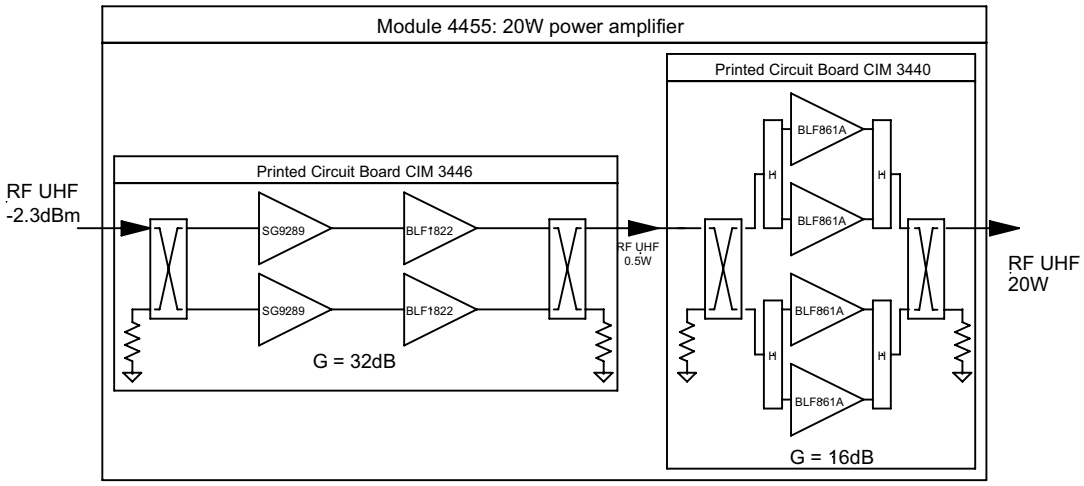
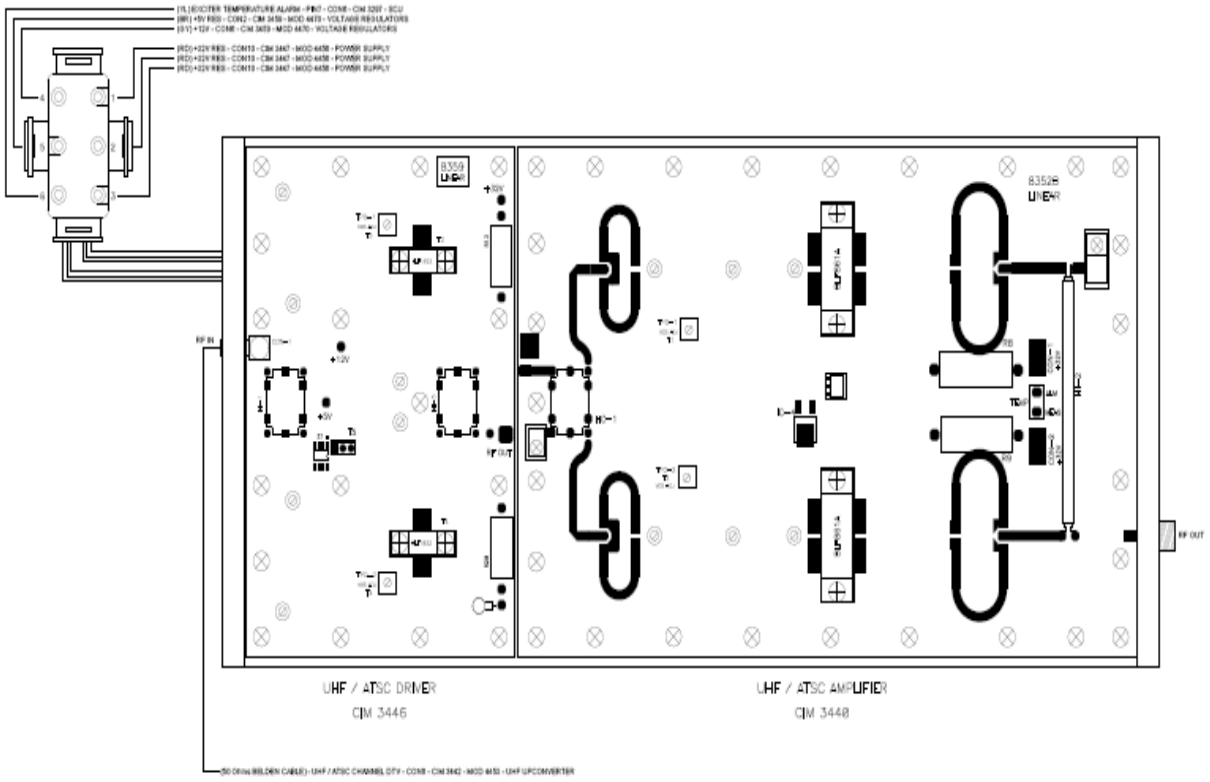


