



# Broadcast Equipment

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FMCS-1  
ALL-IN-ONE  
FM MODULATION MONITOR

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We no longer ship PC Control Software with the units. Please visit **www.belar.com** and download the latest **WizWin®** and **Server PC Control Software**. Software updates will be posted on our website periodically. The **FMCS-1** can be updated in the field using the PC Software.

# Broadcast Equipment

## FMCS-1 All-in-One FM Modulation Monitor

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**BELAR ELECTRONICS LABORATORY, INC.**



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# **Broadcast Equipment**

## **SECTION ONE: OPERATOR'S MANUAL**



**BELAR ELECTRONICS LABORATORY, INC.**



# **1 General Information**

## **1.1 General Description**

The **Belar FMCS-1** All-In-One FM Modulation Monitor is a wideband FM monitor which meets the Federal Communications Commission requirements for measuring the total modulation characteristics of monaural as well as the stereo modulation characteristics of multiplexed FM transmitters. The **FMCS-1** measures modulation and provides high-quality outputs for all the services available on conventional analog FM broadcast stations operating in the 88-MHz-to-108-MHz band. On-board processing provides spectral analysis of the pre-demodulation and post-demodulation signals. Internally generated calibration signals permit checking monitor accuracy at any time. Communications ports and a graphical user interface enable local or remote operation of the **FMCS-1** via an external PC.

## **1.2 Physical Description**

The **FMCS-1** is constructed on a standard 3½ x 19-inch EIA rack mount panel (2 EIA rack units; 89mm x 483mm). The unit and rear-panel connectors extend 14¼ inches (362mm) to the rear of the front face of the rack rails, but additional space should be allowed to accommodate the connectors used to make the necessary electrical connections. The DIN power connector and standard XLR audio output connectors require a total depth of no less than about 16½ inches (419mm) behind the front panel. The front-panel encoder knob protrudes about one inch (25.4mm) outward from the rack mounting.

All connections to the **FMCS-1**: the five-conductor DIN power jack, the RF input connectors, the instrument communications connectors, and digital and analog audio outputs are located on the rear panel. The rear-panel connectors include panel-mounted BNC and XLR plugs, D-sub connectors, RJ-45 jacks, and an F connector.

There are no user adjustments, and all factory adjustments are located within the shielded compartment of the monitor.

An outboard switching power supply module is provided with the **FMCS-1**. It is 5.75 x 3.0 x 1.7 inches (146mm x 76mm x 43mm) and must be mounted within four feet (1.2m) of the rear panel of the **FMCS-1**.

## **1.3 Electrical Description**

The **Belar FMCS-1** is a precision DSP-based solid-state FM receiver that down-converts and demodulates FM signals in the FM broadcast band. Front-panel tuning spans the FM band in 100-kHz increments. The **FMCS-1** may be either driven by high-level RF transmission line samples or off-air from a receiving antenna. The **FMCS-1** provides high-accuracy modulation measurement of monaural and stereo composite signals. User-selectable IF filtering improves measurement accuracy in the presence of IBOC-HD carriers. Modulation indications are presented in peak, RMS, and average forms, via both bargraphs and numerical readouts. The **FMCS-1** also measures the modulation characteristics of up to two SCA sub-carriers and provides operational information and the decoded output for an RDS sub-carrier. All readings are presented on a single 240 x 640-pixel LCD display centered on the front panel.

The **FMCS-1** provides audio outputs for all stereo and SCA program channels. The outputs are available in both analog and digital form. There are eight user-configurable outputs for each format. These are low-distortion, low-noise outputs suitable for driving high-quality audio monitoring equipment via long, terminated lines. The recovered FM composite signal is also available in both analog and digital form. The down-converted FM I and Q signals are provided only in digital form.

Internal processing provides spectrum analysis of the modulated FM carrier, the decoded composite signal and the audio outputs in three graphical displays. User-selectable calibration signals conveniently verify proper operation of the metering circuitry. And, user-selectable test signals are provided for testing audio systems connected to the unit.

Configurable alarms with adjustable thresholds are available for fourteen **FMCS-1** measurement parameters. User-selectable external alarm indications include email messages and relay-contact closures. The **FMCS-1** may be operated as an addressed internet device. Remote operation and interrogation of the

**FMCS-1** by a PC is also possible via either the rear-panel USB Port or RJ-45 Ethernet port using the included **Belar WizWin® Software**. Firmware updates for the **FMCS-1** and its internal Lantronix Ethernet controller are also installed using a PC (with internet access) communicating with the **FMCS-1** through either the USB Port or the RJ-45 rear-panel port.

## 1.4 Electrical and Mechanical Specifications

### RF Inputs

Frequency Range .....	87.3 to 108.1 MHz, Frequency Agile, 100-kHz Increments
High Level Input.....	400 mVrms to 3.5 Vrms, 50Ω, BNC Connector
High Level Input (Optional –6dB Attenuator).....	1 to 7 Vrms, 50Ω, BNC Connector
Antenna Input .....	100μV sensitivity, 75Ω, F-Type Connector, 500 mVrms maximum

### FM Demodulator (Analog/Digital Composite Outputs)

Frequency Response .....	±0.15 dB, 10 Hz to 100 kHz
SNR .....	90 dB, 50/75 μs de-emphasis
Distortion (THD+N).....	0.01%, 50/75 μs de-emphasis
IMD SMPTE (60 Hz / 7 kHz 4:1).....	0.01%

### Stereo Decoder (Analog/AES Outputs)

Frequency Response (L and R).....	±0.1 dB, 10 Hz to 15 kHz
SNR (Stereo).....	90 dB, 50/75-μs de-emphasis
Distortion (THD+N).....	0.01%, 10 Hz to 15 kHz, 50/75-μs de-emphasis
IMD SMPTE (60 Hz / 7 kHz 4:1).....	0.01%
Separation	
L to R, R to L.....	90 dB, 10 Hz to 15 kHz
Crosstalk	
L+R to L–R .....	90 dB min
L–R to L+R .....	90 dB min
SCA to L+R.....	90 dB min
SCA to L–R.....	90 dB min

### FFT Spectrum Analysis (RF, Composite, Audio)

Display Modes .....	Realtime, Peak Hold, Average, Infinite Hold
Amplitude	
Number of Points.....	181
Scale .....	+100.0 to –150.0 dB adjustable
Resolution.....	0.1 dB
Frequency	
Number of Points.....	501
Resolution BW	
RF.....	25, 50, 100, 250, 500, 1000, 1500, 2000, 2500 Hz
Composite .....	5, 10, 25, 50, 125, 250 Hz
Audio.....	1, 2, 5, 10, 25, 50 Hz

### Metering

Modulation	
Total, L, R, L+R, L–R, Pilot, SCA Modulation .....	0 to 150.0%, 0.1% resolution
Pilot, RDS, SCA Injection.....	0 to 15.0%, 0.1% resolution
Accuracy at all Modulation Levels .....	±1.0 % or better
Normalization (except SCA) .....	±75 kHz equals 100% modulation
Normalization (SCA).....	1.0 to 7.0 kHz equals 100% modulation
RMS (dB)	
Total, L, R, L+R, L–R.....	+3.0 to –120.0 dB, 0.1 dB resolution, Flat & 50 μs or 75 μs
AM Noise, Sync AM Noise.....	0.0 to –100.0 dB, 0.1 dB resolution
Separation.....	0.0 to –120.0 dB, 0.1 dB
Crosstalk.....	0.0 to –120.0 dB, 0.1 dB resolution

### Indicators

Total Peak Modulation • L+R Presence • RF Presence • Pilot Presence • RDS Sync & Presence • SCA #1 Peak and Presence  
• SCA #2 Peak and Presence • AM Noise Limit • SYNC AM Noise Limit

### Composite Outputs

Analog (2 buffered) .....	1.5 Vrms @ 100%, 75Ω unbalanced, BNC Connector
Digital (2 buffered).....	LVDS, 100Ω, RJ-45 Jack

### Audio Outputs

Analog Outputs (6 assignable).....	+10 dBm, 600Ω balanced, XLR Connector
Analog Outputs (2 assignable).....	1.4 Vrms, 75Ω unbalanced, BNC Connector

AES-3ID (8 assignable).....	1.0 Vpk-pk, 75Ω, BNC Connector
Headphone (assignable).....	1/4" Phone Jack

**Alarm Outputs**

Relays (4 assignable).....	FORM C, 15-pin Female D-Sub Connector
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**Computer Interface**

USB .....	USB-MINI-B Male Connector
Ethernet 10/100 Base -T .....	RJ-45 Jack

**Power Supply**

Operating Input Voltage .....	90 to 264 VAC
Operating Input Frequency .....	47 to 63Hz
Power Requirements .....	42 Watts

**Environmental**

Temperature Range .....	+14° to +122°F (–10° to +50°C)
Altitude.....	10,000 ft. (3048 m)
Relative Humidity.....	95% max. non-condensing

**Packaging**

FMCS-1 Dimensions .....	19"x3.5"x14.5" (48.26x8.89x36.83 cm), 2 EIA Rack Units
Shipping Weight.....	15 lbs. (6.8 kg)
Shipping Carton (L x W x H) .....	22"x21"x9" (55.9x55.3x22.9 cm)

## 1.5 Accessories

There are no accessories for the **FMCS-1** available from **Belar**.

## 2 Preliminaries

### 2.1 Initial Inspection

Check the shipping carton for external damage. If the carton exhibits evidence of abuse in handling (holes, broken corners, etc.) ask the carrier's agent to be present when the unit is unpacked. Carefully unpack the unit to avoid damaging the equipment through use of careless procedures. Inspect all equipment for physical damage immediately after unpacking. Bent or broken parts, dents and scratches should be noted. If damage is found, refer to Paragraph 2.2 for the recommended claim procedure. Keep all packing material for proof of damage claim or for possible future use.

The **FMCS-1** is shipped with this Operator's Manual, an outboard triple-output switching power supply, a three-conductor line cord, and four black rack-mounting screws.

### 2.2 Claims

If the unit has been damaged, notify the carrier immediately. File a claim with the carrier or Transportation Company and advise Belar of such action to arrange the repair or replacement of the unit without waiting for a claim to be settled with the carrier.

### 2.3 Repacking for shipment

If the unit is to be returned to Belar, attach a tag to it showing owner and owner's address. A description of the service required should be included on the tag. The original shipping carton and packaging materials should be used for reshipment. If they are not available or reusable, the unit should be repackaged in the following manner:

- Use a double-walled carton with a test strength no less than 275 pounds.
- Use heavy paper or sheets of cardboard to protect all surfaces.
- Use at least 4 inches of tightly packed, industry approved shock-absorbing material such as extra firm polyurethane foam or rubberized hair. NEWSPAPER IS NOT SUFFICIENT FOR CUSHIONING MATERIAL.
- Use heavy-duty shipping tape to secure the outside to the carton.
- Use large FRAGILE labels on each surface.
- Return the unit, freight prepaid, via airfreight. Be sure to insure the unit for full value.

## 3 Installation

### 3.1 Operating Environment & AC Line Power

The **FMCS-1** All-In-One FM Modulation Monitor is designed to be mounted in a standard 19-inch (48cm) rack with EIA standard spacing. Air space should be provided above and below the unit to provide cooling. When mounted above heat-generating equipment, consideration should be given to the requirement of the free movement of cooler air around and through the **FMCS-1**. In no instance should the chassis temperature be allowed to rise above 113°F (45°C). Mount the **FMCS-1** in the rack using the four black 10-32 rack mount screws.

The **FMCS-1** is powered by an external switching power supply module (supplied with the unit) that operates on line voltages in the range of 100 to 240VAC, 50 to 60 Hz. It provides outputs of +5 VDC, and  $\pm 12$  VDC for the **FMCS-1** chassis via a 48-inch (1.2m) captive cable and a 5-pin DIN connector. The power supply module is connected to the AC line via an IEC-320 three-conductor cable with a PH-386 grounded connector. When the power supply module is connected between the **FMCS-1** and an appropriate AC line source using an appropriate power cord, the monitor is grounded. (To preserve the grounding when operating the unit from a non-standard two-contact AC outlet, use a three-prong-to-two-prong adapter at the AC-line end and connect the green pigtail on the adapter to a good electrical ground.)

*Use the power supply module supplied with the **FMCS-1**. Substituting another power supply module may result in damage to the **FMCS-1**, or at a minimum, a reduction in performance.*

The **FMCS-1** does not have a power switch. When the AC-line power cord is connected to the power supply module and the module is connected to the DIN power jack on the **FMCS-1** chassis, the unit is operating.

### 3.2 Monitoring Location & RF Signal Source

The **FMCS-1** is designed to operate either at the station's transmitter site or at a remote receiving location using an outdoor antenna.

At the transmitter, an on-frequency RF sample is typically obtained from an auxiliary low-level output of the transmitter or from an adjustable probe in the transmission line to the antenna. Operation using a direct feed from the transmitter provides the most accurate readings and should always be used for proof-of-performance or system performance measurements.

Placing the **FMCS-1** at a remote site, typically the main studio requires an outdoor receiving antenna capable of providing an un-impaired off-air signal of the station(s) to be monitored. For remote monitoring at any distance from the station transmitting, the accuracy of **FMCS-1** readings is dependent on the radio transmission path between the transmitter and the receiving antenna. Also, readings may be compromised in receiving locations off the main beam of the transmitting antenna.

Once the monitoring location is known, follow the set-up directions the appropriate section below. Then, to minimize the chance of damaging the **FMCS-1** by excessive RF input levels, carefully follow the procedures for adjusting the input level following power-up.

### 3.3 FMCS-1 Installation at the Transmitter

Once the **FMCS-1** is properly mounted in the rack (see "Operating Environment," above), make sure the level of the 50 $\Omega$  RF sample to be used to feed the monitor falls between +5dBm and +24dBm, or equivalently between 400mVrms and 3.5Vrms. Operation above +24dBm (3.5Vrms or 10Vpk-pk) may damage the unit; operation below +5dBm (400mVrms) may degrade the accuracy of readings. If there is some doubt about the output level of the RF feed, follow the directions in the following paragraphs carefully.

Prepare, but do not connect, a good quality 50 $\Omega$  coaxial cable, such as RG-58, to connect the source of the RF sample to the "RF INPUT" BNC jack on the rear of the **FMCS-1**. (Note that RF system and coaxial cable feeding the **FMCS-1** high-level input must have an impedance of 50 $\Omega$ . Otherwise, performance of the unit will be degraded.)

The Main Tuning Screen indicates the **FMCS-1** RF input level in the upper-right corner of the display. Both a bargraph and numerical readout indicate the RF Level, with 100% being the optimum value. The bargraph for high-level inputs is demarcated in 20% increments. The bar lights yellow for readings below 80%, green between 80% and 110% and red from 110% to 120%. When the RF input level exceeds 141% (+3dB), a red overload flag appears, prompting the user to reduce the input level or to increase the RF attenuation setting.

### **3.3.1 Transmitter Installation Procedure:**

- 1) Mount the **FMCS-1** in a rack with the required AC power and sufficient cooling.
- 2) Obtain a 50 $\Omega$  RF sample between 400mVrms and 3.5Vrms from either the transmission line or a low-level auxiliary transmitter output. Run, but do not connect, a 50 $\Omega$  coaxial line to carry the RF sample to the rear panel of the **FMCS-1**.
- 3) Apply power to the **FMCS-1**.
- 4) After the Main Tuning Screen appears, tune the **FMCS-1** to the carrier frequency using the encoder knob. (Control of the **FMCS-1** and use of the encoder knob are described under "Front Panel Operation", on page 8.)
- 5) Bring up the RF Popup Menu on the display by depressing the encoder knob. Enter the "Input Select" sub-menu and set the input to "High Level".
- 6) In the RF Popup Menu, or using the encoder alone, set the **FMCS-1** attenuator to -15.0dB
- 7) With the transmitter on, connect the RF sample feed to the **FMCS-1** "**RF Input**" BNC connector. If an excessive RF level alarm comes on, immediately remove the RF feed and reduce the level of the sample at its source.
- 8) Adjust the sample level and **FMCS-1** attenuator setting to obtain 100% RF Level, with an **FMCS-1** attenuation setting of less than 15dB.
- 9) Connect any desired **FMCS-1** outputs and continue with the **FMCS-1** setup.

## **3.4 FMCS-1 Installation at the Studio**

A good off-air (remote) installation of the **FMCS-1** will provide high performance for all but proof-of-performance measurements and critical testing. For studio installation of the unit, proceed as follows.

The Main Tuning Screen indicates the **FMCS-1** RF input level in the upper-right corner of the display. Both a bargraph and numerical readout indicate the RF Level, with a green indication of "-20.0dB" or above being in the optimum range. The bargraph for antenna inputs is demarcated in 20-dB increments. The bar lights yellow for readings below -60.0dB, green between -60.0dB and +1.0dB, and red above +1.0dB. The RF Level indication is 0.0dB when the antenna signal is roughly 3mVrms. When the RF input level exceeds approximately 5mVrms (-35dBm), a red "INPUT OVERLOAD" warning pane appears, prompting the user to reduce the input level or to increase the RF attenuation setting.

### **3.4.1 Off-Air Antenna Requirements:**

- 1) Antenna is oriented directly at the transmitter and has a clear path free of any obstructions or adjacent reflecting surfaces, prominent ground formations, and heavy vegetation. The receiving location should fall in the main lobe of the transmitting antenna, in both the horizontal and vertical planes;
- 2) Avoids strong local sources of radio-frequency interference;
- 3) Provides at least 100 microvolts of the desired signal into 75 $\Omega$ . For optimum performance, 300 microvolts or more is desirable;
- 4) Uses a high-quality, low-loss 75 $\Omega$  coaxial cable, such as RG-59, to connect the receiving antenna to the Antenna Input of the **FMCS-1** with an F connector.

### **3.4.2 Studio Installation Procedure:**

- 1) Mount the **FMCS-1** in a rack with the required AC power and sufficient cooling.
- 2) Set up an appropriate receiving antenna with a clear path to the transmitter. Run a 75 $\Omega$  lead-in with an F connector to the rack.
- 3) Apply power to the **FMCS-1**.
- 4) After the Main Tuning Screen appears, tune the **FMCS-1** to the carrier frequency using the encoder knob. (Control of the **FMCS-1** and use of the encoder knob are described under "Front Panel Operation" on page 8.)
- 5) Bring up the RF Popup Menu on the display by depressing the encoder knob. Enter the "Input Select" sub-menu and set the input to "Antenna".
- 6) In the RF Popup Menu, or using the encoder alone, set the **FMCS-1** attenuator to -15.0dB.
- 7) Connect the antenna lead-in to the **FMCS-1** "**Antenna**" F connector. If an excessive RF level alarm comes on, immediately remove the antenna feed and place a 75 $\Omega$  attenuator in the antenna feed line.
- 8) Adjust the **FMCS-1** attenuator setting to obtain an RF Level reading in the green."
- 9) Connect any desired **FMCS-1** outputs and continue with the **FMCS-1** setup.



## 3.5 FMCS-1 Output Connections

All electrical connections to the **FMCS-1** are made through connectors on the rear panel of the unit. Refer to the photograph of the **FMCS-1** rear-panel on page 3 of the booklet **FMCS-1 Guide to Operations** for the locations of the various connectors.

### 3.5.1 Audio Outputs

There are eight output connectors carrying the monitor audio and test signals in analog form and four output connectors providing eight signals in the serial digital AES/EBU format. (At initial power-up, the monitor signals are automatically assigned to the outputs according to the defaults listed in Table 2: “**FMCS-1** Popup Menu Map,” under “Settings: Outputs”.)

### 3.5.2 XLR Connections (analog channels 1–6)

Analog output channels 1 through 6 employ active-balanced output circuitry designed to drive 600 $\Omega$  differential loads via XLR-type connectors. The outputs are chassis-mounted XLR plugs, with the following connections:

Pin 1	Circuit ground and shield
Pin 2	Negative polarity output
Pin 3	Positive polarity output

Positive polarity has the sense that modulation raising the carrier or sub-carrier frequency results in an increasing output voltage at pin 3 of the connector. The output level is +10dBm into 600 $\Omega$ , or 2.45Vrms, for 100% modulation.

These lines will drive up to 500 feet (150m) of shielded twisted-pair broadcast cable, such as Belden™ 8451, when terminated in 600 $\Omega$ .

If an XLR output is used to drive an unbalanced load, the output connection of the alternate polarity (either pin 2 or pin 3 of the XLR chassis connector) must be connected to pin 1 of that same connector with a short lead.

(Note that while the two outputs of the active-balanced pair may be used to drive separate unbalanced loads, imperfect loading of the line-balancing mechanism of the circuit results in interaction between the two outputs. Independently loading the two signal connections may jeopardize signal integrity.)

### 3.5.3 BNC Connections (analog output channels 7–8)

These two outputs (BNC panel jacks) have un-balanced outputs with a 75 $\Omega$  source resistance. They provide 1.45Vrms open-circuit at 100% modulation, or level. The output sense is positive. These are intended to drive high-impedance loads, such as oscilloscopes and frequency counters. With the default settings, the pilot appears at the channel 7 output with an open-circuit output swing of about 0.4Vpk-pk. This is sufficient to drive many counters.

### 3.5.4 AES/EBU BNC Connections (digital output channels 1–8)

These are four 75 $\Omega$  coaxial outputs conforming to the AES-3ID serial transmission standard for distribution via 75 $\Omega$  coaxial cables. The output swing is 0.5Vpk-pk into a terminated cable. The sources designated as odd-numbered are transmitted ahead of the even-numbered sources in the four output channel pairings of channels 1 & 2, 3 & 4, 5 & 6, and 7 & 8.

### 3.5.5 Composite Signal Outputs

The **FMCS-1** provides precision versions of the recovered composite signals of FM broadcast stations in their un-altered baseband form. These may be used to drive FM exciters in re-broadcast applications, for visual observation on an oscilloscope, or for other test purposes. There are two analog composite outputs and two digital composite outputs. The analog outputs appear on rear-panel BNC jacks and have a source impedance of 75 $\Omega$ . Full modulation, or 75.0 kHz peak deviation, provides about 2.1 volts peak, or about 1.5Vrms, un-terminated. (For a terminated 75 $\Omega$  cable, divide these values by two.) The two digital composite outputs appear on separate RJ-45 jacks and carry 24-bit serial data on an LVDS physical interface. (I and Q outputs of the down-converted FM signal are also available in digital form. Consult the factory concerning their use.)

