Nautel Land-based NDB Systems

Gary Galbraith, P.Eng.
Technical Sales Representative,
Navigational Products

Making Digital Radio **Work.**

Corporate History

- Design, manufacture, sales and support of 3 product lines
  - **Navigational Products**
  - **AM and FM transmitters for radio stations**
  - **Industrial RF products**
- Established in 1969
- Products installed in over 177 countries
- Exceptional field reputation for reliable products
- Dedicated, long-term staff
- Quality Management System audited by Bureau Veritas and registered/certified to **ISO 9001:2008**.

45+ Year History of Innovation

NS Series LF Sonar Amplifier - 2010

VS Series Low Power FM - 2009

NX Series MW 25-50 kW - 2008

NV Series High Power FM - 2008

eLORAN technology - 2008

HD Power Boost technology - 2008

NX Series High Power MW - 2007

WEB based remote control - 2007

Space Propulsion applications - 2007

Vector NDB/DGPS series with Patented Antenna Current Stabilisation – 2005

Adaptive Pre-Correction – 2005

XR Series – 4th Generation AM Transmitters 3 – 50 kW - 2005

HD Radio FM Transmitters &

Direct-to-Channel Digital FM Exciter – 2004

DRM 200 kW, MW transmitter goes on-air in Europe - 2003

Reliable HD Radio Transport

Protocol for FM Digital Broadcast– 2006

NX Link – TCP/IP Based Control - 2006

2002 - DRM and IBOC Digital Compatible AM Transmitters

2000 - Nautel launches 20 kW and 40 kW FM Transmitters

1994-1996 – Nautel launches super efficient 12 kW - 60 kW FM Transmitters

1993 – Nautel launches first 10 kW FM Transmitter

1990 – Nautel launches first solid state 100 kW & 200 kW AM Transmitters

1982 – Nautel launches first solid state 10 kW & 50 kW AM Transmitters

1974 – Nautel launches first solid state 2 kW AM Transmitter

1970 – Nautel introduced first solid state Radio Beacon Transmitter

1969
Dennis Covill
Founds Nautel

Making Digital Radio **Work.**

Product Lines

- **MF AM radio broadcast transmitters (both analog and digital)**
- **VHF FM radio broadcast transmitters (both analog and digital)**
- **LF/MF Navigational non-directional radio beacon (NDB) transmitter systems**
- **LF/MF Differential Global Positioning System (DGPS) transmitters**
- **MF NAVTEX transmitter systems**
- **HF amplifiers and tuning/matching networks for industrial applications and plasma rocket engines**
- **Next Generation LORAN (Long Range Navigation) transmitters**
- **VHF FM weather radio transmitters**
- **LF Sonar amplifiers**

Worldwide Installed Base

- Solid State NDB and DGPS Transmitters
  +4,200 units since 1970

- Solid State MF Telegraph Transmitters
  +200 units since 1970

- Solid State VHF – FM Broadcast Transmitters
  +2,300 units since 1992

- Solid State MW – AM Broadcast Transmitters
  +3,300 units since 1982

- Solid State VHF – FM Weather Radio Transmitters
  +25 units since 2010

…over 12,000 transmitters shipped to date!

Worldwide Navigation Customers

FAA

USCG

USAF

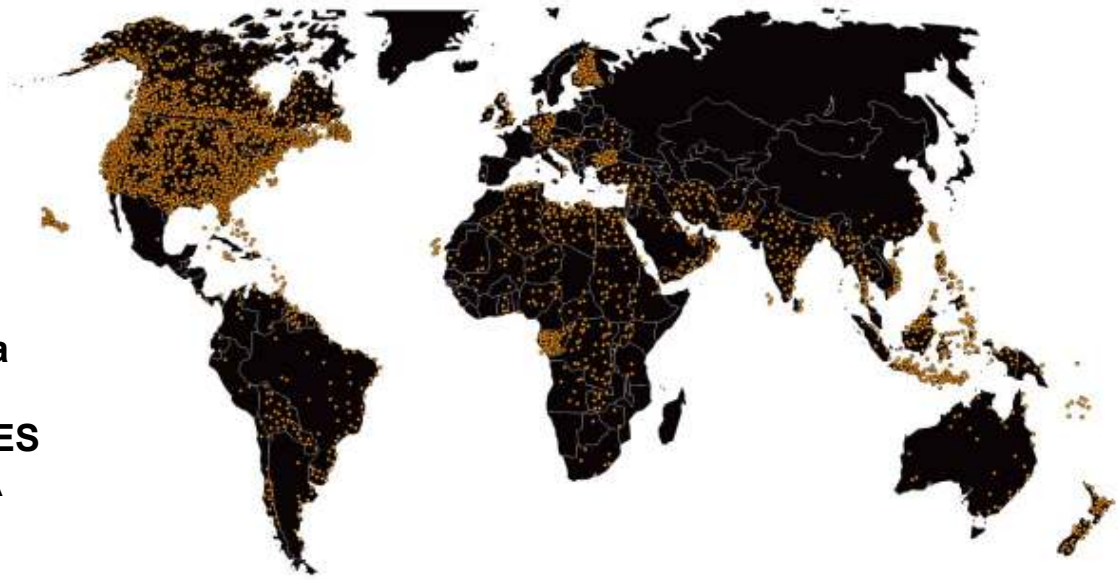
US FHWA

CCG

NAV Canada

AIRSERVICES AUSTRALIA

Installed Nautel Navigation Systems



World Wide Civil Aviation Authorities

ONGC

Shell

INFRAERO

SAIPEM

ICAO

World Wide Offshore Systems Integrators

Design Capabilities

- Multidisciplinary Research & Development team of over 30 technical staff
- In-house design skills:
  - Solid state amplifier design from 100 kHz to 200 MHz
  - Antenna Design and Computer Simulation
  - Analog and Digital Communications theory
  - RF matching, combining and filtering at high power and high voltages
  - RF Magnetics
  - Power Supplies
  - Digital Hardware Design
  - Digital Signal Processing
  - Data Communications Systems
  - Networking and TCP development

Facilities

Nova Scotia, Canada:
- **Headquarters**
- **Production**
- **160 Employees**
- **+ 70,000 sq. ft.**

Maine, USA:
- **Wholly owned subsidiary**
- **Production**
- **40 Employees**
- **+ 36,000 sq. ft.**

Additional Parts Depots - Memphis, TN USA & Cranleigh, Surrey UK
Service Center - Quincy, IL USA

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Production Capabilities

Computerised Fabrication Shop

PWB Assembly

Light Assembly

Final Assembly

Final Production Test

Packing and Shipment

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Quality Manufacturing

- Quality Management System registered/certified to the **ISO9001:2008** international quality standard
- products built to stringent quality standards with industry leading features, performance, and reliability
- products are the result of the pride and craftsmanship of dedicated professionals
- each product is assembled by a team of individual people - no assembly robots or fabrication lines
- production staff with an average of 15 years experience
- Nautel controls every aspect of production from workmanship to electrical components to sheet metal fabrication