Fig.3.8: UHF 48dB gain RF amplification chain, simplified block diagram

Fig.3.9: Module 20W UHF ATSC power amplifier – module 4464

3.1.3.1 General Functional Description



The PCB CIM 3390 delivers is the output nominal ATSC UHF 20W output power for the module 4455 – intermediate directional coupler. Despite the amplifier being designed as a broadband amplifier, due optimization reasons, the amplifier is built in 4 frequency operational bands, as follows:

- channel 14 to 25 (B1) - channel 26 to 38 (B2) - channel 39 to 53 (B3) - channel 54 to 69 (B4)

Despite the different bands, the PCB remains the same, as indicated on the table below:

20W UHF / ATSC EXCITER - MODULE 4464		
CIRCUIT	**CIM**	**CIP**
DRIVER	3446	8359
FINAL STAGE	3440	8352

Table 3.1: Module- 4464 PCB assembles references.
NOTE: CIM stands for the PCB version, and CIP stands for the bill of material version.

3.9.1. Module 4464 – Technical Specifications

CHARACTERISTIC	SPECIFICATION
SMPTE310M INPUT	
FREQUENCY	470 - 862MHz
IMPEDANCE	75 Ohms
CONNECTOR	BNC FEMALE
RETURN LOSS	³ 22dB
RF OUTPUT	
GAIN	FROM 45 TO 48dB
ATSC AVERAGE POWER	UNTIL 20W
HARMONICS	£ -60dB
SPURIOUS EMISSION	< -54dB
INTERMODULATION	< -52dB
CONECTOR	N FEMALE
GENERAL	
POWER SUPPLY	+32V / +12V / +5V
CONSUMPTION	14A (AB CLASS)

3.9.2. Module 4464 – PCB CIM3446 – 32dB Gain Driver 0.5w Amplifier

The PCB CIM 3446 is the driver amplifier for the 20W final amplifier. This circuit is 2 parallels cells, type class A polarization, 90 degree out of phase, able to delivery up to 1W of power usable for DTV/ATSC standard over the 470MHz – 806MHz UHF band.