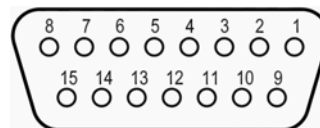


### 3.5.6 Relay Connections

Four Form-C relays provide electrically isolated normally open (NO) and normally closed (NC) contacts to control external circuits. The relays are activated by alarm conditions set by the user in the Alarms/Relay Screen. Maximum ratings of the relay contacts are 10 watts, 0.5 amps, and 200 VDC. Connections to the contacts are made via a chassis-mounted female two-row, 15-pin, sub-miniature D connector with locking nuts mounted on the rear panel of the **FMCS-1**.

The relay D-connector pin numbers are:

Relay	Common	Normally Open (NO)	Normally Closed (NC)
#1	1	3	2
#2	4	6	5
#3	7	9	8
#4	10	12	11



Pins 13–15 are not used.

### 3.5.7 Ethernet Connection

A standard RJ-45 jack is provided to establish a connection between the **FMCS-1** and a local area network. Addressing for the **FMCS-1** network connection is set in the Network Configuration Popup Menu.

### 3.5.8 USB Mini-B Male Connection

The **FMCS-1** may be operated remotely via the rear-panel USB interface using the PC-based **WizWin® Software**. The **FMCS-1** rear-panel connector is a USB Mini-B Male connector.

## 3.6 FMCS-1 System De-Emphasis Settings

The default value of the FM de-emphasis time-constant for monaural and stereo program signals in the **FMCS-1** is 75µsecs. For countries using the 50-µsec standard, the “De-Emphasis” setting in the Unit Settings Popup Menu must be changed. For instructions on how to make this change, refer to the relevant sections under “*Operation*”, beginning on page 7, and the sub-section “Unit Settings Popup Menu”, beginning on page 17. Because 75 µsecs is the unit default, the de-emphasis must be reset every time the “Reset Defaults” option is exercised in countries where the 50-µsec standard is employed.

De-emphasis is defined on page 25 in the “*Definitions*” section.

## 3.7 FMCS-1 RDS Setup

There are no adjustments on the **FMCS-1** directly related to RDS monitoring. Information about the RDS may be found on page 12 under “RDS”, and under the “RDS Basic Data Screen” on page 14.

## 3.8 FMCS-1 SCA Setup

Information about setting up the **FMCS-1** for monitoring SCA signals appears in Section 6.4, “SCA Popup Menus and SCA Setup”, on page 20.

# 4 Operation

## 4.1 The User Interface

The **FMCS-1** is controlled via a single large rotary encoder knob, which incorporates a momentary push switch. A 640 x 240-pixel LCD color display is the primary front-panel readout for the monitor. User-controlled settings of the unit are assigned to the multiple screens and “popup” menus which may be selected for display.

Operation via the front-panel is described below. The unit may also be operated remotely via **Belar’s WizWin® Software** running on a remote PC. The PC may be connected to the **FMCS-1** via either the rear-panel USB port or an Ethernet-type LAN or internet connection. The **WizWin® Software** presents a



virtual image of the **FMCS-1** front-panel display on the PC screen. Therefore, remote operation on a PC mimics operation from the front-panel and will not be discussed. (To download the latest version of the **WizWin® Software**, go to [www.belar.com](http://www.belar.com). Instructions for downloading appear there, as well as in Section 13 of this manual.)

## **4.2 Front Panel Operation**


### **4.2.1 The Rotary Encoder**

*The rotary encoder, much like a computer mouse, provides the means to navigate the **FMCS-1** display screens, to select parameters, and to change settings. For a listing of the top-level screens, see Table 1, “**FMCS-1** Display Screens”, on page 29. For the popup menus and their access points, see Table 2, “**FMCS-1** Popup Menu Map”, on page 30.*

### **4.2.2 Navigation**




Rotating the (rotary) encoder knob navigates through the display screens in both directions, in a wrap-around fashion. The presence of the  symbol, for “Exit Screen”, in the upper-right corner of any screen indicates that the cursor is active in the screen presently in the display and that the cursor is enabled to navigate *only within this screen*. *When the  is absent, the cursor is disabled, and navigation to other screens occurs with rotation of the encoder knob.*

### **4.2.3 Selecting & Changing a Parameter**

For display screens which access user-selectable parameters (and within which navigation is possible), the cursor position is marked by a rectangle formed by thin yellow lines surrounding one of the adjustable parameters in question. To enter any screen and *to make adjustments within the screen, it is first necessary to momentarily depress the encoder knob to activate the cursor*. Then, rotating the encoder knob will move the cursor through the adjustable parameters present on the screen (and only the adjustable parameters) in both directions, in a wrap-around fashion. (Note that the “Exit Screen” symbol  automatically appears when the cursor is activated.)

To change a parameter highlighted by the cursor, momentarily depress the encoder knob. The selected parameter will change from yellow to green. With the parameter highlighted in green, rotation of the encoder knob will change its value. The change will be reflected in the operation of the **FMCS-1** immediately. To move to a different adjustment, momentarily press the encoder knob a second time. The highlighted parameter will turn yellow, locking out further adjustment of that parameter. Subsequent rotation of the knob will move the cursor through the other adjustable parameters present in the displayed screen.

### **4.2.4 Exiting an Adjustment Screen**

If the parameter marked by the surrounding yellow cursor is highlighted green, momentarily depress the encoder to turn it yellow. Rotate the encoder knob until the cursor is at the  Exit Screen symbol at the upper-right corner of the display. Momentarily depress the encoder knob. The  symbol will disappear. Then, with the  symbol absent, rotation of the knob will advance the display to the next screen.

### **4.2.5 Entering a Popup Menu**

Any of the popup menus may be entered through the popup menu selection pull-down, which is accessible from any screen. A listing of the popup menus and the user-adjustable parameters they each contain appears in Table 2, “**FMCS-1** Popup Menu Map”, on page 30.

Depress and hold in the encoder knob sufficiently long for the popup menu selection pull-down to appear. (It is a blue and yellow pane in the upper right of the **FMCS-1** front-panel display.) The initial selection, “RF” is highlighted, and appears in blue type against a yellow background. Other selections in the popup menu selection pull-down are made by rotating and depressing the encoder knob (two rotational detents per selection). Once the desired category has been highlighted, pushing the encoder knob momentarily enters that category, typically offering multiple sub-categories of adjustable parameters.

The desired sub-category again is selected by momentarily depressing the encoder knob. If only a single category is present, a parameter adjustment is then made by rotating the encoder until the desired choice appears. If multiple categories are present, the encoder knob is used to navigate through a multi-parameter

blue pane to select the parameter to be adjusted. In the first case, when the knob selects the parameter options directly, simply depressing the knob following the adjustment clears the popup menu, and returns the user to the display screen.

In the case where a blue, multi-parameter popup menu pane appears, the cursor is automatically activated and is placed at the first adjustable parameter in the pane. In the same manner as for the display screens, a parameter must be highlighted in green to be changed. So, rotate the encoder knob to place the cursor at the parameter to be adjusted. Depress the knob momentarily to highlight the parameter green. Then, rotate the knob until the desired value is obtained. A second pressing of the knob returns the indicated value to a yellow color, locking the adjustment. The knob can now be used to navigate within the blue popup pane to make other adjustments.

#### **4.2.6 Exiting a Popup Menu**

To exit the blue popup pane, first remove any green parameter highlighting, if necessary, by momentarily depressing the encoder knob. Then, move the yellow cursor to the X in the upper-right corner of the pane by rotating the encoder knob. (This “X” serves as an exit symbol, the same as for the  $\blacklozenge$  in the top-level screens.) With the “X” marked with the cursor, depressing the encoder knob momentarily returns the user to the top-level screen. More simply, a popup menu may be exited at any time by depressing and holding the encoder until the menu disappears.

### **4.3 FMCS-1 Modulation Readings: General Description**

Modulation data in the **FMCS-1** is collected over time-windows set by the user. Peak indications are the highest modulation of either polarity occurring during a given window. The metering response is essentially instantaneous. In the **FMCS-1**, Average indications are computed from all of the peak readings taken during the most recent time window. The Minimum indication is the lowest of the peak readings occurring during that same time window.

The metering Time Modes are “Past” time and “Real” time. The durations of the “Past” time window or “Real” time peak-hold may be set to 0.25, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, or 5.0 seconds. An “Infinite” hold-time is also possible. These are all set from the Unit Settings Popup Menu.

In “Past” time mode (with “Infinite: OFF”), the **FMCS-1** samples the appropriate signal stream for the time interval set by the “Hold Time” parameter. The Peak indication is the highest reading taken during that interval. The Average indication is computed from the peak values collected during that same hold-time; the Minimum is the lowest modulation peak occurring during the hold-time.

In “Real” time mode (“Infinite: OFF”), the modulation stream itself controls the starting points of the measurement time windows. In “Real” time, no matter the Hold Time setting, the occurrence of a peak which exceeds the peak presently displayed causes the new, higher peak to be immediately displayed. At the same moment, the Average modulation occurring since the previous update is computed and displayed, along with the Minimum peak value for the interval. The window timer is reset to zero, and the accumulation of modulation data is restarted. It continues until either an even higher Peak reading occurs, or until the time passing since this most recent reset reaches the window length set by the Hold Time parameter.

When the time parameter “Infinite” is “ON,” the highest Peak and Average readings are collected and held until they are replaced by successively higher ones. Correspondingly, Minimum readings are collected until replaced by successively lower ones.

### **4.4 FMCS-1 Bargraph Displays**

Several of the **FMCS-1** screens have three-color bar graphs to indicate dynamically changing signal levels. These tri-color bar graphs provide simultaneous indications of the Peak modulation (in red), the Average modulation (in yellow) and the Minimum modulation (in green). Characteristics of the indications are controlled by settings in the Unit Settings Pop-up Menu. (See Section 6.3.1 on page 17.)

For all settings, the Peak modulation is read at the right edge of the red portion of the bar. Likewise, the right edge of the yellow portion of the bar indicates the Average value, and the right edge of the green portion of the bars indicates the Minimum value occurring during the metering time window. (The space between the three indications is filled for ease in reading.)

The preceding section, “**FMCS-1** Modulation Readings: General Description”, explains how the data for the bargraph readings is obtained.

Descriptions of the individual bargraph screens follow below under Section 5, “The **FMCS-1** Display Screens”.

## **4.5 Spectrum Displays**

The user interface and the operation of each of the three **FMCS-1** spectrum displays are presented in Section 7, “**FMCS-1** Frequency Spectrum Displays and Functions”, beginning on page 21.

# **5 FMCS-1 Display Screens**

## **5.1 Main Tuning Screen**

The **FMCS-1** Main Tuning Screen is the normal observation point for routine monitoring of FM broadcasts. At the top center of the display is the carrier frequency to which the **FMCS-1** is tuned. The two bargraphs at the upper right of the display indicate the RF attenuation and the resulting RF input level of the signal at the indicated station frequency. This assures sufficient signal is present to properly monitor the station. Status indicators and numerical readouts positioned around the station frequency allow quick confirmation of the operational status of the broadcast chain and verification of proper operation.

Only the station tuning frequency and RF attenuation are adjustable in this screen. The tuning frequency is adjusted by manipulating the encoder knob to highlight the displayed frequency in green, then dialing in the desired frequency. (See Section 4.2, “Front Panel Operation” on page 8.) The encoder knob is also used to adjust the RF input attenuation, and accordingly, the RF Level applied to the **FMCS-1** input circuitry. For a high-level RF feed from a transmission line, the desired RF Level should be within a few percent of “100%”. For an RF signal from a receiving antenna, the RF Level indication should fall in the green region of the RF Level bargraph.. (See either Section 3.3 on page 4 or Section 3.4 on page 5, whichever is relevant.)

In addition to the frequency and RF parameters, the upper half of the Main Tuning Screen provides numerical readouts of five principal parameters of an FM Stereo broadcast signal: Total modulation; and the modulation of the Left, Right, L+R, and L–R channels. All indications here are peak values, without de-emphasis, and with the Time Mode, Hold Time, and Units parameters set by the Unit Settings Popup Menu. Total modulation indications are also indicated by a virtual flasher that lights red when the Peak Total modulation exceeds the percentage threshold set in the “Peak Mod” section of the Composite Popup Menu. (This threshold may also be set via the Alarms/Relay Screen.)

The lower half of the Main Tuning Screen provides readings of secondary importance: injection levels for the stereo Pilot, the RDS, and up to two SCA sub-carriers, along with the SCA modulation. Each of these four signals has a dedicated “presence” indicator. The indicator lights green when the signals reach a user-set injection threshold. (The injection thresholds for the four presence indications are set in the Alarms/Relay Screen. The thresholds for the SCA “presence” indications are identical to their “loss-of-signal” injections thresholds, and may also be set in the SCA Popup Menus.)

Injection levels for the Pilot, RDS, and SCA’s are indicated numerically either in “%” or “kHz”, depending on the “Units” setting in the Unit Settings Popup Menu, and are referenced to a 100-percent level of 75 kHz peak deviation of the FM carrier.

The Pilot includes an “AM Mod” indication, which is always displayed in percent. This is the equivalent percentage of amplitude modulation present on the 19-kHz pilot signal. It is a fairly reliable indication of

FM multi-path, with larger percentages indicating progressively worse conditions. This reading is also raised by clipping of the pilot signal that may result from certain types of composite processing at the transmitter. Ideally, this reading would be at or near 0.0%, but should remain below 1.0%.

To the immediate right of the green RDS presence indicator is a yellow lock indicator that remains lit when the **FMCS-1** decoder has locked to the incoming RDS signal and is decoding its data. It goes blank when RDS data recovery ceases.

Indications for the two SCA demodulators are identical. Only SCA #1 will be discussed. The indicator to the immediate right of “SCA#1” in the display lights green when the SCA injection exceeds the injection threshold set in either the SCA Popup Menu or in the Alarms/Relay Screen. Otherwise it is black, whether or not an SCA is present on the frequency to which the SCA demodulator is tuned. To the right of the presence indicator is the peak modulation flasher. The peak modulation flasher lights red when the modulation of the SCA sub-carrier exceeds the modulation threshold set either in the SCA Popup Menu or the Alarms/Relay Screen. The Injection and Peak indications are also presented numerically below the indicators. The readouts are in units of “%” or “kHz”, depending on the “Units” setting in the Unit Setting Popup Menu. The injection readings are referenced to 75.0 kHz peak deviation of the FM carrier, while the Peak indications are scaled so that 100% corresponds to the user-set “Norm” parameter under “DET” in the SCA Popup Menu.

## **5.2 DB Readings Screen**

This screen collects all of the RMS readings provided by the **FMCS-1** on one screen and presents it numerically. As is the case on the other screens, the un-de-emphasized (“flat” or “wideband”) readings are presented in yellow; the de-emphasized RMS readings appear in white.

**Listed in top-to-bottom order, then left to right:**

### **RF Level**

The level of the RF signal (or IF signal, in the case of Antenna inputs) at the input of the **FMCS-1** system input analog-to-digital converter. “0.0dB” is typically the highest reading suggested. Overloads occur at “+3.0dB” for high-level inputs and at “+1.0dB” for antenna inputs.

### **AM Noise<sup>1</sup>**

The level of amplitude modulation present on the FM carrier, de-emphasized with a 75-microsecond time constant, and referenced to 100% AM of the FM carrier.

### **SYNC Noise**

This is the “synchronous AM noise,” the level of amplitude modulation present on the FM carrier, measured across the RF pass-band, without de-emphasis, and referenced to 100% AM of the carrier.

### **Total**

This RMS indication reflects the power in the complete (baseband) signal that modulates the FM carrier. With no modulation of the FM carrier present, this reading is the overall signal-to-noise ratio of the FM transmission system.

### **Pilot**

The 19-kHz stereo pilot signal recovered from the FM demodulator output signal by filtering.

### **L, R**

The levels of the recovered left and right audio program signals.

### **Sep**

The separation between the left and right program channels. It is assumed that the higher of the two levels (L or R) is the “desired” signal. The separation reading is the decibel ratio of the lower-amplitude signal to the higher-amplitude signal. (See Section 5.6, “Separation Bargraph Screen”, on page 14.)

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<sup>1</sup> Both AM Noise and SYNC Noise readings are susceptible to ignition and other amplitude noise when made off-air. Synchronous noise readings are also affected by receiver IF filtering. For that reason, the most accurate AM noise measurements are obtained using the FMCS-1 high-level RF input at the transmitter.



**L+R, L-R**

The levels of the sum and difference audio program signals.

**XTalk**

The stereo crosstalk measured between the sum and difference program channels. It is assumed that the higher of the two levels (L+R or L-R) is the “desired” signal. The crosstalk reading is the decibel ratio of the lower-amplitude signal to the higher-amplitude signal. (See the section “Crosstalk Bargraph Screen” on page 14.)

## **5.3 Stereo Bargraph Screen**

This screen provides a quick visual indication of normal transmission of stereo program material. Six tri-color bar graphs indicate modulation of the Left (L) and Right (R) audio channels, Stereo Pilot, the L+R (or sum channel), the L-R (or difference channel), as well as the Total modulation of the FM carrier.

The horizontal axis, or x axis is marked in “%” (percent), where 100% corresponds to 75 kilohertz peak deviation of the FM carrier. The numerical reading corresponding to each bargraph appears to the right of the respective bargraph in the display. These readings may be set to indicate modulation percentage, or to read directly in kHz deviation of the FM carrier. (See the “Unit Settings Popup Menu” description below.)

The right edge of the red portion of each bar indicates the Peak value of the modulation as a function of time. The right edge of the yellow portion of the bars indicates the average value of modulation, and the right edge of the green portion of the bars indicates the minimum value over the metering time window. (For a description of bar-graph metering, see **FMCS-1** Bargraph Displays on page 9, above. For details about the metering characteristics, refer to the parameters immediately under the heading “Unit Settings Popup Menu” on page 17, below.)

“Total” is the top bar graph of the display. It shows the deviation of the FM carrier, and represents the instantaneous sum of all the components making up the baseband signal which modulates the FM carrier. This is the most important reading. It includes the stereo composite signal (which includes the sum and difference channels and the stereo pilot), any SCA sub-carriers present, the RDS signal if present, as well as any noise and distortion present on the FM carrier.

“Pilot” is the level of the 19-kHz sine wave used to synchronize the stereo demodulation in FM stereo receivers. This is normally set to 9.0% modulation, or 6.75 kHz peak deviation. Because it is a steady tone, only a yellow RMS indication is shown.

Left and Right indications show the modulation of the FM carrier due to the left and right program audio. Here, 100% corresponds to 75 kHz peak deviation of the carrier. For normal operation, maximum Left and Right modulation is 90%, leaving 10% for the modulation of the carrier by the 19-kHz stereo Pilot signal.

At the bottom of this screen are the L+R and L-R bargraphs. The L+R is literally the sum of the Left and Right channel signals and represents the level of the audio program present on a monaural FM receiver. (It is also that component of the composite stereo signal falling below 15 kHz.) The L-R reading indicates the level of the stereo sub-channel. (The stereo sub-channel is the double-sideband suppressed-carrier component of the FM composite signal resulting from modulation of the 38-kHz sub-carrier by the L-R audio difference information.) Normally, it is good practice to maintain the L+R signal fairly high, but less than 90%. The L-R peak levels depend on the stereo content of the audio program material. Except for unusual program material, the L-R level will fluctuate well below 90%. Its reading may approach zero for well-balanced monaural program sources.

## **5.4 SCA Bargraph Screen**

The top bar graph on this screen indicates the injection level for the RDS (Radio Data System) sub-carrier. The lower two bar graphs indicate injection levels and modulation readings for SCA (Subsidiary Communications Authorization) subcarriers, if present.

### **5.4.1 RDS**

RBDS, or Radio Broadcast Data System, is the American implementation of the European RDS. Herein, the acronym RDS will be used to represent both systems.

The injection level of the RDS is that modulation of the FM carrier caused by the presence of the RDS subcarrier in the composite FM signal. It is displayed on the top bar graph in either kHz deviation or in percentage, depending on the Unit Settings. The proper injection range for the RDS subcarrier is between  $\pm 1.0$  kHz and  $\pm 7.5$  kHz peak deviation; the recommended injection level is  $\pm 2.0$  kHz. (In terms of percentages of 75 kHz peak FM carrier deviation, the proper injection range for the RDS subcarrier is between 1.3% and 10.0%, with a recommended injection of 2.7 %.) Because the RDS subcarrier passes through a 57-kHz-wide band-pass filter before metering, small fluctuations in injection readings may normally be visible due to modulation of the subcarrier.

### 5.4.2 SCA

The middle and bottom bar graphs on the SCA Bargraph Screen indicate the injection levels and modulation of each of two SCA subcarriers. The graphs are arbitrarily assigned to the **FMCS-1** SCA decoders #1 and #2, respectively. As the two SCA decoders are identical, only the first SCA decoder will be discussed.

The injection level of an SCA is that modulation of the FM carrier caused by the presence of the SCA subcarrier in the composite FM signal. It is displayed on the upper halves of each of the two lower bar graphs on the SCA Screen labeled “Inj.” Depending on the Unit Settings, the injection is displayed in either kHz deviation or as a percentage of the total modulation of the FM carrier. Injection is displayed both on the top half of the bar graph, as well as numerically at the right side of the screen. SCA injections may vary from just a few percent to more than 20 percent. For standard applications, SCA injections fall in the range of 5% to 15%. Modulation of the SCA sub-carrier itself is displayed on the lower half of each of the two SCA bar-graphs, adjacent to the word “Peak.” The green-yellow-and-red split bar indicates the Minimum, Average, and Peak modulation of the SCA sub-carrier, just as for the **FMCS-1** modulation bar-graphs. (See “**FMCS-1** Bargraph Displays” on page 9.) However, because maximum deviations of SCA subcarriers vary across applications, the reference deviation for a 100% indication is set by the user. The peak readings may be normalized to 100% for deviations of 1.0 to 7.0 kHz in the appropriate SCA Popup Menu.

