MARK-IV VHF NARROWBAND SIGNAL BOOSTER

OPERATIONS & MAINTENANCE (O&M) MANUAL

REVISION 0
SUBMITTED BY:

CANAM TECHNOLOGY, INC.

May, 2011

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Section A. INTRODUCTION

The MARK-IV VHF Narrowband Signal Booster is a Class A Narrowband Signal Booster to operate within range 151-175 MHz for Land Mobile radio FCC Part 90.

This document is the MARK-IV VHF Narrowband Signal BoosterOperations and Maintenance Manual, intended for the Radio Technical Personnel.

This manual is intended to be used with the MARK-IV VHF Narrowband Signal BoosterEquipment only. It is not to be used with any other equipment unless it is authorized by Canam Technology, Inc.

Canam Technology, Inc provide this document "as is" without any warranty of any kind. Canam Technology may make changes to the equipment, software or specifications in this document at any time without notice to the user. These changes will be notified to the party responsible for FCC compliance and they will be incorporated in future releases of this document.

This document may contain typographical errors and technical inaccuracies. Canam Technology will not accept any liability from the use and misuse of this manual, the information contained within, or the consequences of any actions resulting from the use of this information.

Signal boosters such as the MARK-IV VHF Narrowband Signal Boostergenerate radio signals and, therefore, electromagnetic fields. The technical personnel should have a complete understanding of FCC CFR Title 47 sections 1.1307 and 1.1310. Recommendations are included in this Manual, but they do not substitute the FCC guidelines.

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MARK-IV VHF Narrowband Signal BoosterKey Features:

- Narrowband Class A Signal Booster, per FCC Part 90.
- Maximum Output Power at the antenna port 37 dBm per carrier.
- AGC circuit provides a constant output power, regardless of the input power.

This device may require the use of antennas for proper functioning, depending on the application. The installation of the antennas should be performed by qualified technical personnel. All antennas should be fixed mounted and physically secured to one location **The people must be away from the antennas at least 1.0 meters to comply with the RF Human Maximum Permissible Exposure limits, as long as the antenna system gain is lower than 7 dBi.** If greater gain is used the separation should be increased, please refer to the FCC Rules.

If service should be performed on the antenna, please shut down the transmitter or lower its power in order to comply with the maximum permissible exposure.

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Section B. GLOSSARY

- AC: Alternate Current.
- AGC: Automatic Gain Control, typically used on narrowband channel filters.
- DL: Downlink. Transmission link from the base station to the mobile station.
- DSP: Digital Signal Processing/Processor
- ECM: Embedded Control Module (also named as M4-ECM)
- GUI: Graphical User Interface
- iALC: Input Automatic Level Control (Input broadband limiter).
- MCPA: Multi-Carrier High-Power Amplifier
- PSU: Power Supply Unit
- Relay: Electromechanical switch. The system uses Form-C (SPDT) relays for external alarms
    - COM: Common contact or port
    - NC: Normally-Closed contact or port
    - NO: Normally-Open contact or port
- RF: Radio Frequency
- Rx: Receiver
- SNMP: Simple Network Management Protocol.
- Tx: Transmitter
- UL: Uplink. Transmission link from the mobile station to the base station.

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Section C. SAFETY PRECAUTIONS

Ensure that All Operating and Maintenance Personnel do follow INDUSTRY standard Safety Methods and Precautions. There are system-specific precautions that must be enforced, such as:

- Site Safety Policies
- Equipment Handling and Installation
- AC power feeds and Power Supply Converters
- Multi-Carrier (High) Power Amplifier (MCPA) modules hot surfaces
- RF Exposure

C.1 Equipment Handling and Installation

1. The enclosure has a weight of 40 kg approximately.

C.2 Power Supplies

1. When servicing the internal Power Supply and wiring unit, be aware that power lines are in screw terminal blocks.

2. ***CAUTION:*** Removal and Installation requires that the main power switch be in the OFF position, and the power cord be disconnected from the enclosure.

C.3 MCPA Modules

1. Internal MCPA modules are mounted to their corresponding heat sinks and are used to dissipate DC power. Both the Heat Sink and the MCPA module **MAY** be hot.

C.4 RF Exposure

The RF Field Strengths that an individual will be exposed to while doing maintenance is well below the limits set forth by the FCC & State Laws.

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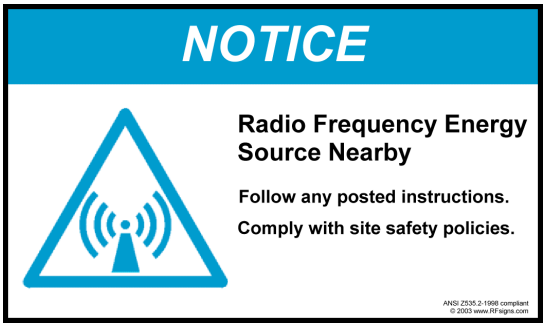
Nevertheless, there are Safety Precautions that should be adhered when performing any RF Tests:

1. Never Operate a Transmitter, or Booster Amplifier without adequate Load/Termination on the Output Port.

2. Ensure all Connections are tight and secured.

3. Ensure all Coaxial Cable Insulation covers the Outer Shield of the cable.

4. Do Not Touch Exposed System Ports or Coaxial Cable if system is Transmitting.



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Section D. THEORY OF OPERATION

D.1 Description

The MARK-IV VHF Narrowband Signal Boosteris a stand-alone bi-directional & multi-channel Signal Conditioner that performs on-channel processing (narrowband filtering, automatic gain control and output level control) on the received signals and provides a composite equalized multi-channel signal suitable to drive its internal high-power amplifiers that feed the RF Tx Output signals.

The core Digital Signals Processor (DSP) board uses state-of-art reconfigurable logic to perform digital signal processing (channelization) thanks to its high-speed parallel hardware, high speed/performance Analog-to-Digital Converters (ADCs) and Digital-to-Analog Converters (DACs) to interface with the analog (Radio Frequency) world. Advanced digital filtering techniques deliver low group delay and excellent phase linearity to support current analog transmissions as well as new digital encoding systems.

High-linearity/low-noise analog interface hardware provides pass-band filtering and gain stages to perform proper signal conditioning to interface with the DSP digital core sub-system.

Discrete Digital I/O alarms are available for external monitoring.

A built-in Web Server provides a Graphical User Interface (GUI) to ease in remote monitoring & control. Access is obtained via a PC's Web Browser and a TCP/IP connection to the Unit.