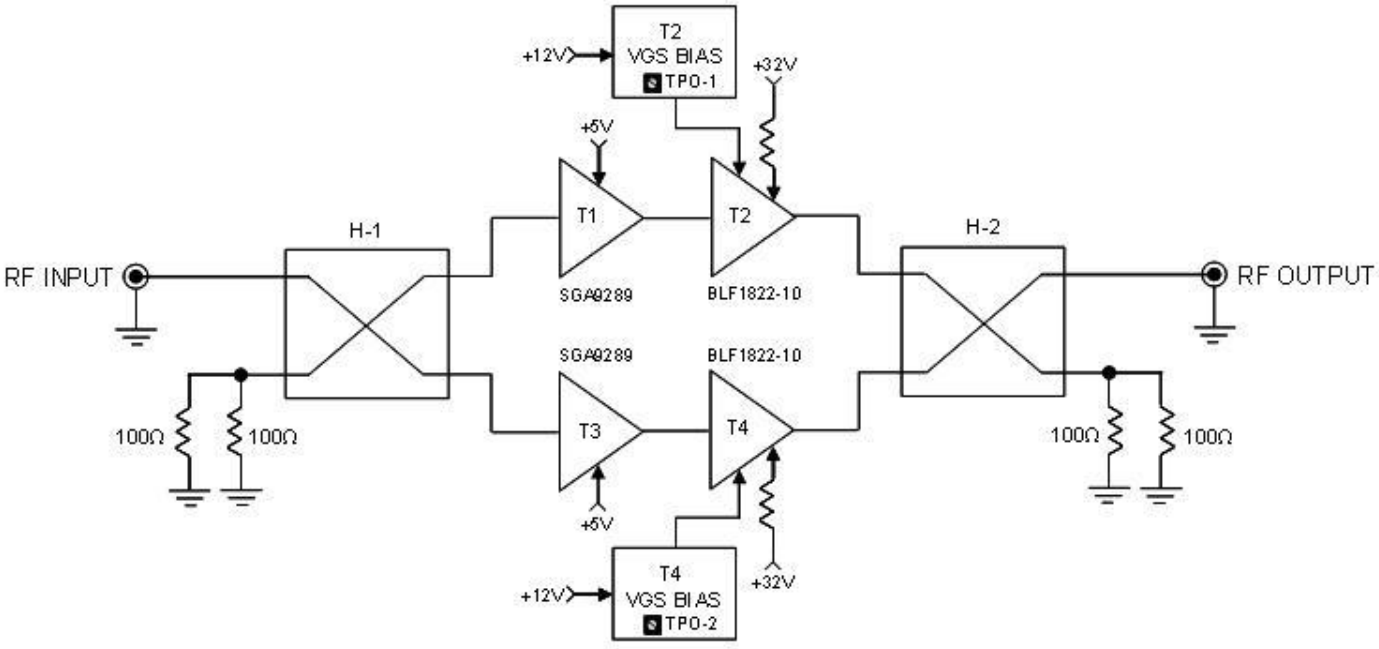


Fig.3.9: Module 4464 – CIM3446 – block diagram

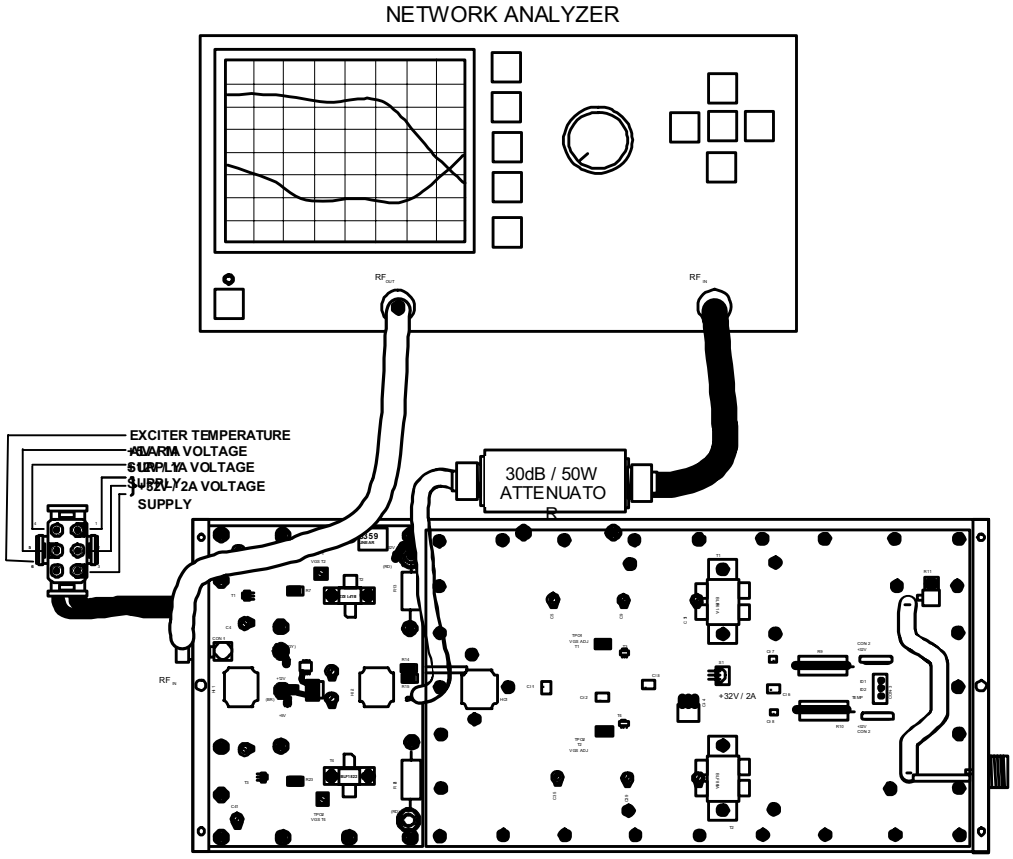
Each amplification cell is composed first by a BJT transistor followed by a LDMOS transistor. The serial connection of these 2 devices delivery 500mW.The parallel combination of these 2 cells via H-2 hybrid, is able than to delivery 1W of RF power.

3.9.3. Module 4464 – CIM 3446 – Technical Specifications

CHARACTERISTIC	SPECIFICATION
INPUT	
FREQUENCY	470 - 862MHz
IMPEDANCE	50 Ohms
CONNECTOR	SMB FEMALE
RETURN LOSS	≥ 22dB
OUTPUT	
GAIN	32dB
ATSC AVERAGE POWER	UNTIL 1W
HARMONICS	≤ -60dB
SPURIOUS EMISSION	< -54dB
INTERMODULATION	< -52dB
CONECTOR	CIP8359
GENERAL	
POWER SUPPLY	+32V / +12V / +5V
CONSUMPTION	+32V / 1,2A ; +5V / 600mA A CLASS

3.9.4. Module 4464 – PCB 3446 – Adjustment Procedures

The PCB CIM3446 can be adjusted either locally, meaning inside of the equipment, (recommended for simplicity) or outside of the equipment. On either situation, one **MUST** always use a 50Ω load connected at the RF output.