Product Families

AM


J1000


XR3 & XR6


XR12


NX25


NX50


NX100-NX800

FM


VS Series


NV3.5, NV5, NV7.5, NV10, NV15, NV20, NV30, NV40

Navigation


Vector Series NDB/DGPS/Navtex


NDB/DGPS/Navtex Antenna Tuning Units


NL Series Next Generation Loran


LF Antennas

Industrial RF


HF Amplifier


Custom Impedance Matcher

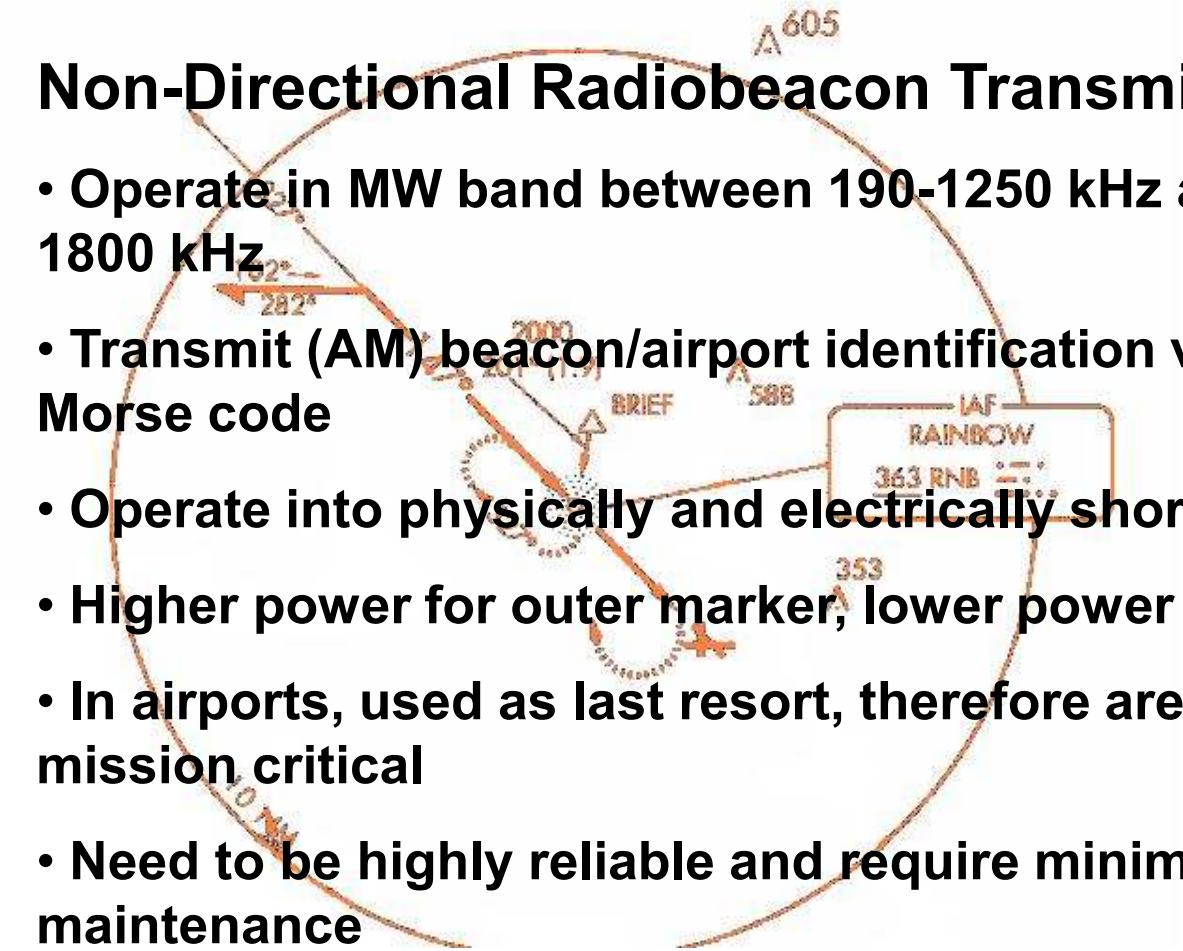

Plasma RF Power Sources


NS Series
LF High Power Amplifier


NG Series
Weather Radio Transmitters

Making Digital Radio **Work.**

NDB Overview



Non-Directional Radiobeacon Transmitters:

- **Operate in MW band between 190-1250 kHz and 1600-1800 kHz**
- **Transmit (AM) beacon/airport identification via keyed Morse code**
- **Operate into physically and electrically short antenna**
- **Higher power for outer marker, lower power for approach**
- **In airports, used as last resort, therefore are considered mission critical**
- **Need to be highly reliable and require minimal maintenance**

NDB Overview

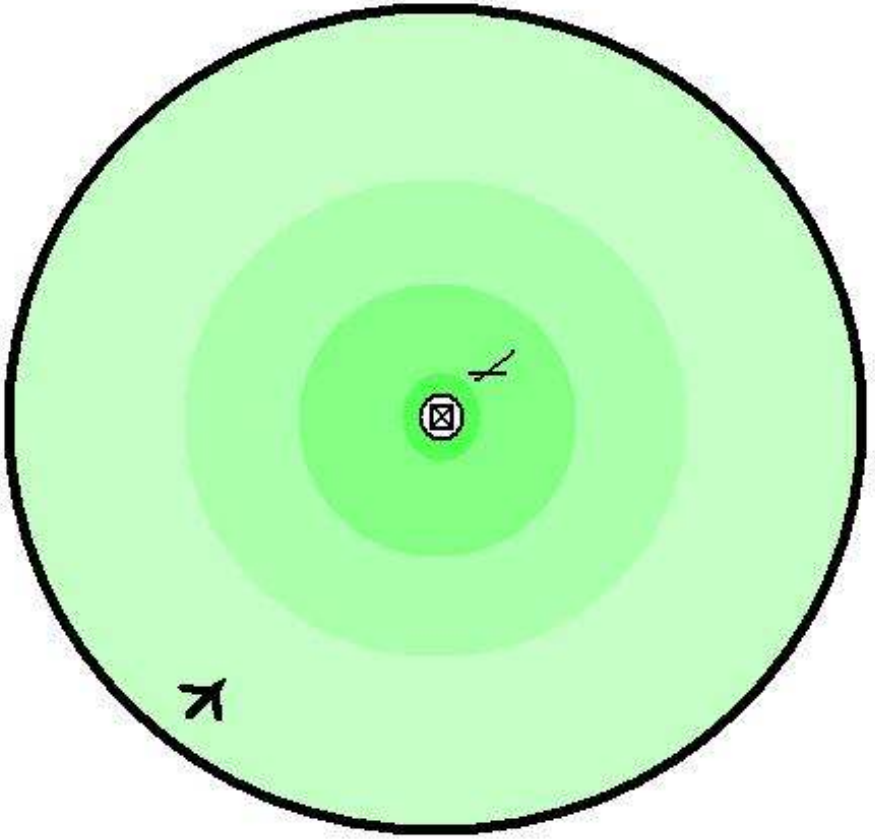
ADF Receiver:

- **Located in aircraft, consist of simple frequency selectable receiver, indicator, and rotating antenna**
- **Acts as field strength meter, with a direction finding needle**
- **Needle points toward strongest indicated source of selected frequency, based on antenna position**
- **When target is underneath, needle spins in circles**

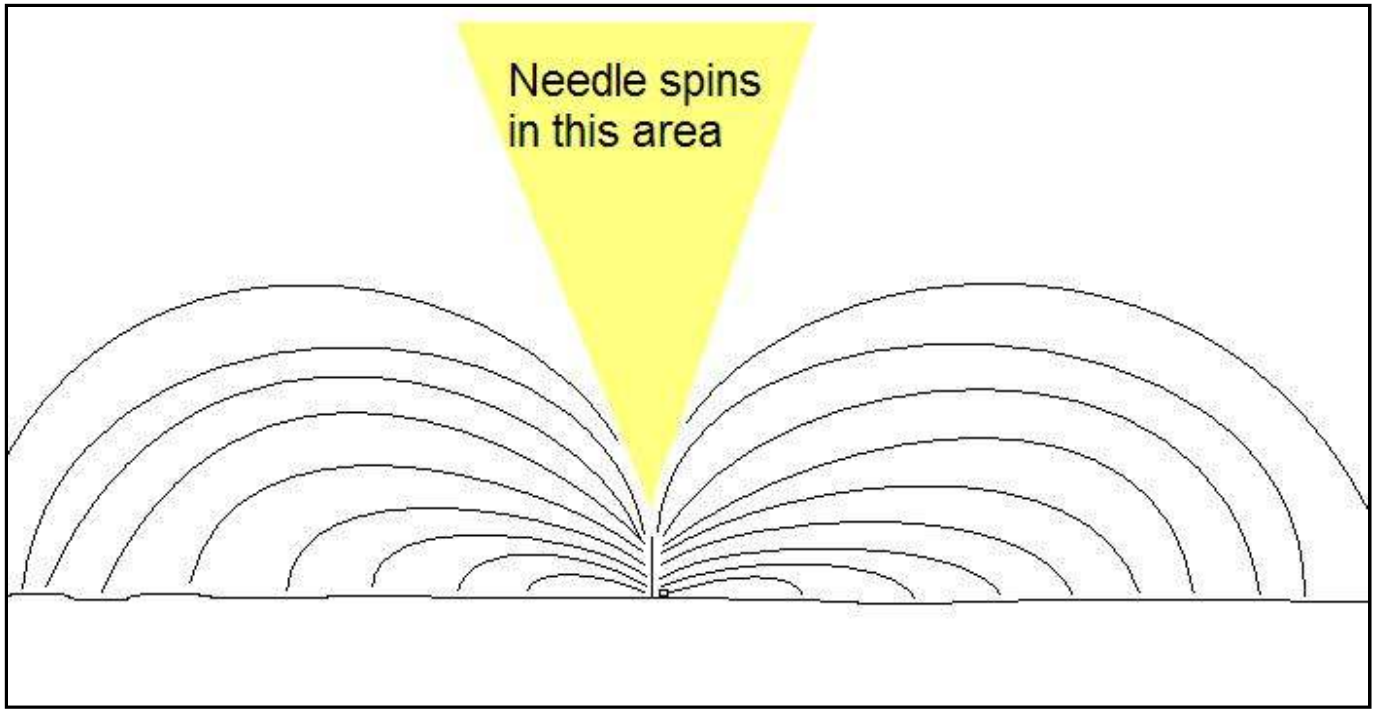
NDB Overview

- **As aircraft approaches NDB, signal strength increases and needle indicates direction**

- **As craft overflies NDB, needle gyrates and ATC provides vectors for final approach to runway**