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D.2 Functional Block Diagram

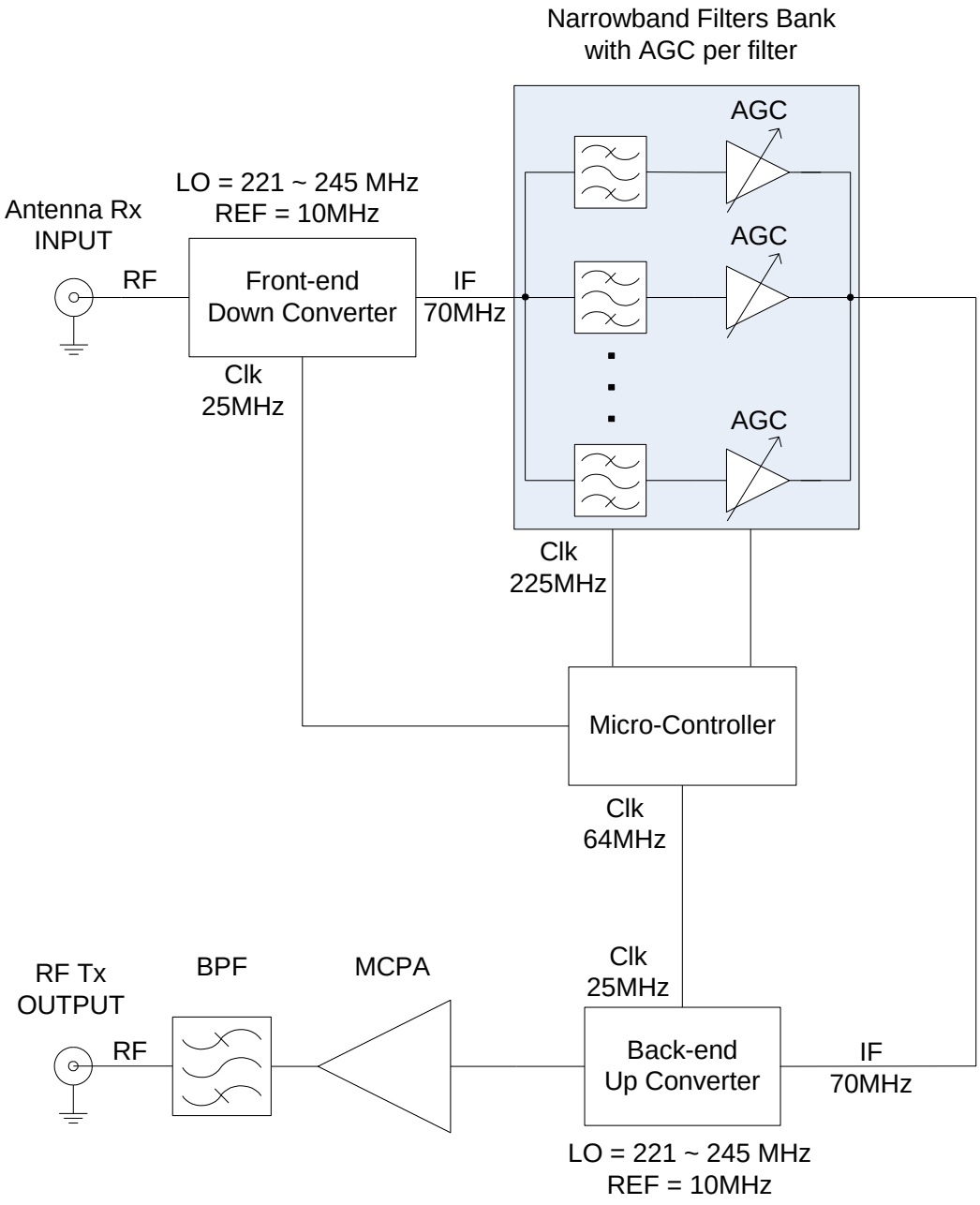

Figure 1 – MARK-IV VHF Narrowband Signal BoosterGeneral Block Diagram

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D.3 Features

- VHF Digital Channelized Unidirectional Amplifier system.
- State-of-the-art Multi-channel digital processing system for on-frequency repeater applications (coverage extension, in-tunnel/in-building, etc).
- Preserves the frequency stability, audio fidelity and data content of the original over-the-air signal with minimum degradation
- 120 dB Gain per filter-window, maximum
- Individual Automatic Gain Control (AGC) per filter ensures effective recuperation of weak signals from far-end or worst case situations users, despite other strong simultaneous signals on-scene. AGC delivers constant output power level per channel regardless of their input level variations.
- High Input Sensitivity (<= -105 dBm) with programmable Individual Rx Threshold level (Squelch) per filter-window.
- Software-Defined Radio System architecture.
- Fully software programmable channel frequencies, monitoring and control settings & status indicators.
- High-linearity/ low-noise analog processing blocks.
- Embedded microcontroller for control and self-monitoring functions.
- Remote control via web-server.
- Discrete Digital I/O alarm signals available,
    - Opto-coupler inputs and relay contact outputs
- AC powered

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D.4 Specifications

• Parameter	Spec
Frequency range	151-175 MHz.
Duty Cycle	Continuous
Minimum Sensitivity for greater than 20 dB output SINAD (DAQ 3.4)	<-105 dBm
Group Delay Variation (GDV) flatness (std. deviation) over 50% bandwidth	5µsec.
Filters Bandwidth	24kHz
Analog FM Modulation Distortion & Digital Modulations B.E.R.	≤ 3%
System net gain per filter window	120 dB max.
Automatic Gain Control (AGC) range, on a per filter-window basis	50 dB
Constant Output level regardless of input level variations, per filter	+/- 2 dB
Broadband Input Automatic Level Control (iALC) range to prevent front-end undesired saturation	30dB
Broadband input power attenuator adjustment range	30dB
Maximum input power (composite) for no-damage	-30 dBm
Input (Rx) IM Rejection	>60 dB
System OIP3	>+58dBm
Output Multi-Carrier Power Amplifier (MCPA) capacity	>43 dBm (25 W)
FCC Certified maximum output power per carrier	37 dBm (5 W)
Composite output power level adjustment range	>20 dB
Output power level adjustment resolution	1 dB steps
Maximum output power per carrier to comply with out-of-channel spurious emission limit (two-tone CW test) FCC Mask B for 25 kHz spacing= -13 dBm FCC Mask D for 12.5 kHz spacing= -20 dBm (mandatory for all services beginning on Jan 2013)	 +31 dBm/carrier +28 dBm/carrier
RF Input & Output impedance (typ) Built-in output circulators for infinite mismatch open load protection.	1.5:1 VSWR
Digital Modulations Support: Seamless performance with all signaling and Trunked Radio Systems, such as P25, iDEN, Motorola MCD-1200, among others. No headers are lost.	Seamless
Major Software Defined Field-Programmable settings and readings	
Filters central frequency (Fo)	in 3.125 KHz steps
Input (Rx) Threshold level	per filter window
Output power AGC set-point level	per filter window
Receive Signal Strength Indicator level – RSSI	per filter window
Output ALC set-point and Composite output power	

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• Parameter	Spec
CTCSS code select	
Enable/disable CTCSS code detection	
Adjustment of RF Power Output level	
Input attenuator and input ALC set-point	
Save & Load system settings, personality	
Interface and Alarms	
Human-Machine-Interface	LCD display with 7-button keypad LED Indicators
Computer Interface	Embedded Web-server support over TCP/IP network.
Internal Sensors, overall system	Temperature, DC Voltage & Current, Output RF Forward & Reverse, Input and Output RF Limiters
Summary Discrete I/O	4) Form-C Relays, dry-contacts 4) Opto-isolated inputs

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D.5 FRONT AND REAR PANEL PORTS AND INTERFACES

Figure 2 shows the system front panel. A brief explanation is given in Table 1.