MODULE 4464

3.9.4.1 Drain Current, (ID) - Adjust for T2 and T4

No RF signal should be present at the RF input of the module 4464. Turn the module ON and wait for 3 minutes for thermal stabilization of the circuit. Use a good quality multi-meter able to read mVdc, avoid to used auto-range multi-meters.

3.9.4.1.1. Transistor T2

1 – Turn TPO-1's knob all way counter clock wise, no T2-ID will be present.
2 – Connect the multi-meter over the terminals of R13, the T2-drain resistor.
3 – Slowly start to turn TPO-1 knob clock wise up to the point that T2 starts to conduct, meaning few mili-volts will be read at the multi-meter. Continue it up to a 3Vdc reading be shown over R13.

3.9.4.1.2. Transistor T4

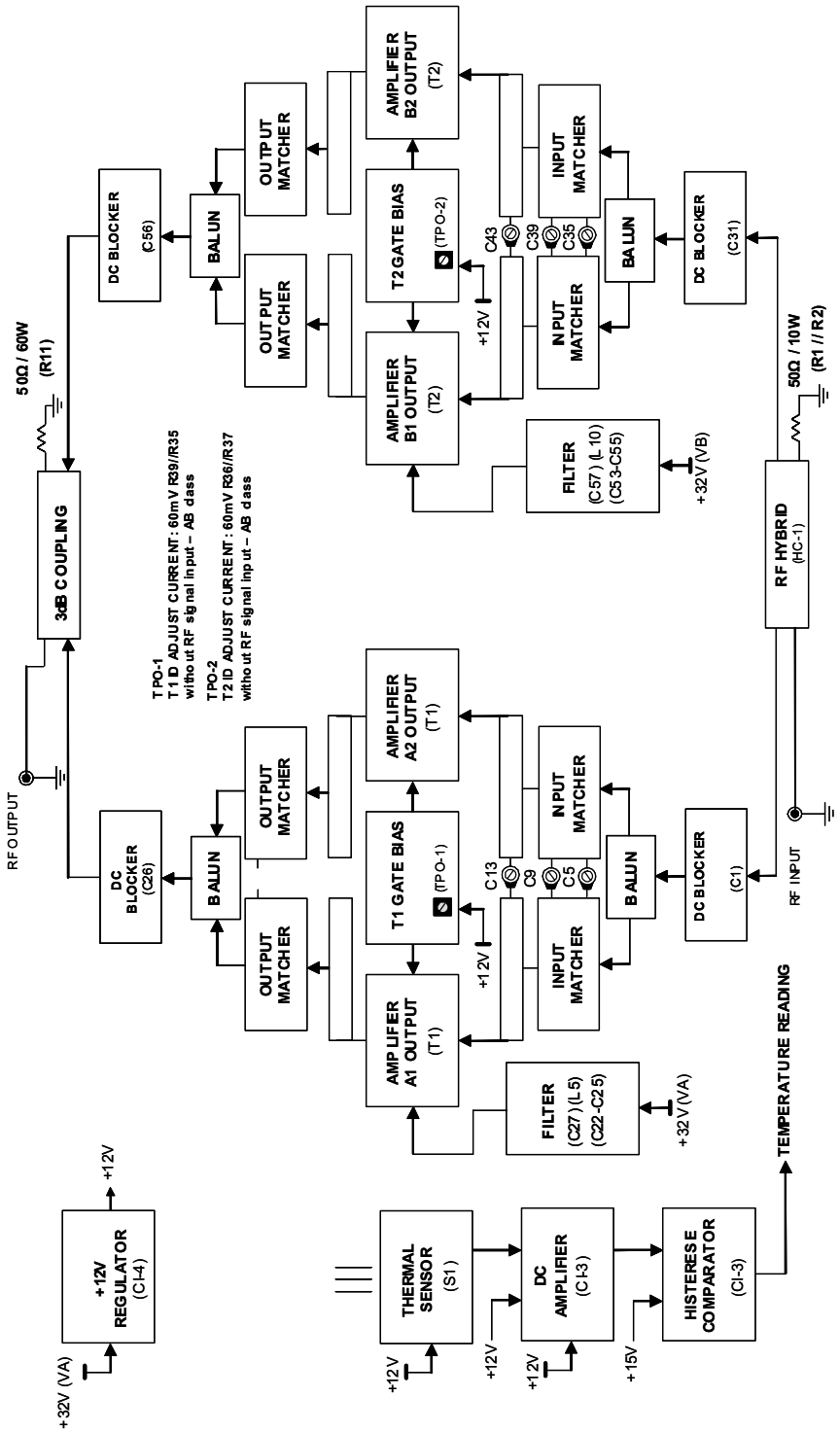
1 – Turn TPO-2's knob all way counter clock wise, no T4-ID will be present.
2 – Connect the multi-meter over the terminals of R28, the T4-drain resistor.
3 – Slowly start to turn TPO-2's knob clock wise up to the point that T4 starts to conduct, meaning few mili-volts will be read at the multi-meter. Continue it up to a 3Vdc reading be shown over R28.