## 5.5 Total dB Bargraph Screen

This screen displays four bargraphs relevant to stereo transmission. The top tri-color bargraph displays Peak readings of the Total modulation of the FM carrier in percent. This bargraph is identical in appearance and function to the Total bargraph on the Stereo Bargraph Screen, indicating Peak, Average, and Minimum modulations.

The remaining three bargraphs provide *RMS* indications of Total modulation, Pilot level, and the level of the 38-kHz stereo subcarrier, all in decibels relative to 75 kHz peak deviation of the FM carrier, or to 0.0dB. These are useful for testing the basic stereo broadcast signal.

The decibel-reading Total bargraph indicates both de-emphasized and un-de-emphasized (or “flat”) *RMS* indications of the modulation of the FM carrier measured across the full bandwidth of the **FMCS-1** detector, 100 kHz. The green portion of this Total bargraph shows the de-emphasized total modulation of the carrier, and the yellow portion represents the wideband, or flat, modulation of the carrier. Both decibel readings appear numerically at the right end of the second bargraph, with the flat reading in yellow, and the de-emphasized reading in white. This bargraph provides direct readout of the overall signal-to-noise ratio of the FM system.

The Pilot bargraph shows the *RMS* pilot level, measured at the output of a band-pass filter in the **FMCS-1**. The nominal value of the stereo pilot is  $-20.92$ dB (9.0%). As the indication is *RMS*, the reading will normally show less fluctuation with modulation than the peak-based Pilot Mod reading appearing on the **FMCS-1** Main Tuning Screen.

The bottom bargraph shows the *RMS* level of the 38-kHz stereo subcarrier present in the composite signal. Since the L–R signal is DSB with suppressed carrier, ideally there should be no 38-kHz subcarrier present in the signal. This reading is made at the output of a band-pass filter centered at 38-kHz. If there is low-frequency L–R modulation present in a stereo signal, leakage of the DSB-SC signal into the passband of the band-pass filter may cause the reading to fluctuate above the true residual.

The RMS indications on this screen are more appropriate for proof-of-performance measurements and testing than for modulation indications.

## 5.6 Separation Bargraph Screen

Five bargraphs important for observing and measuring FM stereo performance appear on this screen. The top two bargraphs provide peak-reading indications of left and right modulation, referenced to 100% modulation at 75 kHz peak FM deviation. These two bargraphs are identical to the L and R bargraphs on the Stereo Bargraph Screen. Red indications are the maximum peak indications, yellow indications are the averaged peak readings and the green portion of the graphs show the minimum modulation values occurring during the time windows. (See “FMCS-1 Bargraph Displays” on page 9 for a more detailed explanation of the tri-color display.)

The middle two bargraphs also indicate the L and R channel modulations, but with RMS responding indications for both the flat, un-de-emphasized signal (in yellow) and the de-emphasized signal (in green). Numerical readouts of both forms of the two signals appear to the right of the two bargraphs. The yellow numbers are flat readings; the white numbers are de-emphasized readings.

The bottom “Sep” (for separation) bargraph computes and displays the *difference* in the un-de-emphasized RMS level readings for the L and R channels. In the computation, the higher of the levels for the two channels is taken as the reference level. The separation reading, in decibels, is the ratio of the amplitude of the lower-level signal to this reference level. Therefore, the separation is in negative dB. (When making separation measurements, the reference level is implicitly assumed to appear in the driven channel.)

The bottom three RMS indications are most useful in performing proof-of-performance measurements and for fast stereo performance testing. They check the integrity of the stereo generator driving the FM broadcast exciter.

## 5.7 Crosstalk Bargraph Screen

Five bargraphs important for observing and measuring FM stereo performance appear on this screen. The top two bargraphs provide peak-reading indications of L+R (sum) and L–R (difference) channel modulation, referenced to 100% modulation at 75 kHz peak FM deviation. These two bargraphs are similar to the L and R bargraphs on the Stereo Bargraph Screen. Red indications are the maximum peak indications, yellow indications are the averaged peak readings and the green portion of the graphs show the minimum modulation values occurring during the time windows. (See “FMCS-1 Bargraph Displays” on page 9 for a more detailed explanation of the tri-color display.)

The middle two bargraphs also indicate the L+R and L–R channel modulations, but with RMS responding indications for both the flat, un-de-emphasized signal (in yellow) and the de-emphasized signal (in green). Numerical readouts of both forms of the two signals appear to the right of the two bargraphs. The yellow numbers are flat readings; the white numbers are de-emphasized readings.

The bottom “XTalk” (for “crosstalk”) bargraph computes and displays the *difference* in the un-de-emphasized RMS level readings for the L+R and L–R channels. In the computation, the higher of the levels for the two channels is taken as the reference level. The crosstalk reading, in decibels, is the ratio of the amplitudes of the lower-level signal to this reference level. Therefore, the crosstalk is in negative dB. (When making crosstalk measurements, the reference level is implicitly assumed to appear in the driven channel.)

The bottom three sum and difference indications are most useful in performing proof-of-performance measurements and for fast system testing. Principally, they check the integrity of the stereo generator driving the FM broadcast exciter.

## 5.8 RDS Basic Data Screen

This screen decodes all the RDS data transmitted by North American stations on the 57-kHz RDS sub-carrier. The RDS output data is displayed as a raw hexadecimal value, followed by the decoded text value. (Source information for the RDS/RBDS broadcast data transmission system may be found in the



international RDS Standard IEC/CENELEC 62106 and the US National Radio Systems Committee NRSC-4-B, US RBDS Standard, dated April 2011, available at [www.nrscstandards.org](http://www.nrscstandards.org).)

The group types (broadcast and) decoded by the **FMCS-1** are:

PI :	Program Identification Code
PS :	Program Service Name
PTY :	Program Type
TP :	Traffic Program
TA :	Traffic Announcement
MS :	Music or Speech Program
Time :	The Encoded time
Date :	The Encoded date
DI :	Decoder Identification
PIN :	Program Item Number
Radio Text :	Up to 64 characters, with embedded carriage returns and line feeds displayed as the “CR” (or carriage return) and “LF” (or line feed) characters, respectively.
Alternate Frequencies:	Frequencies of affiliated transmitters or repeater stations
Group Types:	A list of all of the RDS Group Types present in the broadcast.

No settings can be made from this screen. There are no adjustments on the **FMCS-1** directly related to RDS monitoring. More information about the RDS may be found under “RDS” on page 12.


## 5.9 Alarms/Relay Screen

Fourteen signal characteristics are continuously monitored by the **FMCS-1** to detect improper or undesirable FM broadcast system operating conditions. This screen allows the user to set alarm thresholds and alarm timeouts for these conditions, and to select from three types of indications for each alarm condition. Alarms may be indicated by any combination of three methods. The three alarm methods are a relay contact closure, an e-mail alarm notice sent out over the LAN to which the **FMCS-1** is connected, and an on-screen red alarm notification banner. For the relay contact-closure alarm indication, contacts on one of four different relays may be selected; for the e-mail notice, one of four distinct alarm-message-address combinations may be selected.

The fourteen monitored signals, their alarm threshold ranges, and the default alarm threshold values are shown in Table 3: **FMCS-1** Alarms, Ranges and their Defaults.” The Alarms/Relay Screen allows selection of which relay and e-mail message is activated, but the destination address and contents of the e-mail message are entered via the E-mail Settings Popup Menu.

The Alarms/Relay Screen has seven columns of readouts. This requires a different approach to screen navigation with the encoder wheel. Upon opening the Screen, rotation of the encoder moves the cursor vertically through the left-hand column of 14 possible alarm conditions. Pressing the encoder highlights in green the signal name at which the cursor is resting. Once the signal name is highlighted, further rotation of the encoder moves the cursor horizontally left or right across the five columns of settings, in wrap-around fashion. By pressing the encoder a second time, the setting where the cursor rests is highlighted green, and adjustments may be made to that setting by rotating the encoder.

The seventh column contains tri-color indicators that show the alarm status for each row. They are green when no alarm condition exists for the corresponding signal; they are red when an alarm condition has existed continuously for the duration set by the alarm “Time” parameter. A yellow indication means an alarm condition has started the individual alarm timer, but that the timer has not yet reached the user-set timeout value.

To exit the screen, reverse the encoder manipulation sequence: press the encoder to return the parameter to yellow, rotate the knob to move the cursor to the “Event” column, press the encoder knob to turn the green event to yellow, and then rotate the encoder until the cursor lands on the  icon. Pressing the encoder again, enables selection of other screens by rotating the encoder knob.

Two special cases exist for this screen. The “Total Peak LED” has no associated timeout. The “over-modulation” indicator flashes immediately when a modulation indication exceeds the threshold. Also, the “Loss of RDS SYNC” indication has no threshold adjustment. It is considered either to be locked or unlocked, based on conditions in the RDS decoder.

Setting the threshold of any loss-of-signal alarm to 0.0% disables the alarm function for that signal parameter.

## 6 FMCS-1 Popup Menus

The popup menus listed immediately below appear in the popup menu directory. (The popup menu directory is accessed from any screen by momentarily depressing the encoder knob. The procedure for selecting and entering popup menu appears in Section 4.2.5, on page 8.) For convenience, the SCA and Spectrum Popup Menus are discussed out of order. The description of the SCA Popup Menu appears in Section 6.4 on page 20; the general description of the Spectrum Popup Menu is in Section 7.3 on page 22. Properties specific to the RF, the Composite, and the Audio Spectrum Popup Menus are presented in the discussions of the corresponding Spectrum Screens (in sections 7.4.2, 7.5.2, and 7.6.2).

### 6.1 RF Popup Menu

**Input Select:** Allows selection between “High Level” and “Antenna” inputs.

**Tuning:** Enables the encoder knob to tune the **FMCS-1** input from 87.3 MHz to 108.1 MHz in 100-kHz increments and in wrap-around fashion. This functionality duplicates the station tuning on the Main Tuning Screen.

**Calibrator:** Selects among nine internal test signals used to verify proper operation of the **FMCS-1** system. The composite spectrum, audio spectrum and the outputs produced by the monitor when using these test signals are what the **FMCS-1** would produce from ideal input signals.

OFF - The Calibrator is disabled. The **FMCS-1** functions normally.

ZERO - A data stream with no modulation is applied. Spectrums and outputs are silent.

Mono 1 kHz - A 1-kHz monaural signal with 75 kHz peak deviation, or 100% modulation.

Left 1 kHz - A 1-kHz left-only signal with 90% L modulation. Because of interleaving effects between the L+R, the L-R, & the pilot in the composite signal, Total modulation reads 95.7%.

Left 5 kHz - A 5-kHz left-only signal with 90% L modulation. Interleaving causes Total to read 96.4%.

Left 10 kHz - A 10-kHz left-only signal with 90% L modulation. Total reads 96.5%.

Left 15 kHz - A 15-kHz left-only signal with 90% L modulation. Total reads 95.9%.

SCA 67 92 Zero - A composite signal containing only two un-modulated SCA signals: one at 67 kHz, the other at 92 kHz, each with a sub-carrier injection of 10% (or 7.5 kHz peak deviation). Total reads 19.9%.

SCA 67 92 Mod - A composite signal containing only two FM-modulated SCA signals: one at 67 kHz, the other at 92 kHz, & each with a sub-carrier injection of 10% and with its sub-carrier modulated to 6.0 kHz deviation. Total reads 21.2%. Note that the SCA modulation will be distorted and will not read 100% modulation due to the effects of band-limiting of the sub-carriers.

The test signals are introduced into the **FMCS-1** IF processing chain immediately following the digital down-converter. Accordingly, with the Calibrator operating, the RF Spectrum displays the same spectrum as it would if the Calibrator were not functioning.

**Attenuator:** This allows the user to attenuate the RF input signals (from both the High Level and the Antenna inputs) from 0.0 dB to 31.5 dB, in 0.5-dB steps. The purpose of the attenuator is to prevent overloading the **FMCS-1** input and to bring the RF Level indication near its optimum value: 100% for High-Level inputs and approximately –20.0dB for Antenna inputs. This functionality duplicates the “RF Atten” function on the Main Tuning Screen.

**Filter:** This feature allows the user to choose from among five RF filtering options that optimize the **FMCS-1** for operation both in and out of an IBOC-HD FM broadcast environment. In order of decreasing bandwidth of the RF pass-band the filters are:

Wideband	This is the least restrictive filter. It provides the most accurate readings, except in the presence of IBOC-HD carriers which introduce interference into the demodulated analog signal.
HD -25DB MP1	For IBOC-HD carriers and Service Mode MP1
HD -25DB MP3	For IBOC-HD carriers and Service Mode MP3
HD -50DB MP1	For Service Mode MP1 with elevated HD carrier power, or when measuring AM noise on the FM carrier
HD -50DB MP3	For Service Mode MP3 with elevated HD carrier power, or when measuring AM noise on the FM carrier (This is the most restrictive RF filter.)

The filters designated “HD” suppress the IBOC-HD carriers by the amounts suggested by their names.

Each of the five filters has some effect on modulation readings for analog carriers. Use the least restrictive filter possible that provides satisfactory performance.

**Mute:** The **FMCS-1** disables its composite and audio outputs when Mute is active. At the same time, the composite spectrum, audio spectrum, and RDS screens are all blank. All of these outputs are disabled when the user manually selects “ON” for the Mute option in the RF Popup Menu. When “AUTO” is selected, muting occurs when the RF input level for either the “High Level” or “Antenna” input, whichever is active, drops below the corresponding user-set “Loss of RF” alarm threshold set in the Alarm/Relay Screen. Note that the RF level must also remain below the alarm threshold for the time duration set by the “Time” parameter for the corresponding alarm for muting to become active. “OFF” disables all muting.

## 6.2 Composite Popup Menu

This popup menu allows adjustment of two settings dealing with the demodulated composite FM signal.

**Filter BW:** Four filtering options for the demodulated composite FM signal are available to improve the suppression of noise and interference from IBOC-HD carriers. It is recommended that the composite filter bandwidth be set as large as possible, and no less than required to pass all the services present in the FM signal.

In order of descending bandwidth, the filters are:

Wideband	No filtering of the composite signal occurs. The un-attenuated pass-band extends to 100 kHz.
Stereo+92kHz	Passes the entire composite up to, and including a 92-kHz SCA sub-carrier.
Stereo+67kHz	Passes the composite signal up to, and including a 67-kHz sub-carrier.
Stereo+RDS	Passes the stereo signal, including the RDS sub-carrier. The cutoff of this filter is just above the RDS sub-carrier at 57 kHz.

**Peak Mod:** This sets the threshold for the peak modulation of the FM carrier required to light the peak flasher adjacent to “Total” on the Main Tuning Screen. It is set in “%” (percent). This threshold may also be set via the ALARMS/RELAY SCREEN.

## 6.3 Settings Popup Menus

The following Popup Menus are brought onto the **FMCS-1** display screen by using the encoder to select the “Settings” popup menu from the Popup Menu directory. The settings menus are then selected by rotating the encoder to highlight the desired sub-menu, and depressing the knob.

### 6.3.1 Unit Settings Popup Menu

This menu provides display settings for both the peak readings and the modulation bargraphs of the **FMCS-1**, and controls several miscellaneous functions of the unit. Details not explained for the Popup Menu below appear in the section “**FMCS-1** Modulation Readings: General Description”.

**Time Mode:** In “Real” time mode, any measured peak that exceeds the peak value presently on the display, replaces the peak value on the display with the new, higher peak value instantaneously. The peak value is then displayed for the duration of the hold time, unless a higher peak is detected, in which case the process repeats.. Minimum and Average readings for the bargraphs are computed and displayed. The collection-interval timer is then restarted.

In “Past” time mode, peak readings are collected over the duration set by “Hold Time.” At the end of the hold-time interval, the highest value during that interval is displayed. Minimum and Average readings for the bargraphs are computed and displayed. The hold -interval timer is then restarted.

**Hold Time:** This is the duration of the time interval over which Real and Past time indications are collected before the readings presently displayed are updated. For “Real” time indications, the “Hold Time” is the maximum duration of the collection interval. It may be shorter. Time window durations may be set to 0.25, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, and 5.0 seconds.

**Infinite:** When “ON,” the maximum and minimum peak modulation values occurring over an infinite interval are collected and displayed.

**Units:** Allows certain numerical readouts of modulation to appear in percentages of 75.0 kHz peak deviation (where 100% = 75.0 kHz), or directly in kilohertz (kHz).

**De-Emphasis:** Sets the de-emphasis time constant for main-channel monaural, all stereo audio outputs, and all spectral displays tagged with an asterisk in the Audio Spectrum Popup Menu. The choices are “50 usec” and “75 usec,” where “usec” stands for microseconds.

**Filter Response:** Sets the high-frequency cutoff for all of the L, R, L+R, and L-R signals recovered and metered by the **FMCS-1**, and for those same signals appearing at its outputs. “Normal” sets the cut-off at the standard 15.0 kHz. In the “Extended” setting, the cutoff frequency is raised to 16.5 kHz. This may provide some improvement in the accuracy of peak modulation readings, depending on program content and the audio processing used at the transmitter.

**Remote:** When “ON,” permits remote access to the **FMCS-1** via the USB and RJ-45 rear-panel connectors. “OFF” blocks both USB and Ethernet communications with the **FMCS-1**.

**Screen-Saver:** Blanks the display screen after a pre-set interval of encoder knob inactivity. The encoder is used to set the inactivity interval from one hour to twelve hours in one-hour increments. “OFF” disables the screen-saver.

**Reset Defaults:** Moving the cursor to this position and pressing the encoder knob resets all of the **FMCS-1** settings to their factory default values. In countries that employ 50-μsec de-emphasis, restoring the default settings will require the additional step of setting the “De-Emphasis” to 50 μsec in this same Unit Settings Popup Menu.

**Reboot:** Moving the cursor to this position and pressing the encoder knob re-initializes all the **FMCS-1** processors, just as would occur if the unit were powered-up.

### 6.3.2 Output Settings Popup Menu

This menu is accessed through the Settings Popup Menu.

This Popup Menu allows any one of fifteen audio signals decoded or generated by the **FMCS-1** to be assigned to each of the eight analog outputs (via six XLR panel-mounted plugs and two BNC jacks) and eight AES/EBU digital outputs (via four 75Ω BNC coaxial jacks) on the **FMCS-1** rear panel. These same fifteen audio signals may also be directed to the two individual channels of the front-panel headphone jack. The signal level of the headphone signal pair is adjustable via this menu.

The selection of signals for output include the L, L(\*), R, R(\*), L+R, L+R(\*), L-R, L-R(\*), SCA#1, SCA#2, and Pilot signals. Here, and in the **FMCS-1** on-screen Outputs Popup Menu, “(\*)” indicates either the 50-microsecond or 75-microsecond de-emphasized version of the signal. (The de-emphasis time-constant is set in the Unit Settings Popup Menu.) The SCA#1 and SCA#2 signals are de-emphasized according to the “Resp :” setting in the corresponding SCA Settings Popup Menu. . The pilot signal is available as an output to drive an external counter.

Four internally generated signals may also be directed to the **FMCS-1** outputs for external testing. They consist of three 1-kHz single-frequency tones at the relative levels of 0dB, -3dB, and -6dB, and a “Mute,” or null signal. The “Mute” signal may be activated to check the noise floor of connections to the **FMCS-1**, as well as to provide a quiet source for external testing.

**Analog output channels 1 through 6** employ active-balanced output circuitry designed to drive 600-Ω differential loads. If used to drive unbalanced loads, the alternate output (either pin 2 or pin 3 of the XLR chassis plug) should be connected to pin 1 of the same connector with a short lead. Note that while the two outputs of the active-balanced pair may be used to drive separate unbalanced loads, imperfect loading of the line balancing mechanism of the circuit results in interaction between the two outputs. (Note that analog outputs 1 through 6 employ a DC servo circuit greatly suppresses any DC present in the output signals and minimizes any waveform tilt that might be introduced by high-pass filtering.)

**Analog output channels 7 and 8** are unbalanced and have BNC coaxial connectors. Their source resistance is 1.00 kΩ. These outputs are intended for precision testing. From the factory, channels 7 and 8 offer the option of either employing DC servos like those present in channels 1 through 6, or bypassing the servos for flat response down to DC.

The DC servo circuits that suppress the DC in output channels 7 and 8 may be disabled. As shipped from the factory, jumpers P6 and P5 on the A3 board are placed in their “IN” positions, enabling the servos in

channels 7 and 8, respectively. By moving the jumpers to their “OUT” positions (closer to the **FMCS-1** front panel), the DC servos may be disabled, extending the respective output channel response flat to DC.

The four AES/EBU coaxial BNC output jacks source eight output channels in the pairs “CH 1–2”, “CH 3–4”, “CH 5–6”, and “CH 7–8”. The lower data carries the lower (odd-numbered) output channel signal; the upper data carries the higher (even-numbered) output channel signal. The signal data is 24-bit.

The settings for the **FMCS-1** front-panel headphone output are at the bottom of the Outputs Popup Menu. As for the analog and digital outputs above, one of the fifteen audio signals and four test signals may be chosen for the Left and Right headphone channels. (For normal listening, these sources would almost always be de-emphasized sources—those that included the “(\*)” designation.) Placing the cursor adjacent to “Vol :” on the menu, allows the L- and R-channel headphone volumes to be adjusted as a pair from 1.0% to 100.0% in 1% increments.

### **6.3.3 Network Status Popup Menu**

This menu is accessed through the Unit Settings Popup Menu.

This menu provides information about the addressing of the **FMCS-1** for Internet communications and is read-only. Pressing the encoder knob with “Refresh” highlighted green updates the status indications.

### **6.3.4 Network Configuration Popup Menu**

This menu is accessed through the Unit Settings Popup Menu.

The **FMCS-1** offers either fully automatic Internet device addressing via DHCP, or fully manual address entry.

When “DHCP” in the configuration menu is set to “ON,” the IP Address and the Subnet and Gateway settings are handled automatically. In this case, they all read “<DHCP>”.