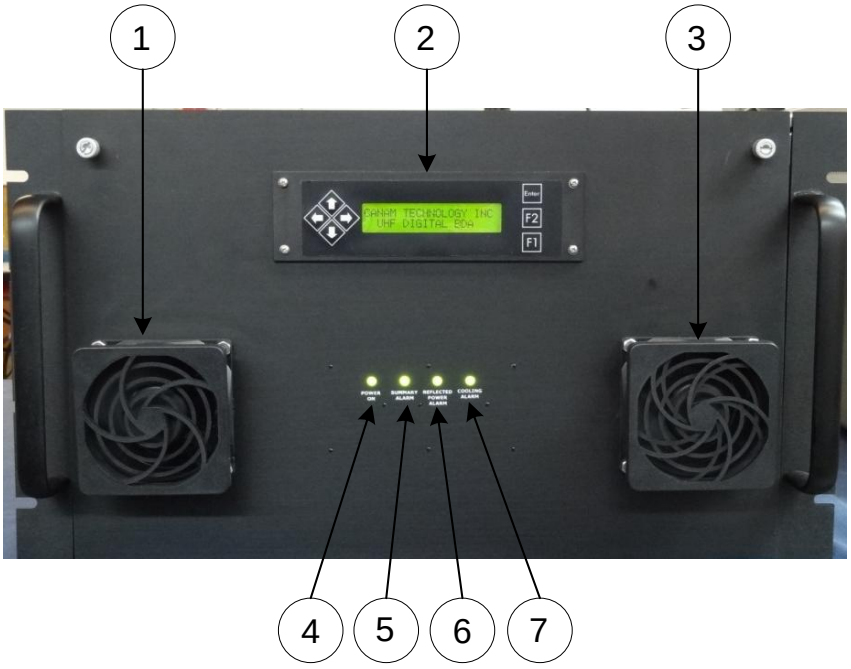

Figure 2 – System Front-Panel

Table 1 – Front Panel details

Item	Description
1	Intake fan 1
2	LCD Display/Keypad
3	Intake fan 2
4	Power ON LED (Green = ok, Red = bad)
5	Summary Alarm LED (Green = ok, Red = bad)
6	Reflected Power Alarm LED (Green = ok, Red = bad)
7	Cooling Alarm LED (Green = ok, Red = bad)

Figure 3 shows the system rear panel. A brief explanation of each connector is given in Table 2.

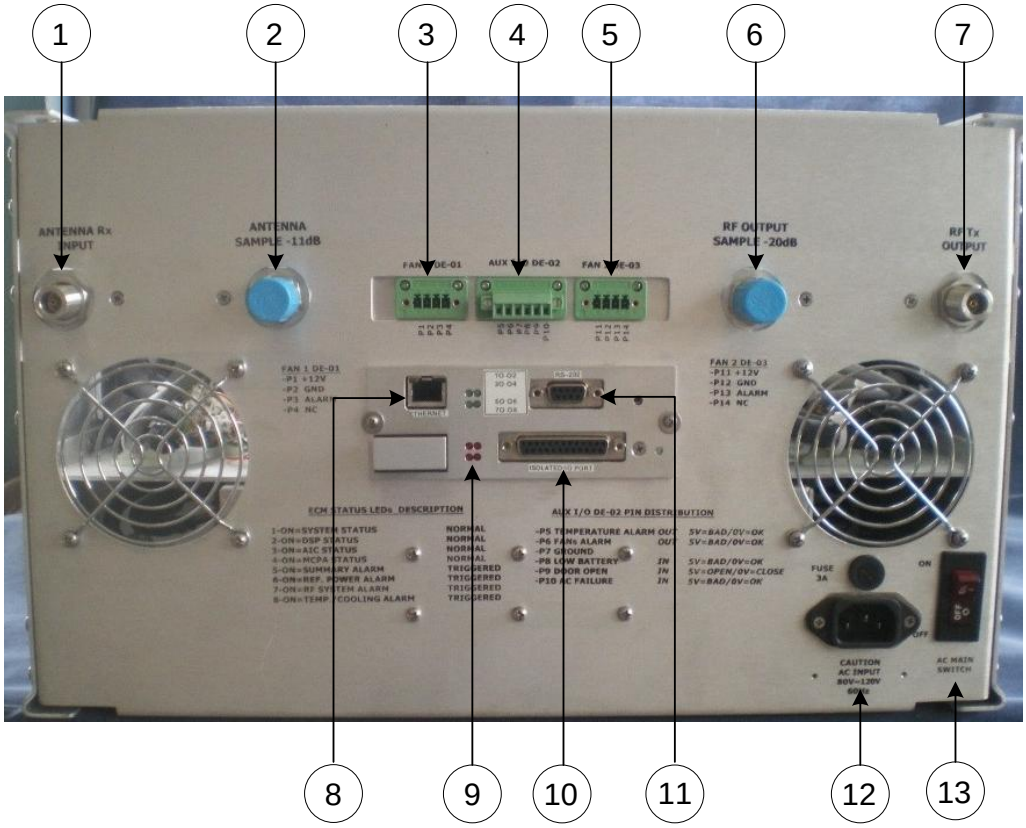

Figure 3 - Rear Panel details.

Table 2 – Rear Panel details.

Item	Description
1	Antenna Rx Input
2	NOT USED
3	NOT USED
4	AUX Digital I/O Connector De-02
5	Not Used
6	Not Used
7	RF Tx Input
8	LAN Ethernet Data Port
9	LED Indicators
10	Discrete Digital I/O DB25 Connector
11	RS-232 Serial Port (Factory Debug)
12	AC Input Receptacle
13	AC Mains On/Off Switch

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D.6 LCD-Display & Keypad assembly

The LCD Display/keypad assembly allows the user/technician to read system information.

Figure 4 – LCD and Keypad Interface

To view the System Network Information scroll down. If the user wishes to go back to the main screen, use the Left arrow Key.

The "+" (plus) sign indicates when more screens are available. If a plus sign is located in the upper right corner, use the Up Key to show the previous screen. If a plus sign appears in the lower right corner (as in Figure 4), then press the Down key in order to see the next screen.

Table 3 – Network Settings available at the Front Panel LCD

Parameters	***Possible values***	***Remarks***
Model Name	---	System Model Name
Serial Number	---	System Serial Number
Filter Model	---	Depends on firmware
IP ADDRESS	---	System IP ADDRESS
SUBNET MASK	---	System Subnet Mask
DEFAULT GATEWAY	---	System Default Gateway

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Section E. INITIAL CONFIGURATION

Canam Technology's Equipment is factory configured. All setup and wiring is performed by Canam's Personnel. There is no need to disconnect the equipment unless the units should be serviced.

If any module should be disconnected, it should only be done by qualified technical personnel.

The unit operates stand-alone and only requires initial configuration, by means of the Web Server Interface (over its LAN Ethernet interface).

The following guidelines provide information on how to get started with the unit.

- Make sure the power switch is **OFF**, and plug the AC power cord into the IEC inlet receptacle.
- Provide a connection from the off-air antenna interface to Antenna Rx Input.
- Provide a connection from the in-tunnel (in-building) antenna point-of-interface to the RF Tx Output.
- The dry-contact alarms are available on a pluggable mini-terminal block on the shelf's rear panel DB-25 connector.
- Additional I/O signals are available on a 6-contacts pluggable terminal block.
- The technician's computer shall be networked with the device, by means of an Ethernet switch/hub or a direct PC-to-device connection using a crossover cable. The computer shall have a Mozilla's Firefox web-browser software installed, or similar.
- Provide a network connection to the system, directly into the ECM LAN port.
    - Use an Ethernet crossover cable for direct connection to a PC computer LAN port.
    - Use a standard straight-thru cord when using a network switch/hub connection

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Once the physical connection has been established, power-on the device. Wait a 2 minutes period for the embedded management software to load-up.