IMPORTANT: The amplifiers at CIM3446 are type class A; the drain currents are independent of the presence, or not of the RF input signal.

3.9.5. Module 4464 – PCB CIM3440 -16dB gain final 20W amplifier

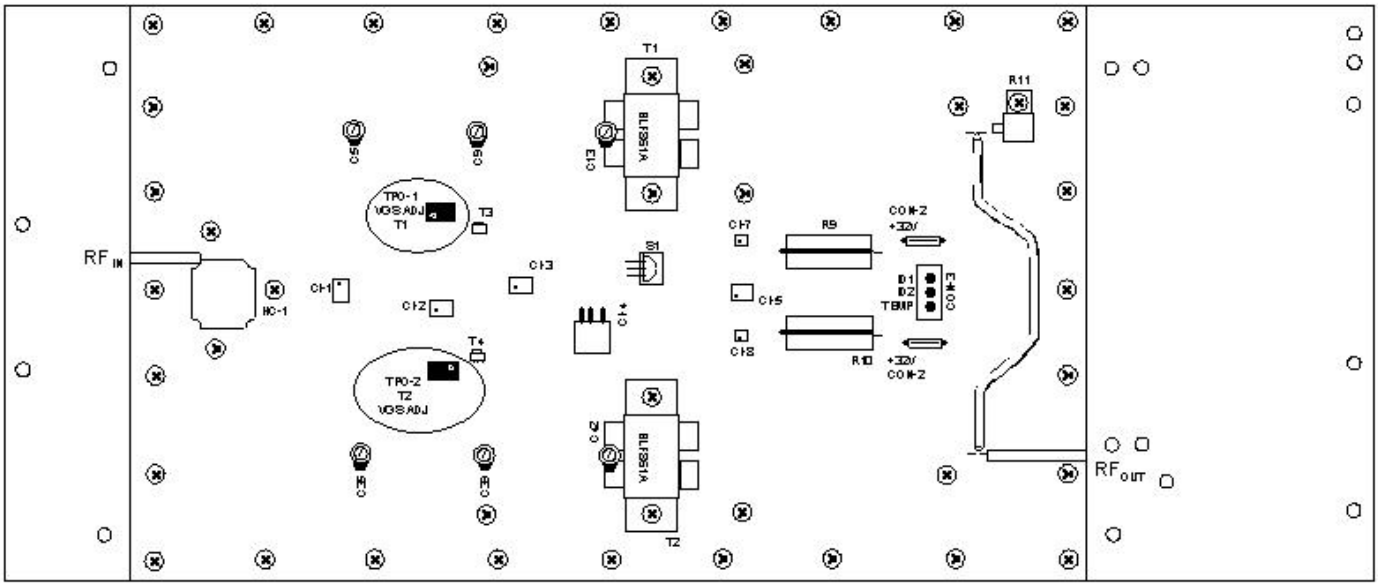
This stage is built with 4 LDMOS transistors distributed in 2 cells of amplification. These 2 cells were designed on push-pull class AB configuration, and than combined. The optimization process by band is also implemented. The same PCB hardware is used for all 4 bands, the CIP8053. The nominal RF output power of each cell is 12.5W, totaling 20W following the output combiner. The overall gain of this stage is between 13dB and 16dB depending on the assigned channel 6MHz UHF band.

According with the Fig. 3.2: block diagram:



3.9.5.1 RF Hybrid Input

This hybrid equally splits the incoming RF signal, keeping the input impedance at 50Ω level on an eventual amplification cell malfunction. This hybrid is built out of 2 coupled transmission lines. In one end of the first transmission line is connected the RF input signal, and on the other end a 50Ω/10W (R1 parallel with R2) resistive termination. On the ends of the second transmission line the coupled RF signal feeds the 2 amplification cells.



TPO-1
T1 ID ADJUST CURRENT: 60mV R39//R35
without RF signal input – AB class
TPO-2
T2 ID ADJUST CURRENT: 60mV R36//R37
without RF signal input – AB class

Fig.3.10: ID current adjust trim-pots location on PCB CIM 3440

3.9.5.2 UHF 12.5W Drive Amplifier – Cell A, Transistor T1

On this cell, the trim-pot TPO-1 at the same time adjusts the VGS1 voltage for T1, and the drained current ID. Trimmers C5, C9 and C13, tunes and adjusts the input impedance. A combination among the trimmers' physical position and transmission lines' length determines the bandwidth behavior. At the input, the capacitor C1 is a input DC de-coupling, and at the output C26 as well.

