# XR6/XR3 Transmitter

# Pre-installation Manual

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The comparisons and other information provided in this document have been prepared in good faith based on publicly available information. The reader is encouraged to consult the respective manufacturer's most recent published data for verification.

nautel
AM/FM Radio Transmitters

**Kevin T. Rodgers**
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**SUPPLIER'S DECLARATION OF CONFORMITY**
According to 47 CFR § 2.1077 Compliance Information

**We:**

Nautel Maine Inc.
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**declare under our sole responsibility that the product:**

| | |
|---|---|
| Product Name: | XR Series AM Transmitter |
| Model Number: | XR6 |

**complies with parts 2 and 73 of FCC rules**

Kevin Rodgers
Chief Executive Officer

Date: August 23, 2019

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Date: August 23, 2019

**NOTICE FOR HD RADIO USERS ONLY**

SALE OR DISTRIBUTION OF THIS DEVICE REQUIRES A LICENSE FROM IBIQUITY DIGITAL CORPORATION.

(Contact licensedproductnotification@xperi.com)

# Contents

# About this manual

This manual provides information about preparing for the delivery and installation of an XR6/XR3 transmitter. This manual is intended for use by field technicians, site managers, and installation planners.

## Using this manual

Read the task list provided in Section 2, "Pre-installation tasks" on page 2-1. The task list describes the preparations you must make prior to receiving and installing the XR6/XR3 transmitter.

Later sections of the manual provide reference information regarding physical, cooling, electrical, and antenna requirements.

## Technical support

Nautel offers technical support to customers over the Internet and by telephone. Nautel's customer support team will answer your questions and work with you to identify and resolve problems.

For technical support, call the Customer Support Team at 902-823-3900 or - in U.S.A. and Canada only - call toll free at 1-877-6NAUTEL (662-8835). Or find us on the Internet at http://www.nautel.com.

For parts and tools information, see "Parts and tools" on page 9-1 of the *XR6/XR3 Pre-Installation Manual*.

For accessories or spares, see "Accessories" on page 10-1 of the *XR6/XR3 Pre-Installation Manual*.

For standard warranty information, see "Pre-installation assistance" on page 11-1 of the *XR6/XR3 Pre-Installation Manual*.

For extended warranty information, see "Pre-installation assistance" on page 11-1 of the *XR6/XR3 Pre-Installation Manual*.

## XR6/XR3 transmitter manuals

The XR6/XR3 documentation suite includes the following documents:

**XR6/XR3 Pre-installation Manual, XR6/XR3-PREINST.** The Pre-installation Manual provides instructions and reference information needed when planning and preparing for the installation of an XR6/XR3 transmitter.

**Nautel Site Protection Manual.** The Site Protection Manual provides detailed information about protecting your site from lightning-related hazards.

**XR6/XR3 Installation Manual, XR6/XR3-INST.** The Installation Manual provides instructions and reference information needed when installing an XR6/XR3 transmitter.

**XR6/XR3 Operating and Maintenance Manual, XR6/XR3-OPS-MAINT.** The Operating and Maintenance Manual provides instructions for operating, maintaining and troubleshooting an XR6/XR3 transmitter. It also provides reference information needed when performing diagnostic procedures.

**XR6/XR3 Troubleshooting Manual, XR6/XR3-TROUBLE.** The Troubleshooting Manual provides detailed technical information about the XR6/XR3 transmitter, including electrical schematics and mechanical drawings.

# Nautel website / Online resources

The Nautel website provides useful resources to keep you up to date on your XR6/XR3.

## Nautel User Group (NUG)

The website includes a special section that customers can log into in order to access the Nautel customer newsletter, product manuals, frequently asked questions (FAQ), information sheets, and information about field upgrades. Registration is available online and is required.

## Documentation: online and printed

The website's NUG section provides online access to all the documentation for your XR6/XR3. Documentation is provided in Acrobat (PDF) format. You can use the documentation online or print the sections that you need.

When using online documents:

- Click on blue text (hyperlinks) to jump to a related section, or to get additional information (e.g., view a term's definition).
- To search a document to find keywords, use Find in Acrobat Reader's Edit menu.
- To quickly find a specific section, click the section in the PDF file's Bookmarks list.

When using printed documents:

- To find keywords, go to the *Index* section at the end of the manual.
- To find a specific term, go to the *List of Terms* section near the end of the manual.

# About safety

All Nautel transmitters are designed to meet the requirements of *EN60215, Safety Requirements for Radio Transmitters*.

The philosophy of *EN60215* is that the removal of any cover or panel that can only be opened using a tool is a maintenance activity, and that any person performing a maintenance activity is expected to be trained for that activity. Under *EN60215*, it is assumed that trained personnel will be knowledgeable and will take precautions such as removing all power to the transmitter before accessing its components.

## Electrical hazards

To remove power from the transmitter, switch off and lock out the ac power. There are three amber LEDs at the bottom rear of the cabinet that glow to remind anyone who has not turned off the power that the system is live and serious danger is present.

**WARNING: It is not enough to remove RF power. The power line is still connected.**

Mount the transmitter ac power disconnect switch/breaker close to the transmitter so that it can be reached quickly in an emergency. Clearly label the disconnect switch/breaker (e.g., EMERGENCY SWITCH).

After turning off the power, always perform a measurement to confirm that the power is off before touching anything within the transmitter. If the wrong breaker was opened, the equipment will be live.

**WARNING: Do not use an ordinary multimeter to check for voltage, since it may have been left inadvertently on the AMP (A) range, triggering a short and an arc blast that could result in severe burns and even death.**

Use only a non-contact voltage probe or a safety voltmeter (available from vendors such as Fluke, Ideal, and Teagam).

Use a proper lockout procedure to ensure that another worker cannot accidentally reapply power while you are performing maintenance on any part of the transmitter or site.

## Lightning hazards

Before opening the transmitter and touching internal parts, remove and solidly ground the antenna connection.

WARNING: It is not enough to ground the antenna terminal with the antenna still connected. Even a small impedance in the ground strap will result in lethal voltages during a lightning strike.

## RF hazards

A serious RF hazard and very high voltages exist in the vicinity of the antenna and its networks during normal operations.

## Toxic hazards

There are devices used in this equipment containing beryllium oxide ceramic, which is non-hazardous during normal device operation and under normal device failure conditions. These devices are specifically identified with "(BeO)" in the *Description* column of the *Troubleshooting Manual's* parts list(s).

Do not cut, crush or grind devices because the resulting dust may be hazardous if inhaled. Unserviceable devices should be disposed of as harmful waste.

## Other hazards

Ensure that appropriate fire alarms and fire extinguishers are available. Extinguishers must be suitable for use on electrical fires.

Many other site safety risks exist. It is beyond the scope of this manual to identify all the risks and procedures.

# Safety precautions

This section provides very important information about protecting the safety of personnel and equipment:

- Personal safety - see page xv
- Site safety - see page xvi
- Equipment safety - see page xviii

## Personal safety

### Training

The training of any personnel who will have physical access to the site or the transmitter is very important. Personnel must be familiar with the transmitter, so that they can avoid physical danger, and be aware of hazards to themselves and the equipment.

Nautel offers a number of training courses covering the basic fundamentals of RF systems and transmitters, and the operation and maintenance of the transmitter. For more information about available courses and schedules, go to the Nautel website at http://www.nautel.com/Training.aspx, or ask your Nautel sales representative.

### Site orientation

When you give personnel access to the transmitter site (e.g., hiring new personnel, or giving access keys to personnel), perform a site orientation to ensure that they are familiar with the site, on-site procedures, and on-site hazards. Cover the following topics:

- Securing the site (locking doors and fences) to prevent unauthorized access
- How and when to call for technical support or emergency assistance
- Areas of the site and pieces of equipment that are *off limits*

### Voltage awareness

Ensure that all personnel that are able to access areas with high voltage circuits or high field strengths are aware of the hazards associated with high voltage. Cover the following topics:

- High voltage or high field strength areas where caution is required
- Physical risks of electric shock
- Risks for personnel with pacemakers or other medical implants
- Induced voltages in high field strength areas
- On-site risks during thunderstorms and lightning strikes
- Operation of safety interlocks (if installed)

### First aid

Nautel does not offer first aid training, since the hazards associated with high voltage and RF energy are not specific to the transmitter. However, the customer should provide first aid training to all personnel who have access to the transmitter site. First aid training should include CPR, care of burns, artificial respiration, and defibrillation if specific equipment is available on-site.

## Site safety

### Controlling access

Transmitters and antennas generate and carry dangerous voltages that can be harmful or fatal. It is very important that you control access to the site and its equipment. To secure your transmitter site, use:

- Locking steel or security doors to prevent casual access
- A perimeter fence to keep trespassers away from the antenna system and feedline
- "No Trespassing" signs
- An alarm system

## Marking hazards

Place warning signs close to any hazardous areas or systems (e.g., the feedline or the antenna system). Make the signs large enough that they cannot be missed. Provide signage in all languages used in the region. These signs are intended not only for authorized personnel, but also for emergency responders or accidental trespassers.

## Qualifying site personnel

Make sure that personnel who have access to the site are qualified to work around electronics and high voltage systems.

## Ac power protection

You should take steps to protect equipment from surges (over-voltage spikes) on the ac power lines. Surges may occur during thunderstorms, or because of malfunctions in the electrical distribution grid. Surge suppressors and ac power conditioners can prevent serious damage to your on-site equipment, including the transmitter.

## RF protection

Transmitters and their antenna systems create intense radio frequency fields at the transmitter site, particularly near the feedline, antenna and tower. At some sites, these fields may cause biological effects, including the heating of body tissues. Intense fields can also create dangerous high voltages on ungrounded, conductive surfaces and objects. At certain points where high voltage conductors come close to grounded conductors (e.g., at feedline junctions or on the tower), dangerous electrical arcing or flashovers can occur. It is very important that you take the following steps to prevent damage to equipment or personnel due to RF fields:

- Use safety interlocks to de-energize transmitters if personnel open doors or panels accessing high field areas
- Place warning signs in any locations where high fields can occur
- Train personnel about the short-term and long-term hazards of RF radiation
- Physically block access to the area around the antenna system, feedline and tower
- Ground all exposed conductive surfaces or objects in high field areas

The RF connection to the transmitter output can be a serious safety hazard. Connect a 50 Ω test load during installation and commissioning. It is recommended that a switch be used to automatically connect the transmitter to the antenna system without human contact with the transmitting conductors.

### Safety interlocks

The transmitter contains an electrical interlock, which is an external circuit that turns off the RF output if any of its switches are opened.

### Ac disconnect switch

Safe operation of the transmitter requires an ac disconnect switch. Lock the ac disconnect switch in the disconnected (open) position during the installation process.

## Equipment safety

### Electrostatic protection

The transmitter's systems are very rugged and resistant to damage. However, it is possible for damage to occur because of high voltage electrostatic discharges during servicing. Train all service personnel to ground themselves to bleed off any static charge before opening the transmitter or touching any exposed components. Provide a grounding wand or known ground (e.g., a grounded metal table) that personnel can use to discharge themselves.

### Surge protection

Surge protection is recommended for your entire site. However, even if you do not use a surge protector on the service entrance to the site, you should install a surge protector in the transmitter's ac power feed to prevent over-voltage from entering the transmitter.

### Lightning protection

The transmitter is designed to resist lightning strike damage. However, intense or repeated strikes could damage the transmitter. We recommend that you install lightning suppression on the antenna, tower and feedline to reduce the effect of lightning strikes on the transmitter itself (and to protect the rest of your site equipment and your personnel). For detailed information about lightning protection, see the *Nautel Site Preparation Manual*, available from your Nautel sales agent, or online from the Nautel website.