After the load up is completed, the device's LCD display will look like this once:

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VHF DIGITAL BDA

Now the device is ready for management functions using the web-browser on the PC computer.

E.1 General guidelines regarding RF connections & operations with test instruments

- ✓ Mute the MCPA prior to connect a signal source to Antenna Rx Input.
- ✓ Avoid excessive input power.
  - Do not drive the input signal above -30 dBm, which is the recommended maximum input level (composite).
- ✓ Make sure your RF Test Instrument (Communications Monitor, Spectrum Analyzer, etc) has an input port rated for high RF power.
  - Do not exceed the test-instrument's input rating.
- ✓ The system has been limited to a maximum gain of 120 dB. A -100 dBm sensitivity will limit to +20dBm maximum output, and so on. For example, to set one channel to +27 dBm desired output, the user may choose to set the RX Threshold to -90 dBm (or -93 dBm minimum)

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E.2 Antenna Installation

The Input and Output antennas are not included with this equipment. Nevertheless, if this device is used in an application that requires direct connection to an antenna, Canam Technology recommends following the FCC guidelines for its installation:

- Antenna Installation should be performed by qualified technical personnel.
- The installations instructions are for the purpose of complying with FCC RF Exposure and are not optional.
- All antennas should be fixed mounted and physically secured to one location.
- Non-building mounted antennas must be greater than 10 meters above ground.
- Minimum Separation to any body part of any person is 25cm.

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Section F. WEB-SERVER GRAPHICAL USER INTERFACE

F.1 First-Time Start Configuration

The system can be connected directly to PC computer using an Ethernet crossover cable or to LAN using a standard straight-thru cord when using a network switch/hub connection

Before to access system built-in Web Server verify your web browser is working with java script enabled.

These are some web links showing HOW-TO enable java script.

http://support.mozilla.com/en-S/kb/Javascript#Enabling_and_disabling_JavaScript
http://support.microsoft.com/kb/154036
http://www.google.com/support/chrome/bin/answer.py?answer=114662

F.1.1 Connecting System directly to PC computer

Use an Ethernet crossover cable for direct connection to a PC computer LAN port.

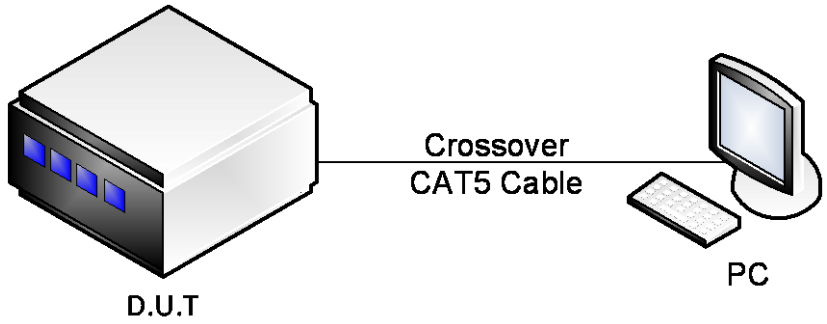

Figure 5 – System connected directly to PC computer.

- Connect the system to PC computer directly into the ECM LAN port.
- The IP address of the equipment is shown in the LCD display. By default it is 192.168.100.87 with Network Mask = 255.255.255.0.

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- To verify IP address press the Down key in LCD Display and Keypad assembly until get IP ADDRESS value.

- Configure the local computer IP address to allow access to the controller, within the same sub-net.

Windows XP

1. Go to **"Start >> Control Panel >>Network Settings"**.
2. Right-Click on the **"Local Area Connection"** and choose **"Properties".**

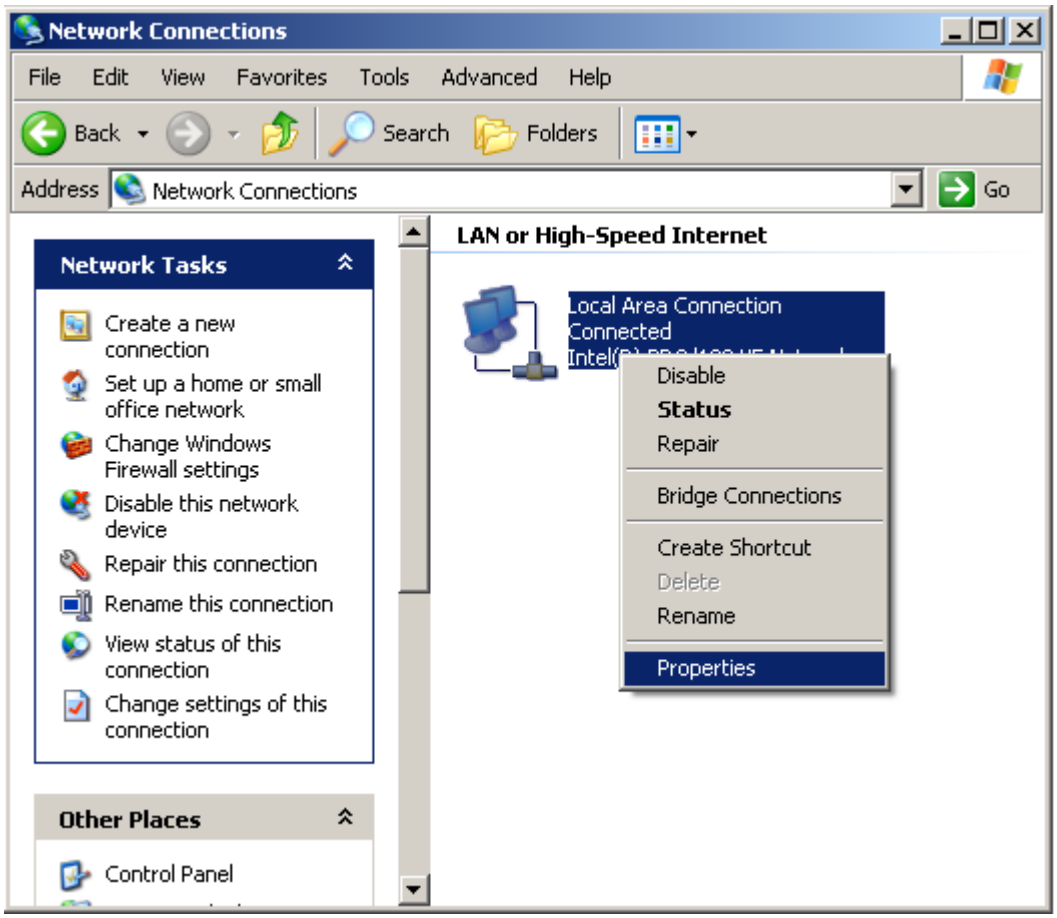

Figure 6 – Menu options for Local Area Connection.

