



BELAR

Broadcast Equipment

FMHD-1

FM HD RADIO MONITOR

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Broadcast Equipment

Operator's Manual

FMHD-1

FM HD Radio Monitor



BELAR ELECTRONICS LABORATORY, INC.

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1 General Information

1.1 General Description

The **Belar FMHD-1** Modulation Monitor for FM HD Radio™ is a state-of-the-art wideband monitor designed specifically for the measurement and characterization of FM hybrid In-Band/On-Channel broadcast signals in the 88-MHz-to-108-MHz band. It simultaneously decodes and meters the modulation of the analog FM carrier and the Main program audio carried by the IBOC digital sidebands (subcarrier sets). In its base configuration, the **FMHD-1** provides multiple high-quality audio output signals for the analog FM program and any one of the digital audio program channels available in an HD™ broadcast. (Optional hardware permits simultaneous monitoring of up to four digital program channels.) The monitor simultaneously presents information about the digital data stream as well as technical and program-related information carried by the data stream. On-board processing provides real-time spectral analysis of the hybrid IBOC RF signal. Internally generated calibration signals permit checking the accuracy of the analog metering at any time. Diagnostics assist servicing the HD Radio system. Communications ports and a graphical user interface enable local or remote operation of the **FMHD-1** via an external PC.

1.2 Physical Description

The **FMHD-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 and adjust the RF input level controls. 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 to easily make connections. The front-panel encoder knob protrudes about one inch (25.4mm) outward from the rack mounting.

All connections to the **FMHD-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 jacks and XLR output plugs, D-sub connectors, RJ-45 jacks, and an F connector. Two rear-panel potentiometers facilitate adjustment of the signal level applied to each of the two high-level RF inputs.

No user adjustments to the monitor circuitry are required to maintain specified performance. All factory adjustments are located within the shielded compartment of the monitor.

An outboard switching power supply module is provided with the **FMHD-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 **FMHD-1**.

1.3 Electrical Description

The **Belar FMHD-1** is a precision DSP-based solid-state FM receiver that down-converts and demodulates FM hybrid In-Band/On-Channel signals in the FM broadcast band. Front-panel tuning spans the 88-MHz-to-108-MHz FM band in 100-kHz increments. The **FMHD-1** may be driven by either high-level RF transmission-line samples, or off-air from a receiving antenna. For installations at the transmitter, the **FMHD-1** provides two isolated, 50-Ω inputs that accept either a single RF feed from one

directional coupler in “common-line” facilities, or separate analog and digital RF samples in “separate-line” facilities.

The **FMHD-1** provides high-accuracy modulation indications of conventional FM Stereo composite signals present on the analog FM carrier of hybrid IBOC broadcasts. Peak analog modulation indications of Total, Pilot, Left, Right, L+R, and L-R are presented both in bargraphs and in numerical readouts. Average and minimum values appear in bargraphs. Simultaneously, the **FMHD-1** decodes and meters the audio levels of the Main HD program, providing both bargraph and numerical indications. By user selection, the HD decoder may be set to provide the audio and program level readings of any other digital audio program present on the station data stream. Supplemental HD decoder modules may be installed to provide simultaneous aural monitoring of up to four HD channels, if present in the data stream.¹

As a monitor of FM hybrid IBOC transmissions, the **FMHD-1** provides visual indicators for time alignment and amplitude agreement of the analog and Main HD programs, as well as an “audio in-phase” indication, to help operators maintain smooth analog-digital blends in receivers. The presence or absence of all eight possible digital audio programs is indicated on the main tuning screen. HD transmission status indications include signal presence, program data acquisition, station information recovery, service mode, received signal-to-noise power, two quality metrics, and the data and audio acquisition times. A second screen presents data specific to the tuned station; a third presents the program information carried on the data stream for listeners.

All readings are presented on a single 640 X 240 pixel LCD display centered on the front panel.

The **FMHD-1** provides audio outputs for all stereo program channels. The outputs are available in both analog and digital form. There are eight user-configurable outputs in analog format. These are low-distortion, low-noise outputs suitable for driving high-quality audio monitoring equipment via long, terminated lines. Any of the audio signals may also be monitored via a front-panel headphone jack. There are six digital user-configurable AES-3ID outputs. The recovered analog FM stereo composite signal is available in both analog and digital form. Four digital composite filters minimize the effects of interference on the composite signal caused by IBOC carriers. The filtered composite signals may be used to drive conventional FM monitors. The down-converted analog FM I and Q signals are provided only in digital form.

Internal processing in the **FMHD-1** provides spectrum analysis of the hybrid IBOC FM RF carrier-set. Special computations provide numerical readouts of the lower, upper, and total sideband power ratios in dBc. User-selectable calibration signals conveniently verify proper operation of the analog FM metering circuitry and other monitors fed by the **FMHD-1** FM composite outputs. Four user-selectable test signals are provided for testing audio systems connected to the unit.

Configurable alarms with adjustable thresholds are available for twenty-two **FMHD-1** measurement parameters. User-selectable external alarm indications include email messages and relay-contact closures. The **FMHD-1** may be operated as an addressed Internet device. Remote operation and interrogation of the **FMHD-1** by a PC is also possible via either the rear-panel RS-232 connector or RJ-45 Ethernet port using the included **Belar WizWin**© software. Firmware updates for the **FMHD-1** and its internal Lantronix

¹ Every **FMHD-1** is provided with at least one HD Radio™ digital audio program decoder. Purchasing a second HD decoder allows simultaneous audio program recovery of two HD programs. The second decoder is simply inserted in an open card-edge connector. Addition of either a third or a third and fourth encoder requires the purchase of one **FMHD-1** expander card in addition to the additional HD decoder cards.

Ethernet controller are also installed using a PC (with internet access) communicating with the **FMHD-1** through either the RS-232 or the RJ-45 rear-panel port.

1.4 Electrical and Mechanical Specifications

RF Inputs

Frequency Range87.3 to 108.1 MHz, Frequency Agile, 100-kHz Increments
High Level Input 1Vrms to 10 Vrms, 50Ω, BNC Connector
Antenna Input.....2.2mV sensitivity², 75Ω, F-type Connector, 500mVrms maximum

Audio Outputs

Analog Outputs (8 assignable)+10 dBm, 600Ω balanced, XLR Connector
AES-3ID (6 assignable)..... 1.0 Vpk-pk, 75Ω, BNC Connector
Headphone (1 assignable) 1/4" Phone Jack

Indicators

Analog Total Peak Modulation • Analog L+R Presence • RF Presence • Pilot Presence • HD Station •
Digital Audio Acquisition • SIS CRC • Audio Time Alignment • Audio Amplitude Alignment •
Audio Polarity • HD Program Presence (8 channels) • HD L+R Presence (8 channels)

Analog FM Modulation Measurement

Modulation (Peak, Ave, Min):

Total, L, R, L+R, L-R0 to 125.0%, 0.1% resolution
Pilot..... 0 to 15.0%, 0.1% resolution
Accuracy is better than 1%. Metering of Analog FM Stereo conforms to legacy FCC guidelines.

FFT RF Spectrum Analysis

Display Modes..... Realtime, Peak Hold, Average, Infinite Hold
Amplitude
Number of Points 181
Scale..... +100.0 to -150.0 dB adjustable
Resolution0.1 dB
Frequency
Number of Points 501
Resolution BW..... 50, 100, 250, 500, 1000, 1500 Hz

Analog FM Composite Outputs

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

Analog FM Composite Output Performance (High-Level Input, LVDS Output)

Frequency Response±0.01 dB, 10 Hz to 100 kHz
SNR..... 100 dB, 75 μs de-emphasis
Distortion 0.001%, 75 μs de-emphasis

Analog FM Composite Output Stereo Capability (High-Level Input, LVDS Output)

Frequency Response (L and R)..... ±0.1 dB, 10 Hz to 15 kHz
SNR (Stereo)..... 90 dB, 75-μs de-emphasis

² For >60 SNR at any of the Composite Outputs.

Distortion	0.001%, 10 Hz to 15 kHz, 75- μ s de-emphasis
Separation	
L to R, R to L	100 dB, 10 Hz to 15 kHz
Crosstalk	
L+R to L-R	100 dB min
L-R to L+R	100 dB min
SCA to L+R	100 dB min
SCA to L-R	100 dB min

Alarm Outputs

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

Computer Interface

RS-232.....9-pin Male D-Sub Connector

Ethernet 10/100 Base -T.....RJ-45 Jack

Physical

Dimensions 19"x3.5"x14.5", 2 EIA Rack Units

Power Requirements 42 Watts, 100-240V, 50/60 Hz

Shipping Weight 15 lbs. (6.8 kg)

1.5 Accessories

For stations wishing to simultaneously decode multiple HD program streams, Belar offers additional separate plug-in IBOC HD™ decoding modules. Each module adds the capability of independently decoding one additional HD stream. Up to three additional modules may be installed, offering a total of four simultaneous HD audio program outputs. The first additional HD decoder plugs into an auxiliary card-edge connector on the **FMHD-1** main circuit board. Addition of either a third or a third and fourth HD encoder requires the added purchase of one expander card for their installation.

There are no other accessories for the **FMHD-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 **FMHD-1** is shipped with the booklet "Guide to Operations," this manual ("FMHD-1 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.

NOTE: All text below that duplicates text appearing on the **FMHD-1** display appears in a Courier font. Example: In this manual, "Bypass" corresponds to the word "Bypass" appearing in the display.