With DHCP “OFF,” all network connection settings must be entered manually. At each grouping of numbers in the identifiers for the IP Address and the Subnet and Gateway, the encoder is used to select a number in the range of “0” to “255.” When the process is complete, move the cursor to “Apply” and press the encoder knob. The Status readout at the bottom of the popup menu will indicate the initiation and processing of the update (“Configuring”, “Rebooting”), success or failure and, finally, the connection activity.

### **6.3.5 Email Settings Popup Menu**

This menu is accessed through the Settings Popup Menu.

This menu enables the user to compose and address up to four different e-mail messages alerting the recipient that the **FMCS-1** has sensed an out-of-tolerance condition. The logical conditions which trigger the messages are set in the Alarms/Relay Screen. Several conditions may trigger the same message, but any single condition can trigger only one message.

To be valid, an email message must have a “TO :” and a “FROM :” The “to” portion must contain the recipient’s local address, immediately followed by an ampersat, “@”, and the domain name of the recipients mail server. If present, the structure of the “CC:” line must be the same. Similarly, the “from” must contain the sender’s local address, immediately followed by “@” and the domain name of the sender’s mail server.

**Procedure:** Once the Email Popup Menu is accessed, rotate the encoder knob to select the message number to be created or edited. Pushing the encoder opens a viewing pane for that message. The cursor is initially at “TO :” Pressing the encoder knob opens a composing line, with the 93 valid characters below. Upon entry in the viewing pane, the display cursor is at the “Cursor” position. By highlighting the word “Cursor” in green and rotating the encoder knob, the active position in the composing line, marked by a blinking underscore character, may be moved left or right—with an end-of-line wrap. One typically rotates the encoder knob to move the cursor from the word “Cursor” to select each successive character from the alphabet, and then momentarily depresses the encoder knob. The selected letter appears on the composing line and the underscore moves one space to the right to accept the next character. When the



address is completed, the encoder is rotated to move the cursor past the word “Cursor” to “Done.” Depressing the encoder returns the user to the email viewing screen.

When an alarm condition triggers an e-mail, the text describing the alarm (the descriptive text appearing in the “Event” column of the Alarms/Relay Screen) is appended to whatever text has been previously entered in the “SUBJECT” line of the e-mail by the user. The subject line may be modified to provide a unique identifier of a specific **FMCS-1** or station. Example: “FMCS-1 WXYZ” would result in an e-mail message with the subject line “FMCS-1 WXYZ: Loss of RF(ANT)” in the event of a Loss of RF e-mail alarm. To create a custom subject line, move the cursor to the box below “SUBJECT:” and press the encoder knob to overwrite the initial text. Proceed as in creating the email address lines, above.

All email addresses in the **FMCS-1** email alerting system are limited to 24 characters; subject-lines are limited to 12 characters.

Once the message has been composed, and with a viable Internet connection to a mail server, operation of the system may be tested by moving the cursor the “TEST” at the bottom of the viewing pane and tapping the encoder. The message should be sent. Highlighting the “X” and depressing the knob, or holding down the knob, exits the menu.

### **6.3.6 Information Popup Menu**

This menu is accessed through the Settings Popup Menu.

This screen is read-only, listing the versions of all firmware present on the **FMCS-1**, along with its model name and the manufacturer’s serial number. The unit serial number appearing on the screen should agree with the number embossed on the manufacturer’s identification label on the rear panel.

## **6.4 SCA Popup Menus and SCA Setup**

Operation of both SCA decoders is controlled by a dedicated SCA Popup Menu (“#1” or “#2”). The Popup sub-menus are accessed from the main Popup Menu directory by selecting “SCA” using the encoder.

The user controls for each SCA decoder in the Popup Menu fall under three headings: “BPF”, “DET” and “SET.” These stand for “Band-Pass Filter”, “Detector”, and “Settings”, respectively. BPF sets operating frequency the SCA demodulator and controls the center frequency and bandwidth of the band-pass filter ahead of the demodulator. DET sets the type of SCA demodulation, its de-emphasis and amplitude scaling. SET adjusts the SCA modulation flasher threshold and muting.

Using the rotary encoder, enter the appropriate SCA sub-menu (#1 or #2). Next, under BPF, use the rotary encoder to set “Freq” to the center frequency of the respective SCA carrier in the composite signal. The range is from 41.0 kHz to 92.0 kHz in 0.1-kHz steps. Then, set the bandwidth “BW” of the band-pass filter to an appropriate range for the transmission and receiving conditions. The range is from  $\pm 1.0$  kHz to  $\pm 16.0$  kHz in 1.0-kHz steps, giving pass-bands of 2-kHz to 32-kHz total bandwidth. Finally, to place the adjustable band-pass filter into the signal path before the SCA demodulator, set “Bypass:” to “OFF”.

The bandwidth for the pre-detector SCA band-pass filter will need to be its widest to accommodate SCA signals with the largest FM deviations and those with the highest modulating frequencies. (A rule of thumb for FM transmission is that the required bandwidth is two times the sum of the peak frequency deviation and twice the highest modulating frequency.)

When the SCA band-pass filter is bypassed (“Bypass: ON”), the signal entering the SCA demodulator is limited to a frequency range of  $\pm 20$  kHz each side of the SCA frequency setting, giving a 40-kHz-wide pass-band. This setting provides the highest quality demodulation of the SCA and is the setting normally used for SCA performance testing.

Detection parameters for the SCA decoder are set under DET. The class of modulation applied to the SCA carrier is set by the cursor at the “Mod” position. Other possibilities exist, but nearly all conventional SCA signals are FM modulated. This parameter should be set to “FM” for the vast majority of SCA’s. “Resp” (for “response”) sets the SCA decoder output de-emphasis time constant to match the pre-emphasis time constant applied to the modulating signal in the SCA generator. Using the rotary

encoder, set the “Resp” parameter to “FLAT”, “75US”, or “150US”, depending on the time-constant in use. (In the display, “US” indicates microseconds.)

The “BW,” or bandwidth, parameter is the cutoff frequency of a low-pass filter which follows the SCA detector. The cutoff is set in 1-kHz increments from 1.0 kHz to 8.0 kHz. Unlike the de-emphasis circuitry, this filter limits the bandwidth of the detected SCA signal before it is metered. An appropriate setting would be determined by program content and operating conditions. Lowering the cutoff frequency reduces noise and false indications due to interference, but can also limit signal fidelity.

The “Norm:” parameter adjusts, or normalizes, the sensitivity of the **FMCS-1** SCA decoder so that full modulation of the SCA sub-carrier results in an indication of 100% on the SCA Peak bar graph. The 100% indication on the **FMCS-1** may be set to correspond to FM deviations of the sub-carrier ranging from 1.0 kHz to 7.0 kHz in 100-Hz increments. Use the rotary encoder to set the appropriate deviation.

In addition to the Peak modulation bar graph, the SCA has a peak modulation flasher that may be set to light whenever modulation of the SCA sub-carrier exceeds a user-set percentage. The flasher threshold may be set to light at modulation levels ranging from 1.0% to 150.0%, in 1% increments. The threshold is set by using the rotary encoder to adjust the “Peak:” parameter under the SET heading in the SCA Popup Menu. The peak flasher allows one to gauge system modulation at a glance, or to easily determine when a critical level has been exceeded.

The “Mute:” parameter controls the conditions under which the SCA sub-carrier is demodulated, metered, and sent to the **FMCS-1** outputs. Three settings of the parameter are possible. In “OFF” mode, there is no muting of the SCA decoder—the demodulator runs at the frequency set in the SCA Popup menu. With no sub-carrier present, noise will be present in the audio output. “ON” mode mutes the SCA decoder, whether or not an SCA sub-carrier is present in the composite signal. No modulation indications or audio output occur. However, if an SCA is present on the prescribed frequency, or within the pass-band of the input band-pass filter, the injection level of that SCA appears both on the Main Tuning Screen and the SCA Bargraph Screen. The corresponding green SCA presence indicator on the Main Tuning Screen remains lit as long as the SCA signal that is present exceeds the injection threshold set in the Popup Menu.

In “AUTO”, the modulation metering and audio output for the SCA sub-carrier are active whenever the SCA injection level exceeds the injection threshold set by the “Thres:” (or threshold) parameter. If the injection falls below the threshold, or if the sub-carrier is turned off, the modulation and presence indications are blocked and the audio output is muted. The injection threshold is set with the rotary encoder. The injection range is 0.0% to 25.0% of the full 75 kHz FM peak deviation, set in 0.1% increments. (A full 25% sub-carrier injection is equivalent to 18.75 kHz peak FM deviation of the carrier.) The muting threshold is normally set slightly below the nominal SCA sub-carrier injection level so that momentary fluctuations in level do not cause unintended muting of the SCA demodulator. For operational convenience, AUTO is normally selected when an SCA is in use.

## **7 FMCS-1 Frequency Spectrum Screens**

### **7.1 General**

The **FMCS-1** incorporates a sensitive and accurate DSP-based FFT (Fast Fourier Transform) spectrum analyzer. The output is an X-Y graph showing the relative amplitude of signal energy the vertical (Y) axis as a function of frequency, extending along the horizontal (X) axis. The **FMCS-1** is capable of displaying the frequency spectrum of the FM RF carrier signal, the composite signal (the complete spectrum of the digitally detected FM carrier signal—equivalently the demodulated “baseband signal”), and several of the audio signals detected by the **FMCS-1**. This capability can be a great aid in troubleshooting problems in the transmission system and in verifying system performance.

The three spectrum displays (RF, Composite, and Audio) are controlled by the rotary encoder acting upon both on-screen parameters and parameters appearing in dedicated sub-menus. The six measurement parameters present on the three spectrum screens follow.

## 7.2 On-Screen Spectrum Parameters

The rotary encoder controls each of the three spectrum displays via six on-screen parameters and several additional parameters that appear in a sub-menu specific to each of the spectrum screens. The six measurement parameters common to the three spectrum screens appear across the tops of the three displays and in their lower-right corners. The parameters are listed below.

**dB:** The “dB” parameter, for “decibel”, effectively varies the measurement scale by moving that portion of the signal spectrum visible on the display up and down vertically. The decibel labels along the vertical axis change accordingly. Note that the “decibel-vertical-span”, or the difference between the dB reading at the top of the display and that appearing at the bottom, is not changed by the dB parameter. That span is controlled by the vertical resolution step size, which varies the decibel resolution per pixel and the number of pixels that fall vertically in the display area. The vertical span is adjusted by the “VR” parameter discussed below.<sup>2</sup>

The largest vertical-axis label is +100dB; the minimum vertical-axis label that appears is –150dB. Depending on the “dB” and “VR” parameter settings, one or neither of these two range limits may fall within the range of a given spectrum display.

**VR:** The “VR,” for vertical resolution, is equivalently amplitude resolution of the displayed spectrum. It is the number of decibels assigned to each vertical pixel in the range of the display. It can be set to between 0.1 decibel (dB) and 0.8 decibel-per-pixel, in 0.1-decibel steps.

**C1:** This parameter sets the decibel amplitude (vertical position) of an adjustable yellow horizontal line (“Cursor 1”) running across the display. The C1 cursor is used to help measure the amplitude of signals falling anywhere across the display window. Highlighting C1 with the encoder and rotating the knob positions the amplitude cursor vertically on the spectrum display. Note that if changes in the dB or VR display parameters would result in the C1 cursor falling above or below limits of the vertical scale, the setting for C1 is automatically set to the appropriate vertical axis limit.

**HR:** The “HR,” for horizontal resolution, equivalently is the frequency resolution of the displayed spectrum. It is the number of Hertz (Hz) assigned to each horizontal pixel in the domain of the display. The resolution range is different for each of the three spectral displays. For the RF Spectrum, the range is 50 Hz-per-pixel to 2500 Hz-per-pixel. For the Composite Spectrum, the range is 5 Hz-per-pixel to 250 Hz-per-pixel. The range for the Audio Spectrum is from 1 Hz-per-pixel to 50 Hz-per-pixel. The total frequency range displayed is the product of the number of columns of pixels in the spectrum display, 501, multiplied by the resolution, in Hz-per-pixel.

**C2:** The C2 cursor parameter sets the frequency (horizontal position) of an adjustable yellow vertical line (“Cursor 2”) spanning the height of the display. Adjusting the C2 parameter with the encoder positions the cursor at the precise frequency indicated numerically to the right of “C2:” in the upper-right corner of the display. This helps to determine the frequency of a specific feature of spectrum, or indicates where to look on the display to find an element of the spectrum.

Note that when the C2 cursor is visible, changes to the frequency resolution (“HR”) parameter will automatically adjust the frequency scale to keep the cursor in the center of the display. In order to zoom in or out at a particular frequency, place the C2 cursor at that frequency and adjust the frequency resolution “HR”. The C2 cursor also provides a numerical readout of the spectral amplitude present at the C2 frequency. The numerical value is displayed directly below the C2 parameter in the upper-right corner of the spectrum display. This number corresponds to the Y-axis value of the display.

**kHz:** The “kHz” parameter (for kilohertz), effectively changes the portion of the frequency spectrum that is visible on the display by moving the frequency axis of the display horizontally to the left or to the right. Note that the “frequency-span”, or the difference between the lowest and highest frequencies displayed, is not changed by the kHz parameter. To change the frequency span of the display, adjust the “HR” parameter as required.

The Popup menus for the RF Spectrum and the Composite Spectrum displays are the same with the exception of an RF mask that is available only in the RF display. The Audio Spectrum Popup menu has the same functionality as the other two, with the additional capability of source selection and a dual-channel display.

## 7.3 The Spectrum Popup Menus

Following are the parameters and controls common to the three spectrum popup menus associated with the three FMCS-1 spectrum displays.

<sup>2</sup> The decibel span of the display is set by the product of “VR,” or the voltage ratio parameter, and the 181 horizontal rows of pixels which make up the vertical portion of the X-Y spectrum display.



## **Display Mode**

**Realtime** - The entire spectral display is updated at the completion of each FFT spectrum calculation. The values are RMS.

**Peak Hold** - In each spectral bin, the display holds the largest spectral amplitude occurring during the previous number of FFT computations set by the "Hold Count" parameter. Once displayed, the peak amplitudes in each spectral bin are held until the completion of the next set of FFT computations and update.

**Average** - For each spectral bin, the display computes the average spectral amplitude occurring over the number of FFT computations set by the "Avg Count" parameters. Once displayed, the average amplitudes in each spectral bin are held until the completion of the next set of FFT computations.

**Infinite** - In each spectral bin, the spectral amplitude is replaced by any higher spectral amplitude that occurs in that bin. That higher value is held until a larger amplitude occurs in that bin or until the mode is exited and restarted, whichever occurs first.

## **Hold Count**

The number of FFT's used to calculate the peak-hold spectrum.

## **Avg Count**

This is the number of FFT's used to calculate the averaged spectrum.

## **0 dB Ref Lev (for "0 dB Reference Level")**

This is used to normalize a user-defined dB value to the "0-dB" reference point on the spectrum display. It provides a way of setting an appropriate amplitude reference to which readings may be compared. It ranges from 0.0 dB to -100.0 dB in -0.1-dB steps.

This parameter adjusts the position of the displayed spectrum relative to the display's vertical scale. The adjustment permits precise direct-reading level comparisons between on-screen amplitudes. By adjusting the "0-dB Ref Lev" parameter so the reference signal falls on the C1 cursor, which is set at "0dB", the *relative* amplitude of any other signal on the screen can then be read directly by moving the C1 cursor to the peak amplitude of the other signal. Alternatively, by placing the C2 frequency cursor on the signal in question, the relative numerical amplitude may be read directly at the right end of the display.

If it is desired to compare the level of a low-level signal to that of a larger signal, possibly using the C1 cursor, one first determines the amplitude of the larger signal using the C1 cursor. By setting the "0-dB Ref Lev" to this amplitude using the encoder, the signal spectrum will shift up so the "0 dB" label on the vertical axis will be directly across from the vertical position of the desired reference signal. Readings on the vertical axis for other signals will then directly indicate the amplitude relative to the desired reference signal.

## **Curve Fill**

When Curve Fill is "ON," that portion of the vertical display between the bottom of the spectrum graph and the measured amplitude for each bin is lit in green. This makes the amplitude indication more obvious. When Curve Fill is "OFF", the amplitude indications consist of a single lighted pixel in each frequency bin.

## **Colors**

When "OFF", all spectrum displays are indicated and filled in green. When "ON", specific portions of the display are color-coded.

## **7.4 RF Spectrum Screen**

The RF Spectrum Screen provides spectral displays of the FM RF carrier signal. The frequency axis indicates "0" at the carrier frequency as set on the Main Tuning Screen. RF frequencies less than the carrier appear on the negative-axis portion of the display; frequencies greater than the carrier appear on the positive portion of the axis. The maximum frequency span that may be displayed is 1.25 MHz, but the RF center frequency may be shifted off-center to enable views as far as 875 kHz to either side of the carrier. Horizontal frequency resolution of the Composite Spectrum Screen is from 50 Hz-per-pixel to 2500 Hz-per-pixel.

### **7.4.1 RF Spectrum Controls**

These are listed in Section 7.2, "On-Screen Spectrum Parameters", beginning on page 22.

### **7.4.2 RF Spectrum Popup Menu**

Note: The RF Spectrum Popup Menu is partially described in Section 7.3, "The Spectrum Popup Menus", beginning on page 22. It is similar to the Composite Spectrum and Audio Spectrum Popup Menus, but with the addition of the NRSC-standard IBOC-HD (In-Band, On-Channel, High-Definition) RF spectrum mask, described below.

The RF Spectrum Popup Menu is selected by pressing in and holding down the encoder knob until the Popup Menu directory appears, selecting and entering "Spectrum," then selecting "RF," and finally pressing the encoder knob again to enter.

The parameters specific to the RF Spectrum Popup Menu and their properties are:

**Mask:** When "ON", outlines the maximum allowed radiation spectrum of the FM IBOC-HD signal on the RF Spectrum with a red-line overlay.<sup>3</sup> When "OFF," no spectral limitation overlay appears on the display.

**Measurements:** When "ON," this feature is intended to activate additional RF measurement functions

## **7.5 Composite Spectrum Screen**

The composite signal is the combination of component signals that FM-modulate the carrier in a modern FM broadcast signal: the DSB-encoded FM-stereo audio signal, the stereo pilot, possibly the RBDS, and one or more SCA signals. The Composite Spectrum Screen displays the frequency spectrum of this signal combination as it emerges from the digital FM demodulator in the **FMCS-1**. The maximum range of the display is nominally from 0 Hertz to 125 kHz. Horizontal frequency resolution of the Composite Spectrum Screen is from 5 Hz-per-pixel to 250 Hz-per-pixel.

Under normal program conditions, this display can reveal undesirable spectral overlap of the component signals and improper amplitude relationships between them. Under test conditions, tone modulation and special test signals can quickly reveal flaws in the generation and transmission of the FM broadcast signal.

### **7.5.1 Composite Spectrum Controls**

The Composite Spectrum Screen offers the same six user-adjusted parameters listed in Section 7.2, "On-Screen Spectrum Parameters", beginning on page 22.

By using the "HR" and "kHz" parameters, the operator can select frequency regions of the composite signal to examine—either the entirety or portions of the L+R signal, the stereo pilot, the L–R signal, the RDS signal, and any SCA carriers present.

### **7.5.2 Composite Spectrum Popup Menu**

Note: The Composite Spectrum Popup Menu is partially described in Section 7.3, "The Spectrum Popup Menus", beginning on page 22. It is similar to the RF Spectrum and Audio Spectrum Popup Menus, but lacks the RF spectrum mask.

This Popup Menu is selected by pressing in and holding down the encoder knob until the Popup menu directory appears, selecting and entering "Spectrum", then selecting "Composite", and finally pressing the encoder knob again to enter.

The parameters specific to the Composite Spectrum Popup Menu and their properties are:

**Color:** When "OFF", all spectrum displays are indicated and filled in green. When set to "ON", specific portions of the composite signal spectrum are highlighted in red, green, and yellow. "AUTO" is intended to automatically sense and indicate the presence of the different components of the spectral display.

**Measurements:** When "ON", this feature is intended to activate additional measurement functions.

## **7.6 Audio Spectrum Screen**

This screen displays the frequency spectrum of audio signals recovered from the FM broadcast signal by the **FMCS-1**. The stereo pilot and four internally generated test signals are also available for display. Three of the test signals are pure 1-kHz sine waves of various levels; the fourth is a null signal. The maximum frequency span of the display is 0 Hz to 22,100 Hz; the largest frequency-axis marker is "24 kHz." Horizontal frequency resolution of the Audio Spectrum Screen ranges from 1 Hz-per-pixel to 50 Hz-per-pixel.

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<sup>3</sup> This spectral mask is defined in the NRSC-5-B hybrid FM IBOC noise and emission limit graph in document NRSC-G201-A, available from the [www.nrsstandards.org](http://www.nrsstandards.org) web-site.

The audio program signals available for frequency analysis are the demodulated L, L(\*), R, R(\*), L+R, L+R(\*), L-R, L-R(\*), SCA#1, and SCA#2 signals. Here, and in the **FMCS-1** on-screen sub-menu, "(\*)" indicates either the 50-microsecond or 75-microsecond de-emphasized version of the signal. (The de-emphasis time-constant is set in the Unit Settings Popup Menu.) The SCA#1 and SCA#2 signals displayed are filtered according to the SCA detector response and bandwidth settings.. The pilot signal may also be displayed in the Audio Spectrum Screen for observation of its fine detail.

The three test signals are 1-kHz single-frequency tones at the relative levels of 0dB, -3dB, and -6dB. Each may be independently displayed and directed to the **FMCS-1** outputs via the Output Settings Popup Menu for testing of external audio circuits. The "MUTE" signal may also be activated to check the noise floor of the Audio Spectrum Screen, as well as to provide a quiet source for testing of external equipment.

The audio spectrum display is useful to confirm transmission of the full audio bandwidth of stereo program signals and proper band-limiting of SCA signals. Many anomalies in frequency response would also become apparent with long-duration "Average" or "Peak Hold" displays of program material or with a broadband noise test source..