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3. Look for **"Internet Protocol"** and click **"Properties".**

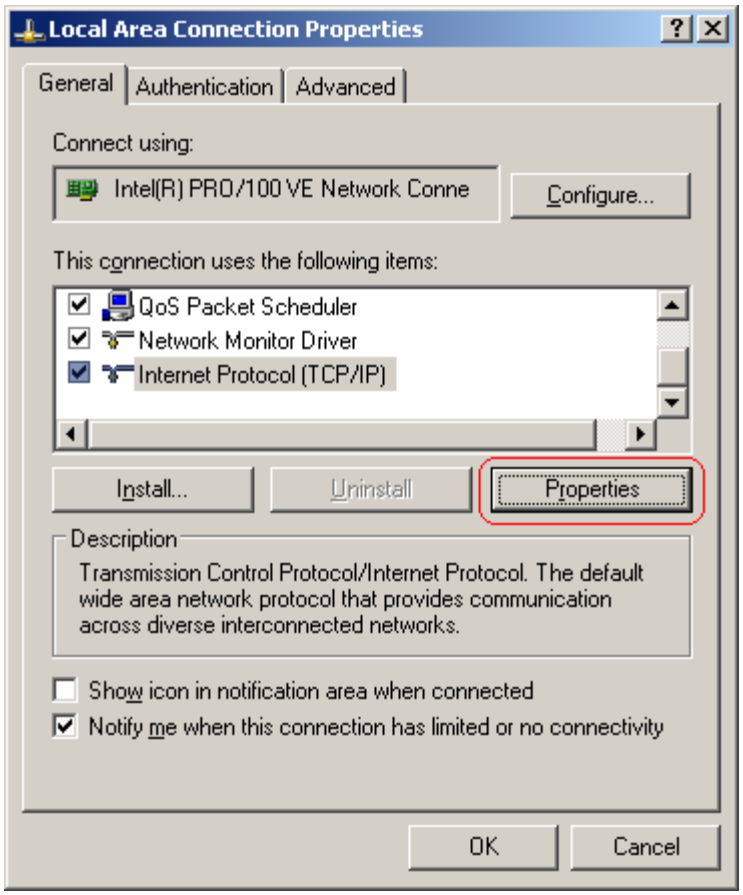

Figure 7 –Local Area Connection Properties.

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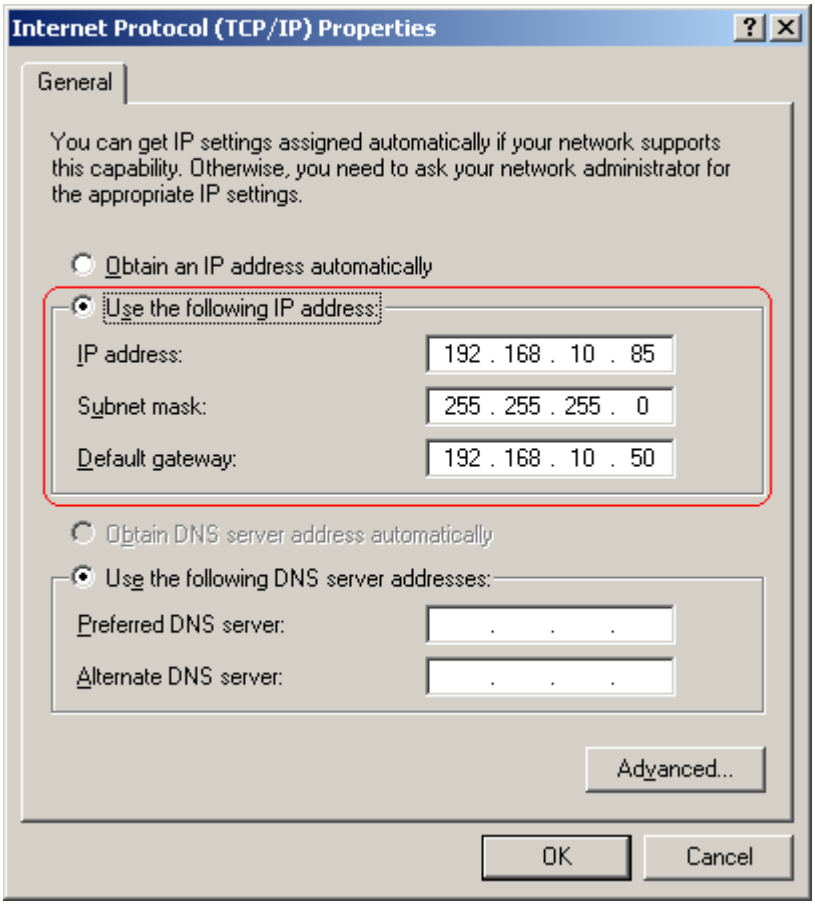

Figure 8 – Internet Protocol (TCP/IP) Properties.

4. Select "Use the following IP Address".
   - Configure PC computer IP address as 192.168.100.X (X is a value between 0-255) with Network Mask = 255.255.255.0.
   - Default gateway can be same value as IP address.

5. For the option "Use the following DNS server addresses" leave blank.

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Windows 7

1. Go to **"Start >> Control Panel >>Network and Internet"**.
2. Left-click on **"View network status and tasks".**
3. In **"Network and Sharing Center"**, right click on **"Local Area Connection"** and go to **"Properties**".

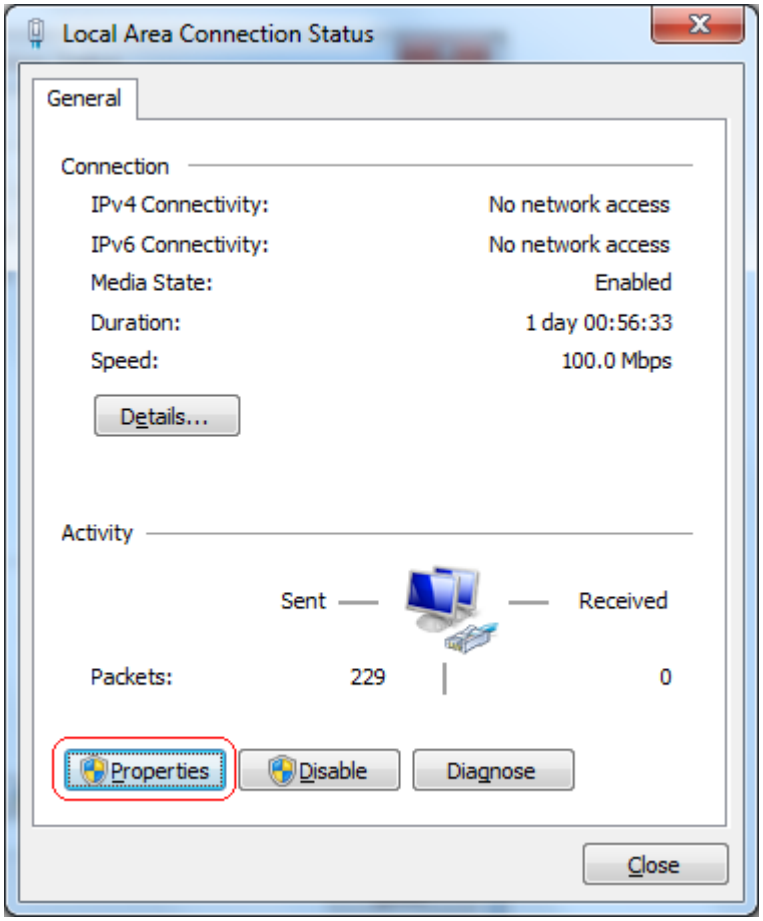

Figure 9 –Local Area Connection Status.