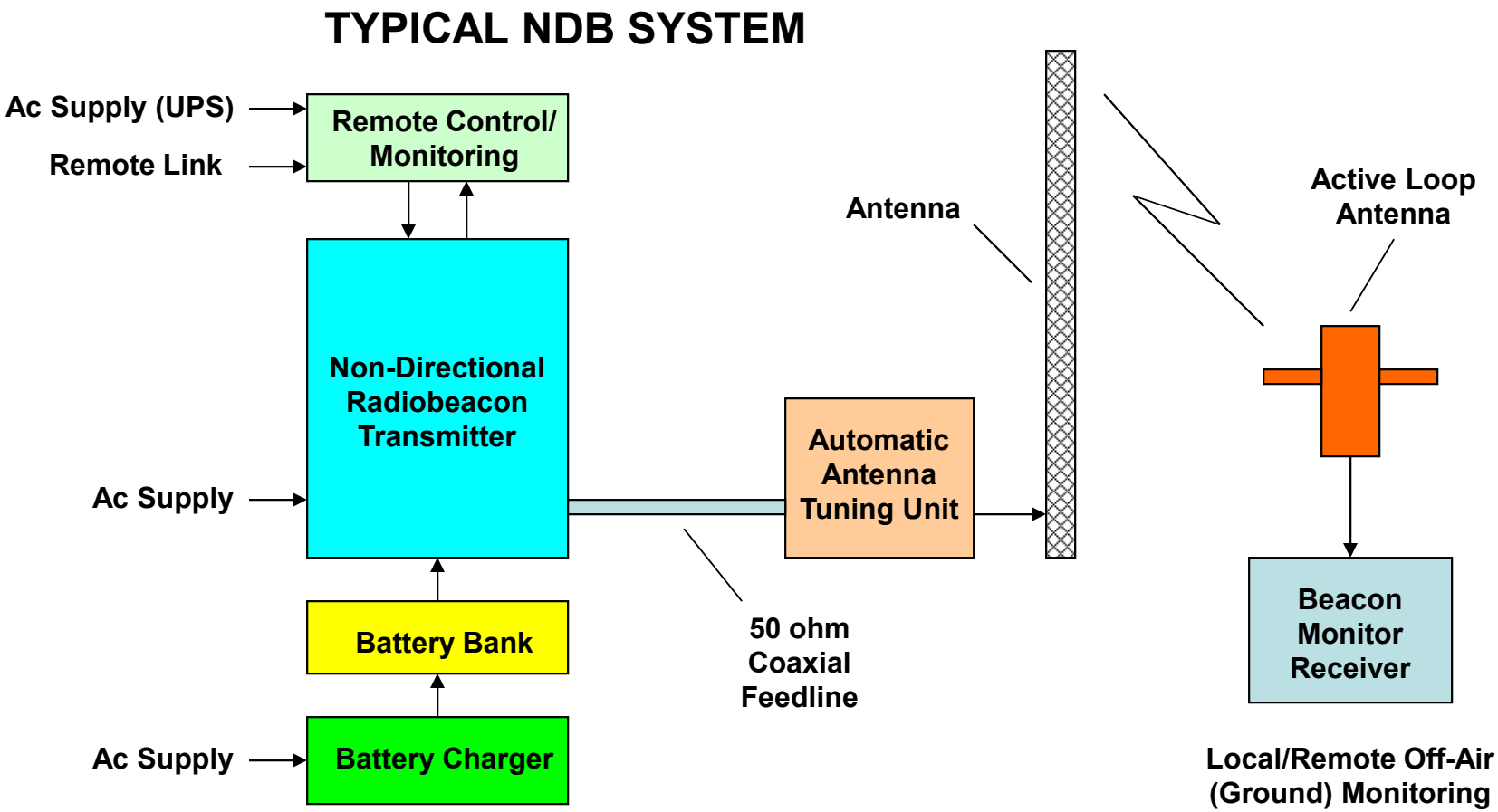


NDB Overview



- **In almost all cases, radiation is omnidirectional**
- **Terrain and buildings can cause reflections and false readings on cockpit instruments**

NDB Overview



NDB Overview

NDB sites typically require a high level of reliability and redundancy, with minimal maintenance

Vector NDB Transmitters

Vector 125/250

125 W & 250 W NDB

ATU-LP

125 W & 250 W NDB
250 W & 375 W DGPS

Vector 500 &
Vector 1000/2000

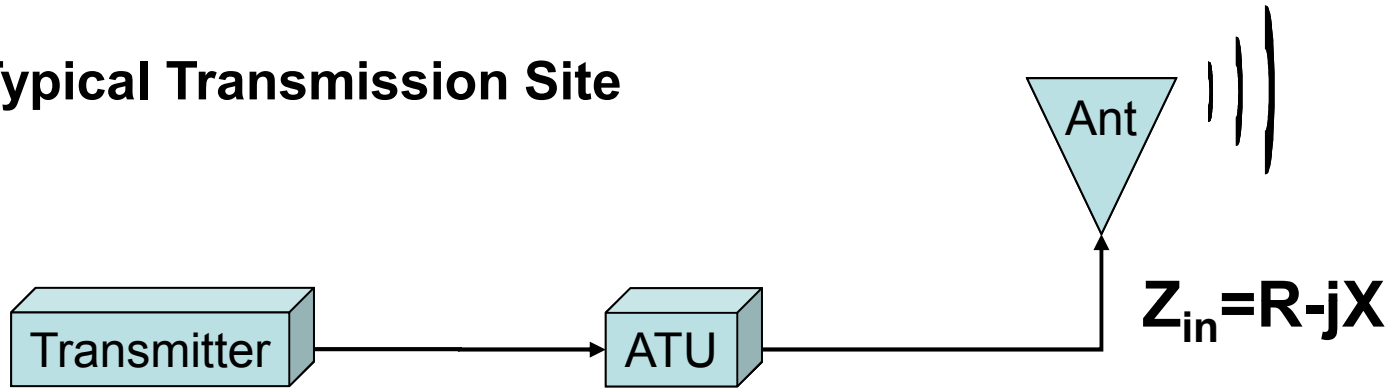
500 W, 1000 W & 2000 W NDB

ATU-HP

500 W, 1000 W & 2000 W NDB
750 W – 3000 W DGPS

Vector System Approach

Typical Transmission Site

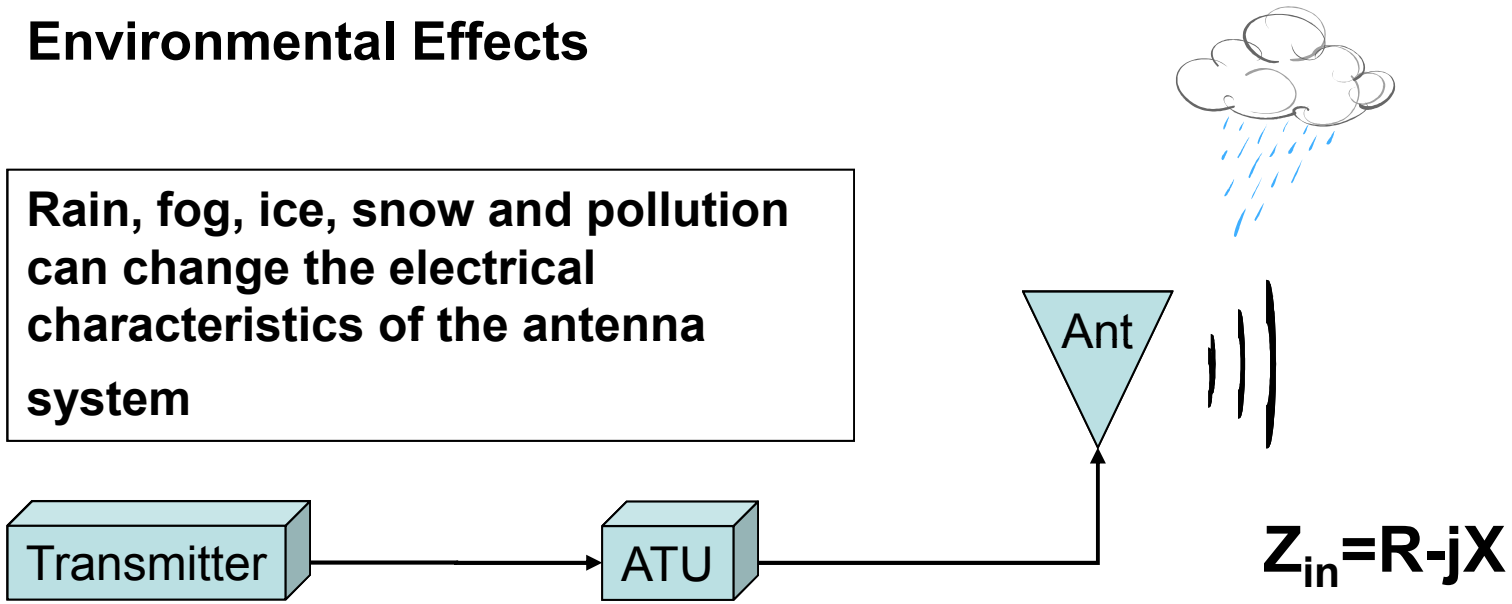


Value of *X* typically 100 times greater than *R*. Conventional technology resonates *X* with an auto-tuned loading coil then matches the resulting *R* to 50 ohms required by the transmitter using a tapped matching transformer that is set up on installation.