### **7.6.1 Audio Spectrum Controls**

The Audio Spectrum Screen offers the same six user-adjusted parameters listed in Section 7.2, "On-Screen Spectrum Parameters", beginning on page 22.

By using the "HR" and "kHz" parameters, the operator can select the entire spectrum or a portion of the spectrum of any of the signals available for frequency analysis.

### **7.6.2 Audio Spectrum Popup Menu**

This Popup Menu has the same user-controlled parameters described in Section 7.3, "The Spectrum Popup Menus", on page 22, but lacks the RF mask feature. Two additional user-controlled parameters available in the Audio Spectrum Popup Menu are:

**Input Type:** When set to "Single", provides one spectral display of one audio source in the **FMCS-1** window. When set to "Double", splits the **FMCS-1** display screen into two sections (left-side and right-side) presenting two audio spectrums simultaneously.

**Input #1:** Allows the encoder to select from the list of audio sources (listed above) for spectral display when operating in the "Single" mode, or selects the source for the left-hand spectral display when operating in the "Double" mode.

**Input #2:** Allows the encoder to select from the list of audio sources for the right-hand spectral display when operating in the "Double" mode. Otherwise, it is non-functional.

**Color:** When "OFF," all spectrum displays are indicated and filled in green. When set to "ON," specific portions of the audio signal are highlighted in red, green, and yellow. "AUTO" is intended to automatically sense and indicate the presence of the different components of the audio spectral display.

**Measurements:** When "ON," this feature is intended to activate additional measurement functions.

## **8 List of Definitions**

### **8.1 Definitions**

#### **μV, UV**

Equivalently, microvolt(s). A microvolt is the root-mean-square voltage of an RF signal, in millionths of a volt. One microvolt is the equivalent of -108.8dBm on a 75Ω system, or -107dBm on a 50Ω system. A "mVrms", or millivolt RMS, is 1000 times a microvolt. A millivolt RMS is -48.8dBm on a 75Ω system, or -47dBm on a 50Ω system.

#### **AES/EBU**

Refers to the Audio Engineering Society/European Broadcast Union standard for transmission of two channels of digital program signals over matched transmission lines. In the case of the **FMCS-1**, the designation refers to AES-3ID, a variation of the standard for transmission over 75Ω coaxial cables.

### **AM Noise**

The level of amplitude modulation present on the FM carrier, de-emphasized with a 75-microsecond time constant, and referenced to 100% AM of the carrier. This reading provides, principally, an indication of the presence of power-supply-induced AC ripple on the envelope of the FM carrier. Modern transmitters typically attain an AM noise level more than 60dB below 100% AM.

Synchronous AM noise is a similar AM indication, but measured without de-emphasis. At the frequency extremes of carrier swings, FM transmission system bandwidth limitations will induce momentary attenuation of the RF carrier that occurs synchronously with the FM modulation. Synchronous AM noise readings quantify this effect. Both these readings appear on the “DB Readings Screen”. (See Section 5.2, on page 11.)

### **Average (AVG)**

For DC signals, the voltage value of a signal integrated over a specified interval of time. In the case of AC signals, the absolute value of a signal voltage integrated over a specified time interval. Because of the importance of maintaining modulation levels in broadcasting, the **FMCS-1** indicates *average modulation* as the averaged value of modulation peaks collected over a user-set time interval.

### **Composite**

This is short for “composite signal.”

The composite signal is the combination of component signals that FM-modulate the carrier in a modern FM broadcast signal: the DSB-encoded FM-stereo audio signal, the stereo pilot, possibly the RBDS (RDS), and one or more SCA signals. It may refer to the signal combination as it enters the FM exciter, before transmission, or the recovered signal combination emerging from a broadband FM demodulator, before its separate its components are processed.

### **Decibel**

Formally, a decibel is the power ratio of two signals based on a logarithmic scale. Decibels, or dB, may be equivalently expressed as ratios of the corresponding signal voltages or currents.

$$dB = 10 \log_{10} \left\{ \frac{P_2}{P_1} \right\} = 20 \log_{10} \left\{ \frac{V_2}{V_1} \right\} = 20 \log_{10} \left\{ \frac{I_2}{I_1} \right\}$$

### **De-Emphasis**

Because FM transmission is susceptible to high frequency noise, special high-frequency attenuation, referred to as de-emphasis, is applied to the detected signals at FM receivers. To compensate for this high-frequency attenuation at the receiver, high frequencies in the program signal are boosted prior to transmission. This is referred to as “pre-emphasis.” By making the pre-emphasis and de-emphasis processes fully complementary, high-frequency noise is suppressed at the receiver without compromising the fidelity of the received signal.

In the **FMCS-1**, the low-pass filtering (a mathematical integration process) of the monaural, stereo or SCA audio signals precisely compensates for the pre-emphasis of these signals at the transmitter. The de-emphasis time-constant (i.e. 50-microsecond, 75-microsecond, or 150-microsecond) refers to the resistor-capacitor-value product that sets the break frequency of the corresponding R-C low-pass filter.

### **DDC**

Digital down-conversion. A digital signal processing technique whereby a digitally sampled RF or IF signal is converted to a baseband signal in I and Q form.

### **DSB-SC**

DSB-SC stands for “double-sideband suppressed-carrier.” This is the method of amplitude modulation of the L-R (or “difference”) audio information in the FM-stereo broadcast signal.

### **DHCP**

Dynamic Host Configuration Protocol. A means by which addressing and communications are automatically established on the Internet.

### **DSP**

An abbreviation for “digital signal processing” which may be used as a methodology (a noun) or an adjective.

### **Dynamic**

Refers to signals that are changing irregularly in time.

### Ethernet

A communications technology for connecting computers over local area networks. It is described in IEEE Standard 802.3. The **FMCS-1** offers the common 10/100 Base-T/TX technology.

### FFT

Stands for “Fast Fourier Transform.” This is a technique used in digital signal processing that greatly reduces the amount computation necessary to calculate the spectrum of a signal sample.

### IBOC

Refers to the USA-based iBiquity™ system for “in-band-on-channel” combined analog and digital FM transmission. IBOC FM transmission is sometimes referred to as “HD,” for high-definition.

### Injection

The “injection” of a signal is that modulation of the FM carrier caused by the signal’s presence as part of the complete baseband signal modulating the FM carrier. It typically refers to the modulation due to the lesser, sine-wave-like components of the baseband signal, such as the Pilot, or RDS and SCA sub-carriers. It may be measured in percent or in kHz-peak-deviation.

### IF

This stands for “intermediate frequency.” Since the **FMCS-1** uses direct sampling of the FM RF Carrier, there is no IF and the output of the tuner is the same RF as the input, only amplified.

### LAN

This stands for “local-area network.” The **FMCS-1** bases its LAN communications on the 10/100-Base-T/TX standard.

### L+R

The sum of the left and right channel audio signals in an FM Stereo signal. The L+R fills the portion of the composite signal below 15 kHz. It is sometimes referred to as the “main channel.”

### L-R

The difference between the left and right channel audio signals in an FM Stereo signal. It is multiplied by a 38-kHz sine wave to generate the stereo sub-channel of the composite signal. The stereo sub-channel, or “difference channel,” falls between 23 kHz and 53 kHz in the composite signal. “L-R” is also used to refer to the modulated difference channel.

### LVDS

Low-voltage differential signaling. This is a standard distribution system for high-speed data over multiple copper twisted pairs.

### MAC

Stands for Media Access Control. The MAC address is relevant to physical-layer communications between the Ethernet and IP realms.

### NRSC

The National Radio Standards Committee, which is a non-governmental radio broadcast standards organization functioning in the United States.

### Peak

The maximum instantaneous value of a waveform, whether modulation, voltage, or current. In the **FMCS-1**, signal peaks are the maximum *absolute values* of a waveform.

### PC

Personal computer.

### Pilot

The 19-kHz sine-wave component of the broadcast composite FM Stereo signal used to synchronize demodulation of the L-R sub-channel at FM receivers. On the **FMCS-1**, the pilot signal is obtained by band-pass filtering the composite signal after its recovery by the FM demodulator.

### Pre-emphasis

The emphasizing of higher audio frequencies of the stereo and SCA audio signals at the transmitter employed to improve the signal-to-noise ratio of the signals recovered at the receiver. This is a signal-differentiating process with a defining time-constant that sets the break frequency for the rising filter response. (See “De-Emphasis”, above.)

### **RF**

Referring to “radio frequency”, either as an adjective, or as a noun

### **RMS**

Root-mean-square. The power-equivalent of a voltage or current signal

### **SNR, S/N**

Signal-to-noise ratio: the power ratio of a signal to the noise present in the same channel. SNR is usually expressed in decibels.

### **Stereo Sub-Carrier**

The second harmonic of the 19-kHz pilot signal which is modulated by the L–R difference audio signal to form the stereo sub-channel. It is also the 38-kHz signal regenerated from the pilot signal, which is used to demodulate the stereo sub-channel at the receiver.

### **Wideband**

This adjective refers to the frequency span of the pass-band for band-pass or low-pass signals. It suggests the widest practical pass-band for a signal. For low-pass signals, it also implies the un-de-emphasized, or “flat” version of the signal.

## **9 Tables**

### **9.1 Table 1 – FMCS-1 DISPLAY SCREENS**

Screens marked with an asterisk (“\*”) contain user-adjustable parameters.

- Main Tuning Screen\*
- dB Readings Screen
- Stereo Bargraph Screen
- SCA Bargraph Screen
- Total dB Bargraph Screen
- Separation Bargraph Screen
- Crosstalk Bargraph Screen
- RF Spectrum Screen\*
- Composite Spectrum Screen\*
- Audio Spectrum Screen\*
- RDS Basic Data Screen
- Alarms/Relay Screen\*

## 9.2 Table 2 – FMCS-1 POPUP MENU MAP

Defaults are listed first, if appropriate.

<b>Popup Heading</b>	<b>Selections</b>	<b>Popup Options</b>
RF	Input Select	Antenna High Level
	Tuning	87.3 to 108.1 MHz, in 0.1-MHz steps (94.5 MHz default setting)
	Calibrator	OFF ZERO Mono 1kHz Left 1kHz Left 5kHz Left 10kHz Left 15kHz SCA 67 92 Zero SCA 67 92 Mod
	Attenuator	0.0 to 31.5dB, in 0.5-dB steps (0.0dB default value)
	Filter	Wideband HD -25dB MP1 HD -25dB MP3 HD -50dB MP1 HD -50dB MP3
	Mute	AUTO OFF ON
	Filter BW	Stereo + 92kHz Wideband Stereo + RDS Stereo + 67kHz
	Peak Mod	0.0 to 150.0%, in steps of 0.1% (100.0% default value)
	(For both SCA demodulators #1 and #2)	
	BPF Bypass:	OFF ON
SCA	BPF Freq:	41.0 to 92.0kHz, in 0.1-kHz steps (67.0kHz default for SCA #1, 92.0kHz default for SCA #2)
	BPF BW:	0.0kHz to 16.0kHz, in 0.1-kHz steps (16.0 kHz default value)
	DET Mod:	FM NONE
	DET Resp:	150 US FLAT 75 US
	DET BW:	0.0kHz to 8.0kHz in 0.1-kHz steps (8.0kHz default value)
	DET Norm:	0.0kHz to 7.0kHz in 0.1-kHz steps (6.0kHz default value)
	SET Peak:	0.0% to 150.0% in 0.1% steps (100.0% default value)
	SET Mute:	AUTO OFF ON
	SET Thres:	0.0% to 25.0% in 0.1% steps (5.0% default value)
	RF Spectrum	Display Mode: Realtime Peak Hold Average Infinite Hold Count: 1 to 100 (10 default value) Avg Count: 1 to 100 (50 default value) 0 dB Ref Lev: -100.0 dB to 0.0 dB (+0.0 dB default value) Curve Fill ON OFF



# FMCS-1 ALL-IN-ONE FM MODULATION MONITOR

Popup Heading	Selections	Popup Options
	Composite Spectrum	Colors:
		ON
		AUTO
		OFF
		Mask:
		OFF
		ON
		Measurements:
		OFF
	Audio Spectrum	Display Mode:
		Realtime
		Peak Hold
		Average
		Infinite
		Hold Count:
		1 to 100
		(10 default value)
		Avg Count:
		1 to 100
Settings	Unit	(50 default value)
		0 dB Ref Lev:
		-100.0 dB to 0.0 dB
		(+0.0 dB default value)
		Curve Fill
		ON
		OFF
		Colors:
		ON
		AUTO
		OFF
		Measurements:
		OFF
		Input Type:
		Single
		Dual
		Input #1:
		L, L(*), R, R(*), L+R, L+R(*), L-R, L-R(*), SCA#1, SCA#2, Pilot, TST 0, TST -3, TST -6, Mute
		Input #2:
		Mute, L, L(*), R, R(*), L+R, L+R(*), L-R, L-R(*), SCA#1, SCA#2, Pilot, TST 0, TST -3, TST -6
		Display Mode:
		Realtime
		Peak Hold
		Average
		Infinite
		Hold Count:
		1 to 100
		(10 default value)
		Avg Count:
		1 to 100
		(50 default value)
		0 dB Ref Lev:
		-100.0 dB to 0.0 dB
		(+0.0 dB default value)
		Curve Fill
		ON
		OFF
		Colors:
		ON
		AUTO
		OFF
		Measurements:
		OFF
		Time Mode:
		Past
		Real
		Hold Time:
		0.25 sec. to 5.0 sec. in 0.5 sec steps
		(0.5 sec default)
		Infinite:
		OFF
		ON
		Units:
		% (percent)
		kHz
		De-Emphasis:
		75 usec
		50 usec
		Filter Resp:
		Normal
		Extended
		Remote:
		ON
		OFF
		Screen Saver:
		OFF
		1hr to 12 hours in 1-hour steps (1 hr. default)
		Reset Defaults
		Reboot

# FMCS-1 ALL-IN-ONE FM MODULATION MONITOR

Popup Heading	Selections	Popup Options
	Outputs	Analog (defaults listed) Ch#1: L(*); Ch#2: R(*); Ch#3: L+R(*); Ch#4: L-R(*); Ch#5: SCA#1 Ch#6: SCA#2 Ch#7: Pilot Ch#8: Mute  AES/EBU (defaults listed) Ch#1: L(*); Ch#2: R(*); Ch#3: L+R(*); Ch#4: L-R(*); Ch#5: SCA#1 Ch#6: SCA#2 Ch#7: Mute Ch#8: Mute  Each channel above can be assigned any of the following signals: L, L(*), R, R(*), L+R, L+R(*), L-R, L-R(*),SCA#1, SCA#2, Pilot, TST 0, TST -3, TST -6, and Mute  Headphone Volume 0.0% to 100.0% in 1% steps (10.0% default)  Headphone L: L(*) R: R(*) Each headphone channel above can be assigned any one of the following signals: L, L(*), R, R(*), L+R, L+R(*), L-R, L-R(*),SCA#1, SCA#2, Pilot, TST 0, TST -3, TST -6, and Mute.
	Network	Status: MAC: 00 : 20 : 4A : D5 : 36 : 73 Host: IP Addr: Subnet: 255.255.0.0 Gateway: DHCP: ON The above are read out only and represent the defaults.  Refresh (Depress encoder knob to refresh readout.)  Configure: IP Addr: 0. 0. 0. 0 Subnet: 255.255.0.0 Gateway: 0. 0. 0. 0 DHCP: ON, OFF  Apply (Depress encoder knob to apply settings.)
Email		(For each of email alarm messages 1 through 4.)
TO:		(an SMTP address of a series of 94 possible characters, 24 characters in length)
CC:		(an SMTP address of a series of 94 possible characters, 24 characters in length)
FROM:		(an SMTP address of a series of 94 possible characters, 24 characters in length)
	SUBJECT:	A series of 12 characters which form the alarm message.
	TEST:	Placing the cursor on "TEST" and depressing the knob sends the message to test its operation without an alarm actually occurring.
Info		Readout only. Lists all firmware versions, the unit model, description and Serial number.

## 9.3 Table 3 – FMCS-1 Alarms/Relay Screen Defaults and Ranges

FMCS-1 Default Frequency: 94.5 MHz						Default RF Attenuation: +0.0dB	
Event	Default Values					Range of Adjustment	
	Threshold	Time (secs)	Relay	E-mail	Display	Threshold	Time (secs)
Loss of RF (Antenna)	-40.0dB	10	N	N	N	-80.0dB to -10.0dB	1 to 600
Loss of RF (High-Level)	50.00%	10	N	N	N	0.0% to 100.0%	1 to 600
High AM Noise	-40.0dB	10	N	N	N	-80.0dB to -20.0dB	1 to 600
High SYNC AM	-30.0dB	10	N	N	N	-80.0dB to -20.0dB	1 to 600
Loss of Total	10.00%	10	N	N	N	0.0% to 100.0%	1 to 600
Total Peak LED	100.00%	10	N	N	N	0.0% to 150.0%	1 to 600
Loss of L+R	25.00%	10	N	N	N	0.0% to 100.0%	1 to 600
Loss of Pilot	5%	10	N	N	N	0.0% to 15.0%	1 to 600
Loss of RDS	2.00%	10	N	N	N	0.0% to 10.0%	1 to 600
Loss of RDS SYNC	N/A	10	N	N	N	N/A	1 to 600
Loss of SCA#1	5.00%	10	N	N	N	0.0% to 25.0%	1 to 600
SCA#1 Peak LED	100.00%	N/A	N	N	N	0.0% to 150.0%	—
Loss of SCA#2	5.00%	10	N	N	N	0.0% to 25.0%	1 to 600
SCA#2 Peak LED	100.00%	N/A	N	N	N	0.0% to 150.0%	—



# **Broadcast Equipment**

## **SECTION TWO: USER'S GUIDE**



**BELAR ELECTRONICS LABORATORY, INC.**



## 10 General Information

### 10.1 Description

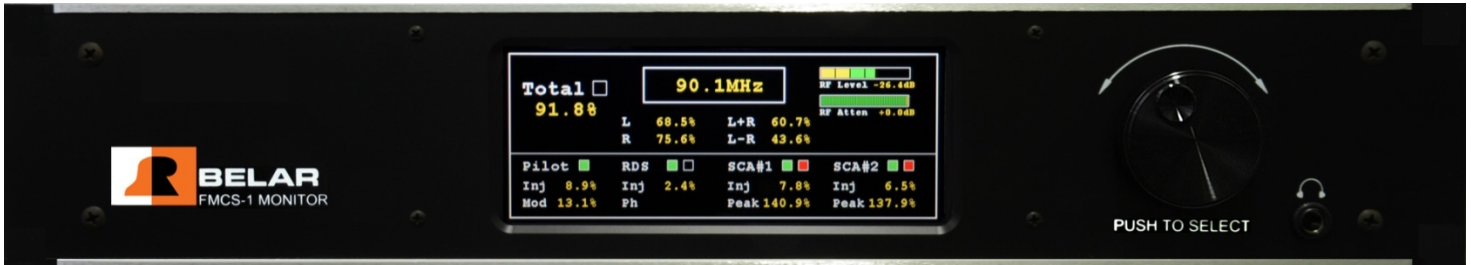
The **FMCS-1** provides a complete solution for the Analog portions of the FM signal. The unit combines the features and functions of an RF amplifier, FM demod, stereo demod, RDS decoder, SCA decoder, and FFT spectrum analyzer in one product. Using state of the art DSP techniques all of the **FMCS-1** processing takes place in the digital domain, this results in FM analog performance that was previously not possible.

### 10.2 Features

- Frequency Agile RF input
- AM & Sync AM Noise measurements
- HD RF carrier rejections filters to improve analog readings in the presence of HD carriers.
- FM Demodulation with 100dB 75  $\mu$ sec SNR
- Variable Bandwidth Composite Filtering
- Stereo Demodulation with 100dB L/R Separations
- Full metering of Analog Peak and RMS values
- RDS Injection/Phase and Full Data decoding
- Two SCA Decoders
- RF, Composite, and Audio FFT Spectrum Analysis
- RJ-45 Ethernet Interface with remote PC software



### 10.3 Front Panel

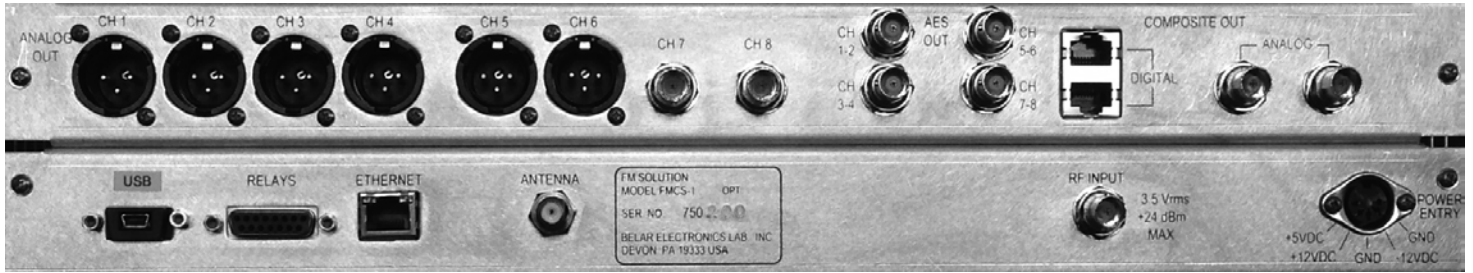


The **FMCS-1** front panel consists of a 640x240-pixel color LCD display, a rotary encoder with push switch and a headphone jack. To change screens rotate the encoder, to select a screen and change any available parameters push on the knob. Once a screen is selected use the cursor to select the parameters on a given screen, to change a parameter select and click on it. Selected parameters change from yellow to green. When finished, click again to return to the cursor for that screen, to exit the screen select the  $\blacklozenge$  icon and click it. The encoder now returns to changing screens.

To access the popup menus press and hold down the encoder for 2 seconds. To navigate the popup menus rotate the encoder to highlight a menu choice and click the encoder. To exit the pop menu at any time, hold down the encoder for 2 seconds.