3.9.5.3 UHF 12.5W Driver Amplifier – Cell B, Transistor 2

On this cell, the trim-pot TPO-3 at the same time adjusts the VGS2 voltage for T2, and the drained current ID. The trimmers C35, C39 and C43, tunes and adjusts the input impedance. A combination among the trimmers' physical position and transmission lines' length determines the bandwidth behavior. At the input, the capacitor C31 is a input DC de-coupling, and at the output C56 as well.

3.9.5.4 Output Combiner

The 12.5W RF signals at the output of cells A and B are combined. The combination circuit is completed with the absorber load, R11 (50Ω/60W). R11 dissipates the extra power in case of failure of one cell, not disturbing the output impedance on the cell that did not fail.

3.9.5.5 Temperature Alarm

The module 4464 is protected against high temperature levels. In case the internal temperature reaches or exceeds 149°F, (65°C). The alarm circuitry is located at PCB CIM3440, and is composed by an thermal sensor S1, by an integrated circuit CI-3. The temperature readings are DC converted and can be measure. This DC voltage is routed directly to the pin #7 at the CON-6 at SCU (PCB CIM3297). If the module temperature exceeds the limits on the module 4464, as consequence, the SCU will send a command to the sub-module 4456 that disrupts the +32V to the module 4464.

3.9.6. Module 4464 – PCB CIM3440 – Technical Specifications

FEATURE	SPECIFICATION
INPUT	
FREQUENCY	470 - 862MHz
IMPEDANCE	50 Ohms
RETURN LOSS	³ 22dB
OUTPUT	
GAIN	13 TO 16dB
RF POWER	UNTIL 20WRMS
HARMONICS	£ -60dB
SPURIOUS EMISSION	< -54dB
INTERMODULATION	< -46dB
IMPEDANCE	50 Ohms
GENERAL	
VOLTAGE SUPPLY	+32V
CONSUMPTION	12A (AB CLASS)

3.9.7. Module 4464 – PCB CIM3440- Adjustment Procedures

Always proceed to adjustment with the CIM3440 terminated by a 50Ω RF load, and make sure that there is no RF signal present at the input of the module during the ID current adjustments.

3.9.7.1 Drain Current ID, Adjustment

Turn the unit ON and wait 3 minutes for thermal stability. Use a good quality multi-meter able to read mVdc, avoid to used auto-range multi-meters.

3.9.7.1.1. Transistor T1

1 - Set the trim-pot TPO-1 all way counterclockwise. On this condition no current flow over the transistor.
2 – Measure the voltage drop over R9. Set the multi-meter for 100mVdc full scale.
3 – Slowly start to turn the TPO-1 trim-pot clockwise up to the point one read 60mVdc over R9.

3.9.7.1.2. Transistor T2

1 – Set the trim-pot TPO-1 all way counterclockwise. On this condition no current flow over the transistor.
2 – Measure the voltage drop over R10. Set the multi-meter for 100mVdc full scale.
3 – Slowly start to turn the TPO-1 trim-pot clockwise up to the point one read 60mVdc over R10.

IMPORTANT: The amplifiers at CIM3440 are type class AB; the drain currents are dependent of the presence, or not of the RF input signal. Higher the RF input signal, higher the ID current will be.

3.9.7.2 Module 4464 – PCB CIM3440 – Curve Response Adjustment

The module 4464 is a broadband UHF amplifier. The curve response is however optimized by band, ch14 to ch25, ch25 to ch38, ch39 to ch53, and ch54 to ch69. The curve response optimization is factory performed and should remain valid even an eventual LDMOS transistor replacement.
The cap trimmers are tuning point for the PCB, they should be tune seeking for best curve/gain response.