Vector System Approach

Environmental Effects

Rain, fog, ice, snow and pollution can change the electrical characteristics of the antenna system

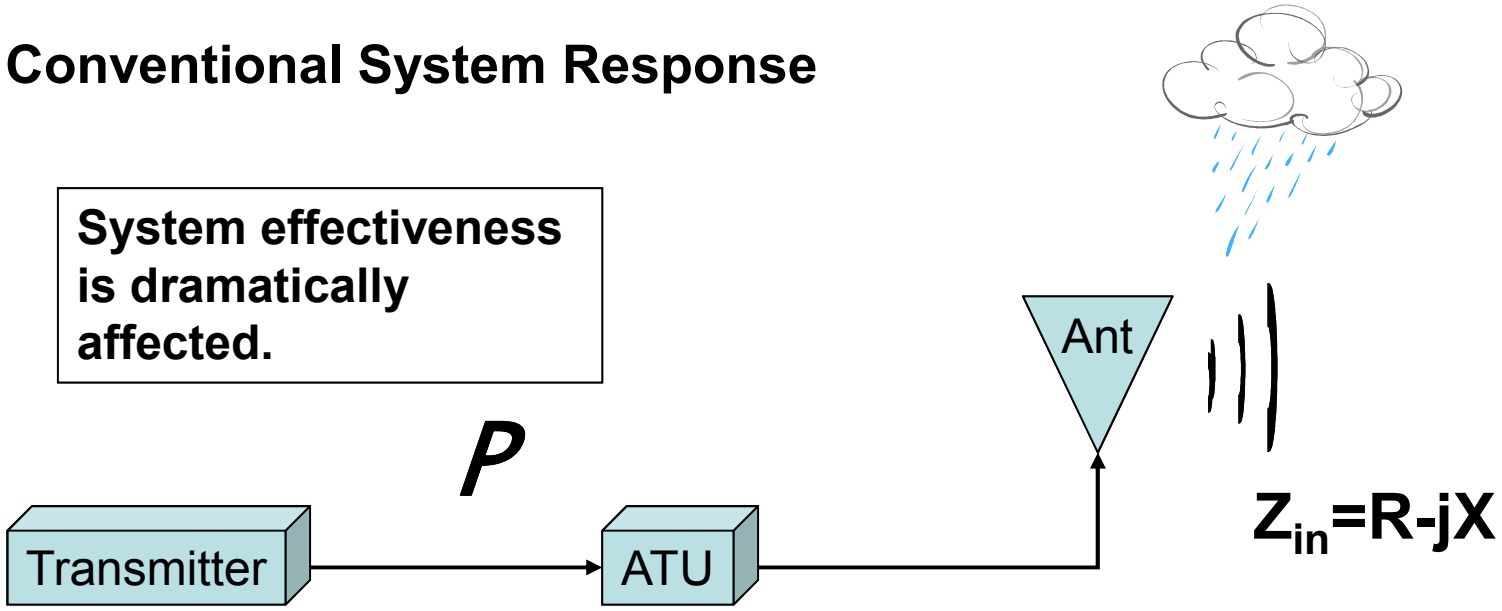


1. Input impedance changes R ±50% X ±5% causing VSWR and change of antenna efficiency.

Vector System Approach

Conventional System Response

System effectiveness is dramatically affected.

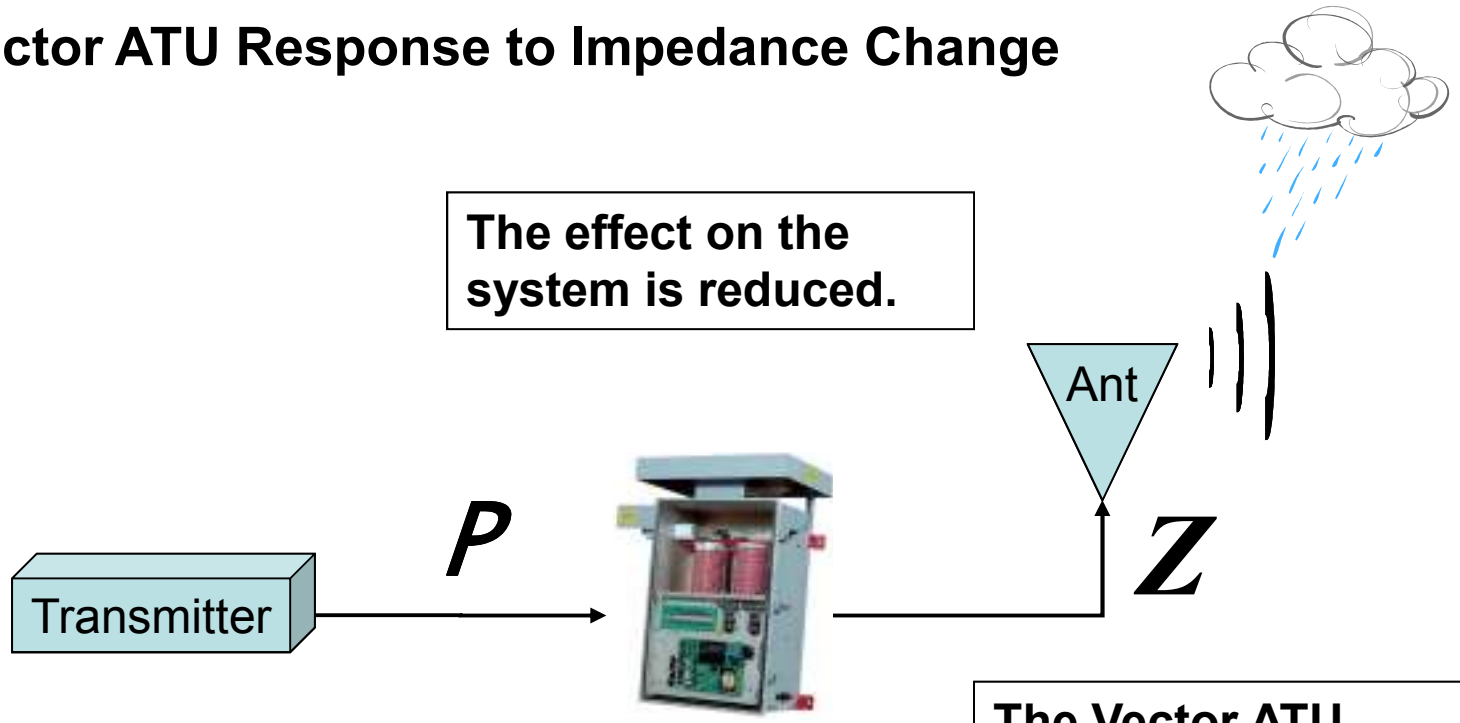


Auto tuning mitigates variation of *X*. Change of *R* causes two detrimental effects:

- **High VSWR** – Transmitter lowers its output power to reduce resulting reflected power. In extreme cases, transmitter may even shut down.
- **Change of Antenna Efficiency** – Even if transmitter power were maintained constant, the variation of antenna efficiency would cause variation of radiated power. A 50% increase in *R* requires a 50% increase in transmitter power.