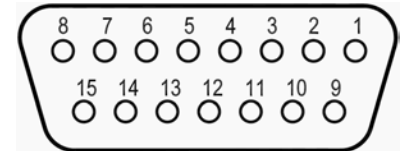
The headphone jack is assignable to any available audio source. To assign the left and right channels see the Outputs popup menu under Settings.

## 10.4 Rear Panel



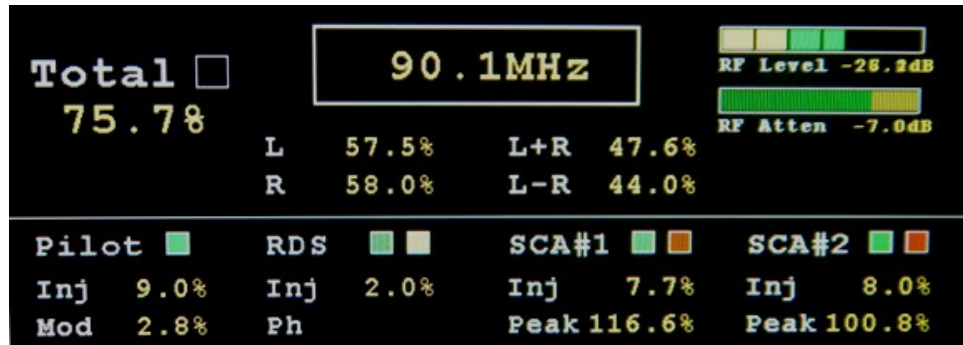
<b>High Level RF Inputs.....</b>	87.5 to 108.0 MHz, 0.5 to 5.0 Vrms, 50Ω, BNC connector
<b>Antenna Input.....</b>	87.5 to 108.0 MHz, 100μV sensitivity, 75Ω, F connector
<b>Analog Composite Outputs .....</b>	1.5 Vrms @ 100% = 75 kHz deviation, 75Ω, BNC connector
<b>Digital Composite Outputs .....</b>	LVDS encoded SCLK, FS, and SDATA, RJ-45 connector
<b>AES-3ID Outputs .....</b>	AES encoded audio, 1.0Vpk-pk, 75Ω, BNC connector
<b>Analog Audio Outputs .....</b>	+10dBm, 600Ω balanced, XLR connector
<b>USB Port .....</b>	USB Mini-B Male
<b>Ethernet Connector.....</b>	RJ-45
<b>Remote Alarm Connector.....</b>	Female, 15 pin D connector,
.....	Form C Relay contacts rated at 10W max, 0.5A max, 200 VDC max.

PIN #	Relay #	Description	PIN #	Relay #	Description
1	1	CM	8	3	NC
2	1	NC	9	3	NO
3	1	NO	10	4	CM
4	2	CM	11	4	NC
5	2	NC	12	4	NO
6	2	NO	13-15	N/A	N/A
7	3	CM			



## 11 Main Screens

### 11.1 Main Tuning Screen



#### SCREEN DISPLAY DATA

<b>Total Peak Indicator:</b>	Total Peak Modulation
<b>Pilot Presence Indicator:</b>	Pilot Tone Presence
<b>RDS Presence Indicator:</b>	RDS Carrier Presence
<b>RDS Sync Indicator:</b>	Indicates the RDS decoder has synced to the RDS data stream as is decoding data
<b>SCA#1 Presence Indicator:</b>	SCA#1 Carrier Presence
<b>SCA#1 Peak Indicator:</b>	SCA#1 Peak Modulation
<b>SCA#2 Presence Indicator:</b>	SCA#2 Carrier Presence
<b>SCA#2 Peak Indicator:</b>	SCA#2 Peak Modulation
<b>Total, Left, Right, L+R, L-R:</b>	Peak Modulation Data
<b>Pilot Injection, Pilot Modulation:</b> Pilot Injection Level, Pilot Modulation represents the AM modulation present on Pilot. This is an indication of off-the-air reception quality or multi-path.	

**RDS Injection:** RDS Injection Level

**SCA#1 Injection, SCA#1 Peak, SCA#2 Injection, SCA#2 Peak:** SCA Injection Level, SCA Peak Modulation is normalized to 100% to a selectable 1.0-7.0 kHz deviation.

**RF Level:** Indicates signal strength in dB for Antenna input, or percent of full scale input level for High Level inputs. To adjust the RF input level, use the RF attenuator to bring the signal into the green region for proper operation. For both High Level and Antenna Inputs the RF Level indicates yellow for low signal level values, green for normal levels, and red for overload levels.

#### SCREEN SELECTABLE DATA

*To select a parameter click on the screen, then use the cursor to select the parameter using the knob, and click again. Adjust the parameter using the knob and click to set the new value.*

*To exit this screen, select the screen icon (in the upper right corner of the screen) and push the rotary encoder dial to exit the screen command mode and return to the screen selection mode.*

**Tuning Frequency:** Selects the Tuning frequency of the FMCS-1 in 100 kHz steps. The unit tunes to the new frequency as the frequency is changed.

**RF Attenuator:** Adjusts RF input attenuator in 0.5dB steps from 0.0 to -31.5dB of attenuation. There are separate attenuators from the High Level and Antenna Inputs.

## 11.2 dB Readings Screen

RF Level	-42.2dB	Total	-102.8dB	-102.8dB
AM Noise	-35.3dB	Pilot	-150.0dB	
SYNC Noise	-14.2dB	38 kHz	-150.0dB	
		L	-150.0dB	-150.0dB
		R	-150.0dB	-150.0dB
		Sep	+0.0dB	
		L+R	-150.0dB	-150.0dB
		L-R	-150.0dB	-150.0dB
		XTalk	+0.0dB	

The dB readings screen contains all the dB RMS readings performed in the FMCS-1, the readings in white are de-emphasized, the yellow readings are flat or wideband.

### SCREEN DISPLAY DATA

**RF Level:** Depending on which RF Input is selected displays the dB level at the A/D Input, the input begins overloading at +3.0dB.

**AM Noise:** AM modulation present on the FM carrier, this reading is de-emphasized by definition.

**SYNC Noise:** AM modulation present on the FM carrier, this reading is wideband.

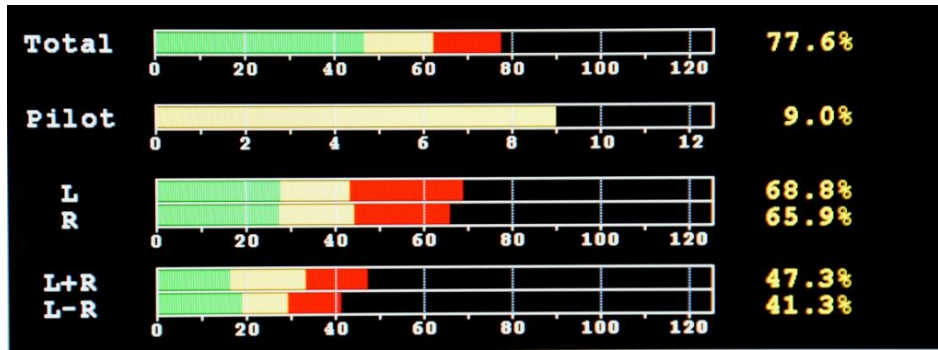
**Total, Pilot, 38 kHz, L, R, L+R, L-R:** All readings are referenced to 0dB = 100% modulation or 75 kHz deviation.

**Sep, XTalk:** Separation and Crosstalk readings are the difference between the flat Left and Right, or L+R and L-R readings.

### SCREEN SELECTABLE DATA

None

## 11.3 Stereo Bargraph Screen



### SCREEN DISPLAY DATA

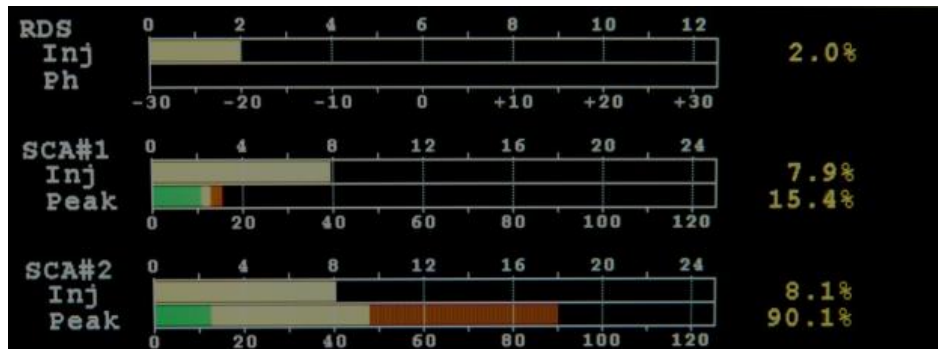
**Total, Pilot, Left, Right, L+R, and L-R:** Peak Modulation bar graphs display the Peak (Red), Average (Yellow), and Min (Green) modulation data.

All readings are referenced to 100% at 75 kHz deviation.

### SCREEN SELECTABLE DATA

None

## 11.4 SCA Bargraph Screen



### SCREEN DISPLAY DATA

**RDS Injection:** RDS subcarrier injection as measured thru a 57 kHz BPF.

**SCA#1 & SCA#2 Injection:** SCA Injections are measured thru a user selectable variable bandwidth BPF; see SCA in the popup menus for settings.

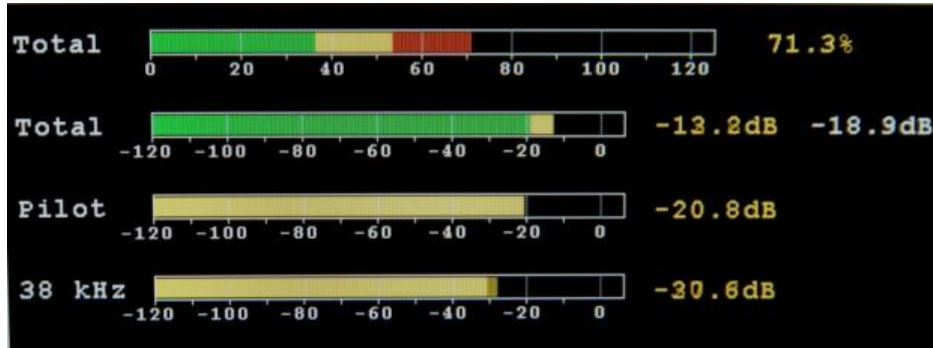
**SCA#1 & SCA#2 Peak:** SCA Peak Modulation bar graphs display the Peak (Red), Average (Yellow), and Min (Green) modulation data. All readings are referenced to 100% at a user specified deviation which is adjustable from 1.0 to 7.0 kHz. See the SCA popup menu.

All Injection readings are referenced to 100% at 75 kHz deviation.

### SCREEN SELECTABLE DATA

None

## 11.5 Total dB Bargraph Screen



### SCREEN DISPLAY DATA

**Total Modulation:** Total Peak Modulation bar graph displays Peak (Red), Average (Yellow), and Min (Green) modulation data.

**Total dB:** Total dB bar graph displays Flat (Yellow) and De-Emphasized (Green) dB RMS data.

**Pilot dB:** Pilot dB bar graph displays the dB RMS value as measured thru the 19 kHz pilot BPF.

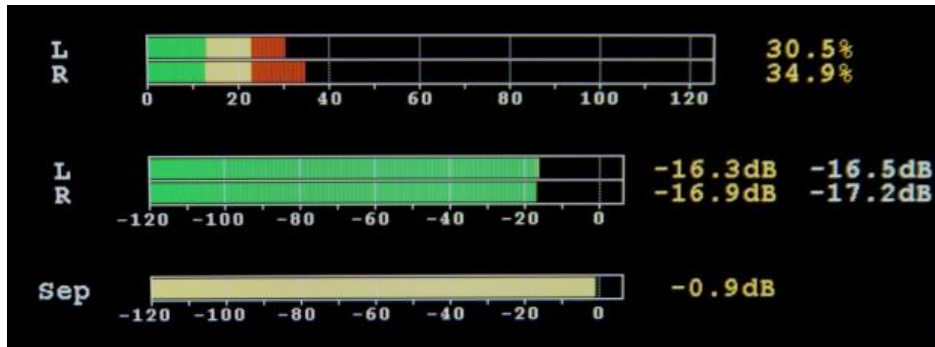
**38 kHz dB:** 38 kHz Subcarrier dB bar graph displays the dB RMS value as measured thru the 38 kHz subcarrier suppression BPF.

All readings are referenced to 100% or 0.0dB at 75 kHz deviation.

### SCREEN SELECTABLE DATA

None

## 11.6 Separation Bargraph Screen



### SCREEN DISPLAY DATA

**Left & Right Modulation:** Peak Modulation bar graph displays Peak (Red), Average (Yellow), and Min (Green) modulation data.

**Left & Right dB:** dB bar graph displays Flat (Yellow) and De-Emphasized (Green) dB RMS data.

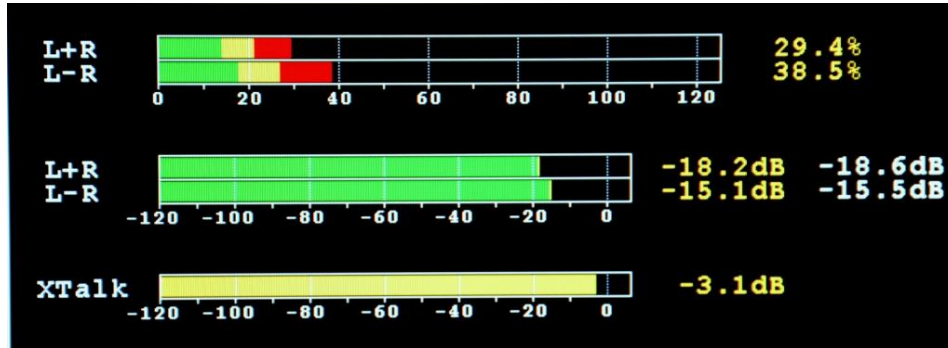
**Separation dB:** Separation dB bar graph displays the dB RMS value of the difference between the Left and Right Flat dB values. The measurement assumes the larger signal is the wanted channel verse the lesser unwanted channel and represents the stereo separation.

### SCREEN SELECTABLE DATA

None



## 11.7 Crosstalk Bargraph Screen



### SCREEN DISPLAY DATA

**L+R & L-R Modulation:** Peak Modulation bar graph displays Peak (Red), Average (Yellow), and Min (Green) modulation data.

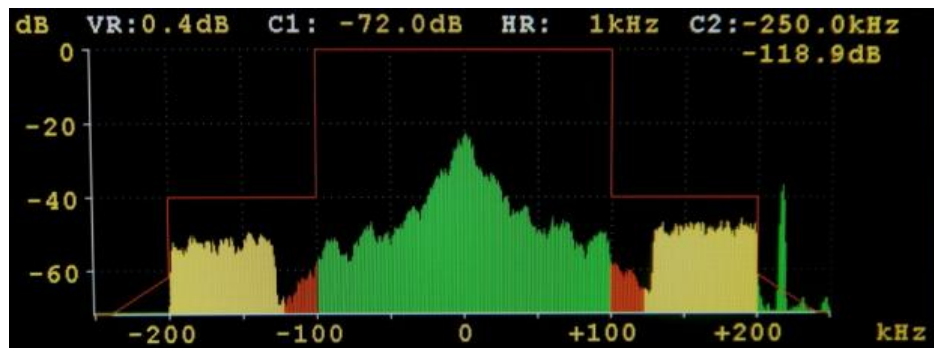
**L+R & L-R dB:** dB bar graph displays Flat (Yellow) and De-Emphasized (Green) dB RMS data.

**Crosstalk dB:** Crosstalk dB bar graph displays the dB RMS value of the difference between the L+R and L-R Flat dB values. This measurement assumes the larger signal is the wanted channel verse the lesser unwanted channel and represents the stereo crosstalk.

### SCREEN SELECTABLE DATA


None

## 11.8 RF Spectrum Screen



The RF spectrum screen displays the RF spectrum centered around the tuning frequency with frequencies above being positive and below being negative. The amplitude and frequency scales are both adjustable and have cursors associated with them. The RF spectrum is maybe colored such that center green represents the analog carriers, yellow the main HD carriers, and red the extended mode HD carriers.

### SCREEN SELECTABLE DATA

To select a parameter click on the screen, then select the choice using the knob, and click again. Adjust the parameter using the knob and click to set the new value. To exit this screen, select the screen  icon and click on it.

**dB:** The dB amplitude scale is scrollable from +100.0dB to -150.0dB in increments of the selected major division.

**VR:** The dB amplitude resolution is adjustable from 0.1dB to 0.8dB per pixel.

**C1:** The C1 cursor is a horizontal amplitude cursor which is adjustable in VR steps.

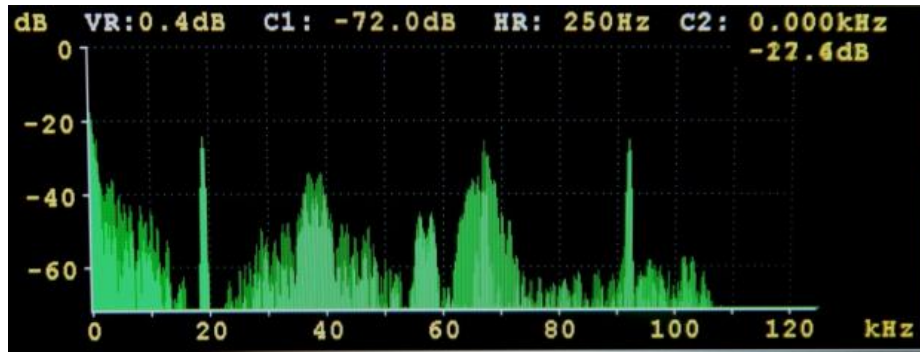
**HR:** The frequency resolution is adjustable in steps of 50, 100, 250, 500, 1k, 1.5k, 2k, and 2.5 kHz per pixel.

**C2:** The C2 cursor is a vertical frequency cursor, which displays the amplitude value at the selected frequency. Frequency step size is determined by the HR setting.

**kHz:** The spectrum frequency is scrollable in the current major division step size approximately  $\pm 1.0$ MHz around the tuning frequency.




## 11.9 Composite Spectrum Screen



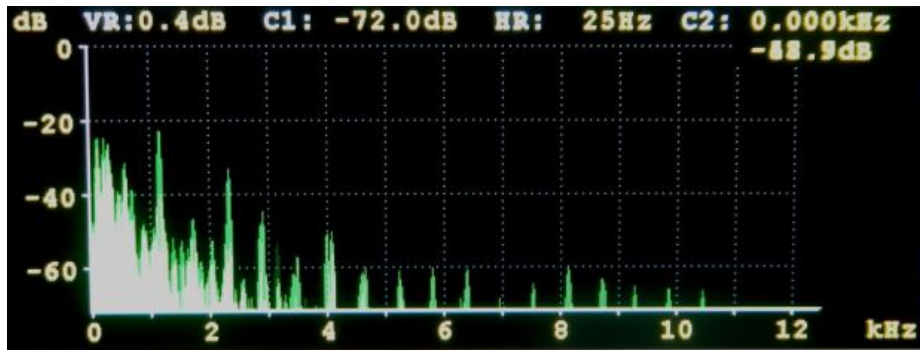
The Composite spectrum screen displays the Composite spectrum from 0 to 150 kHz. The amplitude and frequency scales are both adjustable and have cursors associated with them.

### SCREEN SELECTABLE DATA

To select a parameter click on the screen, then select the choice using the knob, and click again. Adjust the parameter using the knob and click to set the new value. To exit this screen, select the screen  icon and click on it.


- **dB:** The dB amplitude scale is scrollable from +100.0dB to -150.0dB in increments of the selected major division.
- **VR:** The dB amplitude resolution is adjustable from 0.1dB to 0.8dB per pixel.
- **C1:** The C1 cursor is a horizontal amplitude cursor which is adjustable in VR steps.
- **HR:** The frequency resolution is adjustable in steps of 5, 10, 25, 50, 125, and 250 Hz per pixel.
- **C2:** The C2 cursor is a vertical frequency cursor, which displays the amplitude value at the selected frequency. Frequency step size is determined by the HR setting.
- **kHz:** The spectrum frequency is scrollable in the current major division step size over the entire 0 to 150 kHz range.

## 11.10 Audio Spectrum Screen



The Audio spectrum screen displays the Audio spectrums from 0 to 24 kHz. The amplitude and frequency scales are both adjustable and have cursors associated with them.

### SCREEN SELECTABLE DATA

To select a parameter click on the screen, then select the choice using the knob, and click again. Adjust the parameter using the knob and click to set the new value. To exit this screen, select the screen  icon and click on it.

- **dB:** The dB amplitude scale is scrollable from +100.0dB to -150.0dB in increments of the selected major division.
- **VR:** The dB amplitude resolution is adjustable from 0.1dB to 0.8dB per pixel.
- **C1:** The C1 cursor is a horizontal amplitude cursor which is adjustable in VR steps.
- **HR:** The frequency resolution is adjustable in steps of 1, 2, 5, 10, 25 and 50 Hz per pixel.
- **C2:** The C2 cursor is a vertical frequency cursor, which displays the amplitude value at the selected frequency. Frequency step size is determined by the HR setting.
- **kHz:** The spectrum frequency is scrollable in the current major division step size over the entire 0 to 24 kHz range.

## 11.11 RDS Basic Data Screen

PI[5B5A]:WCNY	TP[0]:off	TA[0]:off	MS[1]:Music
PS: WCNY-FM	Time:	DI[01]: Stereo	
PTY[15]:Classicl	Date:	PIN:	
PTYN:			
Radio Text[B] CLASSIC FM			
Alternate Frequencies[ 2] 91.3 89.7			
Group Types: 0A 2A			

The basic RDS data screen displays data encoded on the 57 kHz RDS subcarrier from the RDS decoder.