### Physical protection

Consider physical hazards to equipment at your site, including the transmitter. Ensure that equipment is protected from weather (e.g., rain or flooding), even during extreme weather events. Place equipment so that it is not in the path of swinging doors or high-traffic areas. Do not allow wheeled items like office chairs or tables with wheels in the transmitter room, as these may damage equipment if accidentally pushed or knocked over. Do not place the transmitter under water pipes, drains, or sprinklers. Keep any equipment that generates heat, like the transmitter, away from flammable materials like ceiling panels, cubicle dividers, and curtains.

## Earthquake protection

If the transmitter site is in a region that experiences any noticeable earthquake activity, take steps to prevent the transmitter from shifting or rocking during an earthquake. Even during minor earthquakes, rocking or movement of the transmitter is likely to damage the feedline connection, and could even cause a catastrophic failure of the ac power feed into the transmitter. During larger earthquakes, the weight of the transmitter chassis could be hazardous to nearby equipment or personnel.

# Section 1: Description

This section provides a basic description of the XR6/XR3 transmitter and includes the following topics:



## Capabilities

### Power

The XR6/XR3 is rated (with 140% positive peak modulation) for an RF output of 6 kW (XR6) or 3 kW (XR3) and capable (with 120% modulation) of RF outputs up to 7.5 kW (XR6) or 3.75 kW (XR3).

The operator can vary the power continuously or switch to preset power levels using the XR6/XR3 graphic user interface (GUI). Presets store the power level, active exciter, and power scheduler status on a time-of-day and date basis. The operator can configure exciters on a preset for a specific operating mode (e.g., exciter A for conventional AM, and exciter B for IBOC). The power output can also be scheduled to correspond with authorized daytime power levels.

### Modulation

The XR6/XR3 is capable of double sideband (AM) modulation. With the addition of external signal generators, IBOC and DRM modulation can be provided to the exciter.

### Duty Cycle

The XR6/XR3 will operate at nominal power with a 100% duty cycle – continuously – on an indefinite basis.

### Antenna tolerance

The XR6/XR3 will operate at rated power even with a VSWR of 1.5:1. A higher VSWR results in a protective fallback of output power. The greater the VSWR, the greater the reduction in RF power. (To maintain the quality of digital broadcasts, a maximum VSWR of 1.4:1 is acceptable.)

The XR6/XR3 will not fail or completely shut down, regardless of antenna or feedline failure.

### Remote control and monitoring

The XR6/XR3 remote control and monitoring options allow you to run a multiconductor signaling cable from the transmitter to a remote control board. This option lets you monitor all key parameters of transmitter operation, and control common functions, such as power output and exciter selection.

### Redundancy

The XR6/XR3 features redundancy in all key systems:

- RF power modules *
- Exciters
- Cooling fans

** The standard XR6/XR3 transmitter configuration contains one RF power module. A second RF power module is optional.*

### Ac power

The XR6/XR3 variable power transformer can be set to use a range of input voltages and power frequencies, as described in Section 2, "Installing the power transformer" on page 2-1of the *XR6/XR3 Installation Manual*.

## Options

### DCC

The XR6/XR3 supports Dynamic Carrier Control (DCC) as an optional module. DCC reduces the power of the carrier when the sideband power drops below a threshold (that is, when there are periods of silence in the program content). This reduces overall power consumption.

### IBOC

The XR6/XR3 supports IBOC digital radio as a modulation option. The external IBOC signal source provides a signal to the XR6/XR3 exciter.

### DRM

The XR6/XR3 supports Digital Radio Mondiale (DRM) radio as a modulation option. The external DRM signal source provides a signal to the XR6/XR3 exciter.

## NxLink

An optional NxLink module provides an Ethernet interface between the XR6/XR3 and a LAN (local area network). This interface allows remote control and monitoring of the XR6/XR3 from a computer .

## Safety interlocks

Optional safety interlocks prevent unsafe access to the transmitter until the ac power is removed.

# Section 2: Pre-installation tasks

This section provides a list of tasks that you must perform prior to delivery and installation of the XR6/XR3 transmitter.

WARNING: FAILURE TO COMPLY WITH RECOMMENDATIONS MAY VOID YOUR MANUFACTURER'S WARRANTY. FOR MORE INFORMATION, REVIEW YOUR WARRANTY DOCUMENTS.

## Preparing for installation

To prepare for installation of an XR6/XR3 transmitter, perform the following tasks:

1. Ensure that the correct transmitter configuration is ordered. Check the ac power requirements, preset frequency, IBOC option, and other options.

2. Select a location for the transmitter in the transmitter room. Determine whether additional heating, ventilating or cooling capacity is needed at the site. Identify any special requirements regarding air flow around the cabinet (for example, ducting hot air away from the cabinet, or bringing in external cooling air).

3. If this is an upgrade or replacement transmitter (that is, if the site is already set up for a transmitter), go to Step 7. (If you are upgrading a site, verify the feedline, the lightning protection systems, and the ac power service. Refer to the *Nautel Site Protection Manual*.)

4. Install ac power service into the planned location of the transmitter, and select a location for an ac power disconnect near the transmitter location. For detailed information, see "Electrical power" on page 5-1.

   Be aware of lightning protection issues when installing ac power. Lightning protection is essential to protect both personnel and equipment at your site. Refer to the *Nautel Site Protection Manual*.

5. Install lightning protection on the antenna tower. Refer to the *Nautel Site Protection Manual*.

6. Place a work area with a clear table surface near the transmitter location. Provide electrostatic protection measures in the work area.

7. Order any accessories or optional equipment that you may need.

8. Terminate the transmitter end of the RF feedline with the appropriate mating connector. Unless otherwise specified in contract documents, the transmitter will accept a 1-5/8 inch EIA flange connector.

9. If the transmitter will be used to broadcast IBOC, perform a full impedance sweep of the antenna system. See "Antenna system" on page 8-3.

10. Arrange manpower or lifting equipment to move and assemble the transmitter. You may want to use a forklift to move either the transmitter or its power transformer into place for installation.

11. Implement a safety interlock, if required.

12. If you are going to use an external RF drive, ensure that the drive meets required specifications.

13. If you are going to use an external frequency reference, ensure that the reference source meets required specifications.

14. Prepare to integrate the XR6/XR3 transmitter into your station control circuitry, if required.

15. Train your station technicians and operators on the use and maintenance of the XR6/XR3 transmitter.

## Selecting a location for the transmitter

To ensure that the desired location for the XR6/XR3 transmitter is suitable, perform the following tasks:

1. Ensure that the floor area where the transmitter will be located is able to support the weight of the transmitter system.

   The total weight of the assembled transmitter, once installed, is 213 kg (469 lbs).

2. Measure the space to ensure that the transmitter will fit.
   See Section 3, "Physical requirements" on page 3-1 for transmitter dimensions.

3. Ensure that transmitter room doors and the pathway of access from the receiving dock or building exterior to the installation location are large enough to accommodate the transmitter.

## Installing an antenna feedline

When installing an antenna feedline for the XR6/XR3 transmitter, perform the following tasks:

1. Ensure that the RF feedline that will connect the transmitter and the antenna system has a suitably rated coaxial cable.

2. Connect the shield of the antenna feedline coaxial cable directly to the station reference ground where it enters the building. For more information about the station reference ground, see "Station reference ground" on page 5-4.

3. Install lightning protection devices. For more information about lightning protection, refer to the *Nautel Site Protection Manual.*

4. Pass the center conductor and the shield of the feedline cable through a ferrite toroid that is positioned between the shield ground at the building entrance and the shield termination at the transmitter. Install the ferrite toroid prior to installing flanges on the feedline cable.

    - The ferrite toroid included in the ancillary kit, provided by Nautel with the transmitter, can be used for coax cables with diameters up to 1 5/8 inches (1.625 in.). For larger diameters,contact Nautel support for recommendations (see page 11-3), or consult additional, outside suppliers.

# Section 3: Physical requirements

This section provides physical specifications for the XR6/XR3 transmitter and its components, and lists physical site requirements. This section includes the following topics:



## Clearances

Required minimum clearances are 1.2 m (4.0 feet) at the front of the transmitter, and 1.8 m (6.0 feet) at the rear of the transmitter. (The clearance at the rear of the transmitter is required to allow installation of the power transformer. Less clearance may be acceptable if special arrangements are made to install the transformer.) No clearance is required on either side of the transmitter.

Check the clearance to ensure that you will be able to open all doors and access panels. The front control panel is hinged on the left (when looking at the front of the transmitter).

Also consider access to the rear of the transmitter during transformer installation and servicing, and access to the front of the transmitter during power module replacement. You must allow space to open the front panel and slide out any of the power modules. These modules slide straight in and out of the shelf unit in the front of the transmitter.

Internal fans pull cooling air through air filters in the upper rear panel. The cooling air exhausts as a low velocity stream through openings on top of the transmitter.