3 Installation

3.1 Operating Environment & AC Line Power

The **FMHD-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 **FMHD-1**. In no instance should the chassis temperature be allowed to rise above 113°F (45°C). Mount the **FMHD-1** in the rack using the four black 10-32 rack mounting screws provided.

The **FMHD-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 ±12 VDC for the **FMHD-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 **FMHD-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 **FMHD-1**. Substituting another power supply module may result in damage to the **FMHD-1**, or at a minimum, a reduction in performance.*

The **FMHD-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 **FMHD-1** chassis, the unit is operating.

3.2 Monitoring Location & RF Signal Source

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

Monitoring hybrid IBOC HD™ FM broadcasts at the transmitter presents multiple connection possibilities for the **FMHD-1**. It is important that the RF samples used for monitoring (as well as for determining compliance with spurious emissions limits) be taken as close to final antenna feed point as possible. This way, all of the effects of any band-limiting or other imperfections in the RF system are included in the performance and spurious emissions measurements.³

Common-Line Facilities:

For the low-level combining case, a single high-level RF sample to feed the **FMHD-1** is taken from the transmission line to the antenna. Similarly, in the case where the analog and digital signals are combined at high-level in a coaxial combiner, a single high-level RF sample is taken from the transmission line to the antenna. It is important that the directional coupler used to obtain this RF sample have sufficient bandwidth to provide an accurate representation of spurious emissions. Additionally, it is recommended that the directivity of the coupler be at least 30dB to prevent reflected power in the line from overloading or corrupting the readings of the **FMHD-1** or other instrumentation used to evaluate the RF system.

Separate-Line Facilities:

In the situation where two transmitters independently feed either a dual-feed antenna or two separate antennas via two transmission lines, the two high-level inputs on the **FMHD-1** are fed RF samples obtained from each transmission line. A precision RF combiner in the monitor sums the analog and digital RF components to form the complete IBOC RF signal, while maintaining isolation between the two RF feeds. Two rear-panel set screws allow adjustment of the relative amplitudes of the analog and digital portions of the HD signal so that the **FMHD-1** spectrum display and relative power calculations accurately represent the off-the-air signal. Just as for common-line HD facilities, it is important that the directional couplers used to obtain the RF samples have sufficient bandwidth and directivity to both 1) provide an accurate spectral representation of the transmitted signal and 2) to prevent overloading or corruption of the readings of the **FMHD-1** or other test instruments.

NOTE: Because the analog and digital RF signal levels in separate-line facilities are adjusted independently at the monitor, it is necessary to have completed the NRSC-recommended mask compliance measurement immediately prior to setting the input levels on the **FMHD-1**. Otherwise the monitor's indication of the analog-to-digital sideband power ratio will be inaccurate.

Monitoring at the Studio:

Placing the **FMHD-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

³ Recommendations for measurements of hybrid FM IBOC transmission systems are presented in National Radio Systems Committee document *NRSC-G201-A, NRSC-5 RF Mask Compliance: Measurement Methods and Practice, April 2010*. This document is available on-line at www.nrscstandards.org.

monitoring at any distance from the station transmitting, the accuracy of **FMHD-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 in the appropriate section following below. Then, to minimize the chance of damaging the **FMHD-1** by excessive RF input levels, carefully follow the procedures for adjusting the input level(s) following power-up.

3.3 FMHD-1 Installation at the Transmitter

Once the **FMHD-1** is properly mounted in the rack (see “Operating Environment,” above), make sure the level of both the *analog* and *digital* 50Ω FM RF samples to be supplied to the monitor are less than 10Vrms (28.3Vpk-pk). **Operation above 10Vrms input may damage the unit.** Simultaneously, for separate-line facilities, a sufficient analog RF signal level must be provided so that a proportionally scaled IBOC *digital* RF signal sample does not fall below 1Vrms (2.8Vpk-pk). Otherwise, accuracy of the monitor readings may be reduced. If there is any 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 50Ω coaxial cable, such as RG-58, to carry the analog RF sample from its source to the BNC jack labeled “IN 1” on the rear of the **FMHD-1**. (The jack is located within the “RF INPUTS” demarcation on the rear panel.) Note that the RF sample source and the coaxial cable feeding the **FMHD-1** high-level inputs must have an impedance of 50Ω. Otherwise, performance of the unit will be degraded.

For separate-line facilities, similarly prepare, but do not connect, a second 50Ω coaxial cable to carry the digital RF sample from its source to the BNC jack labeled “IN 2” on the rear of the **FMHD-1**.

The **FMHD-1** RF input level is displayed near the center of the “Main Tuning Screen”, directly under the tuning frequency readout. When the RF “Input Select” is set to “High Level”, the RF level indication is a bargraph indicating in percent, which is demarcated in 20% increments. One hundred percent is the optimum value. The bar lights yellow for readings below 80%, green between 80% and 110% and red from 110% to 120%. Operation anywhere in the green region will provide adequate performance.

Transmitter Installation Procedure—Separate-Line Facilities:

1. Mount the **FMHD-1** in a rack with the required AC power and sufficient cooling.
2. Obtain a 50Ω RF sample of less than 10Vrms from the analog antenna transmission line. Install, but do not connect, a 50Ω coaxial line to carry the RF sample to the rear panel of the **FMHD-1**.
3. Obtain a 50Ω RF sample of less than 10Vrms from the digital antenna transmission line. Run, but do not connect, a 50Ω coaxial line to carry the RF sample to the rear panel of the **FMHD-1**.
4. Apply power to the **FMHD-1**.
5. After the Main Tuning Screen appears, tune the **FMHD-1** to the carrier frequency using the encoder knob. (Control of the **FMHD-1** and use of the encoder knob are described under “Front Panel Operation”, on page 11.)
6. 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”.
7. Set the potentiometer adjacent to jack “IN 1” on the rear panel to roughly three-quarters fully clockwise. Set the potentiometer adjacent to jack “IN 2” on the rear panel to roughly one-half full.
8. With the analog transmitter on, connect the analog RF sample feed to the **FMHD-1** “IN 1” BNC jack. If the RF Level bargraph indicates red, immediately remove the RF feed and reduce the level of the analog RF sample at its source.
9. Adjust the **FMHD-1** “IN 1” potentiometer setting to obtain approximately 100% RF Level.

10. With the digital transmitter on and transmitting data, connect the digital RF sample feed to the FMHD-1 “IN 2” BNC jack. If the RF bargraph indicates red, immediately remove the RF feed and reduce the level of the digital RF sample at its source.
11. Using the rotary encoder, activate the FMHD-1 “RF Spectrum Screen”. (See Section 4 beginning on page 11 for instructions.) Activate the “Spectrum” popup menu and set “Measurements:” to “ON”.
12. While observing the “Ratio” indication in the spectrum display, carefully adjust the “IN 2” potentiometer to obtain the same IBOC carrier-to-sideband power ratio reading as was previously obtained using the NRSC-G201 mask compliance procedure.
13. Connect any desired FMHD-1 outputs and continue with the FMHD-1 setup.

Transmitter Installation Procedure—Common-Line Facilities:

1. Mount the FMHD-1 in a rack with the required AC power and sufficient cooling.
2. Obtain a 50 Ω RF sample of less than 10Vrms from the analog antenna transmission line. Install, but do not connect, a 50 Ω coaxial line to carry the IBOC RF sample to the rear panel of the FMHD-1.
3. Apply power to the FMHD-1.
4. After the Main Tuning Screen appears, tune the FMHD-1 to the carrier frequency using the encoder knob. (Control of the FMHD-1 and use of the encoder knob are described under “Front Panel Operation”, on page 11.)
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. Set the potentiometer adjacent to jack “IN 1” on the rear panel to roughly three-quarters fully clockwise.
7. With the analog transmitter on, connect the IBOC RF sample feed to the FMHD-1 “IN 1” BNC jack. If the RF Level bargraph indicates red, immediately remove the RF feed and reduce the level of the RF sample at its source.
8. Adjust the FMHD-1 “IN 1” potentiometer setting to obtain approximately 100% RF Level.
9. Using the rotary encoder, activate the FMHD-1 “RF Spectrum Screen”. (See Section 4 beginning on page 11 for instructions.) Activate the “Spectrum” popup menu and set “Measurements:” to “ON”.
10. If the RF sample is properly obtained, the “Ratio” indication in the spectrum display should be the same as the IBOC carrier-to-sideband power ratio previously determined using the NRSC-G201 mask compliance procedure.
11. Connect any desired FMHD-1 outputs and continue with the FMHD-1 setup.

3.4 FMHD-1 Installation at the Studio

A good off-air (remote) installation of the **FMHD-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 **FMHD-1** RF input level just below the tuning frequency numerals at the top-center of the display. Both a bargraph and numerical readout indicate the RF Level, with a green indication of “-60.0dB” or above being in the optimum range. The bargraph for off-air inputs is demarcated in 20-dB increments. The bar lights yellow for readings below -60.0dB. Red indicates an input overload—immediately reduce the input level.

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 2 millivolts of the desired signal into 75 Ω . For optimum performance, 300 microvolts or more is desirable;
4. Uses a high-quality, low-loss 75 Ω coaxial cable, such as RG-59, to connect the receiving antenna to the Antenna Input of the **FMHD-1** with an F connector.