### SCREEN DISPLAY DATA

**PI:** Program Identification Code

**PS:** Program Service Name

**PTY:** Program Type

**PTYN:** Program Type Name

**TP:** Traffic Program

**TA:** Traffic Announcement

**MS:** Music/Speech Program

**Time & Date:** Current Encoded Time and Date

**DI:** Decoder Identification

**PIN:** Program Item Number

**Radio Text:** Up to 64 characters of text, Embedded carriage Returns and Line Feeds are displayed as CR and LF characters









**Alternate Frequencies:** Frequencies of neighboring transmitters or repeater stations

**Group Types:** Displays all the RDS Group types currently being broadcast


### SCREEN SELECTABLE DATA

None

## 11.12 Alarms/Relay Screen

Event	Thres	Time	Relay	Email	Disp	
Loss of RF (ANT)	-40.0dB	10 sec	N	N	N	
Loss of RF (HL)	50.0%	10 sec	N	N	N	
High AM Noise	-40.0dB	10 sec	N	N	N	
High SYNC AM	-30.0dB	10 sec	N	N	N	
Loss of Total	10.0%	10 sec	N	N	N	
Total Peak LED	100.0%	N/A	N	N	N	
Loss of L+R	25.0%	10 sec	N	N	N	
Loss of Pilot	5.0%	10 sec	N	N	N	

### SCREEN SELECTABLE DATA

To select a parameter click on the screen, then select the event using the knob, and click again. Use the encoder to select the event parameter and click, set the new value, and click again. To exit the event, select it, and click. The events scroll as the cursor is moved thru the list. To exit this screen, select the screen  icon and click on it.

Events can be set to trigger any one of four relay closures, 4 email addresses, or display in a popup alarm window on the FMCS-1.

Alarm Status is indicated with a multi-colored graphical LED. Red indicates the alarm is active, yellow indicates the alarm has met the threshold but not the time criterion, green indicates no alarm condition.

**Loss of RF (ANT):** Loss of RF on Antenna Input, Threshold -10.0 to -80dB; Time 1 to 60 sec

**Loss of RF (HL):** Loss of RF on High Level Input, Threshold 0 to 100.0%; Time 1 to 60 sec

**High AM Noise:** High AM Noise Level, Threshold -20.0 to -80.0dB; Time 1 to 60 sec

**High SYNC Noise:** High AM Synchronous Noise Level, Threshold -20.0 to -80.0dB; Time 1 to 60 sec

**Loss of Total:** Loss of Peak Total Modulation, Threshold 0 to 100.0%; Time 1 to 60 sec

**Total Peak LED:** Total Peak Level Exceeded, Threshold 0 to 150.0%; Time N/A

**Loss of L+R:** Loss of L+R or Mono program, Threshold 0 to 100.0%; Time 1 to 60 sec

**Loss of Pilot:** Indicates Pilot Tone is present, Threshold 0 to 15.0%; Time 1 to 60 sec.

**Loss of RDS:** Indicates RDS subcarrier is present, Threshold 0 to 10.0%; Time 1 to 60 sec

**Loss of RDS SYNC:** Indicates RDS decoder has synced to RDS data stream and is decoding data, Threshold N/A; Time 1 to 60 sec

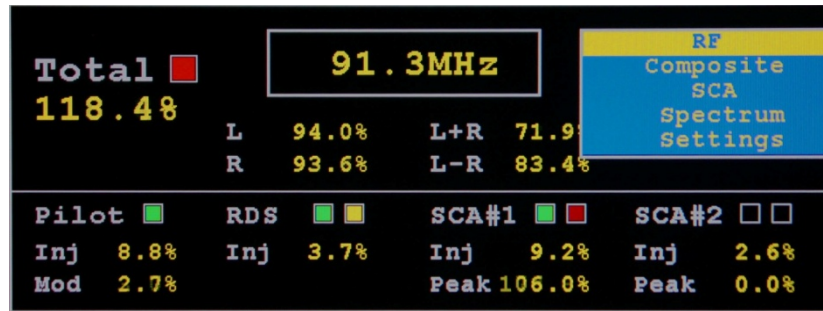
**Loss of SCA#1:** Indicates SCA#1 subcarrier is present, Threshold 0 to 25.0%; Time 1 to 60 sec

**SCA#1 Peak LED:** SCA#1 Peak Modulation Level Exceeded, Threshold 0 to 150.0%; Time 1 to 60 sec

**Loss of SCA#2:** Indicates SCA#2 subcarrier is present, Threshold 0 to 25.0%; Time 1 to 60 sec

**SCA#2 Peak LED:** SCA#2 Peak Modulation Level Exceeded, Threshold 0 to 150.0%; Time 1 to 60 sec

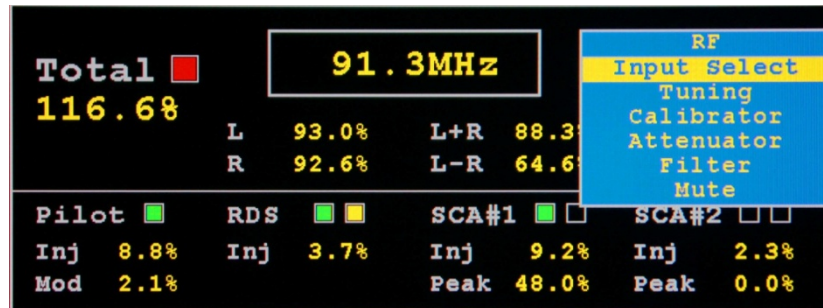
## 12 Popup Menus



Many of the FMCS-1 Parameters and Information are accessed using popup menus. To access the popup menus press and hold down the encoder for 2 seconds. To navigate the popup menus rotate the encoder to highlight a menu choice and click the encoder. To exit the pop menu at any time, hold down the encoder for 2 seconds.

<b>RF:</b>	Settings which affect the RF portion of the signal
<b>Composite:</b>	Settings which affect the Composite or baseband part of the signal
<b>SCA:</b>	Subcarrier settings for SCA#1 & SCA#2
<b>Spectrum:</b>	RF, Composite, and Audio spectrum settings
<b>Settings:</b>	Unit, outputs, and network settings and information

### 12.1 RF Popup Menu



**Input Select:** Select which RF input is used Antenna (off the air) or High Level (tx site).

**Tuning:** Allows frequency tuning of the unit from any screen.

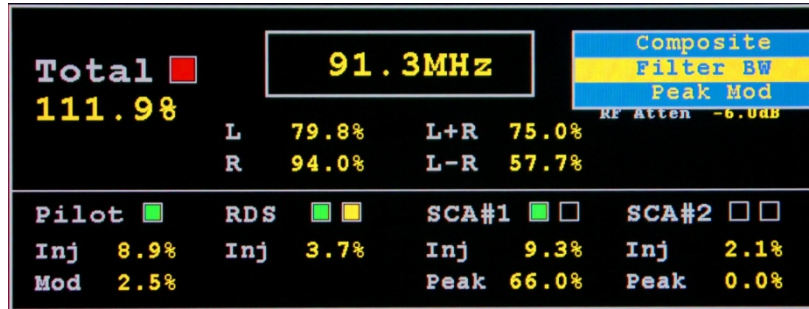
**Calibrator:** Activates internal RF calibrator. Calibrate waveforms: off, zero (un-modulated carrier), mono 1kHz (1 kHz sine wave 75 kHz deviation), left 1 kHz (1 kHz 90% left only), left 5 kHz (5 kHz 90% left only), left 10 kHz (10 kHz 90% left only), left 15 kHz (15 kHz 90 left only), SCA 67 92 zero (un-modulated 67 kHz and 92 kHz subcarriers at 10% injection), and SCA 67 92 1 kHz (1 kHz modulated 67 kHz and 92 kHz subcarriers , 6 kHz deviation, 10% injection).

**Attenuator:** 0.0 to -31.5dB step attenuator adjustable in 0.5dB steps. There are separate attenuators on both the Antenna and High Level inputs, the input select determines which attenuator is active.

**Filter:** RF filter which affects all analog readings. Filter choices: wideband, HD -25dB MP1, HD -25dB MP3, HD -50dB MP1, and HD -50dB MP3. Wideband mode should be used for the most accurate readings, except in the presence of HD carriers which introduce interference into the demodulated analog signal. If HD carries are present, the HD -25dB filter is recommended to suppress the HD carriers, choose the MP mode based on the HD service mode being broadcast. The HD -50dB filters are recommended when making AM noise measurements in the presence of HD carriers or when running elevated HD carrier power.

**Mute:** Mutes composite and audio outputs. In addition to manually turning the mute on or off, auto muting is done based on the thresholds for the high level and antenna inputs on the alarm/relay screen.

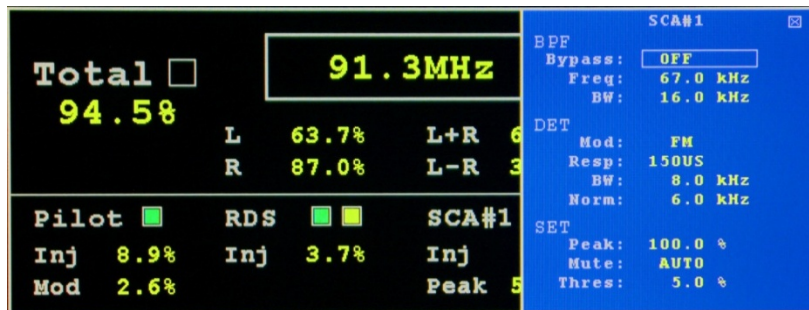
## 12.2 Composite Popup Menu



**Filter BW:** Selects Composite filter bandwidth: Stereo + RDS (passes stereo plus 57 kHz RDS), Stereo + 67 KHz (passes stereo thru 67 kHz SCA, and Stereo + 92 kHz (passes stereo thru 92 kHz SCA), and wideband. To reduce the interference from off-air-noise or HD carriers it is recommended that the Composite filter bandwidth be set as low as possible depending on the SCA's present.

**Peak Mod:** Adjusts the threshold for the Total peak light on the Main Tuning Screen. When the threshold is exceeded, the red peak flasher will signal the condition.

## 12.3 SCA Popup Menu



The FMCS-1 contains two independent SCA decoders SCA#1 and SCA#2. The parameters and setup of these decoders are the same so only one will be described.

**BPF Bypass:** SCA BPF bypass. When OFF the selected BPF filter is applied to the SCA before demodulation, ON removes the BPF which results in approximately a  $\pm 20$  KHz bandwidth around the center frequency.

**BPF Freq:** Adjusts the center frequency of the SCA BPF filter, adjustable from 41.0 to 92.0 kHz in 0.1 kHz steps.

**BPF BW:** Selects the SCA BPF bandwidth around the center frequency. The range is 1.0 to 16 kHz in 1 kHz steps.

**DET Mod:** Specifies the type of detector used to demodulate the SCA. Choices are FM or None.

**DET Resp:** The Detector Response maybe be set to Flat, 75  $\mu$ sec, or 150  $\mu$ sec.

**DET BW:** Selects the Detectors LPF bandwidth, choices are 1.0 to 8.0 kHz in 1.0 kHz steps.

**DET Norm:** Adjusts the normalization used to scale the modulation readings. The range is 1.0 to 7.0 kHz in 0.1 kHz steps. The normalization is typically set to the maximum deviation of the SCA carrier; this normalizes the SCA peak reading for 100% @ max SCA deviation.

**SET Peak:** Sets the SCA Peak Indicator limit. When this value is exceeded, the SCA peak indicator on the Man Tuning Screen will turn red. Range is 0.0 to 150.0% in 1.0% steps.

**SET Mute:** Selects how the Mute function is applied to the SCA readings and Audio output. The Mute may be turned OFF (no muting), ON (always muted), or AUTO (based on the SET Thres).

**SET Thres:** Adjusts the threshold for the Mute and SCA Presence Indicator on the Main Tuning Screen. Range is 0.0 to 25.0% of SCA injection in 0.1% steps.



## 12.4 RF Spectrum Popup Menu



**Display Mode:** The Display Mode affects how the spectrum data is presented, in Realtime mode the spectrum is updated with new data each time, Peak Hold displays the highest value in the last Hold Count value of spectrums, Average displays the average of the last Average Count of spectrums, and Infinite holds the highest values until reset.

**Hold Count:** Determines how many spectrums are used to compute the maximum values at each data point when the Display Mode = Peak Hold.

**Avg Count:** Sets how many spectrum are used to compute the spectrum average when the Display Mode = Average.

**0dB Ref Lev:** The 0dB Reference Level normalizes the 0dB point on the spectrum display to a specific dB value.

**Curve Fill:** Determines whether the spectrum display is a signal line or filled in from the bottom up.

**Colors:** Changes the normally green spectrum display into a multi-color display with green representing the analog portion, yellow the normal HD carriers, and red the extended HD carriers.

**Mask:** Enables the RF spectral mask defined for HD radio.

**Measurements:** Enables any additional measurements associated with the spectrum.

## 12.5 Composite Spectrum Popup Menu



**Display Mode:** The Display Mode affects how the spectrum data is presented, in Realtime mode the spectrum is updated with new data each time, Peak Hold displays the highest value in the last Hold Count value of spectrums, Average displays the average of the last Average Count of spectrums, and Infinite holds the highest values until reset.

**Hold Count:** Determines how many spectrums are used to compute the maximum values at each data point when the Display Mode = Peak Hold.

**Avg Count:** Sets how many spectrum are used to compute the spectrum average when the Display Mode = Average.

**0dB Ref Lev:** The 0dB Reference Level normalizes the 0dB point on the spectrum display to a specific dB value.

**Curve Fill:** Determines whether the spectrum display is a signal line or filled in from the bottom up.

**Colors:** Changes the normally green spectrum display into a multi-color display.

**Measurements:** Enables any additional measurements associated with the spectrum.

## 12.6 Audio Spectrum Popup Menu



**Input Type:** Selects a single or dual input spectrum.

**Input #1:** Input Select #1 determines the input source used for all single spectrums and channel #1 of dual spectrums.

**Input #2:** Input Select #2 determines the input source for channel #2 of dual spectrums.

**Display Mode:** The Display Mode affects how the spectrum data is presented, in Realtime mode the spectrum is updated with new data each time, Peak Hold displays the highest value in the last Hold Count value of spectrums, Average displays the average of the last Average Count of spectrums, and Infinite holds the highest values until reset.

**Hold Count:** Determines how many spectrums are used to compute the maximum values at each data point when the Display Mode = Peak Hold.

**Avg Count:** Sets how many spectrum are used to compute the spectrum average when the Display Mode = Average.

**0dB Ref Lev:** The 0dB Reference Level normalizes the 0dB point on the spectrum display to a specific dB value.

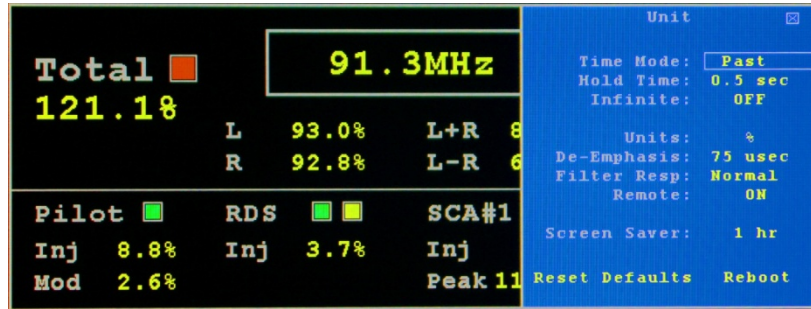
**Curve Fill:** Determines whether the spectrum display is a signal line or filled in from the bottom up.

**Colors:** Changes the normally green spectrum display into a multi-color display.

**Measurements:** Enables any additional measurements associated with the spectrum.



## 12.7 Unit Settings Popup Menu



**Time Mode:** The Time Mode affects all the peak modulation readings and bar graphs. In Real Time Mode when a peak exceeds the current displayed peak the value is updated immediately to the new value and held for the Hold Time, until either a new peak is detected or the Hold Time is met. In Past Time Mode, the unit waits the Hold Time and displays the highest peak which was detected during that time period.

**Hold Time:** Adjusts the Peak Hold Time from 0.25 to 0.5-5.0 seconds in 0.5 second increments.

**Infinite:** When Infinite Hold is enabled, the highest peak values are held until disabled. Infinite Hold affects all the modulation readings and bar graphs.

**Units:** The units for modulation data may be displayed in either % where 100% = 75 kHz deviation, or directly in kHz deviation.

**De-Emphasis:** Sets the De-Emphasis for all de-emphasized readings to either 50  $\mu$ sec or 75  $\mu$ sec.

**Filter Response:** Selects the Left, Right, L+R, & L-R frequency response. The normal setting uses the standard 15 kHz bandwidth for readings and audio outputs. The extended option increases the filter bandwidth to 16.5 kHz. Extending the filter response can result in more accurate L, R, L+R, & L-R peak modulation readings. This is dependent on the audio programming and processor settings.

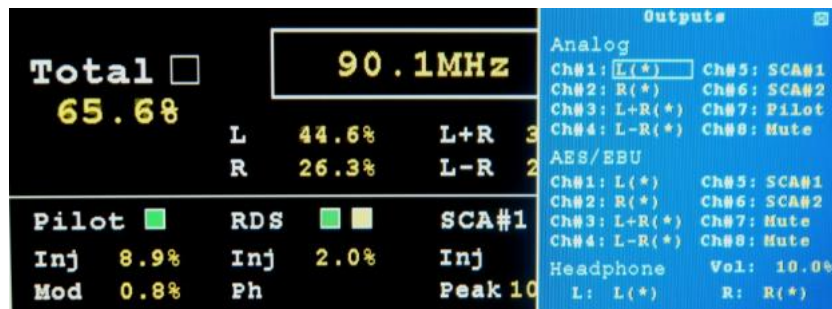
**Remote:** Allows or blocks remote connections to the unit via the USB port or RJ-45 connector.

**Screen Saver:** The Screen Saver turns off the LCD's backlight after a specified period without any encoder activity. The choices are off, & 1 to 12 hours in 1 hour increments.

**Reset Defaults:** To reset the unit back to factory defaults click on the Reset Defaults Button.

**Reboot:** To reboot the unit click on the Reboot Button.

## 12.8 Output Settings Popup Menu



The FMCS-1 provides 8 channels of analog audio output, 8 channels of AES/EBU output, and a headphone output. Any one of these output jacks maybe assigned any of the available audio: Mute, L, L(\*), R, R(\*), L+R, L+R(\*), L-R, L-R(\*), SCA#1, SCA#2, Pilot, Test 0dB, Test -3dB, & Test -6dB. The (\*) is the de-emphasized audio, otherwise the audio is flat. The SCA#1 & SCA#2 audio de-emphasis is selected in the SCA pop up window. The Test waveforms are a 1 kHz sine wave at 0, -3, & -6dBFS.

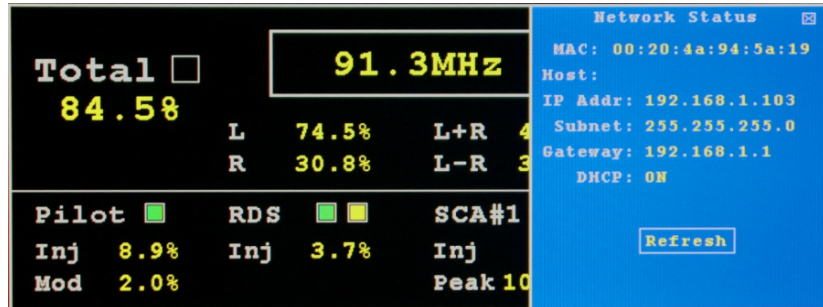
**Analog CH#1-CH#8:** Routes the specified audio source to the selected Analog Channel.

**AES/EBU CH#1-CH#8:** Routes the specified digital audio source to the selected AES/EBU Channel.

**Headphone L & R:** Assigns the audio program to the headphone Left & Right channels.

**Headphone Volume:** Sets the Headphone volume, range is 1 to 100% in 1% steps.

## 12.9 Network Status Popup Menu



**MAC:** MAC address of the FMCS-1.

**Host:** The Hostname of the FMCS-1.

**IP Address:** IP Address assigned to the unit.

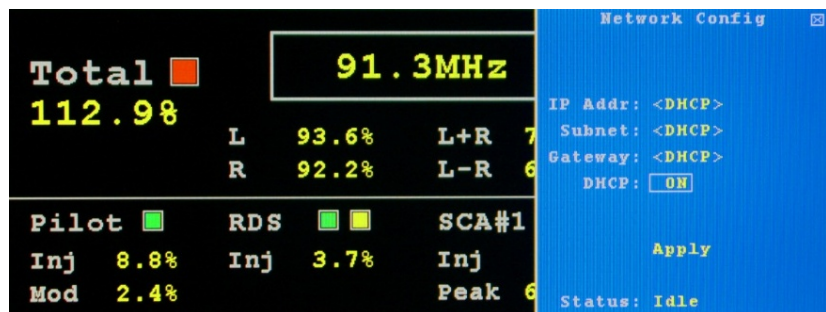
**Subnet:** Subnet address.

**Gateway:** Gateway address.

**DHCP:** Status of DHCP.

**Refresh:** To refresh the network status information click on the Refresh button.

## 12.10 Network Configure Popup Menu



**IP Address:** DHCP must be disabled to enter a static IP

**Subnet:** DHCP must be disabled to enter a Subnet

**Gateway:** DHCP must be disabled to enter a Gateway

**DHCP:** Enables or Disables DHCP. If DHCP is enabled the IP, Subnet, and Gateway addresses will be assigned automatically by the DHCP server. To set a static IP address DHCP must be disabled.