# Dimensions

**Figure 3.1: XR6/XR3 transmitter dimensions**

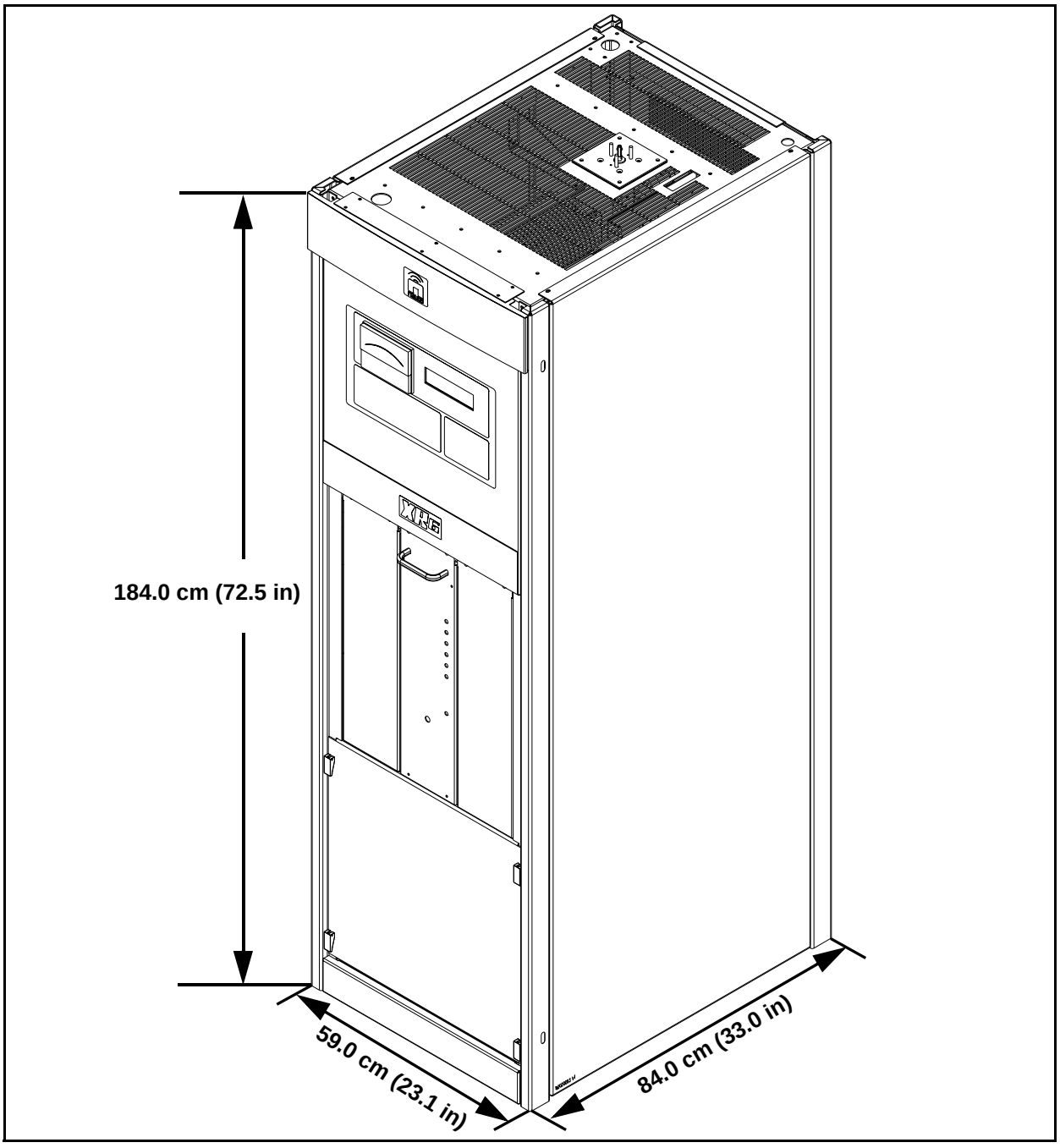


**Figure 3.2: XR6/XR3 transmitter cabinet – top view**

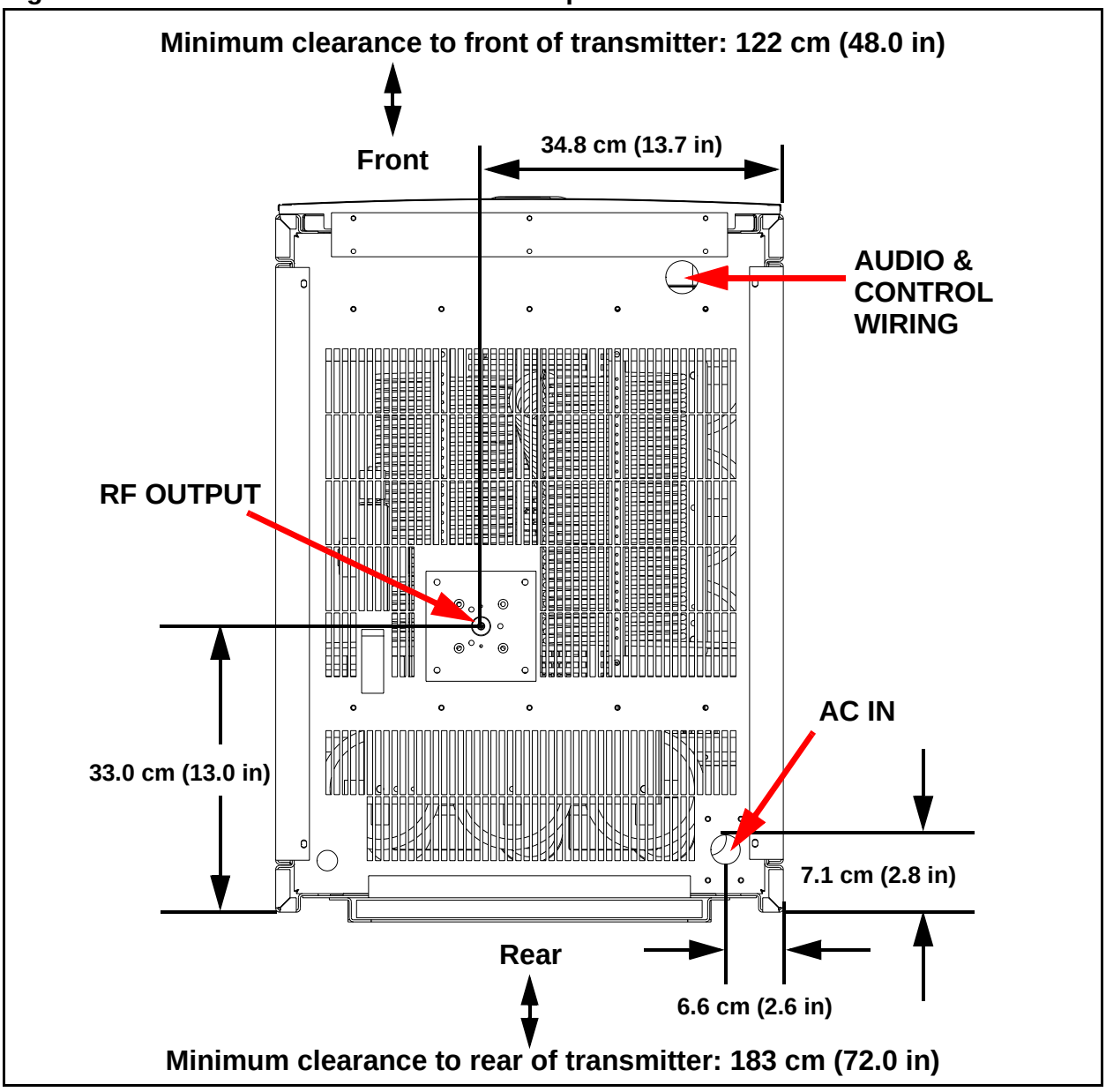
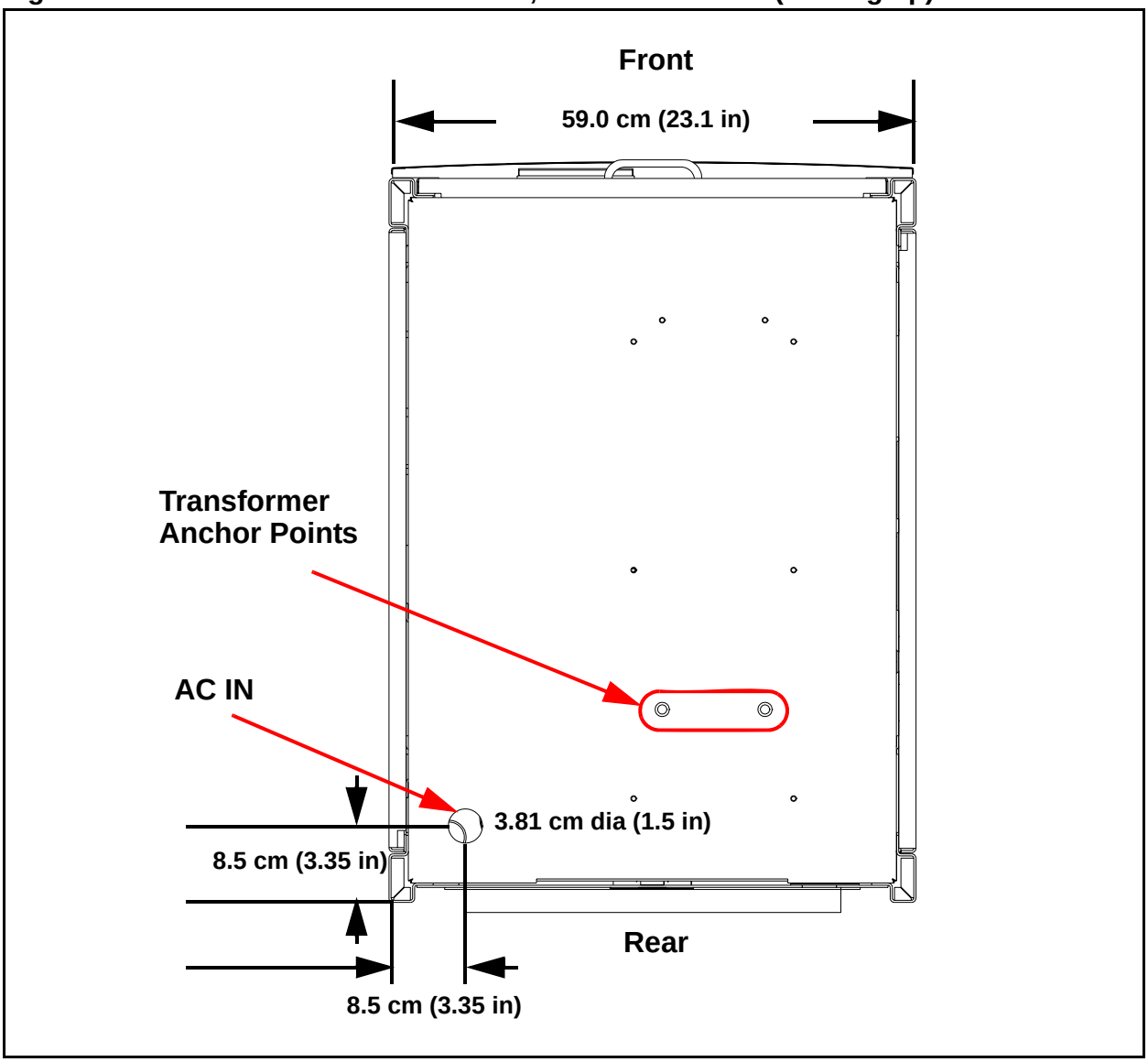


**Figure 3.3: XR6/XR3 transmitter cabinet, seen from below (looking up)**



## Weights

See Table 3.1 for the various weights of transmitter components, including crated and uncrated weights.

**Table 3.1: XR6/XR3 Weight of components – Includes 1 RF Power Module**

| Crate contents | Uncrated weight | Crated weight |
|---|---|---|
| Main cabinet<br>(no RF power modules or power transformer) | 125 kg (275 lbs) | N/A |
| Main cabinet<br>(with 1 RF power module, no power transformer) | 145 kg (319 lbs) | 237 kg (521 lbs) |
| XR6 Power transformer | 68 kg (150 lbs) | 110 kg (242 lbs) |
| XR3 Power transformer | 47 kg (104 lbs) | 89 kg (196 lbs) |
| Assembled transmitter, XR6<br>(total installed weight) | 213 kg (469 lbs) | N/A |
| Assembled transmitter, XR3<br>(total installed weight) | 192 kg (423 lbs) | N/A |

# Section 4: Cooling requirements

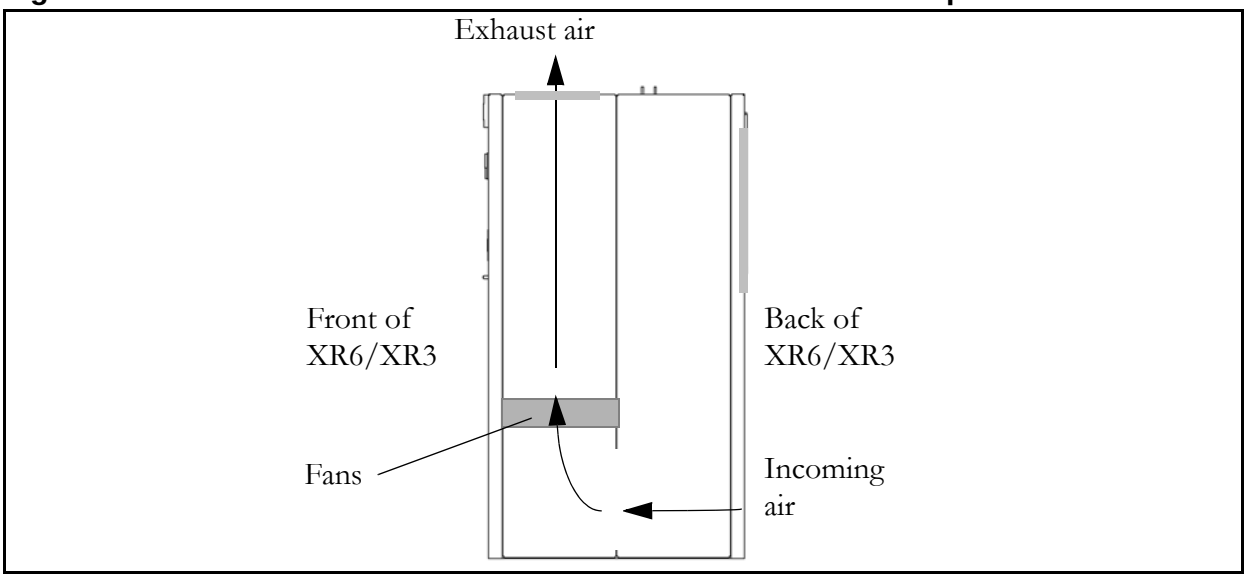
This section provides information about heating and cooling requirements for the XR6/XR3 transmitter site. Topics in this section include:



## Air flow in the transmitter

The XR6/XR3 uses redundant cooling fans and hot-air convection to ensure effective cooling. Cool air is drawn in through a filter in the lower portion of the back of the transmitter. Air circulates into the base of the transmitter, and is then pushed up through the front rack of the transmitter by a set of fans. Warm air exits the transmitter through the grill or duct at the top of the transmitter.