Studio Installation Procedure:

1. Mount the **FMHD-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 75Ω lead-in with an F connector to the rack.
3. Apply power to the **FMHD-1**.
4. After the Main Tuning Screen appears, tune the **FMHD-1** to the carrier frequency using the encoder knob. (Control of the **FMHD-1** and use of the encoder knob are described under “Front Panel Operation” on page 11.)
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. Connect the antenna lead-in to the **FMHD-1** “Antenna” F connector. If the RF level bargraph on the Main tuning Screen indicates red, immediately remove the antenna feed and place a 75-Ω attenuator in the antenna feed line.
7. Adjust the external attenuator to obtain an RF Level bargraph reading in the green.”
8. Connect any desired **FMHD-1** outputs and continue with the **FMHD-1** setup.

3.5 FMHD-1 Output Connections

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

3.5.1 Audio Outputs

There are eight XLR output connectors carrying the monitor audio and test signals in analog form and three BNC output connectors providing six 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: “**FMHD-1** Popup Menu Map,” under “Settings: Outputs”.)

3.5.2 XLR Connections (analog channels 1–8)

Analog output channels 1 through 8 employ active-balanced output circuitry designed to drive 600Ω 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 600Ω, 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 600Ω.

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 AES/EBU BNC Connections (digital output channels 1-6)

These are three 75Ω coaxial outputs conforming to the AES-3ID serial transmission standard for distribution via 75Ω coaxial cables. The output swing is 0.5Vpk-pk into a properly terminated cable. The sources designated as odd-numbered are transmitted first; those designated as even-numbered follow in the three output channel pairings of channels 1 & 2, 3 & 4, and 5 & 6.

3.5.4 Composite Signal Outputs

The **FMHD-1** provides precision versions of the demodulation composite signals of analog FM broadcast stations in their un-altered baseband form. These may be used to drive FM exciters in re-broadcast applications, for performing proof-of-performance testing of FM Stereo broadcasts, for 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 75Ω. Full modulation, or 75.0 kHz peak deviation, provides about 2.1 volts peak, or about 1.5Vrms, un-terminated. (For a terminated 75Ω cable, divide these voltages 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.)

To obtain the most accurate measurements, with the lowest noise and distortion residuals, set up the **FMHD-1** at the transmitter and use a high-level input signal taken from the transmission line feeding the antenna. With this arrangement, the analog receiver front-end is bypassed. When the LVDS digital-format Composite Output is used, the entire demodulation chain in the **FMHD-1** is DSP-based.

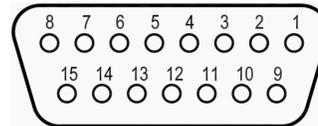
3.5.5 Relay Connections

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 **FMHD-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.



3.5.6 Ethernet Connection

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

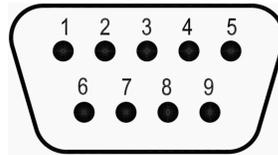
3.5.7 RS-232 Connection

The **FMHD-1** may be operated remotely via the rear-panel RS-232 serial interface using the PC-based **WizWin**© software. The **FMHD-1** rear-panel RS-232 connector is a male, two-row, 9-pin, D sub-miniature connector with locking nuts.

The RS-232 D-connector pin numbers are:

Description	Pin#	Type
CTX	1	Input
RX	2	Input
TX	3	Output
RTS	4	Output
GND	5	Ground

Pins 6–9 are not used.



3.6 FMHD-1 System De-Emphasis

All audio outputs of the **FMHD-1** are de-emphasized, i.e. the audio has the same frequency response at the output as the program signals driving the IBOC encoder feeding the transmitter. The analog channel outputs conform to the US standard 75-microseconds. De-emphasis is defined on page 34 in the “*Definitions*” section.

4 Operation

4.1 The User Interface

The **FMHD-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 **FMHD-1** via either the rear-panel RS-232 port or an Ethernet-type LAN or internet connection. The **WizWin** software presents a virtual image of the **FMHD-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. Instructions for downloading appear there, as well as in Sections 9.3 and 9.4 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 **FMHD-1** display screens, to select parameters, and to change settings.* For a listing of the top-level screens, see Table 1, “**FMHD-1** Display Screens”, on page 40. For the popup menus and their access points, see Table 2, “**FMHD-1** Popup Menu Map”, on page 41.

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 the present 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 successfully 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 in the upper-right corner of the display 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 setting. The change will be reflected in the operation of the **FMHD-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, “**FMHD-1** Popup Menu Map”, on page 41.

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 **FMHD-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 or condition is obtained. A second pressing of the knob returns the indicated value to a yellow color, locking the adjustment. The cursor re-appears, and the encoder knob can now be used to navigate within the blue popup pane to make other adjustments.

(In some cases, it is the cursor *position* which indicates the desired state. In the Program Selection Screen for example, once the cursor is set at the correct position, another momentary pressing of the encoder highlights the desired selection in green. Rotation of the encoder returns the cursor to the selection category, where another momentary pressing of the encoder returns the parameter indicator to yellow and restores navigational capabilities within the screen.)

4.2.6 Exiting a Popup Menu

A popup menu may be exited anytime by depressing and holding the encoder until the menu disappears.

Another, but more involved way to exit a popup menu is to simply reverse the procedure used to make a selection in a Popup Menu. To exit a popup pane, if necessary, first remove any green parameter highlighting by momentarily depressing the encoder knob. Then, move the yellow cursor to the X exit symbol in the upper-right corner of the pane by rotating the encoder knob. With the “X” marked by the cursor, momentarily depressing the encoder knob returns the user to the top-level screen.

4.3 FMHD-1 Modulation/Program-Level Readings (screen label change)

Due to the unique nature of the hybrid IBOC FM HD™ transmission system, the Belar **FMHD-1** presents two types of modulation indications. The analog FM channel for the hybrid system is monitored for peak frequency deviation of the analog FM carrier, with 75.0 kHz peak deviation representing 100% modulation—the FCC limit. This analog modulation indication is displayed in the “Total” bargraph on the “Analog FM Stereo Screen”. Modulation indications for the IBOC digital channels are more correctly referred to as *program levels*. All levels in the digital channels are limited to an absolute maximum level, referred to as *full-scale*. Because of the large amount of headroom normally maintained in digital audio systems, the hybrid IBOC system introduces scale factors into the metering of the analog and digital program channels. These factors allow the level indications to occupy a larger portion of the display range for ease in reading. The scaled analog and digital program levels are presented in the Audio Bargraphs Screen, along with the Scale Factor in force for the display. The default scale factors are –6.0dBFS, or six decibels below full-scale, for the digital program audio and –10.0dBFS for the analog program audio. The analog audio program level is metered after de-emphasis. The digital audio is metered as heard.

The processing and indication of the analog and digital readings—whether for modulation levels or for program levels—is handled in the same manner in the **FMHD-1**. Modulation data is collected over time-windows set by the user. Peak indications are the highest modulation (or program level) of either polarity occurring during a given window. The metering response is essentially instantaneous. In the **FMHD-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 **FMHD-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 or level 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 FMHD-1 Bargraph Displays

Two of the **FMHD-1** display screens have three-color bar graphs to indicate dynamically changing signal levels. These tri-color bar graphs provide simultaneous indications of the Peak modulation or program level (in red), the Average level (in yellow) and the Minimum level (in green). Characteristics of the indications are controlled by settings in the Unit Settings Pop-up Menu. (See Section 6.3.1 on page 25.)

For all settings, the Peak indication 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, “**FMHD-1** Modulation/Program-Level Readings”, explains how the data for the bargraph readings is obtained.

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

4.5 Spectrum Display

The user interface for, and the operation of the **FMHD-1** spectrum display are presented in Section 7, “**FMHD-1** Frequency Spectrum Display and Functions”, beginning on page 29.

5 The FMHD-1 Display Screens

5.1 Main Tuning Screen

The **FMHD-1** Main Tuning Screen is an observation point for routine monitoring of FM IBOC broadcasts. At the top center of the display is the carrier frequency to which the **FMHD-1** is tuned. The

“RF Level” bargraph just below the tuning frequency numerals indicates the RF input level of the signal at the indicated station frequency. This bargraph indicates whether sufficient signal is present to properly monitor the station. Status indicators and numerical readouts positioned around the screen display the operational status of the digital FM transmission system and allow verification of operation.

Only two monitor parameters may be set in this screen: the station tuning frequency and the source program stream for Digital Decoder #1. The tuning frequency is adjusted by manipulating the encoder knob to highlight the frequency numerals in green, then dialing in the station frequency. (See Section 4.2, “Front-Panel Operation” on page 11.) Adequate signal level can then be confirmed by observing the “RF Level” bargraph. For a high-level RF feed from one or two transmission lines, the 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 0 on page 7 or Section 3.4 on page 8, whichever is relevant.)

To the right of the tuning frequency readout are status indicators for the eight possible IBOC digital program streams, “HD 1” through “HD 8”. If the status box adjacent to a channel designator is lit yellow, the corresponding program stream is available from this station. An empty box to the left of the channel designator indicates that no corresponding program stream is available in the received broadcast. The program stream selected for processing by Decoder #1 is marked by a green box adjacent to that channel’s designation. A red box indicates that a channel that is not available has been selected for Decoder #1.

For operational convenience, this set of eight program status indicators can also be used to *select* which program stream is sent to Digital Decoder #1. With the **FMHD-1** output settings appropriately set, selecting a digital program stream for Decoder #1 allows one to easily direct its decoded output to the front-panel headphone jack, or any of the eight appropriately configured rear-panel monitoring outputs.