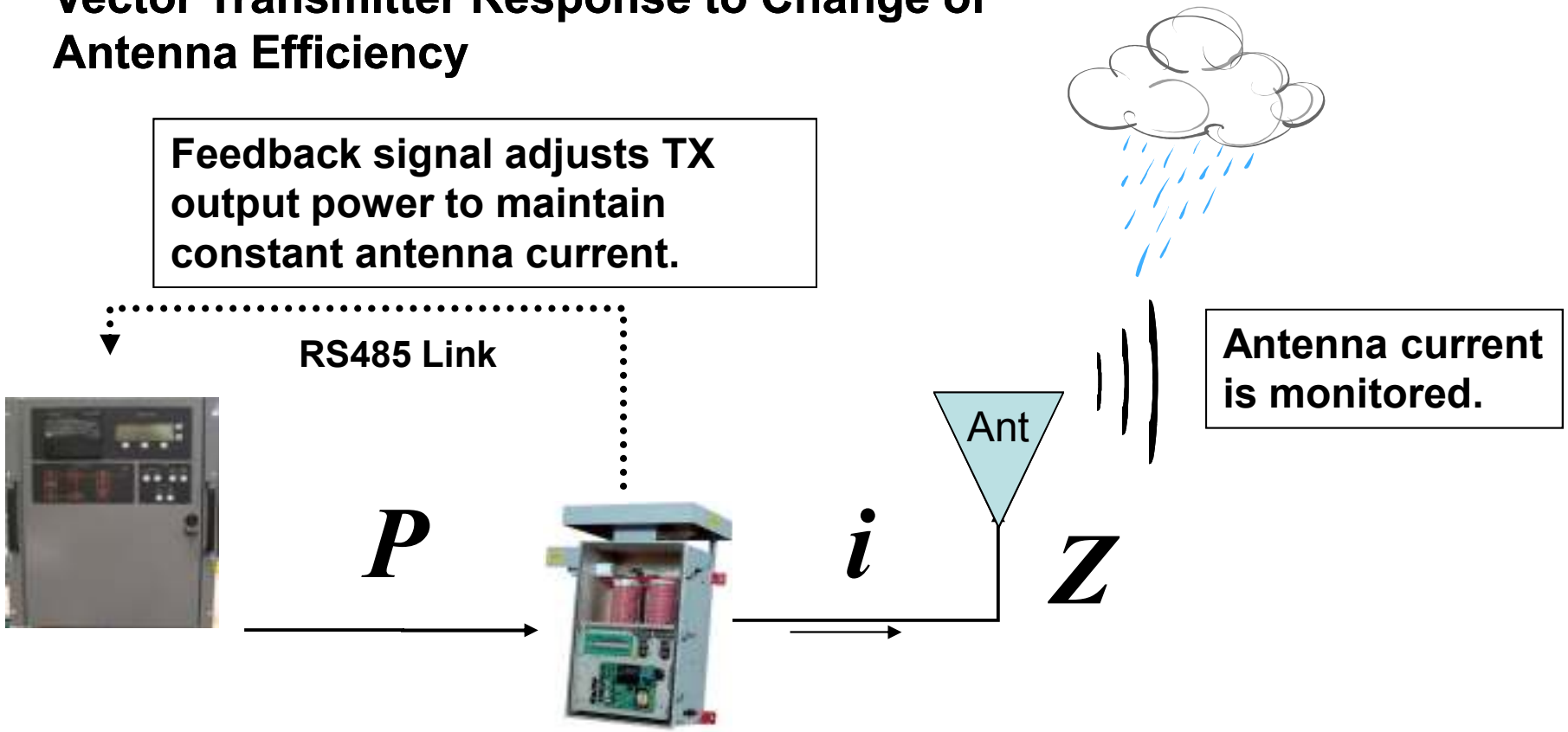
Vector System Approach

Vector ATU Response to Impedance Change



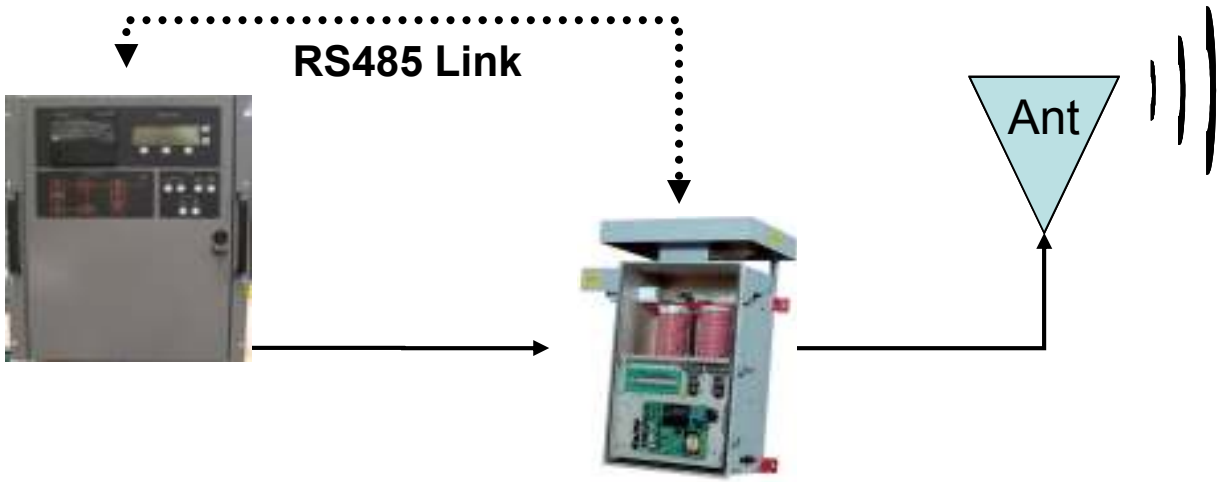
Vector System Approach

Vector Transmitter Response to Change of Antenna Efficiency



Vector System Approach

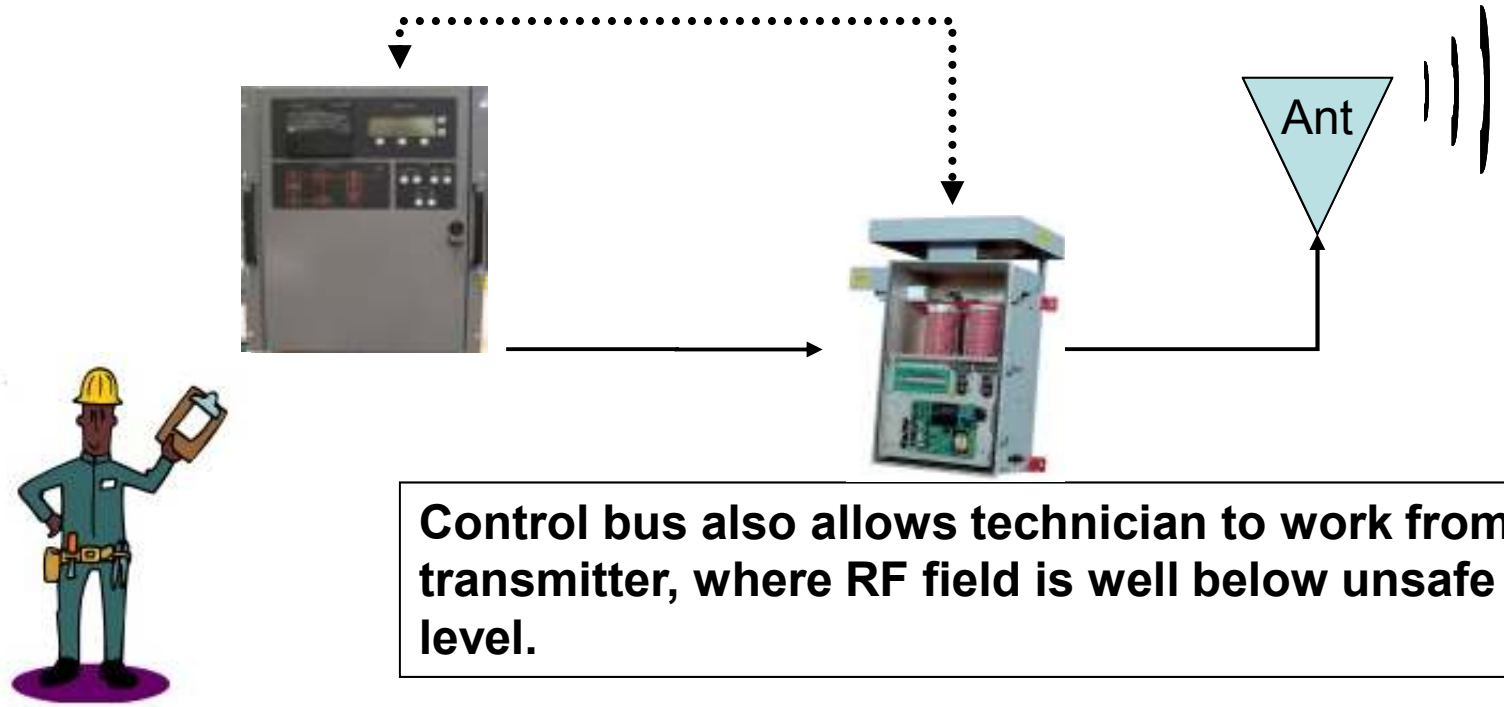
RF Field Exposure