**Figure 4.1: Air flow in the XR6/XR3 transmitter cabinet with back panel filter installed**



# Cooling

Do not allow the transmitter room ambient air temperature to exceed 50°C (122°F) at sea level. Cooler temperatures are recommended in order to improve the reliability of the transmitter.

- De-rate the ambient temperature 3ºC (5.4°F) per 500 m – or 2ºC (3.6°F) per 1,000 feet – above sea level.

**Example:** At 1600 m (1 mile) above sea level, maximum ambient temperature should not exceed 40.4ºC (104.7°F).

Ensure that hot air from the transmitter is not drawn back into the transmitter's cool air intake.

## Cooling plant requirements

**Table 4.1: Cooling plant requirements for the XR6**

| Transmitter output (watts) | Waste heat (watts) | BTU/hour (x1000 Btu) | Modulation | Air conditioning required in a closed system (tonnes) |
|---|---|---|---|---|
| 6,000 | 1,843 | 6.29 | 100% | 0.54 |
| 6,000 | 1,673 | 5.71 | 85% | 0.47 |
| 6,000 | 1,229 | 4.19 | 0% | 0.36 |

**Table 4.2: Cooling plant requirements for the XR3**

| Transmitter output (watts) | Waste heat (watts) | BTU/hour (x1000 Btu) | Modulation | Air conditioning required in a closed system (tonnes) |
|---|---|---|---|---|
| 3,000 | 921 | 3.15 | 100% | 0.27 |
| 3,000 | 837 | 2.86 | 85% | 0.24 |
| 3,000 | 615 | 2.10 | 0% | 0.18 |

### Calculating BTU cooling requirements

To determine the number of British thermal units (Btu) being generated per hour as waste heat, multiply the average RF output power (in watts) by 0.19 (the heat factor at rated power) and then multiply the product by 3.413.

### Closed loop or forced air cooling systems

Closed loop or forced air cooling systems can be used, so long as the air is well filtered to prevent dust and insects from entering the transmitter, and so long as a minimum of 200 cubic feet per minute (CFM) at 0.5 pounds per square inch (PSI) is supplied to the intake duct.

## Heating

The transmitter room must contain a heating system that will ensure the ambient air temperature does not drop below 0°C (32°F).

# Section 5: Electrical requirements

This section describes electrical power and electrical protection requirements associated with the XR6/XR3 transmitter. This section includes the following topics:



**CAUTION: Technical pre-commissioning activities described in this section require technical decisions and the customization of electrical circuits. Do not attempt to perform these activities unless you are a certified electrician.**

Refer to the *Nautel Site Protection Manual* for information about requirements associated with lightning protection.

## Electrical power

The transmitter is preconfigured to operate from a 50/60 Hz, 3-phase (3-wire plus ground, Wye or closed delta)or 1-phase (2-wire plus ground) ac power source. You select the number of phases and specific voltage range when you order the transmitter.

### Nominal voltage (minimum and maximum)

The primary winding of the main ac power transformer contains taps to accommodate voltages that differ from the ideal voltage of the power source. These taps provide increments and are selected during installation to provide the nominal voltage for the transmitter.

The high voltage transformer comes with the following standard taps:

**Table 5.1: Nominal Voltages**

| Ac Power Source | Transformer | Standard Voltage Taps |
|---|---|---|
| 3-phase | LV | 198, 208, 218, 229, 239, 250 |
| | HV | 342, 361, 380, 399, 418, 437 |
| 1-phase | - | 200, 220, 240, 260 |

## Voltage stability

The ac power source nominal voltage must be stable to within plus or minus 10% under all loading conditions. The transmitter contains circuitry that maintains the RF output at the preset carrier level for voltage variations within the specified range, provided the correct transformer tap is chosen.

**Table 5.2: Voltage Stability**

| Ac Power Source | Transformer | Voltage Range | |
|---|---|---|---|
| | | Minimum | Maximum |
| 3-phase | LV | 188 | 263 |
| | HV | 325 | 459 |
| 1-phase | - | 180 | 286 |

## Power consumption

When operating at 6 kW (XR6) or 3 kW (XR3) with 100% modulation by a continuous sine wave, power consumption is approximately 10.8 kW (XR6) or 5.4 kW (XR3). When operating at 6 kW (XR6) or 3 kW (XR3) with no modulation, power consumption is 7.2 kW (XR6) or 3.6 kW (XR3).

Power consumption for a specific station will depend on the programming format and the level of audio processing. Nautel recommends the ac power source have a 25% over-capacity to ensure adequate regulation.

## Ac power switch

Install an external ac power disconnect between the ac power source and the transmitter. (Nautel can provide a suitable ac power disconnect, if required.) For safety, place the ac disconnect close to the transmitter and label it TRANSMITTER EMERGENCY ON/OFF SWITCH.

## Ac transient power protection

Protect all conductors from the ac power source by connecting bi-directional surge protection devices between each conductor and the station reference ground. In addition, pass all the conductors, as a group, through a ferrite toroid. Install a ferrite toroid on the ac feed between the transmitter and the bi-directional surge protector.)

- The ferrite toroid included in the ancillary kit, provided by Nautel with the transmitter, can be used for most ac supply cables. For larger diameters, contact Nautel support for recommendations (see page 11-3), or consult additional, outside suppliers.

A surge protector panel containing suitably rated varistors is available from Nautel. Install the surge protector panel close to the station reference ground, and as close as possible to the ac service entrance.

The ac power source usually has the lowest impedance path to ground during a lightning strike and normally carries most of the lightning-induced current away from the transmitter site. When lightning hits the power source (for example, striking a transmission line near the transmitter site), a significant induced current may flow towards the transmitter. The goal of lightning protection is to route the current around the transmitter to the best available ground.

For detailed information about surge protectors and lightning protection, refer to the *Nautel Site Protection Manual*.

**Recommended configuration for three-phase ac power source.** Use a 4-wire Wye (star) configuration, with the three phases balanced to ground.

**CAUTION:**
**For three-phase applications do NOT use open delta ac power sources that use two identical transformers. These systems are susceptible to third harmonic distortion and line transients, and may cause peak voltages to exceed the line voltage. This can cause increased power supply noise or even component failure (for example, rectifier failure).**

## Wiring

Table 5.3 on page 5-4 shows the wiring recommendations for each ac voltage, and identifies the wire gauges that are specified for worst case conditions. Smaller gauges may be used when actual conditions related to transmitter power and wiring allow it. A certified electrician should be consulted to ensure that all wiring meets local electrical code requirements.

**CAUTION:**
**Table 5.3 on page 5-4 is based on recommendations by the Canadian Electrical Code. Local codes may vary.**

**Table 5.3: Ac power wiring requirements**
**Power @ 100% modulation:**

| Cable Temperature Rating | 60°C | 75°C | 90°C | Voltage | Amps/Phase |
|---|---|---|---|---|---|
| Wire Size: AWG | 6 | 6 | 6 | 208 V ac, 3-ph | 32 (XR6), 16 (XR3) |
| | 6 | 8 | 8 | 240 V ac, 3-ph | 27 (XR6), 13.5 (XR3) |
| | 10 | 10 | 10 | 380 V ac, 3-ph | 17 (XR6), 8.5 A (XR3) |
| | 4 | 4 | 4 | 220 V ac, 1-ph | 59 (XR6), 29.5 (XR3) |

## Station reference ground

Install a station reference ground that provides a continuous, low impedance path to the earth.

If a surge protector is not being used, connect the transmitter cabinet's designated safety ground point, the shield of the coaxial feedline, and the ground connection of the power source directly to the station reference ground using a copper strap that is at least 10 cm (4 in.) wide. Ensure that the site's ac service entrance ground is directly connected to the station reference ground outside the transmitter building.

If a surge protector is being used, connect the transmitter cabinet's designated safety ground point, the shield of the coaxial feedline, and the ground connection of the power source directly to the surge protector, using a 10 cm (4 in.) copper strap. Connect the surge protector to the station reference ground using a copper strap that is at least 10 cm (4 inches) wide.

Ac power can enter the transmitter cabinet through the right rear side of the top panel (see Figure 3.2 on page 3-3)or the rear side of the bottom panel (see Figure 3.3 on page 3-4).

Ensure that the transmitter site's grounding rods are adequate. For more information about electrical grounding protection, see the *Nautel Site Protection Manual*.

# Section 6: Control and monitoring

This section describes control and monitoring of the XR6/XR3 transmitter. This section includes the following topics:



## Controls

The XR6/XR3's graphic user interface (GUI) lets you control a number of transmitter functions and set parameters and schedules. (For detailed information about the GUI, refer to the *XR6/XR3 Operating and Maintenance Manual*.) In addition, you can control the on/off status, the active (A/B) exciter, the preset RF power level, the power level adjustment, and system alarm reset remotely by means of a conventional remote control interface (see "Remote control circuits and alarms" on page 6-7 or a LAN, using the optional NxLink module (see "LAN interface (NxLink)" on page 6-13).

## Alarm definitions

This section describes the alarms that may occur, and what they indicate.

### DC voltage supply faults

#### Fan P/S fault

The 48 V power supply used for the fans is monitored. A fault will be reported if the voltage varies by more than ± 10%.

#### RF drive P/S fault

The 62 V power supply used for the RF drive is monitored. A fault will be reported if the voltage varies by more than ± 10%.

### LVPS fault

The +24 V, +15 V, -15 V and +5 V power supplies are monitored. A fault will be reported if the voltage varies by more than ± 10%.

- One or more of these faults will result in only one **LVPS Fault** message on the **Status** screen, though each one would be logged separately in the **Event Log**.

### High B+ voltage

A fault is reported when the B+ voltage goes above 380 V. No other action will be performed automatically.

### Low B+ voltage

For three-phase XR6 transmitters, there are three B+ voltage levels that will be automatically selected to provide optimum performance: 315 V, 190 V and 115 V. For three-phase XR3 transmitters, there are two B+ voltage levels: 220 V and 115 V. For single-phase XR6 transmitters, there are four B+ voltage levels: 315 V, 196 V, 115 V and 69 V. For single-phase XR3 transmitters, there are four B+voltage levels: 220 V, 196 V, 115 V and 69 V.

This alarm is triggered when the B+ voltage falls below the factory-set alarm threshold. The alarm threshold is factory calibrated to be approximately 250 V, 150 V or 91 V - for three-phase XR6 transmitters - to correspond to the B+ voltage level currently in use. For three-phase XR3 transmitters, the alarm threshold voltage is factory calibrated to be approximately 174 V or 91 V. For single-phase XR6 transmitters, the alarm threshold voltage is factory calibrated to be approximately 250 V, 155 V, 91 V or 55 V. For single-phase XR3 transmitters, the alarm threshold voltage is factory calibrated to be approximately 175 V, 155 V, 91 V or 55 V.

Besides being noted on the transmitter's GUI **Status** screen, and by the alarms, this alarm also causes the following:

- a shutback
- the softstart relays to open
- the fans to turn off

Recovery from this alarm is automatic when the B+ voltage rises above the factory-set alarm threshold, which is factory-calibrated to 265 V, 160 V and 97 V - for three-phase XR6 transmitters - depending on which B+ voltage is selected (see "Low B+ voltage" on page 6-2). For three-phase XR3 transmitters, the factory-calibrated threshold is 185 V or 97 V. For single-phase XR6 transmitters, the factory calibrated threshold is 265 V, 165 V, 97 V or 59 V. For single-phase XR3 transmitters, the factory calibrated threshold is 185 V, 165 V, 97 V or 59 V. The recovery process is the same as the power on process.

## Output network faults

### High DC current

This alarm is triggered when the dc current goes above approximately 41 A (XR6) or 21 A (XR3).

### High RF current

This alarm is triggered when the RF current exceeds the factory-set alarm threshold.