4. Look for **"Internet Protocol Version 4 (TCP/IPv4)"** and click **"Properties".**

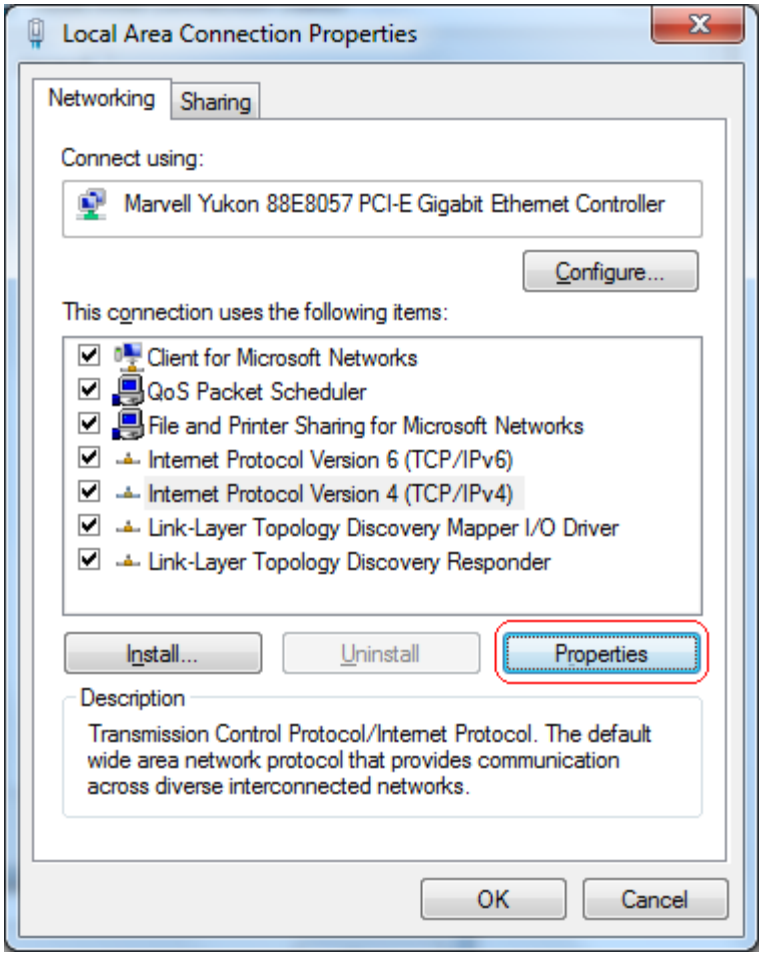

Figure 10 –Local Area Connection Properties.

5. Follows steps 4 and 5 as for Windows XP.

- Open a web browser and access the equipment by typing, in the address bar, the IP address of the equipment (ex.: http://192.168.100.87).
    - Login with username = operator, password = operator.

F.1.2 Connecting System to local area network

Use standard straight-thru cable for network switch/hub connection.

To connect system to LAN, it is necessary to know the subnet the PC computer is currently plugged into.

If no network is available the user shall remain using the crossover interconnection

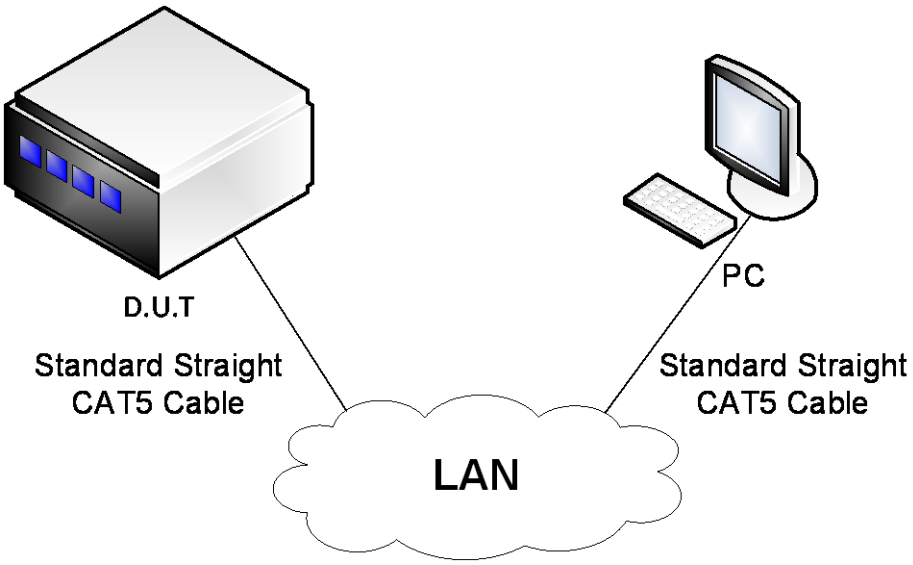

Figure 11 – System connected into local area network.

- Configure System IP address avoiding conflict with other devices IP addresses.

    - First, it is necessary use procedure in previous section F.1.1.
    - Open a web browser and access the equipment by typing, in the address bar, the IP address of the equipment.

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- Login with username = admin, password = admin.

- Go to the "Network Settings" page (see left-side menu) to change the current settings to be assigned by the network administrator.

  - IP Address, Network Mask, Gateway Address.
  - The controller requires a fixed address; it does not allow DHCP settings.
  - Enter or press "Apply" button to apply the new parameters, and then restart the system.
  - Now the system controller can be plugged into the local area network served by your LAN Switch or Router.

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F.2 Web Server Operations

The built-in Web Server provides a Graphical User Interface (GUI) to ease in remote monitoring & control. Some pages shown by the Web Server are the following:

- "Main Status": depicts status alarm indicators and meters.
- "Main Settings": is used to configure system-level macro settings.
- "Filter Settings" contains the settings that can be configured for each filter window.