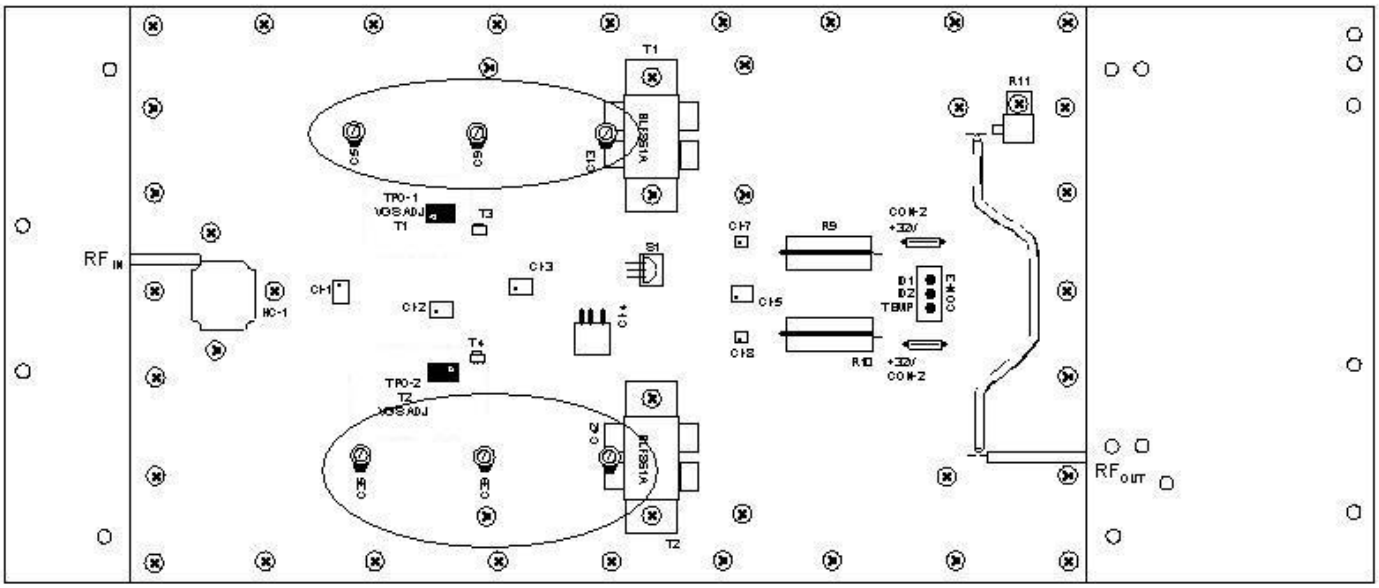


Fig.3.11: Cap trimmers location on PCB CIM 3440

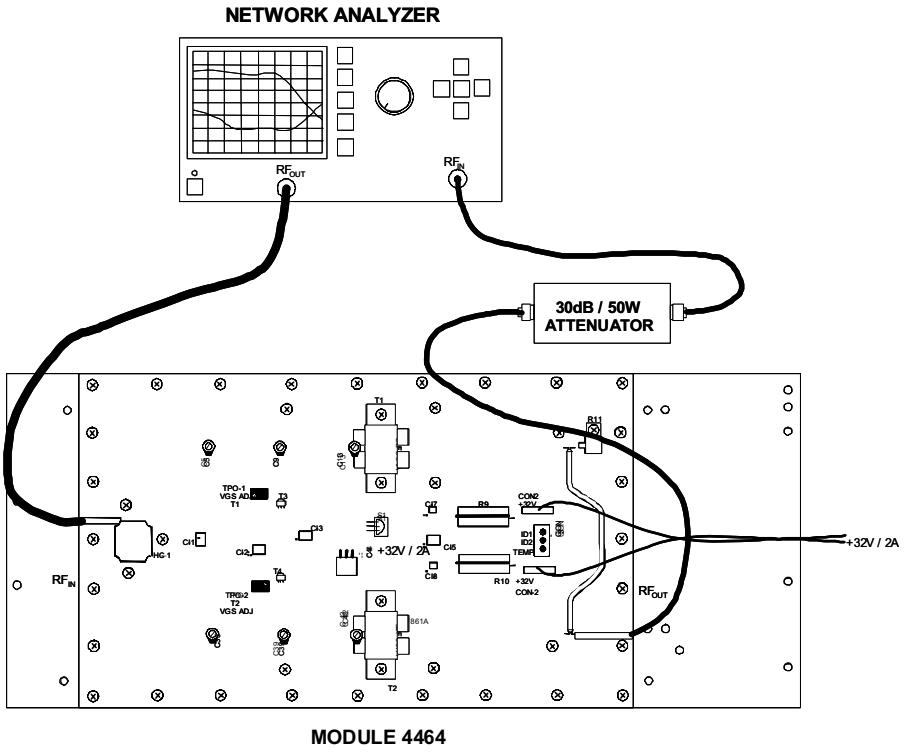


Fig. 3.12: Suggested gain and curve response evaluation for PCB CIM3440

The network analyzer level should be set upfront for -20dBm at the assigned UHF channel band. Monitor the results at the output of the PCB CIM3440. Tune the cap trimmers for best curve response, flat shape inside the band. Watch the gain according with the indication below:

- 16dB – Band 1: ch14 to ch25.
- 15dB – Band 2: ch26 to ch38.
- 15dB – Band 3: ch39 to ch53.
- 14dB – Band 4: ch54 to ch69.