### High VSWR shutback

This alarm is triggered when the reflected power exceeds the factory-set alarm threshold - approximately 480 W (XR3) or 960 W (XR6).

### Total power limit

This fault is triggered when the product of the B+ (dc) voltage and the dc current is greater than approximately 15 kVA (XR6) or 7.5 kVA (XR3).

- This fault causes an immediate *cutback*, but not a *shutback*.

## Exciter faults

### Mod driver fault A

This fault is reported to the microcontroller only if exciter A is selected. If the exciter transfer function is set to *auto*, then the microcontroller will attempt a changeover to exciter B. If it cannot, or if the exciter transfer function is set to *manual*, then this fault will cause a *shutback*.

### Mod driver fault B

This fault is reported to the microcontroller only if exciter B is selected. If the exciter transfer function is set to *auto*, then the microcontroller will attempt a changeover to exciter A. If it cannot, or if the exciter transfer function is set to *manual*, then this fault will cause a *shutback*.

### Auto changeover

This event is caused by a fault in the active exciter when the exciter transfer function is enabled (set to *auto*). These faults cause exciter changeovers: Mod Driver Fail A/B, RF Driver Fail, or PDM Drive Fail.

This fault causes the Changeover LED on the transmitter's front panel to light. It will remain lit until it is manually cleared. No further auto changeovers are possible until the alarm is cleared.

- The Auto changeover alarm can be cleared remotely by re-selecting the active exciter, or locally by using the transmitter's GUI Preset screen.

### RF driver fault

This fault indicates a problem with the RF drive on the current exciter. If the exciter transfer function is set to *auto*, then the microcontroller will attempt a changeover to the other exciter. If it cannot, or if the exciter transfer function is set to *manual*, then this fault will cause a *shutback*.

### PDM drive fault

This fault indicates that the PDM drive has stopped functioning. If the exciter transfer function is set to *auto*, then the microcontroller will attempt a changeover to the other exciter. If it cannot, or if the exciter transfer function is set to *manual*, then this fault will cause a *shutback*.

## Cutbacks

### Cutback level (1-8)

If three shutbacks occur within five seconds, the transmitter will enter a power reduction mode called a *cutback*.

There are eight levels of cutbacks, the last being a reduction to almost no forward power.

At any given cutback level, there is a predefined time limit that must expire before the cutback level returns to the previous level (e.g., level three back to level two). If there are no further cutbacks, this process continues until *Level 0* (normal) is reached.

The cutback recovery process can be overridden by adjusting the power (up or down), or by initiating a reset - by pressing **Reset** on the transmitter's GUI **Status** screen or by remote application.

## Remote interface faults

### Ext. interlock open

The external interlock input is wired to the remote interface PWB by the end user, and triggered by the conditions that they set (e.g., opening the door to the transmitter room). A triggered interlock may indicate a safety issue.

### Ext. PDM inhibit

An **EXTERNAL PDM INHIBIT** alarm indicates that an external PDM inhibit command is present. The external PDM Inhibit is wired to the remote interface PWB.

### Int. serial fault

This alarm indicates that there is no communication with the remote interface PWB.

The control/display PWB requests updates from the remote interface PWB every 200 ms. This alarm is triggered when a control/monitor PWB's request for information is not acknowledged by the remote interface PWB within two seconds.

### Mod. protection

This fault is reported from the remote interface PWB. The fault indicates that excessive low frequency modulation has triggered the transmitter's protection circuit.

## Softstart faults

### Softstart active

The softstart relays are initially open for 1.6 seconds when the transmitter is first powered on. The software should close the relays after 1.6 seconds and clear this alarm.

While active, this alarm causes a *shutback* and inhibits the RF drive and fan power supplies.

### Softstart overtemp

The software keeps track of the calculated temperature of the softstart resistors and triggers this fault if that value is greater than 150°C (302°F).While this fault is on, RF power will not be available.

The temperature is assumed to rise 20°C (68°F) for each cold start, and 10°C (50°F) for each warm start. The calculated temperature falls exponentially between starts.

The transmitter's GUI **Status** screen will show the current, calculated temperature, if it is above 150°C (302°F).

CAUTION:
Performing a warm or cold start while this fault is active is strongly discouraged.

## RF Power module faults

### PM Fault A or B*

- A fault is being reported by power module A or B.

* **Note:** A second RF power module is optional with an XR6 or XR3 transmitter.

## Other faults

### Low backup battery

This fault indicates that the backup battery voltage has fallen below an acceptable level. The fault may be caused by weak batteries, or a fault in the detection or alarm circuitry on the control/monitor PWB.

The backup battery should be replaced while ac power is **ON**. *If the ac power faults, without adequate backup battery power, then the log files will be lost.*

CAUTION:
Do not wait for an extended period to replace the batteries. The control/monitor PWB's microcontroller may not retain its settings if ac power is turned off when the backup battery voltage is too low.

## Remote control circuits and alarms

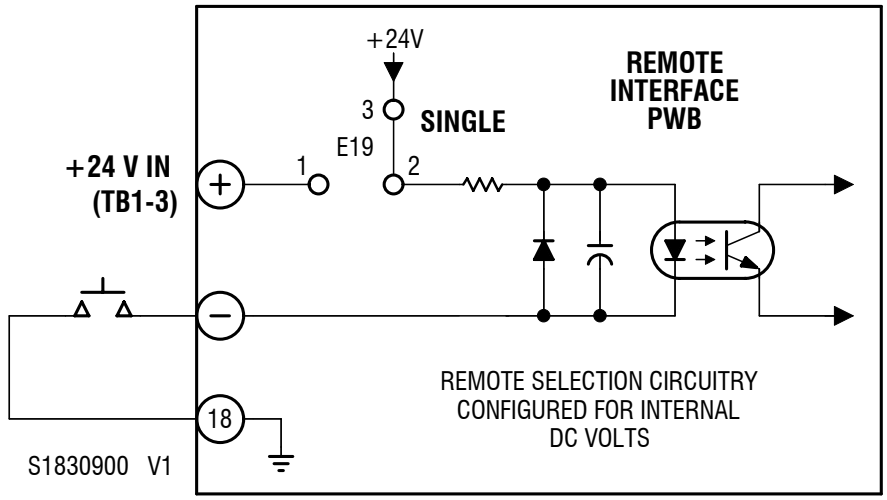
You can control the active (A/B) exciter, the on/off status of the RF power stage, the preset RF power level, the power level adjustment, and system alarm reset remotely. The remote interface PWB contains a selection circuit that lets you select internal (single ended input) or external (differential input) input for all controlled functions.

The external control circuits interface with the transmitter through opto couplers on the remote interface PWB. The opto couplers buffer and isolate the external circuits and prevent any unwanted transients from affecting transmitter operation while remote control is selected at the transmitter.

The switching circuits for the remotely controlled functions must be the equivalent of a normally open (momentary) switch. The switches must be configured to operate as a single-ended input using the transmitter's 24 V dc as the source, or as a differential input using an external dc power supply (24 - 30 V). Each control function has negative inputs on the remote interface PWB. The positive external **+24 V IN** input (TB1-3) is used by all control functions.

**Option 1 - Single Ended Input (Internal V dc).** When you use the transmitter's 24 V as the current source for a control function's opto coupler, configure the circuit on the remote interface PWB for a single ended input. The **SINGLE/DIFF** 3-pin header (E19) must have its 2-socket shunt post connected between pins 2 and 3 to configure the circuit.

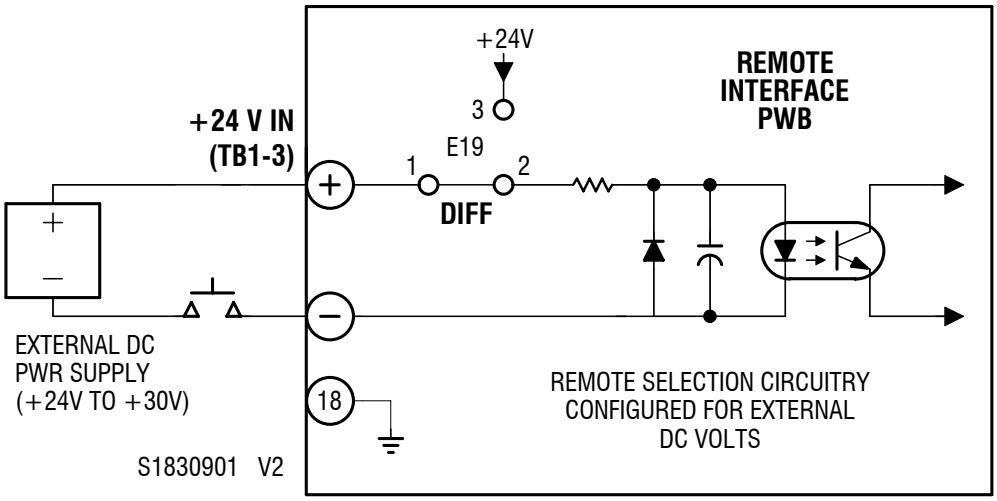
**Figure 6.1: Single-ended Input Selected**




A negative logic (active state is a current-sink-to-ground) command must be applied to the control's negative (-) input. To avoid a ground loop, obtain the ground from TB1-18.

**Option 2 - Differential Input (External V dc).** When you use an external dc voltage (24 V to 30 V) as the current source for a control function's opto coupler, configure the control function's external switching circuit and the remote interface PWB's selection circuit for a differential input. The SINGLE/DIFF 3-pin header (E19) must have its 2-socket shunt post connected between pins 1 and 2 to configure the circuit.

**Figure 6.2: Differential Input Selected**




The normally open/momentarily closed switch should be located between the dc voltage's negative output and the remote control circuit's negative (-) input.

## Inputs

This section describes the remote inputs to the system. These inputs are only accepted by the system if the remote/local status is set to remote, unless otherwise noted. That setting can only be made by a local user.

Inputs are toggled between states by an active pulse unless otherwise noted. To ensure proper operation, the duration of the active pulse should be a minimum of 250 ms.

Note: The external PDM inhibit input is intended to be used in conjunction with antenna switching circuitry, to ensure minimal RF output current is flowing during the opening/closing of contacts in the transmitter's RF feed cable. An active **PDM inhibit** condition must be applied, to inhibit the RF output, prior to contact opening. The active condition must be maintained until contact closure has occurred, and an appropriate impedance has been connected to the transmitter's RF output. The RF output will instantly be restored to its original level when the active condition is removed.

- TB2-6 (-): PDM INHB terminal. Continuous active signal inhibits the PDM by causing a shutback. This also works when the remote/local status is set to local.

- TB1-1 and TB1-2: EXT INTLK terminals. A short circuit between the pins for normal operating status, an open between these pins causes a shutback. This also works when the remote/local status is set to local.

- TB1-4 (-): RF OFF terminal. Same as pressing the RF Off button on the front panel. Provide an active pulse to activate.

- TB1-6 (-): RF ON terminal. Same as pressing the RF On button on the front panel. Tells the system to provide RF power if possible. Provide an active pulse to activate.

- TB1-8 (-): RESET terminal. Causes a system reset. Provide an active pulse to activate.

- J3-23 (-): *IBOC Input Select A* input. Sets IBOC/Analog for Exciter A. Continuous active signal selects IBOC input, otherwise analog input is selected.

- J3-25 (-): *IBOC Input Select B* input. Sets IBOC/Analog for Exciter B. Continuous active signal selects IBOC input, otherwise analog input is selected.

- J2-10 (-): *Preset Scheduler (Auto/Man)* input. Enables or disables the Automatic Preset (formerly power level) changes. Provide an active pulse to toggle between Auto or Manual modes.

The following inputs will only take effect when the Preset Scheduler Mode is set to Manual.

- J2-12 (-): *Preset 1* input. Selects RF power preset 1 of 6. Provide an active pulse to activate.

- J2-14 (-): *Preset 2* input. Selects RF power preset 2 of 6. Provide an active pulse to activate.