F.2.1 Main Status Page

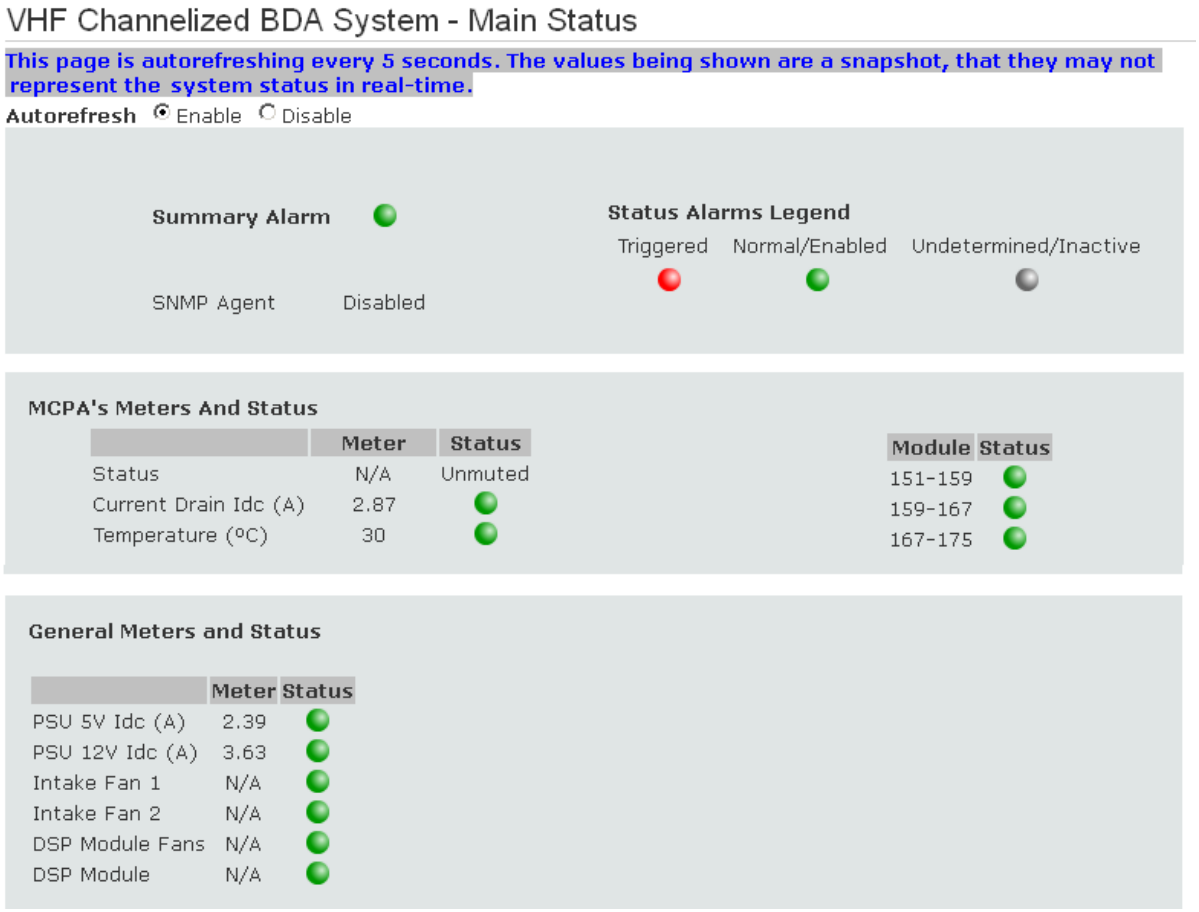

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Figure 12 – Main Status page

This page shows meters and the different alarms. The auto-refresh radio-button allows periodic page updates every 5 seconds approximately.

Summary Alarm	Master Summary alarm Indicator. Green if no single alarm is present in the system, Red otherwise.
SNMP Agent	Shows the SNMP Agent current status (It is disable for this model).

MCPA's Meters and Status

Status	Indicates if the MCPA Output is "Unmuted", "Muted" or "Muted".
Current Drain Idc (A)	Power Amplifier DC current drain. The Status indicator will be green when the current is within the operating levels, red otherwise.
Temperature (ºC)	Power Amplifier heat-sink temperature. The Status indicator will be green when the temperature is within the operating levels, red otherwise.
Modules Status	Indicator is Green if module is active with no alarms, red otherwise.

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General Meters and Status

PSU 5V Idc (A)	5Vdc current meter. Indicator is green if current is within the operating levels, red otherwise.
PSU 12V Idc (A)	12Vdc current meter. Indicator is green if current is within the operating levels, red otherwise.
Intake Fan 1/ Intake Fan 2	Indicator. Green if front fans are fully operational as detected by the air flow sensors; red otherwise.
DSP Module fans	Indicator. DSP module fan is fully operational; red otherwise.
DSP Module	Indicator. It will be green if DSP Module firmware or communication are working as expected; red otherwise. In case, the alarm is triggered (indicator red), the icon ⚠ DSP Not Responding is displayed in Main Status and Filter Settings Pages. Any action related to DSP Filters configuration is blocked. In addition, the MCPAs are automatically muted. The message "Both MCPA have been automatically muted due to a DSP Module Alarm" is displayed in Main Settings page.

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F.2.2 Main Settings Page

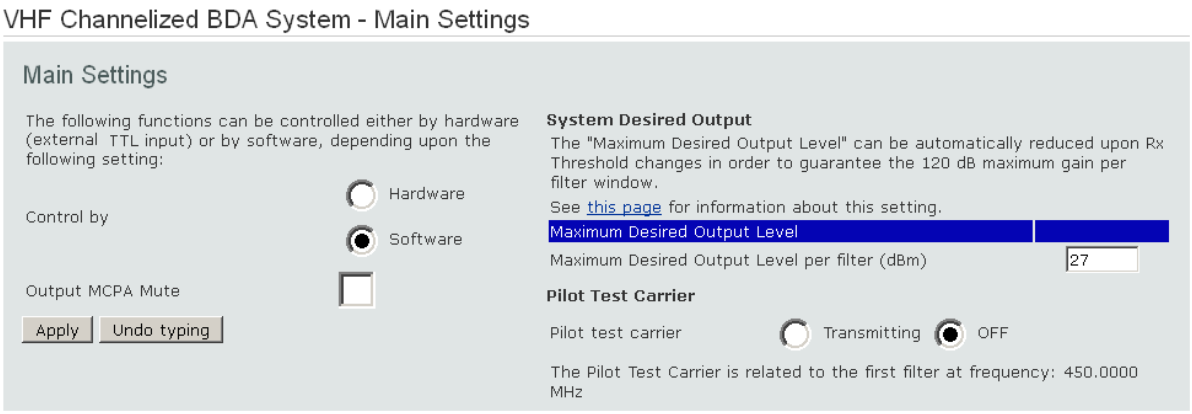

Figure 13 – Main Settings page

The Main Settings page is for configuring general system-level macro settings.

Output MCPA Mute Mute/unmute MCPA.

"Control by:"

For the "MCPAs' MUTE" and "Reflected Power Alarm Reset" commands, the user can set the preferred control method by choosing Software or Hardware in the "*Control by*" field.

a. If the user chooses hardware control, the controller will respond to the opto-isolated inputs located in the DB-25 to screw terminals break-out board and the software commands for these two parameters will have no effect.

   When "Control by Hardware" is selected the MCPA is automatically unmuted unless the corresponding opto-isolated input is energized.

b. On the other hand, if the user chooses software control, the controller will respond to these software commands instead of to the opto-isolated inputs.

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Maximum Desired Output Level per filter(dBm):

Allows the configuration of the output level such as the maximum gain per path will be less than or equal to 120dB.

The specified value cannot be modified in case the maximum gain would be greater or equal than 120dB.

The Maximum Desired Output Level is the user setting or goal set point for the RF Output power level per filter window, subject to the following two constraints:

1. **Maximum Gain of 120dB:**

   The maximum gain for any filter window may not exceed 120dB. Due to the Automatic Gain Control (AGC) function, the system calculates the Gain starting at the minimum signal level able to be received, which is defined by the Rx Threshold (Squelch) setting. Signals coming in at that threshold level will be amplified a maximum of 120 dB. Therefore:

   - Actual Maximum Desired Output (Set-point) <= Lowest Rx Threshold + 120dB.

     THUS: The User entered Set-point may be automatically reduced to meet the maximum 120dB Gain. For example, this will happen if the User reduces an Rx Threshold setting. below the lowest previously defined.
   - The Desired Output (Set-point) values are limited by this constraint.
   - NOTE: This equation is driven by the lowest Rx Threshold value in the filters bank, i.e. if at least one filter is set lower than the rest, that value drives the output Set-Point for the entire bank.

Press the "Apply" button to apply changes to the current state. The current state applied to system is saved to the controller's internal nonvolatile memory for effective recovery after a power loss or system reset.

Pilot Test Carrier:

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Turn on/off the pilot test carrier which is related to first channel at current first channel frequency.