3.10. Module 4456 – 60A Multiple Power Supply

In the ADVANCED TV line all DC power supplies uses a switching technology, type full-bridge powered by 208 up to 240 Vac, showing overall efficiency above 80%. As part of the power supply design, there is a power factor corrector, PFC, circuit. Besides correct the power factor to close to 1, this circuit also contributes to reduce the harmonic content returning from the unit into the AC mains.

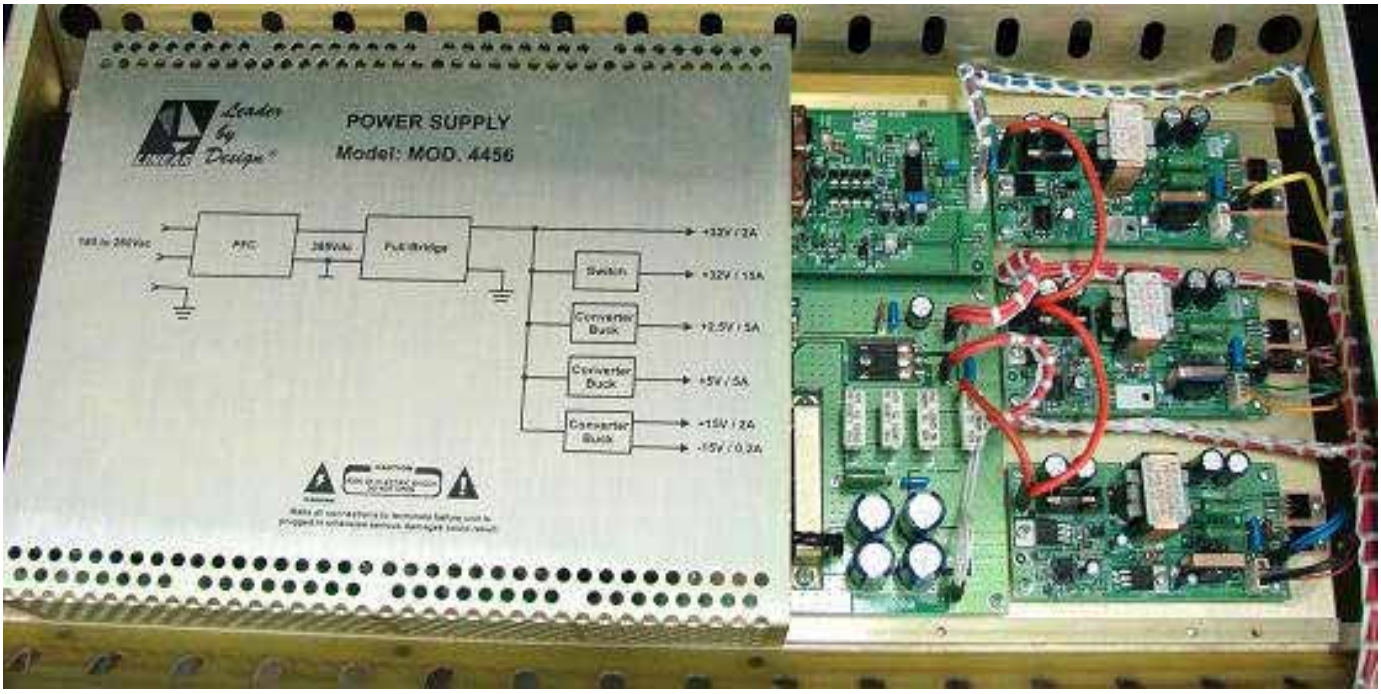


Fig. 3.13: Module 4456 – 60A multiple power supply

The module 4456 generates the following voltage values for this drawer internal use only:

Voltage	Current
+32V Fixed	2A
+32V ON/OFF according to command.	15A
+15V Direct	1A
+15V	2A
-15V	200 mA
+5V	5 A
+2.5V	5 A

Table 2 - Module 4456: Listing of Voltage and current, per each power supply.

The multiple power supply module 4456 is composed by the following PCB's:

POWER SUPPLY - 4456		
CIRCUIT	CIM	CIP
POWER FACTOR CORRECTION (PFC)	3447	8360
FULL BRIDGE		
FULL BRIDGE CONTROL	3429	8339
PFC CONTROL	3427	8337
+2.5V / 5A BUCK CONVERTER	3460	8370
+5V / 5A BUCK CONVERTER	3459	8370
+15V / 2A; -15V / 200mA BUCK CONVERTER	3461	8370

Fig. 3.13: Module 4456 - Circuit functions: electrical schematic diagram, (CIM), and printed circuit board, (CIP).

3.10.1. Module 4456 – Block Diagram