- J2-16 (-): *Preset 3* input. Selects RF power preset 3 of 6. Provide an active pulse to activate.

- J2-18 (-): *Preset 4* input. Selects RF power preset 4 of 6. Provide an active pulse to activate.

- J2-20 (-): *Preset 5* input. Selects RF power preset 5 of 6. Provide an active pulse to activate.

- J2-22 (-): *Preset 6* input. Selects RF power preset 5 of 6. Provide an active pulse to activate.

Note: A minimum one second interval between commands is required for the following two exciter selection commands.

- TB1-14 (-): EXCITER A terminal. Causes a changeover to select exciter A as the main exciter. Setting is saved in current preset. Provide an active pulse to select this exciter.

- TB1-16 (-): EXCITER B terminal. Causes a changeover to select exciter B as the main exciter. Setting is saved in current preset. Provide an active pulse to select this exciter.

- TB1-10 (-): POWER INCREASE terminal. Increases the power level of the current preset. Send an active pulse to increase the power slightly, or send a signal of greater duration to continue increasing the power.

- TB1-12 (-): POWER DECREASE terminal. Decreases the power level of the current preset. Send an active pulse to decrease the power slightly, or send a signal of greater duration to continue decreasing the power.

## Remote status and alarm indications

Outputs that indicate the status of operator controlled circuits are available on connectors J2 and J3 on the remote interface PWB. A switching device for each alarm output provides current-sink-to-ground when a logic true condition exists.

The switching circuit provides an open collector for a logic false condition and has no influence on the external monitoring circuit.

The following outputs are available:

Note: All outputs are active low.

- J3-18: *Exciter Changeover*. See "Auto changeover" on page 6-3.

- J2-24: *Preset Scheduler On Status*.

- J3-21: *Auto Exciter Status*. Indicates if the current preset allows auto exciter changeover in the event of failures. (Set from the GUI only.)

- J3-20: *Memory Battery Alarm*. See "Low backup battery" on page 6-5.

- J3-19: *RF Overcurrent Alarm*. See "High RF current" on page 6-3.

- J2-23: *Exciter B Status*. Indicates which exciter is presently active.

- J3-15: *LVPS Fail*. See "LVPS fault" on page 6-2.

- J3-14: *Exciter Fail*.

- J3-13: *Pwr Mod Fail*. One or more power modules has a fault.
- J3-12: *Low B+*. See "Low B+ voltage" on page 6-2.
- J3-11: *High VSWR*. See "High VSWR shutback" on page 6-3.
- J3-17: *Cutback*. See "Cutback level (1-8)" on page 6-4.
- J3-16: *Shutback*. Indicates that a shutback is currently active.
- J3-3: *RF On Status*. Indicates that the RF On LED is active, showing the operator's request for RF power.
- J3-(5,6,7,8,9,10): *Preset (1-6) Status*. Indicates which preset is currently active.
- J3-4: *Remote Status*. Indicates whether or not the system is in Remote or Local control mode. Changes can only be made remotely if the transmitter is set to Remote mode. The local user's control of transmitter operation is limited, unless the transmitter is set to Local mode.

# Remote performance monitoring

The transmitter provides outputs that let you monitor RF performance. They include dc voltages that represent the forward power level, the reflected power level, the B+ voltage and the dc current. In addition, a true RF sample of the RF output voltage waveform is available for external monitoring. These outputs are provided on the remote interface PWB.

## Analog samples

Sample voltages, in the range of 0 to 4 V are provided for the following system parameters:

- J2-1: *Fwd Power*
- J2-3: *Refld Power*
- J2-5: *B+ Voltage*
- J2-7: *Dc Current*
- J8: *RF Monitor*

**Forward power level.** A buffered dc voltage that reports the forward power level on J2-1. This voltage is a pure square law function and will be 3.9 ± 0.5 V when the forward power is 6.5 kW (XR6) or 2.8 ± 0.5 V when the forward power is 3.3 kW (XR3). The monitoring circuit's impedance must be greater than 1,000 ohms.

**Reflected power level.** A buffered dc voltage that reports the reflected power level on J2-3. This voltage is a pure square law function and will be 3.9 ± 0.5 V when the reflected power is 960 W (XR6) or 2.8 ± 0.5 V when the reflected power is 480 W (XR3). The monitoring circuit's impedance must be greater than 1,000 ohms.

**B+ volts.** A buffered dc voltage on J2-5 that is directly proportional to the dc voltage from the main dc power supply. This voltage will be 3.0 V when the dc voltage being applied to the RF stage is 312 V. The monitoring circuit impedance must be greater than 1,000 ohms.

**Dc Current.** A buffered dc voltage on J2-7 that reports the dc current level of the main B+ power supply. The output is 3.0 ± 0.5 V with a dc current of 40 A.

**RF monitor sample.** A true sample of the RF output voltage waveform is available through the J8 BNC connector (RF MONITOR) on the remote interface PWB. The RF monitor output is intended to be applied to a station modulation monitor with a 50 Ω input impedance. It may also be monitored by an oscilloscope during maintenance procedures. The RF monitor output can be set to provide 1.0 V rms or 5.0 V rms for each preset power level, provided they are preset to a level that is between 600 W and 6 kW (XR6) or between 300 W and 3 kW (XR3).

Note: Some older modulation monitors may not accept a 1 V input.

Note: The output level range is determined by the setting of the BYPASS/GAIN switch. When the switch is set BYPASS, the RF monitor sample voltage is a nominal 1 V rms. When the switch is set to GAIN, the RF monitor sample voltage increases to a nominal 5 V rms. The rms output level is adjusted from the GUI. Setting the level higher than the limit determined by the BYPASS/GAIN switch [1 V rms or 5 V rms (carrier)] will cause distortion in the waveform, and may prevent accurate measurement of the modulation depth.

## LAN interface (NxLink)

A serial port is available on 9-pin D-sub connector J12 of the XR6/XR3's remote interface PWB. This port allows you to remotely control and interrogate the XR6/XR3's operational status. If the NxLink Ethernet interface module option is installed and you wish to use it as the remote interface, connector J12 is linked to Port 1 of the NxLink module. Refer to the *NxLink Technical Instructions Manual* for further details on the NxLink module.

# Section 7: Other considerations

This section describes other considerations regarding the XR6/XR3 transmitter.



## External RF drive source

You can apply an externally generated RF drive (carrier frequency only) to the remote interface board's digital EXT RF IN BNC connector (J6). This replaces the internal carrier frequency oscillator for one or both exciters (A/B).

Note: There is only one external RF drive input. If you use it for both exciters, duplicate the RF drive source (main/standby), and incorporate an automatic changeover circuit to select the standby source if the main source fails.

The external RF drive must:

- be the carrier frequency ($fc$), within ± 5 Hz or 5 parts per million (ppm), whichever is greater, when it is not being modulated.
- have a peak-to-peak amplitude of between 5.0 V and 12 V (sine wave or square wave).
- be spectrally pure when it is not being modulated.

Note: Any signal connected to the EXT RF IN input may affect the transmitter's RF output. To comply with regulatory limits on emissions, ensure that the RF drive source is acceptable.

## Installing an external RF drive source

1. If the RF drive for one or both exciters is to be applied from an external source, connect its wiring as follows:

   – Route RF drive coaxial cable through a cable entry hole in the cabinet and through the ferrite toroid, to the vicinity of the remote interface PWB.
   – Cut the RF drive coaxial cable to length, terminate it with a coaxial BNC connector and connect it to the remote interface PWB's EXT RF connector (J6).

2. Configure either (or both) exciter RF synthesizer(s) to operate on Ext RF drive by setting the E4 jumper(s) to 1-2.

# External 10 MHz frequency reference

You can apply an externally generated 10 MHz signal (such as a GPS clock signal) for use as the reference frequency for the RF drive (carrier frequency) to the 10 MHz REFERENCE INPUT BNC connector J2 on each RF synthesizer PWB.

1. The external 10 MHz frequency reference (one for each RF synthesizer PWB) must:

   – remain stable at 10 MHz within ± 20 Hz
   – have a peak-to-peak amplitude of between 2.2 V and 8.0 V (sine wave or square wave)
   – be spectrally pure, since spurs may pass through to the transmitter output.

2. Configure each RF synthesizer PWB by setting E2 to 1-2 and E1 to 1-2.

# Section 8: RF output requirements

This section describes requirements associated with the antenna and RF cabling to be used with the XR6/XR3 transmitter.

Antenna considerations include the following:

- Antenna feed cable
- Antenna system - see page 8-3

For detailed information about protecting the transmitter system from antenna lightning strikes, see the *Nautel Site Protection Manual*.

## Antenna feed cable

### Maximum voltage

The maximum voltage at the transmitter's connection to a 50 Ω load is 2,617 V peak, when operating at 6 kW (1,851 V peak at 3 kW), with 125% modulation.

### High voltage feed throughs

Be very careful whenever a high voltage RF conductor passes through a wall or bulkhead. Gas insulation flashovers can occur in poor installations. Ensure that this part of your installation is installed by professionals experienced with high-power radio frequency circuits.

**Insulator flashover.** Surface flashovers along an insulator occur when there is an electrical breakdown in the gas (normally air) at its surface. The mechanism that triggers a flashover depends on the insulation surface conditions. Gas breakdown flashover occurs when one or more of the following conditions are met:

- The voltage field at the insulator surface or at an adjacent electrode reaches the critical breakdown level for the gas.
- The electrode or insulator interface is poor or dirty, resulting in a three material junction. This creates excessive high voltage stress on the air insulator, causing a gas breakdown flashover.
- Moisture damage on the insulator surface creates regions of high voltage that can cause a gas breakdown flashover.

**Three-material junctions:** A frequent cause of breakdowns at an insulator surface is the junction of three materials: a metal conductor, a solid insulator, and a gas insulator. The insulators form a capacitive RF divider between the metal conductor and the grounded periphery. Since the dielectric constant of the solid is higher than the gas (air), the high voltage stress is concentrated on the air.

It is very important to minimize the junction's stress gradient and to avoid triple junctions wherever possible.

WARNING: FAILURE TO PROVIDE CORRECT STRESS CONTROL AT HIGH RF VOLTAGE CONDUCTOR/INSULATOR JUNCTIONS CAN CAUSE INSULATOR BREAKDOWNS OR EVEN FIRES.

**Bowl type bushings.** Use bowl type bushing insulators to increase the surface tracking distance from the central conductor to the grounded periphery or wall.

**Insulator Breakdown/Damage.** An insulator can be damaged during gas breakdown flashovers. When current flows across the surface of an insulator, especially when it is coated with a conductive contaminant that is slightly damp, carbon tracks can form. Once this occurs, the track provides a conductive path and reduces the effectiveness of the insulator.

Pitting and erosion of the insulator may also occur. To reduce the possibility of tracking damage, clean all insulator surfaces periodically, and use stress control techniques at the conductor/insulator junction.

**Other causes.** Other causes of breakdowns may include improperly adjusted spark balls or the disruption of air gaps by rain, snow, insects, birds, grass, or an accumulation of pollution (soot) on insulator surfaces.

## Small radius conductors

Be careful when using small radius conductors to carry high RF voltages and currents. If the radius is too small it may cause a local corona, which can lead to a breakdown.

## Feedline testing

Test the RF transmission system from the transmitter flange to the antenna before putting the transmitter into service. This is very important, especially if you are re-using an existing site with a previously installed feedline. Ensure that the entire system can tolerate the expected peak voltages of normal operation, especially those occurring during modulation peaks, without breaking down.

## Antenna system

Ensure that the antenna system meets or exceeds the standards specified in EIA Standard TR-101-A, paragraph 8(b), with a normal impedance of 50 ohms at the carrier frequency. The transmitter will operate with a maximum VSWR of 1.5:1, or with sideband VSWRs of up to 2:1 when the carrier frequency impedance is 50 ohms. However, overall system performance degrades as the VSWR increases.