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F.2.3 Filter Settings Page

In this page the user can configure the filters as follow:

- The "Apply to all filters" section allows configuring all filters using the same Rx Threshold, Hysteresis, Fine-Tune Output Level and Tx Enable / CTCSS Tone Enable / AGC enable status.

  Pressing the "Apply" button (it is enabled upon a setting change) the values in the fields will be applied to all filters.

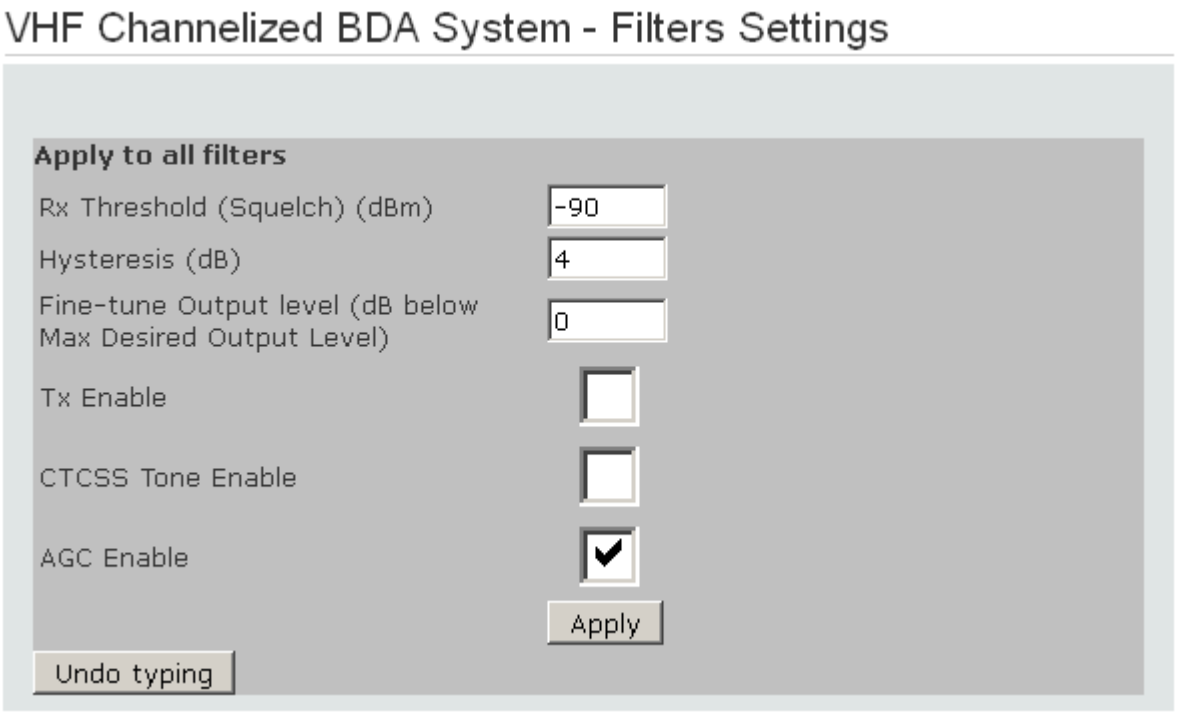

Figure 14 – Filter Settings page (1/2)

- The user may define the settings for each filter window as is shown in
- Figure 15.

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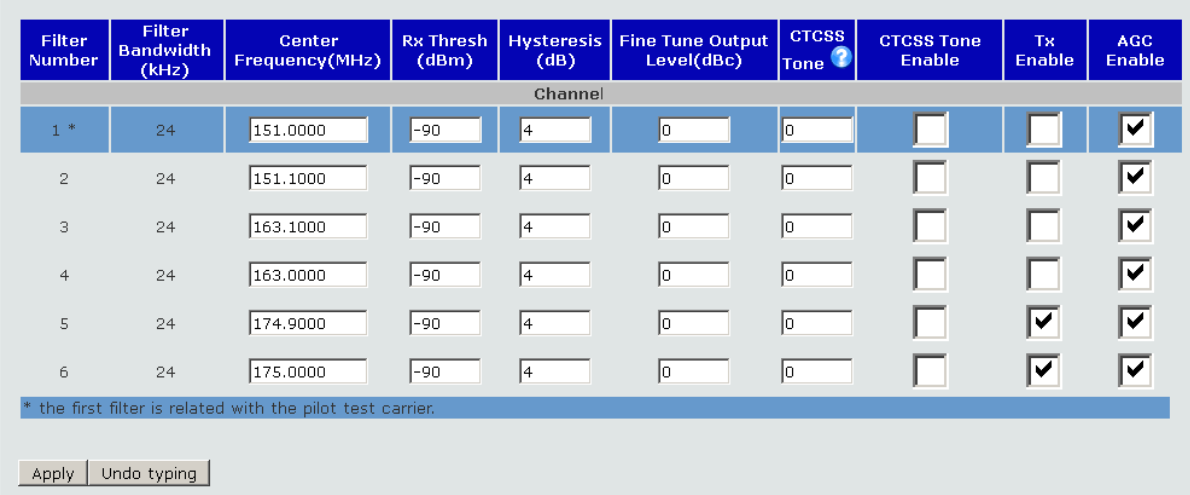

Filter Number	Filter Bandwidth (kHz)	Center Frequency(MHz)	Rx Thresh (dBm)	Hysteresis (dB)	Fine Tune Output Level(dBc)	CTCSS Tone	CTCSS Tone Enable	Tx Enable	AGC Enable
Channel									
1 *	24	151.0000	-90	4	0	0	☐	☐	☑
2	24	151.1000	-90	4	0	0	☐	☐	☑
3	24	163.1000	-90	4	0	0	☐	☐	☑
4	24	163.0000	-90	4	0	0	☐	☐	☑
5	24	174.9000	-90	4	0	0	☐	☑	☑
6	24	175.0000	-90	4	0	0	☐	☑	☑

* the first filter is related with the pilot test carrier.

Apply | Undo typing

Figure 15 – Filter Settings page (2/2)

Filter Number — Read-only attribute. Processing slot number.

Filter Bandwidth (kHz) — Read-only attribute. The filter Bandwidth is defined by the Filter Configuration.

Center Frequency (MHz) — Filter Center Frequency (MHz).

Rx Threshold (dBm) — Rx Squelch Level.

Hysteresis (dB) — Rx Squelch hysteresis.

Fine-Tune Output Level (dBc) — It is a fine-tuning control that provides 5 dB range. It defines how many dB below of Maximum Desired Output Level (defined in Main Settings page) the particular signal will be.

CTCSS Tone — CTCSS Tone Frequency. In order to choose the tone frequency, write one of the indexes shown in pop up window when you pass the mouse pointer over ? symbol.

CTCSS Tone Enable — CTCSS enable/disable.

Tx Enable — Transmitter ON/OFF.

AGC Enable — AGC ON/OFF.

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How to update operational settings?

- Write down the desired value in corresponding field.
- Press enter or "Apply" button for the system to validate the data.
- Using the checkboxes click once and then press "Apply" button.

Useful Tips for configuring Filters

- Center frequency corresponds to the filter-window center. For narrowband windows, please make sure the programmed frequency corresponds to the actual radio signal frequency to avoid interference.

- The Fine Tune Output Level setting is used for adjusting down the carrier power level on an individual "per-window" basis, and provides around 5 dB fine-tuning range.

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