To select the data stream applied to Decoder #1, using the encoder, the cursor is first positioned to the desired program stream indicator, one of the boxes “HD 1” through “HD 8”. Then the encoder knob is depressed momentarily to highlight the marked indicator green. Of course, only channels marked yellow are available for selection. This program stream selection may also be performed using the Program Selection Screen. (See page 21.)

The upper-left corner of the Main Tuning Screen has three status indicators important for monitoring FM IBOC digital broadcasts. The topmost “HD Station” indicator turns green when the **FMHD-1** has locked onto the IBOC digital carriers. Second from the top, the “Digital Audio” indicator lights green when the selected digital audio stream is recovered. The “SIS CRC” indicator, third of the three, remains green as long as cyclic redundancy checks for the Station Information Service data frames continue to be valid. Note that the Digital Audio indication is typically the last of the three indicators to light, due to the 6–8-second combined time alignment and diversity delays present in the IBOC system.

The lower half of the Main Tuning Screen presents transmission performance information about the digital component of the IBOC HD signal. These metrics are listed below, in top-to-bottom order in the first column, then in the second.

Service Mode

This is the Primary Service Mode of the Hybrid or Extended Hybrid digital IBOC signal. The alternatives, MP1, MP2, MP3, MP11, MP5, and MP6 indicate which carriers are present in the IBOC digital sidebands.

CD/N0

This is carrier-to-noise ratio. “CD” is the total power in both digital sidebands; “N0” (more properly N_0) is the power-spectral-density measured in a 1-Hz bandwidth. Readings are typically in the neighborhood of 70 dB under good receiving conditions.

QI

This is a numerical quality assessment of the currently selected audio program signal, on a scale of 0 to 15. Fifteen represents the best assessed quality.

DAAI

The digital audio availability indicator is a filtered, or smoothed, metric for program quality, also scaled from 0 to 15. Fifteen represents the best assessed quality. It is specific to the chosen program stream.

MPA CODEC Mode

This is the designation of the codec configuration for the selected audio program.

Acq. Time Data

This is the measured time delay (in milliseconds) between acquisition of synchronization with the IBOC digital carriers and the receipt of the first valid cyclic redundancy check in a Station Information Service data frame.

Acq. Time Audio

This is the measured time delay (in milliseconds) between acquisition of synchronization with the IBOC digital carriers and the first recovery of an audio signal.

5.2 SIS Data Screen

This display presents information about the “Station Information Service” data transport stream, as well as some of the data it provides to FM IBOC HD receivers. The upper half presents data concerning the data stream itself. The data for the upper half of the display are listed below, in top-to-bottom order in the first column, then in the second.

Port ID

This is the port used in the data transport to deliver a particular service stream. Data port “5” is the data port for SIS processing.

Service ID

This is the service identifier of the basic SIS data. It is “28”.

Session Type

This is the session type for basic SIS data. It is “00”.

Num Types

This is the number of basic SIS data types the IBOC decoder module is able to send to the host controller.

SIS Block Count

This is the total number of blocks of SIS data received, using a one-digit hexadecimal representation. (The range of counts is from 0 to 15.)

ALFN

This stands for "Absolute Layer 1 Frame Number". It is incremented by 1 each time the SIS Block Count wraps around the hex value 0x00.

ALFN Status

A "0" indicates the ALFN count is valid. An indication of "3" indicates an invalid ALFN count.

Time Lock Status

Indicates whether the station's time and frequency references are locked with the GPS signal. Possible states are "LOCKED", "UNLOCKED", and "Not Valid".

The lower half of the SIS Data Screen presents data that would be seen by the listener.

FCC ID

This is the unique FCC (USA only) facility identification number.

Network ID

Reserved.

Short Name

This is the three- or four-letter call sign, possibly with "-FM" appended.

Long Name

This is a series of up to 56 characters that may include the station call sign or other message. The coding is based on the least-significant 7 bits of the ISO-8859-1 character set.

Country

This is the decimal representation of the 10-bit binary number formed from the two five-bit binary codes for alphabetical characters from the ISO 3166-1-alpha-2 code elements for the country. For the "US" code elements, the translation reads "658".

Lat

This is the latitude of the feed point of the transmit antenna in decimal degrees. Northern hemisphere locations are indicated by the prefix "N".

Long

This is the longitude of the feed point of the transmit antenna in decimal degrees. Western hemisphere locations are preceded by "W".

5.3 PSD Data Screen

"PSD" stands for "Program Service Data". This screen is split vertically into two halves. The upper half displays presence information for the IBOC digital program streams and technical details about the program service data stream packet headers and the data transmission. The lower half displays the decoded Program Service Data itself.

Along the top of the PSD Data Screen, is a row of eight “PSD Data” status indicators. They take the names of the eight possible IBOC digital program streams: “HD1” through “HD8”. Those streams highlighted in yellow or green are the program streams available in the received broadcast, with green indicating for which program service the Program Service Data is being displayed in the lower half of the display. Indicators that are (light) gray represent program streams that are unavailable in this broadcast, with red indicating that an unavailable channel of Program Service Data has been inadvertently selected in this screen. (This might occur when the station has been changed to one lacking the previously selected program service.) Note that not all IBOC digital program streams carry the additional Program Service Data. For these cases, the data display remains blank.

Selection of the Program Service Data for display is described at the end of this section.

We describe the data presented in the top half of the Data Screen below, again listed in top-to-bottom order in the first column, then in the second.

Port ID

This is the port used in the data transport to deliver a particular service stream. Data port “4” is the data port for SIS processing.

Service ID

This is the identifier of the basic PSD service/application.

Session Type

This is the session type for basic PSD data. It is “00”.

Num Packets

The number of packets in the queue to be read by the host processor. It really is an indicator of the “number of packets available”.

Packet Length

The number of bytes in the PSD packet.

Sequence Number

A PSD packet identification tag which can be used to properly arrange PSD packets if they are received out of order by the decoder.

Overflow Status

A “1” indicates that the message output queue has overflowed.

In the lower half of the PSD Data Screen, there are five message categories. Their content is modified according to the format of the program offering: music, talk, or an announcement. These fields are taken from the ID3v2.3 standard. The first four are limited to 128 characters.

Title: The program song title, the talk topic, or the announcement or advertisement title.

Artist: The artist name, the show host, or the author/sponsor.

Album: The album name, the show name, or the sponsor name.

Genre: For music, these descriptions are derived from a table. For talk or announcements, the genre is “speech”.

Comment: The short field contains the title for the comment field. The content field contains information appropriate to the program type.

Selection of the Program Service Data Stream is made by accessing the PSD Data Screen via the rotary encoder knob. Once the display appears, pressing the encoder knob momentarily activates the cursor in the display. The encoder knob is rotated to move the cursor through the eight possible PSD selections. Momentarily depressing the encoder knob with the cursor at the desired PSD designator activates the corresponding PSD stream, if available. Exiting the screen is handled by advancing the cursor to the “Exit” symbol in the upper-right corner and momentarily depressing the encoder knob. Further rotation of the knob will select other screens for the display.

5.4 Audio Bargraphs Screen

This screen allows the user to select and singly display the audio levels for either the analog program or any of the IBOC digital program channels actively decoded by an **FMHD-1** digital decoder. Peak, average, and minimum values for the Left, Right, L+R, and L–R audio signals are available as percentages of their full-scale values. Across the top of this screen are indicators for the single analog program channel and the eight digital IBOC program channels possible in hybrid IBOC HD™ broadcasts. The analog channel is designated by “ANL”; the HD channels are indicated by “HD1” through “HD8”. Those channels highlighted in yellow or green are the program streams available for metering, with green indicating which audio program levels are presently displayed. Enunciators that are (light) gray represent program streams that are unavailable for metering, with red indicating that an unavailable program channel has been selected for metering. (This might occur inadvertently when the station has been changed to another lacking the previously selected program service.)

For audio metering of a digital program channel to be possible, an **FMHD-1** digital decoder must be assigned to that digital program stream. The assignment of decoders is established by a user selection made in either the Main Tuning Screen or the Program Selection Screen. (See page 21, below.) Note that Program Service Data is automatically available for any channel for which it is inserted at the transmitter. No HD™ decoding is necessary to recover this data.

The program levels displayed in this screen conform to the program level metering described in Section 4.3 on page 1. The peak modulation percentages are displayed at the right-end of the corresponding graphs, with the scale factor common to all the readings shown just above the bargraphs. Settings for the dynamics and other characteristics of bargraphs are made in Section 6.3.1, the Unit Settings Popup Menu, on page 25. As described in Section 4.3, the program level readings displayed in this screen are scaled differently than for conventional FM-Stereo broadcasts.

The Left and Right program levels are self-explanatory. They are useful in determining the utilization of the digital stereo program channels. At the bottom are the L+R and L–R bargraphs. The L+R is literally the sum of the Left and Right channel signals. The L–R reading indicates the level of the stereo difference information. Normally, it is good practice to maintain the L+R signal fairly high. 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 that of the L+R. Its reading may approach zero for well-balanced monaural program sources.

5.5 Analog FM Stereo Screen

This screen monitors the conventional FM-modulated carrier which carries the analog FM Stereo broadcast portion of hybrid IBOC HD™ broadcasts. The 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. Numerical readouts of the peak readings appear to the right of the respective bars in the display.