Advances in digital modulation schemes like IBOC and DRM systems require better performance from antenna systems. To ensure the proper operation during digital broadcasting, ensure that the VSWR does not exceed 1.4:1 at the carrier frequency ±15 kHz.

In order to achieve the proper sideband symmetry (Hermitian symmetry) needed for IBOC operation, you may need to adjust the tuning of the antenna system to balance the impedances at the sidebands. You must perform a full impedance sweep of the antenna system before broadcasting IBOC. This requires information about phase versus frequency for Hermitian symmetry at the power amplifier. The information will be provided with the transmitter at time of shipment. For information about your transmitter's RF phase, contact Nautel Customer Support.

# Section 9: Parts and tools

This section describes parts associated with the XR6/XR3 transmitter, and tools needed during installation and routine operation. Topics include:



## Contacting Nautel

You can reach Nautel to order parts or for technical assistance at:


**Nautel Limited**
10089 Peggy's Cove Road
Hackett's Cove, NS Canada B3Z 3J4
Phone: +1.902.823.3900
877 6NAUTEL
Fax: +1.902.823.3183

Email: support@nautel.com

Web: www.nautel.com


## Parts supplied by Nautel

### Ancillary parts kit

An ancillary parts kit is shipped with the XR6/XR3. This kit contains hardware needed during the installation process. The kit includes toroids, spare fuses, screws and other miscellaneous hardware.

## Documentation

See "XR6/XR3 transmitter manuals" on page ix.

## Parts not supplied by Nautel

Some parts and materials required to complete installation are not supplied by Nautel. The parts you need vary with the installation requirements. The list of parts you normally provide yourself during installation include:

- A suitable 50 Ω RF output coaxial cable, terminated by the proper connector, complete with center male connector at the transmitter end.
- All external control and monitor wiring, including the associated terminating devices, conduit and conduit clamps.
- All electrical power cables, including conduit, terminating devices, and conduit clamps.

## Parts ordering

You can order replacement parts from your Nautel sales agent, or directly from Nautel through the Nautel website.

## Module replacement program

Nautel offers a module replacement program for customers who require expedited servicing and replacement of faulty modules. The module replacement program provides immediate replacement of failed modules with refurbished modules.

- The replacement module is shipped to the customer as soon as the customer reports the failure. The customer then returns the failed module to Nautel within 30 days using the same shipping package.

## Tools for installation

The tools you need during transmitter installation include the following:

- Digital voltmeter
- Philips screwdrivers, sizes #1 and #2
- Pliers
- Wire cutters
- Slot screwdriver, 5 mm (3/16 inch)
- Metric and Imperial socket set up to 24 mm (15/16 inch)
- Metric and Imperial wrench set up to 25 mm (1 inch)
- Feeler gauge (to measure spark gap)

# Section 10: Accessories

This section describes accessories and optional equipment for the XR6/XR3 transmitter. Accessories include the following:

- Ac line surge protection
- Automatic antenna transfer control unit - see page 10-2
- Automatic switching system - see page 10-4
- Dynamic carrier control unit - see page 10-4
- Spares - see page 10-4
- Documentation - see page ix

## Contacting Nautel

You can reach Nautel to order parts or for technical assistance at:

**Nautel Limited**
10089 Peggy's Cove Road
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Phone: +1.902.823.3900
877 6NAUTEL
Fax: +1.902.823.3183

Email: support@nautel.com

Web: www.nautel.com

## AC line surge protection

A surge protector panel is recommended for all equipment at the transmitter site. The surge protection panel helps to protect the site from lightning induced voltage transients on the ac power source or the antenna or ground system. Nautel offers an ac line surge protection panel, which is suitable for use with the XR6/XR3 transmitter. (Various versions are available, depending on your ac configuration and supply voltage.) However, you can use any surge protector with at least a 1,500 Joule per phase rating.

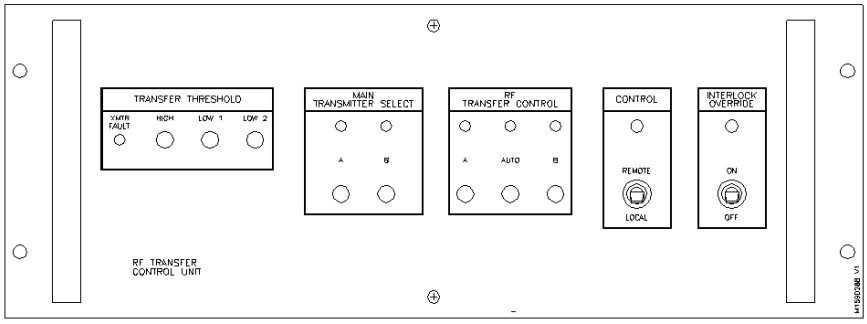
Connect the surge protector's ground terminal directly to the station reference ground using a 10 cm (4 in.) wide copper strap. Also connect the surge protector's ground directly to the ac power supply ground, the transmitter's grounding point, and the common ground for the site. Ensure that the common ground is isolated from any other sources of ground (for example, grounding rods not connected to the station reference ground), to prevent lightning charges from bypassing the surge protector and passing through the ground and into the site.

Place the surge protector as close as possible to the ac service entrance, minimizing both the physical and electrical distance between the service entrance and the surge protector. For detailed information about surge protection, refer to the *Nautel Site Protection Manual*.

## Automatic antenna transfer control unit

The automatic antenna transfer control unit is a 19-inch, rack-mountable assembly that is used in conjunction with two Nautel AM or FM broadcast series transmitters that are to be connected in a main/standby configuration. The control unit controls the on/off status of the transmitters by controlling the status of their safety interlock circuits. It also controls the ac voltage applied to relays or contactors, to determine the routing of the RF output of the on-air transmitter to the antenna. See "Automatic switching system" on page 10-4. The control unit allows manual or automatic switching of the main and standby transmitters. In automatic mode, the forward power levels of both transmitters are monitored. If the main (on-air) transmitter's RF output falls below a preset threshold (typically 3 dB), an automatic changeover to the standby transmitter takes place. An interlock override feature allows the operator to enable the RF output of the standby (off-air) transmitter into a dummy load for maintenance or troubleshooting.

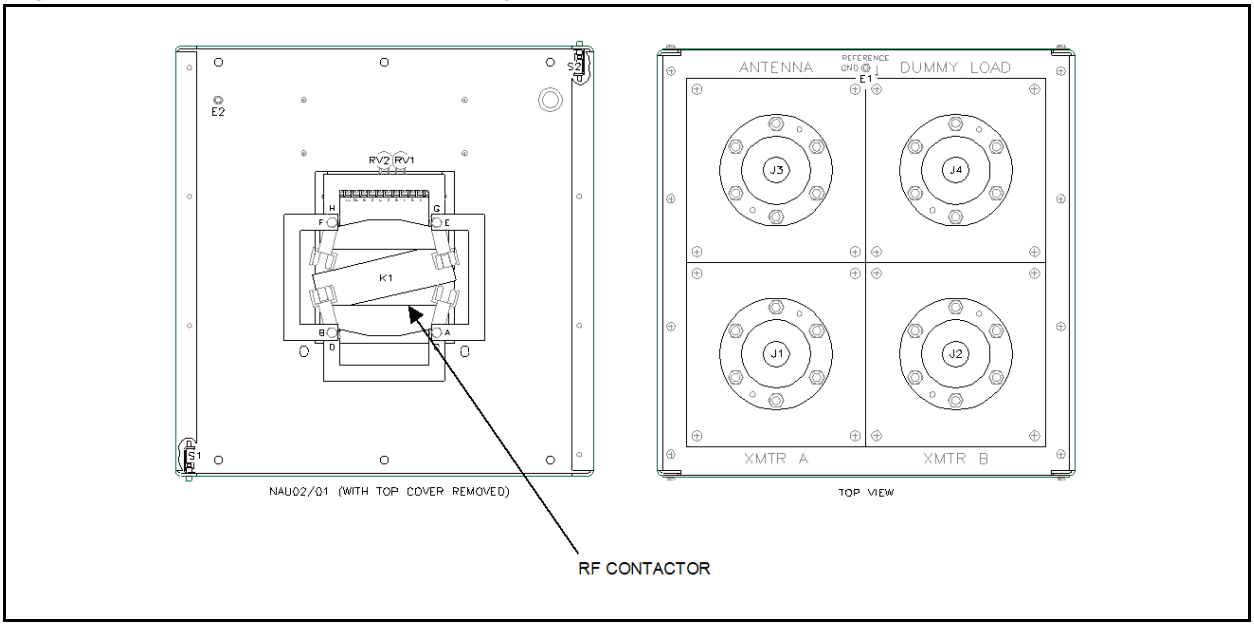
**Figure 10.1: Automatic antenna transfer control unit**




## RF contactor

The RF contactor is an RF output switching device for a main/standby control cabinet that interfaces main and standby transmitters (less than 15 kW RF output power) between an antenna and a dummy load. Typically, an automatic antenna transfer control unit controls the RF contactor's position by applying ac voltage to the 'set' or 'reset' solenoid of the RF contactor. The RF contactor's position determines the routing of the transmitter outputs to the antenna and dummy load. Micro-switches on the RF contactor provide interlock control for both transmitters and prevent 'live' switching.

**Figure 10.2: RF contactor assembly**



## Automatic switching system

The automatic switching system is a changeover rack for the XR6/XR3 that includes an automatic antenna transfer control unit and an RF contactor. The main component of the automatic switching system is a double-pole, double-throw latching switch.

## Dynamic carrier control unit

The Dynamic Carrier Control (DCC) option is an add-on, DSP-based module for the XR6/XR3 exciter. This system reduces ac power consumption by reducing the carrier power when the instantaneous modulation level of the transmitter drops below a threshold. The DCC unit supports Amplitude Modulation Companding (AMC), Dynamic Amplitude Modulation (DAM) and Dynamic Carrier Control (DCC) algorithms with various selectable carrier compression levels. Enhanced AMC may also be available.

## Spares

### spares kit

The spares kit includes fans, fuses, and semiconductors. Contact Nautel Customer Support for details about the contents of the spares kit for your transmitter.

### XR series RF power module

The XR RF power module integrates four modulators and eight amplifier units, with a combined power output rating of 9.4 kW, including carrier and modulation. It is compatible with all XR series transmitters.

**Figure 10.3: XR RF power module**

## RF Module testing cable and test load

The RF module testing cable allows bench testing and troubleshooting of RF power modules using a direct connection to the transmitter.

The test cable provides a temporary connection from the transmitter to an RF power module that has been removed from the transmitter and placed on a workbench. The test cable provides low-level, safe voltages, that allow the diagnosis of RF power module problems — this is a unique feature of Nautel transmitters.

The RF power module test load provides a low power load suitable for operating an RF power module on the test cable only.

## Plug-in power amplifier unit

The XR series power amplifier is a broadband, 1,000 watt plug-in unit compatible with all XR series transmitters.

**Figure 10.4: XR power amplifier unit**

## Plug-in power modulator unit

The power modulator unit is a 2,000 watt plug-in unit compatible with all XR series transmitters.

**Figure 10.5: Power modulator unit**

# Section 11: Pre-installation assistance

Nautel provides a number of support options to help you during pre-installation planning and preparation:



## Pre-installation consulting

Nautel field support specialists are available to answer questions and work with you to ensure that your site will be ready for the installation of your XR6/XR3 transmitter. For support, contact Nautel Customer Service and request assistance (see "On-site support" on page 11-3).

## Installation and commissioning service

Nautel offers an installation and commissioning service to customers who want assistance with configuring and commissioning a new Nautel transmitter. After the customer completes the transmitter assembly and installation, Nautel technical personnel will spend up to three days on-site to help make the ac power, RF and remote connections, and to assist with the configuration and testing of Nautel equipment.

The customer is responsible for ensuring that the following stages of installation have been completed, prior to the arrival of Nautel personnel:

- Ac power wiring for the transmitter has been installed and connected at the breaker panel or the building's service entrance. If local electrical codes allow Nautel personnel to connect the transmitter to the ac supply, using the customer's cable, that task is included in this service. Otherwise, the customer must ensure that an approved electrician is present for this task.