Unlike manually tuned ATUs, the Vector system reduces the need to expose technicians to the high RF fields near the ATU

Vector System Approach

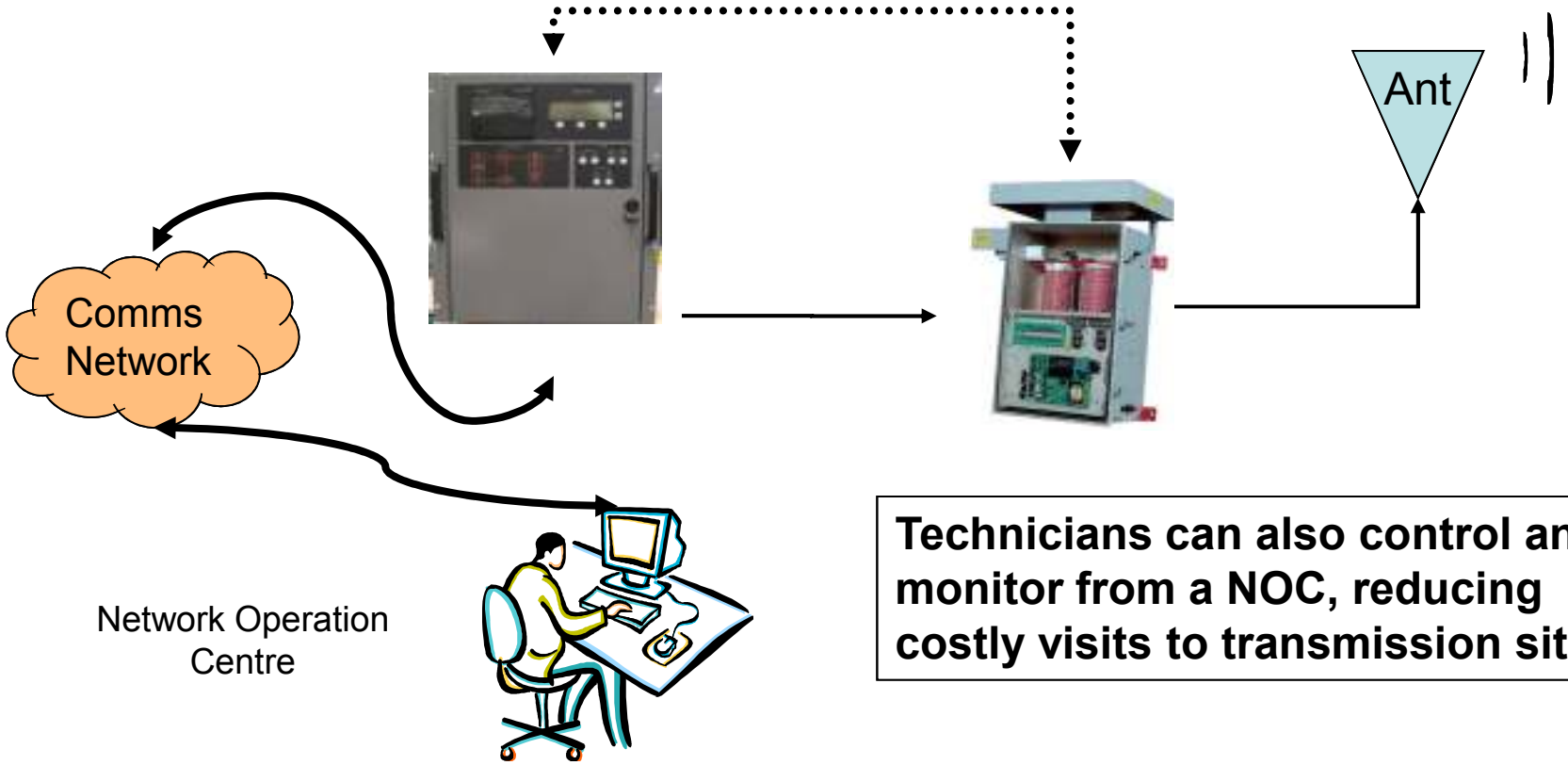
Vector Remote Control and Monitoring



Control bus also allows technician to work from transmitter, where RF field is well below unsafe level.