The right edge of the red portion of each bargraph 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 **FMHD-1** Bargraph Displays on page 1414, above. For details about the metering characteristics, refer to the parameters immediately under the heading “Unit Settings Popup Menu” on page 25, 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 analog FM carrier. This is the most important analog reading. It includes the stereo composite signal (which includes the sum and difference channels and the stereo pilot), 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.

There are no user-controllable settings accessible from this screen.

5.6 Time Alignment Screen

Though referred to as the Time Alignment Screen, this screen provides information about the relative polarity, time alignment and amplitudes of the analog FM and hybrid IBOC HD™ main program streams. This information is important to assure sonically smooth blending of the analog and digital HD audio when receivers transition between the two modes.

The two bars in the middle of the screen indicate the amplitude and timing relationships between the main analog and digital signals. For both amplitude and timing, the red indicator shows a short-term value of the respective error, and the wider yellow bar shows long-term averaged errors.

The upper bar shows the relative amplitude of the analog and digital L+R signals, approximately the loudness perceived by a listener. The error in relative amplitude is indicated over a range of ± 20.0 dB, with a resolution of 0.1 dB. Listeners can detect differences of about one decibel, so it is best to keep the amplitudes within about ± 1.0 dB. Differences in the way the analog and digital program audio is processed will make level matching more difficult.

The lower bar shows the time alignment between the main analog and digital audio programs. It is metered in increments of 22.68 microseconds, or the sample period of 44.1-kHz digital audio streams. The range of indication is $\pm 16,384$ samples, or ± 371.5 milliseconds. This time relationship is adjusted in the HD encoder/processor at the transmitter.

To improve resolution of the timing error, the “HR” setting (for horizontal resolution) may be adjusted for full-scale timing error indications of ± 256 samples, or ± 5.8 milliseconds. Depress the encoder knob momentarily to activate the cursor on the screen. Press a second time to highlight the HR reading in green. Rotate the encoder knob to set the timing error resolution.

The upper-left corner of the display has a “Polarity” indicator. When green, the analog and digital audio signals have the same relative waveform polarity. If the indicator is red, the analog and decoded digital waveforms are 180 degrees out of phase. With perfect time alignment, an audio phase reversal will cause at near cancellation of audio at the receiver output at some point in the analog-digital blending process. With timing errors, the cancellation can produce undesirable effects in the audio. This condition should be corrected somewhere in the audio chain ahead of the analog or HD exciters.

Quick visual confirmation of proper hybrid setup is afforded by a green polarity indication and two red and yellow indicators at the centers of the two graphs on this screen.

5.7 Program Selection Screen

The Program Selection Screen indicates which of the eight possible digital program streams are present in the received IBOC HD broadcast and which digital decoders are processing those streams. The program types carried by each digital program stream are identified by numeric code and descriptive text. Decoder selections and assignments may be made in this screen using the rotary encoder.

The eight possible HD program streams are listed in the column along the left side of the screen: “HD1” through “HD8”. (HD1 is the Main HD program, and “HD2” through “HD8” correspond to Supplemental Programs 1 through 7.) Columns two and three of the display indicate the program type by numerical code and descriptive text, respectively.

The data block on the right-hand side of the display has four columns of enunciators, eight enunciators to a column. The four columns individually correspond to the four HD™ decoders, designated “D1” through “D4”, possibly incorporated in an FMHD-1. The right-hand data block essentially represents a switching matrix indicating the availability, unavailability, or the selection of a program data stream as an HD decoder input. An enunciator lit yellow or green indicates a program stream is available. A green enunciator indicates the HD decoder marked at the top of the respective column is assigned to the audio program stream marked at the extreme left of the respective row. Any audio programs marked green in this screen are available for output to the Audio Bargraph Screen and the XLR, AES, or headphone audio

outputs. (These selections are made in the Output Settings Popup Menu, as described on page 26.) A single red indicator in a column may indicate that the decoder assigned to that column is not present in the unit, or that the audio program assigned to that row is not available in the broadcast, or both. In this screen, red indicates a *non-functional* condition.

Decoder D1 is used to calculate the time and level alignments between the analog and digital portions of a hybrid IBOC transmission. So D1 is typically assigned to the Main HD program HD1. Otherwise, these indications in the Time Alignment Screen will indicate “*** Out of Range ***”.

Changes to the allocation of all the decoders present in the **FMHD-1** to the available program streams may be made in this screen. (Only inputs to HD Decoder D1 may be controlled from the Main Tuning Screen.) Once the Program Selection Screen appears, momentarily depress the rotary encoder. This sets the cursor at D1. Rotating the encoder will move the cursor through the four decoder choices and the exit icon  in a wrap-around manner. Once the cursor is placed at the desired decoder, tapping the encoder knob will highlight the marker green. Turning the encoder knob then will move the cursor down (or up) through the eight rows of possible audio programs and the decoder at the top of the column, in a wrap-around fashion. Once the cursor is placed in the desired program row, tapping the encoder will highlight the enunciator green (if both the program and the decoder are available). If the enunciator lights red, the assignment is non-functional.

To exit after setting a decoder input, move the cursor to the decoder marked at the top of the present column and momentarily depress the encoder knob. The decoder designator will turn yellow. Advance the cursor to the exit symbol  in the upper-right of the screen and again tap the encoder knob. Rotation of the encoder will advance through the screens in the display.

5.8 BER Data Screen

This screen provides readouts of bit-error-rate information useful for evaluating transmission performance of the hybrid FM IBOC system. For the BER testing, special data test sequences are generated in the HD Exciter. These data sequences are decoded and analyzed by test algorithms running in the HD decoder in the receiving **FMHD-1**.

When the BER test mode is activated at the HD Exciter, bit-error performance for the P1, P2, and P3 Primary logical channels, along with block-error performance for the PIDS (Primary IBOC Data Services) logical channel is displayed. The number of bits (and blocks) processed, the number of errors occurring, and the error rates are all displayed. During normal HD broadcasts, the twelve readouts indicate “N/A”, for Not Available.

To run a test, the BER test sequences are activated at the HD Exciter. The **FMHD-1** cursor is advanced to “Acquire” in the BER screen by the rotary encoder, and the encoder momentarily depressed. The **FMHD-1** begins accumulating and displaying error data. Moving the cursor to “Reset” and depressing the encoder knob restarts the counts. This allows determining whether adjustments in the transmitter plant have affected the system performance without completely restarting the test procedure.

If the BER Test Mode is de-activated and subsequently re-activated at the HD Exciter, the *Acquire* command must be re-issued to initiate a new measurement sequence in the **FMHD-1** decoder.

5.9 Alarms/Relays Screen

Twenty-two signal characteristics are continuously monitored by the **FMHD-1** to detect improper or undesirable hybrid FM IBOC 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 **FMHD-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 twenty-two monitored signals, their alarm threshold ranges, and the default alarm threshold values are shown in Table 3: **FMHD-1 Alarms/Relays Screen Defaults and Ranges.**”, page 46. 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 22 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.

One special case exists for this screen. The “Total Peak” alarm has no associated timeout. The over-modulation alarm is triggered immediately when a modulation indication exceeds the user-set threshold.

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

6 The FMHD-1 Popup Menus

The **FMHD-1** Popup Menus are blue display panes that group the parameter settings and information specific to one aspect of monitor operation in one place. Typically, these are the lesser-used adjustments that would be inconvenient to control from the main **FMHD-1** display screens. The panes are selected for presentation by a screen pull-down that displays the categories (and sub-categories) of Popup Menus. Their access and navigation are described in detail in Sections 4.2.5 and 4.2.6, beginning on page 12.

The popup menus listed in this section appear in the popup menu directory. The popup menu directory is accessed from any screen by depressing the encoder knob for two seconds. For convenience, the RF Spectrum Popup Menu is described as part of the discussion about the RF Spectrum Screen, in Section 7.3, beginning on page 30.

The Popup Menu categories and their associated domains of control follow:

RF Controls for the RF input, tuning, calibration, and output muting

Composite Controls for the composite filter bandwidth and peak modulation settings

Spectrum Controls for the RF spectrum display

Settings Controls for metering and display properties, audio outputs, networking connections, e-mail messaging, troubleshooting data for the HD decoders, and unit software version and serial information.

6.1 RF Popup Menu

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

Tuning: Enables the encoder knob to tune the **FMHD-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, but allows one to tune to alternate stations without leaving the screen present in the display.

Calibrator: Selects among seven internal test signals used to verify accuracy of the FCC-standard modulation indications presented in the **FMHD-1** Analog FM Stereo Screen. These test signals also confirm proper operation of the *analog* FM demodulator which provides these indications. The demodulated test signals appear at the **FMHD-1** Composite Output on the rear panel. However, the calibration signals *do not* pass through the demodulator which provides the audio metering indications and audio output of the analog portion of the hybrid FM IBOC signal. Nor are the calibration signals visible on the RF Spectrum Screen.

OFF - The Calibrator is disabled. The **FMHD-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, and the pilot in the composite signal, Total modulation reads 95.6%.

Left 5 kHz -A 5-kHz left-only signal with 90% L modulation. Interleaving causes Total to read 96.2%.

Left 11 kHz -An 11-kHz left-only signal with 90% L modulation. Total reads 95.7%.

Left 15 kHz -A 15-kHz left-only signal with 90% L modulation. Total reads 96.3%.

Mute: The **FMHD-1** composite and audio outputs are disabled when Mute is active. These outputs are disabled when the user manually selects “ON” for the Mute option in the RF Popup Menu. When “AUTO” is selected, muting of both 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 remain below the alarm threshold for the time

interval set by the “Time” parameter for the appropriate RF level threshold alarm for muting to occur. “OFF” disables all muting.