**Apply:** To apply network configuration changes click the Apply button.

**Status:** Displays the status of the Lantronix when a new configuration is being applied.

## 12.11 Email Settings Popup Menu

<b>Total</b> <span style="color: red;">■</span> <b>91.3MHz</b> <b>109.8%</b>			<b>EMAIL #1</b> <span style="float: right;">✖</span>		
L 84.0% L+R 6 R 92.9% L-R 7			TO: <input type="text"/>		
Pilot <span style="color: green;">■</span> RDS <span style="color: green;">■</span> <span style="color: yellow;">■</span> SCA#1 Inj 8.9% Inj 3.7% Inj Mod 3.0% Peak 10			CC: <input type="text"/>		
			FROM: <input type="text"/>		
			SUBJECT: <input type="text"/>		
			<input type="button" value="TEST"/>		

**TO:** Email address to which email alerts will be sent. 24 characters max. This field must be set.

**CC:** Optional email address to which email alerts will be copied. 24 characters max

**FROM:** Email address alerts will be sent from. 24 characters max. This field must be set.

**SUBJECT:** Email subject prefix. 12 characters max.

**Test:** To send a test email click on the Test button.

## 12.12 Info Settings Popup Menu

<b>Total</b> <span style="color: red;">■</span> <b>91.3MHz</b> <b>106.6%</b>			<b>Info</b> <span style="float: right;">✖</span>		
L 62.5% L+R 6 R 82.4% L-R 4			BOOT: 1.20 11/29/11 MAIN: 1.20 11/29/11 DSP#1: 1.07 10/18/11 DSP#2: 1.01 03/19/10 DSP#3: 1.03 11/29/11 DSP#4: 1.03 11/29/19 DSP#5: 1.03 02/17/10 DSP#6: 1.02 02/17/10 MICRO: 1.10 08/02/11		
Pilot <span style="color: green;">■</span> RDS <span style="color: green;">■</span> <span style="color: yellow;">■</span> SCA#1 Inj 8.9% Inj 3.7% Inj Mod 2.1% Peak 8			UNIT: FMCS-1 COMPLETE SERIAL#: 750004		

**BOOT:** Processor Boot Code Version and Date.

**MAIN:** Processor Main Code Version and Date.

**DSP#1-DSP#6:** Digital Signal Processors #1 thru #6 Code Versions and Dates.

**MICRO:** Micro Processor Code Version and Date.

**UNIT:** Unit configuration.

**SERIAL #:** The unit's serial number.

# **Broadcast Equipment**

## **SECTION THREE: SOFTWARE & FIRMWARE**



**BELAR ELECTRONICS LABORATORY, INC.**



## 13 Belar WizWin® Software, Setup & Firmware Updates

### 13.1 Initial Software Installation

- 1) **DOWNLOAD** the **Belar WizWin® Software** from the BELAR website at: <http://www.BELAR.com/update/index.html>
- 2) Locate and **RUN** the **setup.exe** file. Follow the screen prompts.
- 3) If connecting to the unit using the RJ-45 network connector, download the Lantronix Device installer using the link on our webpage. Also available from Lantronix at: [http://ltfaq.custhelp.com/app/answers/detail/a\\_id/644](http://ltfaq.custhelp.com/app/answers/detail/a_id/644)
- 4) Install the Device Installer software.

### 13.2 Connecting the Unit to your computer

#### 1) Network Connection

- a. **DHCP:** If connecting to a network with a DHCP server in place (the Unit is shipped with DHCP enabled) connect the Unit to your network, on the same subnet as the computer you loaded the **Belar WizWin® Software**, then power cycle the unit.
- b. **APIPA:** If your network does not have a DHCP server the Unit will select an APIPA (Automatic Private IP Address) address in the 169.254.xxx.xxx range with a subnet of 255.255.0.0 You can then use an isolated (non DHCP) switch or a crossover cable to connect the **FMCS-1** to your computer.
- c. You must set the computer IP to the same 169.254.xxx.xxx range with the 255.255.0.0 subnet. (Most computers set to DHCP enabled will default to an APIPA address if no DHCP server is present when they are booted up)
- d. **Static IP:** Currently static IP's must be set using the Lantronix Device Installer software. (Please see Section 13.6 Setting a Static IP)

#### 2) USB Connection

- a) Connect a USB A-Male to Mini-B cable

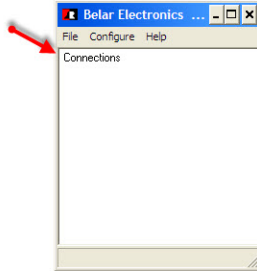
## 13.3 Configuring the Belar WizWin® Software

### 1. Finding the Unit's IP address

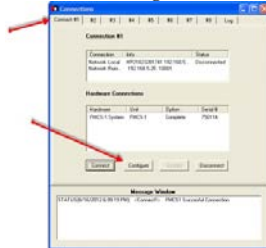
- To Obtain the IP address of the FMCS-1, activate the Unit's popup menus, then go to the "Settings" > "Network" submenu to display the current network information. In order for the unit to correctly assign a DHCP or APIPA address the unit must be power cycled after the RJ-45 cable is connected to the unit.

### 2. RUN the Belar WizWin® Software:

#### a) Then 'SELECT' "Connections"



#### b) A pop-up dialog box will appear 'SELECT' Connection #1 then 'CLICK' the "Configure" Button



#### c) Under the individual Tabs in the Configure Dialog Box 'SELECT' or ENTER the following information.

##### i. Hardware Type: 'SELECT' FMCS-1

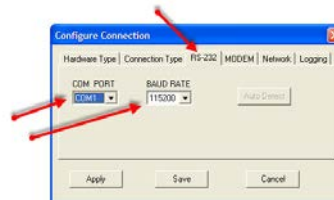


##### ii. Connection Type: 'SELECT' Network – Ethernet or RS-232 – Serial



##### iii. RS 232 Connection

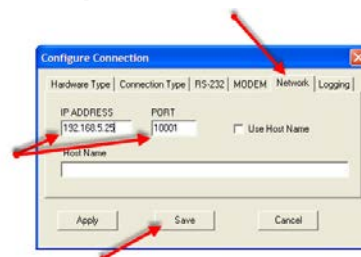
If using the serial connection on the FMCS-1, CHECK the appropriate option, then 'SELECT' the RS-232 tab, 'SELECT' the appropriate "Com Port" and 'SET' the "Baud Rate to 115200



##### iv. Network Connection

'ENTER' the IP Address of the FMCS-1 obtained from the Network Settings menu. For a direct connection to the unit using Belar WizWin® Software, the port number should be set to 10001.

If connecting to the BELAR Server Program, the IP address will be the address of the hosting computer and the port will be set between 81 & 88 to correspond with the listening port set in the Server Program. Alternatively, a Host Name can be substituted for the IP address. If so, please check the 'Use Host Name' box.

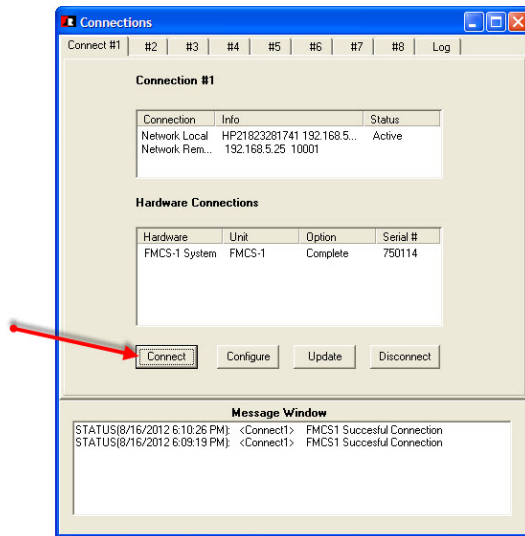


### 3) then 'CLICK' "Save" to save and close the "Configure Connection" dialog box.

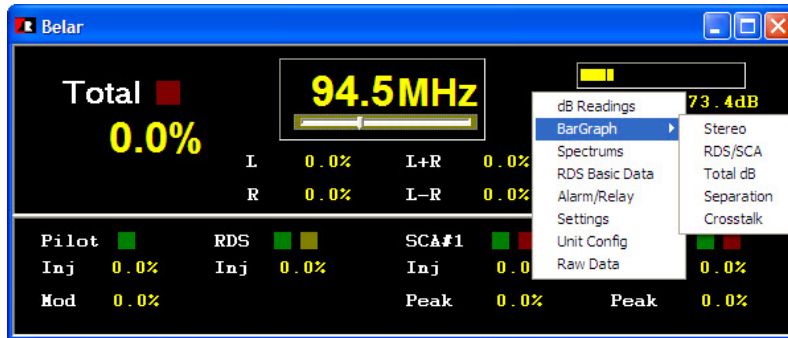


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- 4) 'CLICK' on the "Connect" button in the Connections Window. The Unit should connect and bring up a virtual front panel of the Unit.



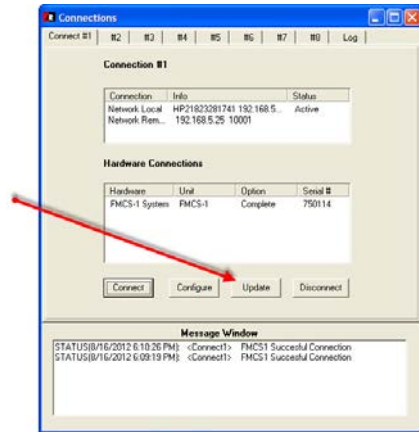
- 5) 5) You can navigate around the unit controls by right clicking on the unit and selecting screens and functions from the drop down menus that appear.



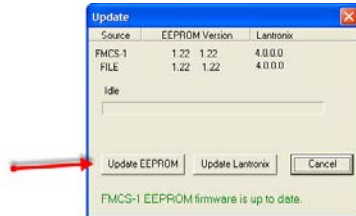
## 13.4 Updating the FMCS-1 Firmware

The update file is embedded in the **Belar WizWin® Software**. In order to update the unit a connection must first be established using the **Belar WizWin® Software** program. (See section 13.3)

- 1) In the Connections Window, 'SELECT' the "Update" button.



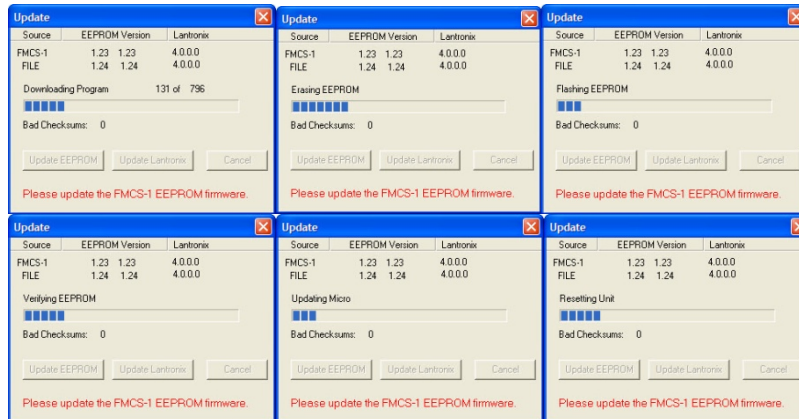
- 2) An Update Dialog Box will pop-up, 'CLICK' the "Update EEPROM" button to start the update process.



If you are attempting to install a firmware version older than or equal to your current version a warning box will appear, 'SELECT' the "Confirm" button if you want to continue.

The front panel of the Unit will show the updating progress which takes about 10-20 minutes to complete. Afterwards the unit should reboot automatically.

### **DO NOT INTERRUPT THE UPDATE PROCESS AFTER IT HAS STARTED**

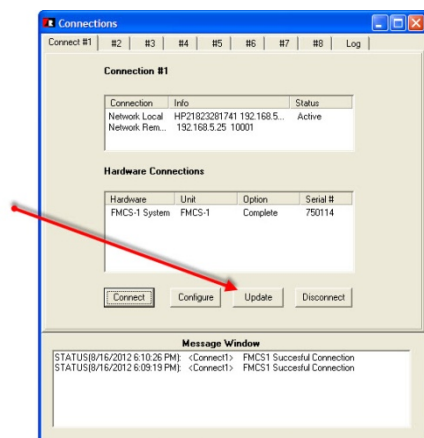


## 13.5 Updating Lantronix Network Interface Controller

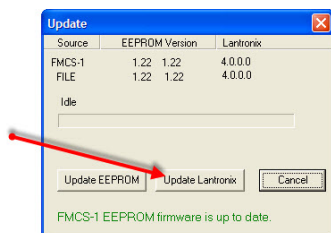
Some older units have Lantronix firmware below version 4.0.0.0. We recommend updating these Lantronix to Version 4.0.0.0. In order to update the Lantronix using **Belar WizWin® Software**, the **FMCS-1** must be version **1.18** or higher. Please update the unit's firmware first, if necessary. (See section 13.4)

The update file is embedded in the **Belar WizWin® Software**. In order to update the unit, a connection must first be established using the **Belar WizWin® Software** program. (See section 13.3)

- 1) In the Connections Window, **'SELECT'** the **"Update"** button.

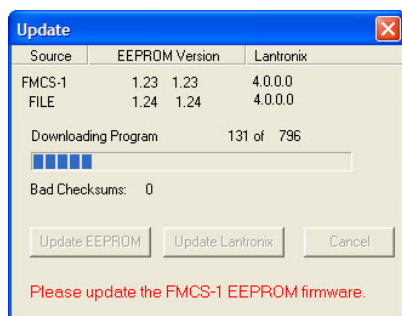


- 2) An "Update Dialog Box" will pop-up. The **FMCS-1's** Lantronix version is displayed on the first line, the update version is displayed on the second line. **'CLICK'** the **"Update Lantronix"** button to start the update process.



The front panel of the Unit will show the updating progress which takes about 20 minutes to complete. Afterwards, the unit should reboot automatically.

### **DO NOT INTERRUPT THE UPDATE PROCESS AFTER IT HAS STARTED**



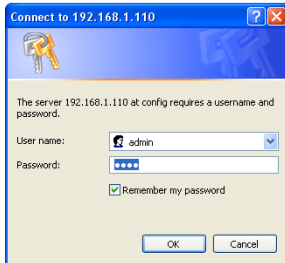
The Lantronix update will save the IP settings present before the update and reconfigure the Lantronix after the update, then reboot the device. During the update process, the Network connection will be closed and after the unit reboots a new connection will be established. If the Lantronix was configured for DHCP this may result in the unit's IP address changing. If this occurs, use the Lantronix Device installer or the unit's Network Settings menu to determine the new IP address. The **Belar WizWin® Software** will have to be reconfigured using this new IP address before the software can connect to the unit. (See section 13.3)

## 13.6 Setting a Static IP address using the Lantronix Device Installer Web Interface

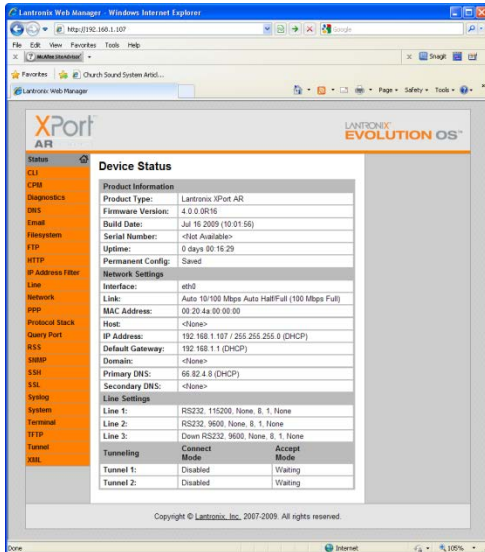
In order to use the Lantronix Device Installer Web interface the Lantronix must be running firmware version 4.0.0.0 or higher. Please update the Lantronix firmware before continuing if required. (See section 13.5). The Lantronix web interface may be accessed from the device installer, or from a standard web browser. The default user name and password are:

User name: **admin**

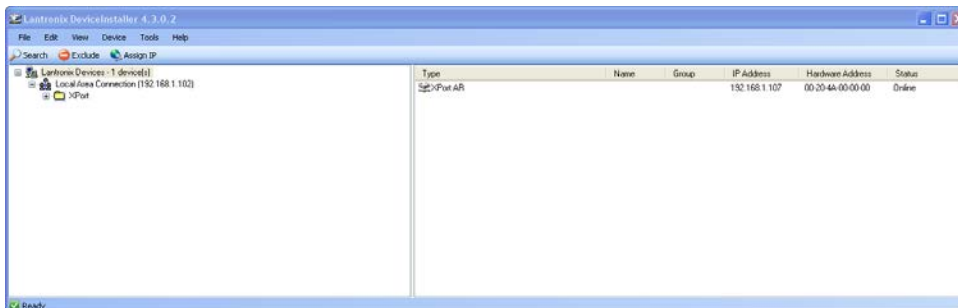
Password: **PASS**



To access the Web interface using a web browser just enter the unit's IP address in the address bar, in the example below the IP address is 192.168.1.107. The browser will then prompt for a username and password as mentioned above.

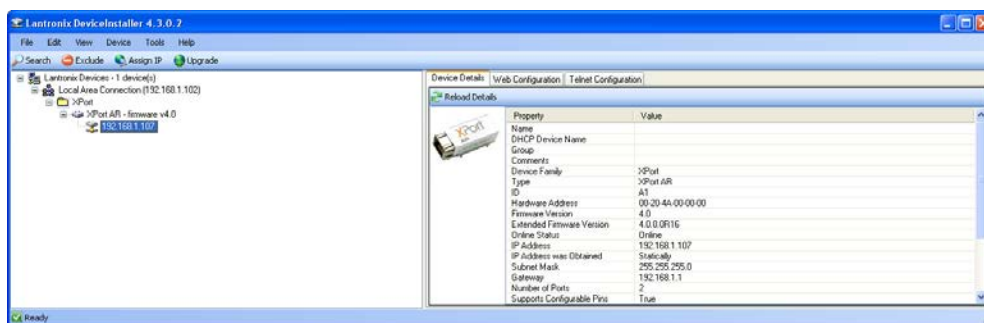


To use the Lantronix Device Installer software, install and run the software, the Lantronix will appear as **XPort** on the left and **XPort AR** on the right side. **DOUBLE CLICK** the **XPort AR** symbol on the right hand side.



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‘CLICK’ on the “Web Configuration Tab”, and then ‘CLICK’ the green right hand arrow on the tool bar. A username/password box will pop-up as displayed above. ENTER the default username and password.



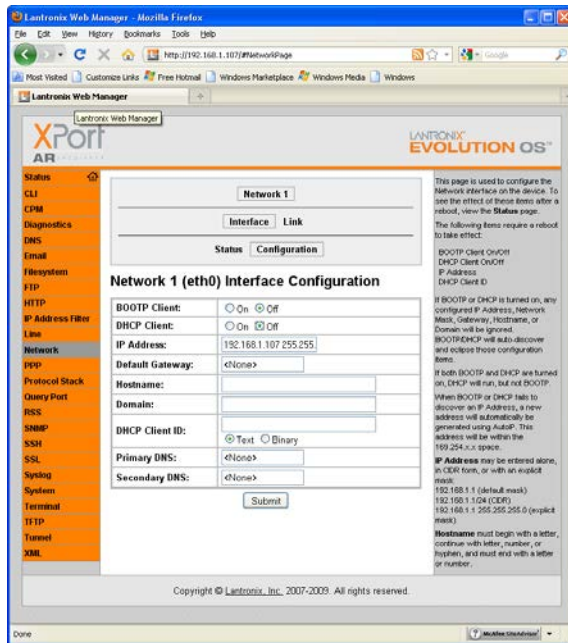
Both the Web browser and Device Installer display the same information in the same format. The Web Browser is quicker if you already know the Unit's IP address.



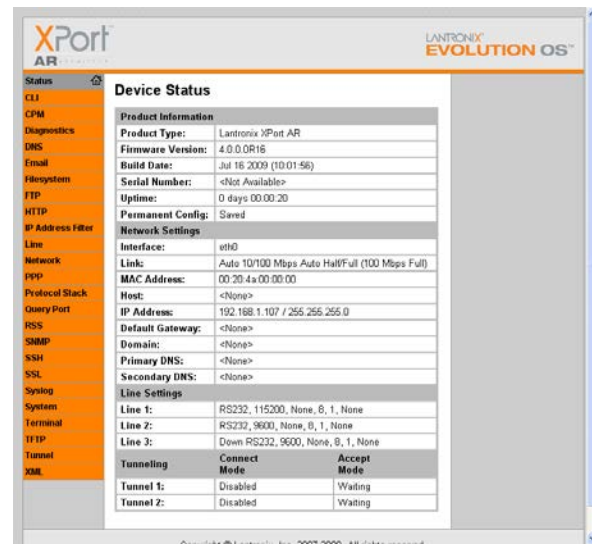
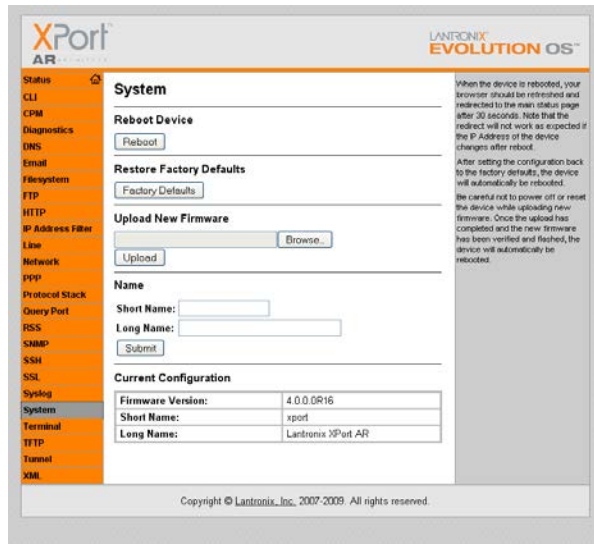
## FMCS-1 ALL-IN-ONE FM MODULATION MONITOR

To set the Static IP **‘CLICK’** on the **“Network”** button on the left hand side. Next, **‘SELECT’** the **“Configuration”** box in the center. From this screen, **ENTER** the static IP address and subnet mask in the **“IP Address”** box using the format xxx.xxx.xxx.xxx xxx.xxx.xxx.xxx.

In the example below, I have entered “192.168.1.107 255.255.255.0”. Make sure the BOOTP and DHCP Client are both in the **“Off”** position. A Default Gateway, Hostname, or Primary DNS can also be set at this time. After all the settings are correct **‘CLICK’** the **“Submit”** button at the bottom of the screen. The changes will take effect on the next reboot.



To reboot the Lantronix, power cycle either the unit or **‘CLICK’** on the **“System”** button on the left. **‘CLICK’** the **“Reboot”** button under the system menu. After a prompt, the Web Interface will close and then re-open showing the Device Status. Check to make sure the settings are correct. The unit should now be set to this Static IP address.







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