- The customer has prepared the RF coaxial cable – used to connect the transmitter to the antenna – and installed the required connector. The customer has also installed the RF coaxial cable in place and connected it to the antenna, while leaving the transmitter end of the cable unconnected.

- Where required, all remote control and monitoring cables have been installed and connected to the station equipment (e.g., modulation monitor, frequency monitor, and power meter).

- The site has been made ready for the equipment, and adequate protection against lightning and lightning-induced transients has been provided.

- The transmitter has been unpacked, closely checked for any damage caused by shipping, and then assembled.

- The following test equipment has been made available at the site:

  – Two-channel oscilloscope (with probes)

  – Audio signal generator

  – Distortion analyzer

  – Spectrum analyzer

  – Modulation monitor

  – Frequency counter

  – 50 Ω test load (rated for 150% of carrier power, VSWR less than 1.1:1)

Nautel's service representative takes full responsibility for commissioning the transmitter, validating all external interfaces (i.e., the ac supply, RF output, remote control and monitoring equipment) and checking out the equipment prior to activation. The service representative turns on the transmitter, performs all adjustments and set-up procedures, and carries out *proof of performance* tests at the site. These tests ensure that the transmitter is operating normally in compliance with its specifications. The service representative also provides a demonstration and a short explanation of the operation of the transmitter. Finally, the customer signs an *Acceptance of Installation Certificate* that provides feedback to Nautel regarding the commissioning service.

## Online documentation

Nautel provides documentation online to customers, letting you familiarize yourself with specifications, operation, maintenance and troubleshooting prior to the delivery of your equipment.

## On-site support

If you require on-site assistance, Nautel's field support specialists can help you prepare your site, and ensure that your XR6/XR3 transmitter installation can proceed as quickly as possible. For more information about onsite support, including scheduling and pricing, contact Nautel Customer Service:

- Telephone: +1.902.823.3900
- Fax: +1.902.823.3183
- Email: support@nautel.com

After business hours (Atlantic time or Eastern time in North America), requests sent by fax or email will be acknowledged within one working day.

## Training

Nautel's SBE-certified broadcast training programs satisfy your day-to-day knowledge requirements. Students participating in Nautel's broadcast transmitter or RF basics training programs earn one SBE credit for each completed day of training. Nautel's comprehensive selection of training programs will help a customer's staff develop valuable skill sets, reduce downtime, and make the most of the customer's technology investment.

Nautel training programs are made up of individual modules that can be *mixed and matched* to meet the customer's specific training needs. All Nautel training courses are available at the Nautel Training Center. Training can also be provided at the customer's facility, for training the customer's technical staff on the customer's transmitter.

All training courses at the Nautel Training Centre combine classroom and hands-on laboratory work to ensure a balanced learning experience. Many of our classes also include diagnostic lab exercises.

Nautel training courses feature:

- Limited class sizes to ensure maximum student participation and access to equipment

- Emphasis on need-to-know, day-to-day knowledge
- Labs that focus on the tasks most often performed at the transmitter site.

### XR series on-site or factory training

This includes product overview, site and pre-installation, theory of operation, testing and adjustments, operating instructions, system-level troubleshooting, component-level troubleshooting, component parts lists, and wiring route sheets.

## Standard warranty

Nautel Limited/Nautel Incorporated, hereinafter referred to as Nautel, guarantees all mechanical and electrical parts of the equipment for a period of 13 months from date of shipment.

1. A "Part Failure" shall be deemed to have occurred when the part has become defective, or does not have the characteristics required for the specified equipment performance:

   (a) When the equipment is operated within the design parameters, and

   (b) When the equipment is installed and adjusted according to Nautel's prescribed procedures as stated in the instruction manual.

2. Nautel shall provide replacements for all "Parts" at no cost to the Customer when they become defective during the warranty period, and upon the return of the defective part.

3. In the event that a "Part" fails during the warranty period and causes damage to a sub-assembly that cannot be readily repaired in the field, the entire sub-assembly so damaged may be returned to Nautel for repair. The repairs will be made without charge to the Customer.

4. Where warranty replacements or repair are provided under items 2 or 3, Nautel will pay that part of the shipping costs incurred in returning the part/assembly to the Customer.

5. Warranty replacement parts and repair, which are provided under items 2 or 3, shall be guaranteed for a period of ninety days from date of shipment or until the end of the original warranty period, whichever occurs later.

6. Nautel will not assume responsibility for any charges incurred by other than Nautel employees.

7. Nautel shall have the privilege of investigating whether failures have been caused by factors beyond its control.

8. Nautel shall in no event be liable for any consequential damages arising from the use of this equipment.

9. When requesting a warranty repair/replacement, please provide complete and accurate information. Observe the instructions regarding "Equipment being returned to Nautel" on page 11-6 and provide the information requested.

10. When ordering spare/replacement parts, please provide complete and accurate information. Refer to the parts list of the Repair manual for ordering information. Provide as much of the information requested for 'Equipment Being Returned to Nautel' on page two of this warranty as is practical. The information identified by an asterisk is the minimum required.

## Technical assistance

Nautel's field service department provides telephone technical assistance on a 24 hour, seven days a week basis. Requests by other media (facsimile or e-mail) will be responded to the next working day if received after Nautel's normal working hours. Contact the appropriate field service centre from the following:

**Nautel Limited**
10089 Peggy's Cove Road
Hackett's Cove, NS Canada B3Z 3J4
Phone: +1.902.823.3900 or
Toll Free: +1.877.6NAUTEL (6628835) (Canada & USA only)
Fax: +1.902.823.3183

**Nautel Inc.**
201 Target Industrial Circle
Bangor, Maine USA 04401
Phone: +1.207.947.8200
Fax: +1.207.947.3693

**Customer Service (24 hour support)**
+1.877.628.8353 (Canada & USA only)
+1.902.823.5100 (International)

Email: support@nautel.com
Web: www.nautel.com

## Module exchange service

In order to provide Nautel customers with a fast and efficient service in the event of a problem, Nautel operates a factory rebuilt, module exchange service which takes full advantage of the high degree of module redundancy in Nautel equipment. This module exchange service is operated from Nautel's factory in Bangor, Maine and Hackett's Cove, Nova Scotia. These two locations allow us to provide a quick turn around service to keep our customers on the air. During the transmitter's warranty period, up to thirteen months from shipment, repair and exchange of modules is at no charge to the customer. When the warranty has expired, a charge of 80% of the list price for all exchanged modules is made. If the faulty module is returned to Nautel within 30 days, a credit is issued reducing this charge by one half to 40% of the list price. USA customers are required to contact our Bangor, Maine facility. Canadian and overseas customers should contact our Nova Scotia, Canada facility.

## Equipment being returned to Nautel

For all equipment being returned to Nautel and all requests for repairs or replacements:

- Obtain an RMA number from Nautel (you must have an RMA number to return equipment)
- Mark the item as 'field return'
- Mark the item with the RMA number assigned by Nautel
- Address the item to the appropriate Nautel facility

Complete and accurate information regarding the equipment being returned will ensure prompt attention and will expedite the dispatch of replacements. Refer to the nameplate on the transmitter and/or the appropriate module/assembly to obtain name, type, part and serial number information. Refer to the parts list of this manual or the appropriate service instruction manual for additional ordering information.

The following information should accompany each request (* denotes minimum required information):

- *Model and serial number of equipment
- *Name of part/assembly
- Serial number of part/assembly
- *Complete reference designation of part/assembly

- *Nautel's part number of part/assembly
- *OEM's part number of part/assembly
- Number of hours in use
- Nature of defect
- *Return shipping address

## Extended warranties

Nautel's standard 13-month warranty provides excellent coverage and satisfies most customers' needs. However, if you want extended coverage, Nautel offers one- and two-year Extended Warranty Plans to cover electrical and mechanical repairs or replacements for all Nautel equipment.

### Coverage

The Extended Warranty Plan includes:

- A module exchange program for many common modules and circuit boards (North America only)
- Toll-free hotline (North America only)
- Necessary labor performed by Nautel authorized personnel to repair the product to meet factory specifications
- Necessary components
- Modifications to correct performance problems
- Return shipping.

## Details

Extended Warranty Plans must be purchased prior to the expiration of original 13-month warranty.

One-year Extended Warranty Plans add an additional year (12 months) of coverage after the end of the customer's standard 13-month warranty. The two-year plan adds an additional two years (24 months).

Only repairs done at Nautel's facilities or by Nautel authorized personnel will be covered by the Extended Warranty Plans.

You must ship faulty products back to Nautel, prepaid, and in the original package or in a package that provides equivalent protection.

Nautel can choose to repair or replace equipment.

## Purchasing a one- or two-year Extended Warranty Plan

If the transmitter is still covered by its original 13-month warranty period, you can contact Nautel by telephone, fax, mail, or email with the model number, serial number and date of purchase.

Once you purchase a Nautel Extended Warranty Plan, you receive an extended warranty plan certificate, plan number, and a toll-free number (North America only) to call for any service-related issues.

## Using the Extended Warranty Plan

Contact Nautel's Canadian or U.S. service facility by phone, fax, or email as soon as a problem occurs. The following will be required when contacting Nautel:

- Extended warranty plan number
- Product model number
- Serial number
- Brief description of the problem

If Nautel's service technicians are unable to solve the problem over the telephone, Nautel will give you an RMA number. You then return the module or circuit board to a Nautel service facility, so that Nautel can provide a replacement. *Do not ship a component back to Nautel until you have an RMA number.*

# Section 12: List of terms

This section defines some of the terms that are used in Nautel documentation.

**AES-EBU.** Audio Engineering Society/European Broadcasting Union (AES/EBU) is the name of a digital audio transfer standard. The AES/EBU digital interface is usually implemented using 3-pin XLR connectors (the same type connector used in professional microphones). One cable carries both left- and right-channel audio data to the receiving device.

**AMC.** Amplitude Modulation Companding

**Antenna Tuning Unit (ATU).** A device that matches the transmitter to the impedance of the antenna.

**B+.** The high voltage dc generated by the transmitter's ac power supply for use within the transmitter. The B+ voltage is used to supply the transmitter's modulators and other transmitter circuitry.

**Cutback.** A reduction in RF output power, caused by a total power limit fault or the occurrence of three shutbacks within a five second period.

**DAM.** Dynamic Amplitude Modulation.

**DCC.** Dynamic Carrier Control.

**DSP.** Digital Signal Processing.

**HD Radio.** High Definition (HD) Radio is another term for In Band On Channel (IBOC) technology. HD Radio is a trademark of iBiquity Digital Corporation.

**IBOC.** Nautel In-Band-On-Channel technology provides high quality digital audio over existing AM radio channels.

**IPM.** Incidental Phase Modulation

**NE IBOC.** Nautel's In-Band-On-Channel signal generator. See IBOC. Required for XR series IBOC installations.

**PDM.** Pulse Duration Modulation.

**Preset.** A setting that controls power level, active exciter, and power scheduler status on a time-of-day and date basis. Exciters can be configured on a preset for a specific operating mode (for example, Exciter A - conventional AM, and Exciter B - IBOC). The XR6/XR3 allows you to pre-program up to six presets.

**Shutback.** A complete loss of RF output power, caused by any one of a variety of faults, including high VSWR, low B+ voltage, high RF current, RF drive failure, external interlock or spark gap.

**Surge protection board.** An electrical panel that protects equipment from electrical surges in the ac power supply, antenna or site ground caused by lightning strikes.

**VSWR.** Voltage standing wave ratio. This is an expression of the ratio of forward voltage to reverse voltage on the feedline and antenna system. An ideal VSWR of 1:1 provides maximum transmitter-antenna efficiency.

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# XR6/XR3

## Pre-installation Manual

Document: XR6/XR3-PREINST

Issue: 3.0 2009-07-15

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