6.2 Composite Popup Menu

This popup menu allows adjustment of two settings dealing with the demodulated *analog* FM composite signal used exclusively to provide the modulation indications for the Analog FM Stereo Screen and the rear-panel Composite outputs.

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

In order of descending bandwidth, the filters are:

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 subcarrier.

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 of peak modulation required to activate the “Total Peak” alarm. It is set in “%”, where 100% corresponds to 75-kHz peak deviation of the analog FM carrier. This threshold may also be set via the Alarms/Relay Screen, where its timeout and the alarm activations may be controlled.

6.3 Settings Popup Menus

The following Popup Menus are brought onto the **FMHD-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 control settings for both the peak readings and the modulation bargraphs of the **FMHD-1**, and controls several miscellaneous functions of the unit. Details not explained for the Popup Menu below appear in the section “**FMHD-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. That peak value is then displayed for the duration of the Hold Time, unless a higher peak is detected first, in which case the process repeats. Minimum and Average readings during that interval are computed and displayed in the bargraphs. 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 occurring during that interval is displayed. Minimum and Average readings during that interval are computed and displayed in the bargraphs. 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. “Hold 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 collected over a semi-infinite interval are displayed.

Remote: When “ON,” permits remote access to the **FMHD-1** via the RS-232 and RJ-45 rear-panel connectors. “OFF” blocks both RS-232 and Ethernet communications with the **FMHD-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. (The display is blanked by turning off the LCD screen backlighting.)

Reset Defaults: Moving the cursor to this position and pressing the encoder knob resets all of the **FMHD-1** settings to their factory default values.

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

6.3.2 Output Settings Popup Menu

This Popup Menu allows any one of fifty-six audio signals (or signal combinations) decoded or generated by the **FMHD-1** to be assigned to each of the eight XLR analog outputs and six AES/EBU digital outputs (available from three 75Ω BNC coaxial jacks) on the **FMHD-1** rear panel. These same fifty-six 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 also adjustable via this menu.

Forty-eight of the output signals available consist of groupings of the four stereo audio signals L (left), R (right), L+R (left-plus-right), and L–R (left-minus-right) ultimately derived from the eight digital audio program streams possible in hybrid FM IBOC broadcasts. Thirty-two of these forty-eight audio signals consist of the eight groupings of L, R, L+R, and L–R marked as taken from the eight possible digital audio program streams (designated HD1 through HD8). These outputs are designated in manner of “HD1 L”, “HD5 R”, “HD3 L–R”, ..., etc. Sixteen of these forty-eight audio signals consist of four groupings these same L, R, L+R, and L–R audio signals alternately marked as taken from the *outputs* of the four HD decoders, D1 through D4. These outputs are designated in the manner of “D1 L”, “D3 R”, ..., etc. By assigning an audio output to one of the (possibly) four **FMHD-1** HD decoder outputs, any of the eight audio program streams may be auditioned by simply re-assigning the input to that decoder using the Program Selection Screen. (As the individual decoders use HD1 through HD8 as *their* sources, duplication of the program streams at the outputs is possible. This redundancy may offer some operational convenience.)

The four analog outputs (L, R, L+R, and L–R) have only the single analog-FM source. These are marked in the manner “ANL L”, “ANL R”, “ANL L+R”, and “ANL L–R”.

Four internally generated signals may also be directed to any of the fourteen **FMHD-1** rear-panel 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. These are designated as “TST 0”, “TST -3”, “TST -6”, and “Mute”. The Mute signal may be activated to check the noise floor of connections to the **FMHD-1**, as well as to provide a quiet source for external testing. These four test signals also are available in the two channels of the front-panel headphone jack.

Analog output channels 1 through 8 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.

Analog outputs 1 through 8 employ a DC servo circuit greatly suppresses any DC present in the output signals while minimizing any waveform tilt that might be introduced by conventional high-pass filtering.

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

The settings for the **FMHD-1** front-panel headphone output are at the bottom of the Outputs Popup Menu. As for the analog and digital programs above, one of the fifty-two audio signals and four test signals may be chosen for either the Left or Right headphone channel outputs. The sources are chosen by the encoder knob with the cursor placed adjacent to either the “L:” or “R:” at the bottom of the screen. Placing the cursor at, and then highlighting in green, the number displayed to the right of “Vol:” permits adjustment of the headphone volume. Subsequent rotation of the encoder knob adjusts the L- and R-channel headphone volumes, as a pair, from 1.0% to 100.0% in 1% increments.

6.3.3 Network Status Popup Menu

This sub-menu is accessed through the `Network` selection in the Settings Popup Menu.

This menu provides information about the addressing of the **FMHD-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 sub-menu is accessed through the `Network` selection in the Settings Popup Menu.

The **FMHD-1** offers either fully automatic Internet Protocol 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 sub-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 **FMHD-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 an "@" 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 FMHD-1 or station. Example: "FMHD-1 WXYZ" would result in an e-mail message with the subject line "FMHD-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 momentarily press the encoder knob to overwrite the initial text. Proceed as in creating the email address lines, above.

All email addresses in the **FMHD-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 sub-menu is accessed through the Settings Popup Menu.

This screen is read-only, listing the versions of all firmware present on the **FMHD-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.

7 FMHD-1 RF Spectrum Screen

7.1 General

The **FMHD-1** incorporates a sensitive and accurate DSP-based FFT (Fast Fourier Transform) spectrum analyzer which displays the frequency spectrum of the hybrid FM IBOC HD™ signal. This signal contains both the analog FM RF signal and the digital IBOC OFDM subcarrier sets (or sidebands). The output is an X-Y graph showing the relative amplitude of signal energy, displayed along the vertical (Y) axis, as a function of frequency, which is displayed along the horizontal (X) axis. This capability can be a great aid in troubleshooting problems in the transmission system and in verifying system performance.

The frequency axis of the display 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 at one time is 750 kHz, but the RF center frequency may be shifted off-center to enable views as far as 825 kHz to either side of the carrier. Horizontal frequency resolution of the RF Spectrum Screen is from 50 Hz-per-pixel to 1,500 Hz-per-pixel. A RF spectrum mask may be superimposed on the display to quickly evaluate compliance with FM emission limitations.

The spectrum display is controlled by the rotary encoder acting upon both on-screen parameters and parameters appearing in a dedicated sub-menu. The six on-screen measurement parameters available are described below.

7.2 On-Screen Spectrum Parameters

The rotary encoder controls the spectrum display via six on-screen parameters and several additional parameters that appear in a sub-menu. The six measurement parameters appear across the top of the display and in its lower-right corner. The parameters are:

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.⁴

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

⁴ 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.

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 range is 50 Hz-per-pixel to 1,500 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 axis to keep the cursor near 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.

7.3 The RF Spectrum Popup Menu

The RF Spectrum Popup Menu is selected by pressing in and holding down the encoder knob until the Popup Menu directory appears, rotating the encoder to select "Spectrum", and then momentarily depressing the encoder knob to enter.

Following are the parameters and controls which appear in the **FMHD-1** RF Spectrum Popup Menu.

Display Mode:

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

Peak Hold - The display holds the largest spectral amplitude occurring in each spectral bin 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 - The display computes the average spectral amplitude occurring in each spectral bin 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 - The spectral amplitude is replaced by any higher spectral amplitude that occurs in that spectral 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 (for "Average 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 easily 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 maximum 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 edge 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", the entire RF spectrum is indicated in green. When "ON", specific portions of the RF spectral display are color-coded. When Colors is "ON", the central analog region of the spectrum is green, the main IBOC sidebands are yellow, and the regions mainly dedicated to the extended IBOC sidebands are red. [The green highlighting extends to ± 100 kHz. The red highlighting starts at ± 100 kHz and extends to ± 122 kHz each side of the analog carrier. The yellow highlighting starts at ± 122 kHz and extends to ± 200 kHz.]

Mask:

Setting Mask to "ON" superimposes an adjustable red-line overlay on the FMHD-1 RF spectrum display to assist in determining compliance with NRSC and FCC emission standards. The mask is centered at the analog FM carrier frequency, as set in the Main Tuning Screen. The central amplitude is set at "0dB" to facilitate level measurements relative to the analog carrier, or in units of dBc. The relative amplitudes of the two steps extending from ± 100 kHz to ± 200 kHz each side of the carrier are independently adjustable.

(This simplifies measurements for stations operating with asymmetric digital sideband power levels.) Adjusting the “LSB Limit” and “USB Limit” parameters allows the mask to measure conformance with both the waveform noise and spurious emission limit and the hybrid IBOC digital sideband power level limitation.

The mask is set so that with the RF Spectrum Screen set for 1-kHz-per-pixel horizontal resolution, the decibel amplitudes conform to the standards for measuring sideband power levels, noise, and spurious emissions. For a discussion of the measurement techniques, refer to *NRSC-G201-A*.⁵ Typically, when making these measurements, the top of the vertical axis would be set to “0dB” using the “dB” on-screen parameter setting. (An un-modulated analog FM carrier would just reach this 0-dB reference line, but the **FMHD-1** internal computational capability determines the analog FM carrier power with a modulated carrier.) Table 6 of *NRSC-G202* shows the appropriate power spectral density “limit-lines” for an RF mask to guarantee conformance with the prescribed total digital-sideband-power-to-carrier-power-ratio⁶. (This ratio is also called the digital sideband power ratio relative to analog, or “dBc”.) For a –20dBc power ratio, Figure 6 from *NRSC-G202* recommends using –40.0dBc/kHz as a mask limit-line for emissions. Likewise, for a –14dBc digital-to-analog power ratio, the recommended mask power level limit is –34dBc/kHz. The limit-line amplitudes are all numerically 20dB below the allocated digital-to-analog ERP ratio, but measured in dBc/kHz. This discussion is applicable only for the case of symmetric sideband powers. Tables in *NRSC-G202* cover cases for asymmetric IBOC digital sidebands powers.⁷

With `Mask` set to “OFF”, no spectral-limit overlay appears.

LSB Limit:

This parameter adjusts the power level of the lower sideband mask step relative to 0 dBc, the reference analog carrier level of 0dB. It is varied using the rotary encoder from “–40.0 dB” to “–20.0 dB” in 0.1-dB increments.

USB Limit:

This parameter adjusts the power level of the upper sideband mask step relative to 0 dBc, the reference analog carrier level of 0dB. It is varied using the rotary encoder from “–40.0 dB” to “–20.0 dB” in 0.1-dB increments.

Measurements:

When “ON”, this feature activates a standardized computation of the power of the analog FM carrier and the individual hybrid IBOC sideband power levels. The horizontal resolution is automatically set to 1-kHz resolution bandwidth and the averaging count set to 50. The following results are displayed along the right edge of the screen:

⁵ This spectral mask is defined in the NRSC-5-B hybrid FM IBOC waveform noise and emission limit graph, Figure 1, in document *NRSC-G201-A*, April, 2010, available from the <http://www.nrsstandards.org> web-site.

⁶ Power limits for the hybrid IBOC digital sidebands were set in FCC Order DA 10-208, adopted January 27, 2010 and released January 29, 2010. The Order is included as Annex 1 in NRSC document *NRSC-G202*, of September, 2011. It is available at <http://www.nrsstandards.org>.

⁷ The 191 digital carriers falling in the 69-kHz-wide IBOC bands each side of the analog carrier frequency for the MP1 service mode result in a PSD numerically 21.4 dB below the nominal digital sideband power ratio relative to analog, but expressed in units “dBc/kHz”. Example, for a prescribed ratio FM Digital ERP to FM Analog ERP of –20dBc, the power spectral density of the IBOC digital sidebands is –41.4dBc/kHz. This is the sideband level we expect to see in a 1-kHz resolution bandwidth reading on a spectrum analyzer. So the NRSC-recommended limit-lines at –40dBc/kHz provide some margin for error.

ANL Pwr The power existing in the analog FM carrier.

LSB Pwr The total power in the hybrid IBOC lower digital sideband.

USB Pwr The total power in the hybrid IBOC upper digital sideband.

HD Pwr The total power in both hybrid IBOC digital sidebands.

Ratio The ratio of the total power in the IBOC digital sidebands (HD Pwr) to the power in the analog FM carrier (ANL Pwr). (This is the ratio regulated by the Federal Communications Commission.)

When the **FMHD-1** is properly installed, the `Measurements` feature provides quick verification of the correct relative IBOC HD™ power levels. Note that activating the RF Spectrum Measurement function establishes a fixed set of display parameters for the RF Spectrum Screen.

8 List of 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 **FMHD-1**, the designation refers to AES-3ID, a variation of the standard for transmission over 75Ω coaxial cables.

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 **FMHD-1** indicates *average modulation* as the averaged value of the peak modulation readings collected over a user-set time interval.

Common-Line Facilities

In FM hybrid IBOC transmitter facilities, this refers to the situation where the high-power analog and digital components of the hybrid signal are fed to the antenna system via a single transmission line. The analog and digital portions of the transmitted signal may be combined in a high-level RF combiner. The analog and digital signals may also be combined at low-levels or in a split-level system, and then amplified. Finally, the hybrid signal combination may be synthesized directly and then amplified to the required power as one signal.

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 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.

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

dBFS

This is the abbreviation for “Decibels relative to Full-Scale”. In pulse-code modulation, analog signals are represented as a series of digitally-encoded numbers, each corresponding to the amplitude of the analog waveform at successive instants in time. The largest signal amplitude that may be accurately represented in a pulse-code modulation system is referred to as “full-scale”. This maximum is the reference voltage used for calculating dBFS:

$$dBFS = 20 \log_{10} \left\{ \frac{V_2}{V_{FS}} \right\}.$$

Because the coding process breaks down (clipping occurs) at levels above V_{FS} , dBFS readings are always negative.

dBc

This abbreviation may be translated as “Decibels relative to Carrier Power”. (See the definition for “Decibel”, above.) In this case, the reference power in the expression,

$$dBc = 10 \log_{10} \left\{ \frac{P_2}{P_{ref}} \right\} = 10 \log_{10} \left\{ \frac{P_2}{P_{carrier}} \right\}$$

is the power level of the carrier. For FM hybrid IBOC systems $P_{carrier}$ is the assigned power of the analog FM carrier.

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

De-emphasis is not relevant to the program audio carried by the digital transmission portion of the hybrid IBOC system.

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 portion of the analog FM 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 **FMHD-1** offers the common 10/100 Base-T/TX technology.

FFT

This 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.

HD Radio™

This is a trademark of the iBiquity™ Corporation. It refers to the USA-based iBiquity system for "in-band-on-channel" combined analog and digital FM transmission, which has been approved by the Federal Communications Commission.

High-Level Combining

In FM hybrid IBOC transmitter facilities, this refers to the situation where the analog and digital carriers are produced in separate transmitters. The outputs of the two transmitters are either combined in a high-level RF combiner for broadcast, or are applied either to a dual-feed antenna or to two independent antenna systems. (The first case is referred to as a common-line facility; the last two cases are separate-line facilities.)

Hybrid FM IBOC

This is the system that combines a modulated analog FM carrier with digitally modulated Primary Main subcarriers that take the form of two sidebands. In some cases, additional Extended Main digital sidebands are included as part of the two sidebands.

IBOC

Refers to the system in which digital carrier sets are established within the spectral band allocated to an analog FM station, centered at its allocated center frequency.

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.” In the **FMHD-1**, IF refers to the down-converted FM-modulated RF signal present at the output of the tuner employed to recover broadcast signals applied to the antenna input. The IF is centered at approximately 10.7 MHz.

LAN

This stands for “local-area network”. The **FMHD-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 generator 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.

Low-level Combining

In FM hybrid IBOC transmitter facilities, this refers to the situation where the analog and digital carriers are combined at low-level then amplified in a common power amplifier. The output of the power amplifier is fed to the antenna on one transmission line. This is a “common-line” transmitter facility.

LVDS

This is the abbreviation for “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.

OFDM

Orthogonal frequency-division multiplexing. A method of encoding data on multiple carriers at different frequencies.

PAD

In the HD Radio context, this refers to “Program Associated Data”. This is another expression for Program Service Data, defined directly below.

PSD

In the HD Radio context, this refers to “Program Service Data”. This is the information transmitted as part of the data stream for the benefit of the audience. For musical formats, this information typically would include information such as the title, artist, album, and genre of a selection, and possibly include commentary.

Peak

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

PC

A 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 **FMHD-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 monaural and stereo and 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

This refers to “radio frequency”, either as an adjective, or as a noun.

RMS

This is the root-mean-square. It is the power-equivalent of a voltage or current signal.

Separate-Line Facilities

In FM hybrid IBOC transmitter facilities, this refers to the situation where two transmitters independently feed either a dual-feed antenna or two separate antennas via two transmission lines. (This situation requires two samples be applied to the FMHD-1, and that the system losses are carefully accounted for when the input levels to the monitor are set.)

SIS

This is the Station Information Service. It is a system that carries textual information about the station broadcasting the data. It is carried as part of the digital data stream of the IBOC system. The information may include station call-sign, geographical coordinates of the transmitting antenna, country, and long station identifiers.

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 Software Setup and Unit Update Information

The **FMHD-1** may be connected to a computer using the **Belar WizWin© Software**, which can be downloaded from our website at www.belar.com. Connections can be made using the RS-232 port or Ethernet jacks on the rear panel. In addition to accessing the unit remotely, the **Belar WizWin Software** may also be used to update the **FMHD-1** firmware in the field.

Please check our website at www.belar.com for the latest software updates, as we are always improving our products and adding features.

9.1 Connecting to the unit using the RJ-45 Network Jack

- a. Download and Install the latest version of **Belar WizWin© Software** from our website.
- b. If connecting to a network with a DHCP server in place (the **FMHD-1** is shipped with DHCP enabled) connect the **FMHD-1** to your network, on the same subnet as the computer you loaded the **Belar WizWin© Software**, and power cycle the unit.
- c. If your network does not have a DHCP server, the **FMHD-1** will select an APIPA (Automatic Private IP Address) address in the 169.254.xxx.xxx range with a 255.255.0.0 subnet. You can then use an isolated (non DHCP) switch or a crossover cable to connect the **FMHD-1** to your computer. 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. To obtain the Units IP address on the **FMHD-1**, activate the popup menu and select Settings, under Settings select the Network: Status submenu to display the current network information. Make sure that the **FMHD-1** is power cycled after the RJ-45 cable has been connected to the unit.
- e. To set a Static IP address on the **FMHD-1**, activate the popup menu and select Settings, under Settings select the Network: Configure submenu to enter the IP Address, subnet, and gateway. DHCP must be disabled to set a static IP.
- f. Run the **Belar WizWin Software** and select “Connections” from the window. A pop-up dialog box will appear, select “Connection #1” and click the “Configure” Button. Using the tabs in the Configuration Dialog Box set the “Hardware Type” to “**FMHD-1**”, set the “Connection Type” to “Network-Ethernet”, and under “Network” set the “IP Address” to the address displayed on the **FMHD-1**, then set the “PORT” to “10001”, click the “Save” Button to finish. Finally, click the “Connect” Button and the unit will connect and display a virtual front panel of the unit.

9.2 Connecting to the unit using the RS-232 Port

- a. Download and Install the latest version of **Belar WizWin© Software** from our website.
- b. Connect the unit to the computer using a 9-pin serial modem cable.
- c. Run the **Belar WizWin Software** and select “Connections” from the window. A pop-up dialog box will appear, select “Connection #1” and click the “Configure” Button. Using the tabs in the Configuration Dialog Box set the “Hardware Type” to “**FMHD-1**”, set the “Connection Type” to “RS-232”, under “RS-232” set the “COM Port” to the COM Port being used on the computer, click the “Save” Button to finish. Finally, click the “Connect” Button and the unit will connect and display a virtual front panel of the unit.

9.3 Updating the FMHD-1 Firmware

Establish a computer connection to the unit using either the RS-232 Port or the RJ-45 Ethernet Jack. See the previous instructions for connecting to the **FMHD-1**.

With the **Belar WizWin© Software** running and connected to the **FMHD-1** the virtual front panel of the unit should be visible. In the “Connections” Dialog Box click the “Update” Button, a “Update” Dialog Box will appear showing the **FMHD-1** units current software version and the Files software version. A warning message will appear if the File software version is the same or older than what is currently in **FMHD-1** unit. To start the update click the “**Update EPROM**” Button, the front panel of the **FMHD-1** will show the update status.

9.4 Updating the FMHD-1 Lantronix® Ethernet Controller

The Lantronix Ethernet Controller should be updated to version **4.0.0.0** for proper operation of the unit. Establish a computer connection to the unit using either the RS-232 Port or the RJ-45 Ethernet Jack. See the previous instructions for connecting to the **FMHD-1**.

With the **WizWin Software** running and connected to the **FMHD-1** the virtual front panel of the unit should be visible. In the “Connections” Dialog Box click the “Update” Button, a “Update” Dialog Box will appear showing the **FMHD-1 Lantronix** current software version and the Files software version. To start the update click the “**Update Lantronix**” Button, the front panel of the **FMHD-1** will show the update status.

10 Tables

10.1 Table 1. - FMHD-1 DISPLAY SCREENS

Screens marked with an asterisk (“*”) below contain user-adjustable parameters or selections. The screens are listed in the same sequence as they appear in the display. (In this manual, however, the RF spectrum Screen is the last to be described.)

- Main Tuning Screen*
- SIS Data Screen
- PSD Data Screen*
- Audio Bargraphs Screen*
- Analog FM Stereo Screen
- RF Spectrum Screen
- Time Alignment Screen*
- Program Selection Screen*
- BER Data Screen*
- Alarms/Relay Screen*

10.2 Table 2. - FMHD-1 POPUP MENU MAP

Defaults are listed first, if appropriate.

Popup Heading	Selections	Popup Options
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 11 kHz Left 15 kHz
	Mute	AUTO OFF ON
Composite	Filter BW	Stereo + 92kHz Stereo + RDS Stereo + 67kHz
	Peak Mod	0.0 to 150.0%, in steps of 0.1% (100.0% default value)

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Popup Heading	Selections	Popup Options
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 (-20.0 dB default value)
	Curve Fill	ON OFF
	Colors:	ON AUTO OFF
	Mask:	OFF ON
	LSB Limit:	-40.0 dB to -20.0 dB (-40.0 dB default value)
	USB Limit:	-40.0 dB to -20.0 dB (-40.0 dB default value)
	Measurements:	OFF ON (This provides automatic sideband power level calculations.)
Settings	Unit	Time Mode: Past Real
		Hold Time: 0.25 sec. to 5.0 secs. in 0.5 sec steps (0.5 sec default)
		Infinite: OFF ON

**Popup
Headings**

Selections

Popup Options

Remote: ON
 OFF

Screen 1hr to 12 hours in 1-hour steps
Saver: OFF; (1hr default)

Reset
Defaults

Reboot

Settings

Outputs

Analog (defaults listed)

Ch#1:	ANL L;	Ch#5:	HD2 L
Ch#2:	ANL R;	Ch#6:	HD2 R
Ch#3:	HD1 L;	Ch#7:	HD3 L
Ch#4:	HD1 R;	Ch#8:	HD3 R

AES/EBU (defaults listed)

Ch#1:	ANL L;	Ch#5:	HD2 L
Ch#2:	ANL R;	Ch#6:	HD2 R
Ch#3:	HD1 L;		
Ch#4:	HD1 R;		

(Each channel above can be assigned any of the following signals: L, R, L+R, L-R, TST 0, TST -3, TST -6, and Mute. For L, R, L+R, and L-R, the source must be selected from the choices ANL, HD1 through HD8, or D1 through D4.)

Headphone L: D1 L
 R: D1 R

(Each headphone channel above can be assigned any one of the signals listed above for the rear-panel outputs.)

Headphone 0.0% to 100.0% in 1% steps
Volume (10.0% default)

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Popup Heading	Selections	Popup Options	
Settings	Network	Network Status	MAC: 00:20:4a:d5:37:9a (sample address) Host: IP Addr: xxx.xxx.xxx.xxx Subnet: 255.255.255. 0 Gateway: xxx.xxx.xxx.xxx DHCP: ON (The three addresses above are to indicate their form only.) OFF (Addresses are fixed.) Refresh (Depress encoder knob to refresh readout.)
		Network Configure	IP Addr: xxx.xxx.xxx.xxx Subnet 255.255.255. 0 Gateway xxx.xxx.xxx.xxx DHCP: ON (All three addresses above default to "<DHCP>".) OFF (The addresses are entered manually.) Apply (Depress encoder knob to apply settings.) Status: "IDLE" or "ACTIVE" (read-only)
		Email	(The entries below are present in each of the four alarm messages, Email #1 through Email #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.

Popup Headings	Selections	Popup Options
Settings	Decoders	<p>(The read-outs and settings below are available in a popup for each of the four HD decoders possibly installed in the FMHD-1.)</p> <p>Status: Detected or Not Detected</p> <p>Command Errors: The failure percentage of command errors issued to the iBiquity IBOC digital module.</p> <p>Status Messages: A running list of operational and status indications issued by the IBOC digital module.</p> <p>Clear: Placing the cursor on "Clear" and depressing the knob clears the list of status messages from the popup display pane.</p> <p>Reset: Placing the cursor on "Reset" and depressing the knob repeats the command sequence which established the decoder's present operational status.</p> <p>Reboot: Placing the cursor on "Reboot" and depressing the knob reloads the decoder's software.</p>
	Info	<p>Read-out only. Lists the version of all software in use in the FMHD-1, along with the unit model and the manufacturer's serial number.</p>

10.3 Table 3. - FMHD-1 Alarms/Relays Screen Defaults and Ranges

FMHD-1 Default Frequency: 94.5 MHz

Event	Default Values					Range of Adjustment	
	Threshold	Time (secs)	Relay	E-mail	Display	Threshold	Time (secs)
Loss of RF (Antenna)	-65.0dB	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
Loss of Total	10.00%	10	N	N	N	-80.0dB to -20.0dB	1 to 600
Total Peak	100.00%	N/A	N	N	N	0.0% to 150.0%	N/A
Loss of ANL L+R	10.00%	10	N	N	N	0.0% to 100.0%	1 to 600
Loss of Pilot	5.00%	10	N	N	N	0.0% to 15.0%	1 to 600
HD Station LED	N/A	10	N	N	N	N/A	1 to 600
HD Audio LED	N/A	10	N	N	N	N/A	1 to 600
SIS CRC LED	N/A	10	N	N	N	N/A	1 to 600
QI Value	10	10	N	N	N	0 to 15	1 to 600
CD/NO	+50.0dB	10	N	N	N	+30.0dB to +80.0dB	1 to 600
Loss of HD1 L+R	10.00%	N/A	N	N	N	0.0% to 150.0%	1 to 600
Loss of HD2 L+R	10.00%	N/A	N	N	N	0.0% to 150.0%	1 to 600
Loss of HD3 L+R	10.00%	N/A	N	N	N	0.0% to 150.0%	1 to 600
Loss of HD4 L+R	10.00%	N/A	N	N	N	0.0% to 150.0%	1 to 600
Loss of HD5 L+R	10.00%	N/A	N	N	N	0.0% to 150.0%	1 to 600
Loss of HD6 L+R	10.00%	N/A	N	N	N	0.0% to 150.0%	1 to 600
Loss of HD7 L+R	10.00%	N/A	N	N	N	0.0% to 150.0%	1 to 600
Loss of HD8 L+R	10.00%	N/A	N	N	N	0.0% to 150.0%	1 to 600
Time Align +	+50 samples	10	N	N	N	0 to +250 samples	1 to 600
Time Align -	-50 samples	10	N	N	N	0 to -250 samples	1 to 600
Audio Polarity LED	N/A	N/A	N	N	N	0.0% to 150.0%	1 to 600



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