Vector System Approach

Vector Remote Control and Monitoring



Technicians can also control and monitor from a NOC, reducing costly visits to transmission site.

Vector NDB Transmitters

- **Patented solution to maintain system coverage regardless of undesirable antenna effects such as ground resistance changes**
- **Built in Diagnostics allows the user to easily identify fault to Lowest Repairable Unit locally or remotely**
- **Non operational side can be tested locally or remotely without need for dummy load while main side remains on air**
- **Available in Single and Dual Configurations**
- **Commonality of Parts and Assemblies throughout all power levels**
- **Vector enhanced Remote Control/Monitor to extended and remote control/monitoring locations**

Vector 500W – 2000W Transmitter Overview

Exciter/Monitor

- Dual Exciter and Critical Monitor available for NDB/DGPS, Single for Navtex
- Analog and digital metering
- Enhanced Remote Control/Monitor
- Simple LCD graphical user interface

AC Distribution

• AC Circuit Breaker is optional

Power Probe and Series Combiner

RF Power Blocks

- Highly efficient and hot pluggable dual power modules containing PAs, modulators, SMPS
- Frequency agile harmonic filter
- Cost effective field upgrades to higher power level

DC Distribution

• +48 V dc or +144 V dc Input is optional with reverse polarity protection and low voltage disconnect
• +48 V dc Battery charger can be installed internally

Making Digital Radio **Work.**

Vector Graphical User Interface and Display

Analog Meter

User configurable display of any one of the following parameters: Forward Power, Reflected Power, Antenna Current, DC Voltages, DC Current, VSWR, AC Voltage, Transmitter, Temperature and PA Volts

System Diagram

Provides user with local display of the status of the critical blocks within the transmitter

Diagnostic Display

Allows complete local transmitter and ATU control, status and local/remote health monitoring and provides a 256 event log

Vector 125W/250W Transmitter Overview

Exciter/Monitor

- Available with Single or Dual Exciter and Critical Monitor circuitry
- Analog and digital metering
- Enhanced Remote Control/Monitor
- Simple LCD graphical user interface

RF Power System

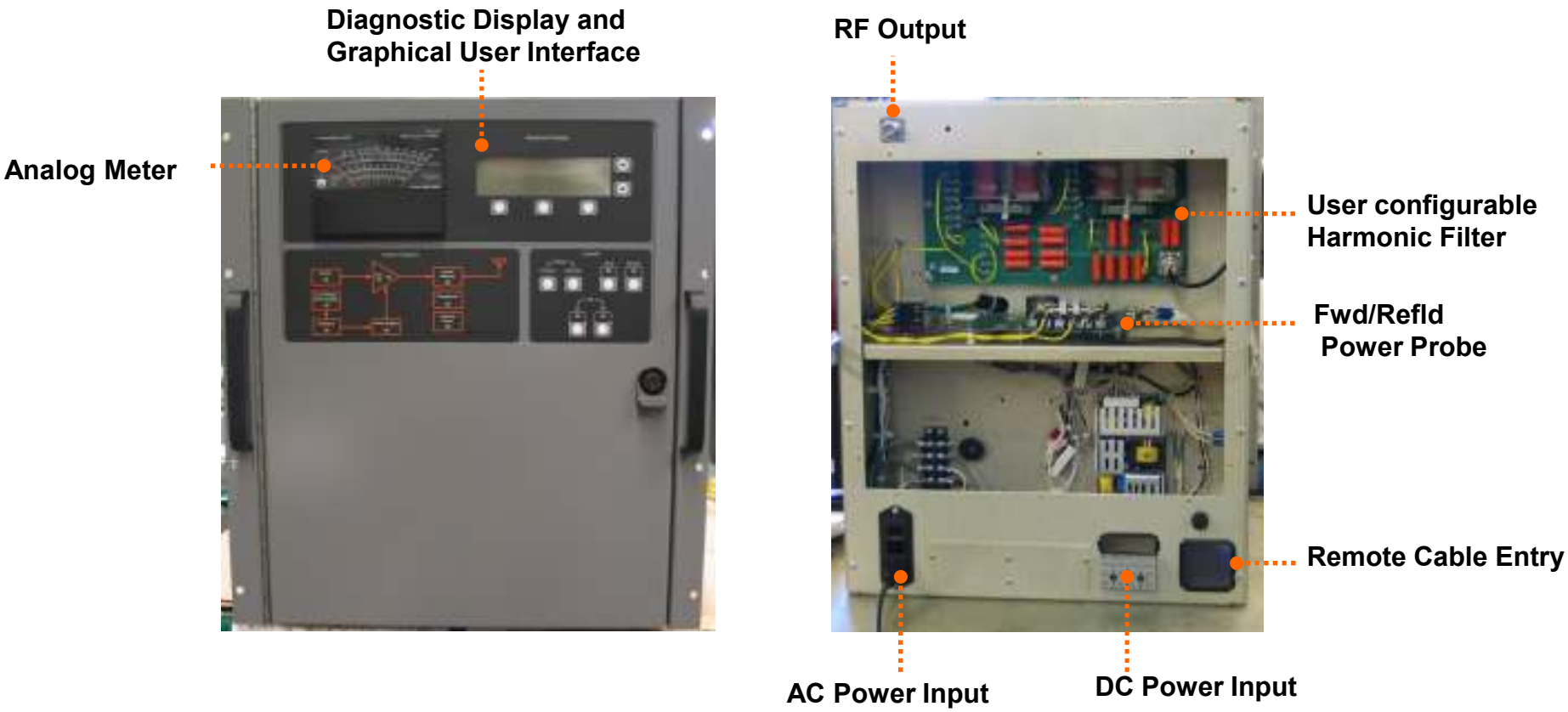
- Available with Dual or Single Highly efficient power modules containing PAs, modulators, SMPS
- Frequency agile harmonic filter

Back-up DC Supply Option

• +24 V dc or + 48 V dc Input is optional with reverse polarity protection and low voltage disconnect
• External +24 V dc or + 48 V dc Battery charger available

Making Digital Radio **Work.**

Vector 125W/250W Front and Rear Views



Vector 125W/250W RF Power Module

Highly Efficient
Pulse Duration Modulator (PDM)

PDM Filter

Highly Efficient
Class D Power Amplifier

Impedance
Matching RF
Transformer

Switch Mode Power Supply

- 90 V ac to 270 V ac
  (Vector 125/Vector D200)
- 170 V ac to 270 V ac
  (Vector 250/Vector D375)
- 47 Hz to 63 Hz
- No adjustments necessary

Vector 125W/250W Exciter Overview

Direct Digital Synthesizer

Not installed when configured as Low Power Vector DGPS transmitter

Exciter Interface

Contains circuitry to switch exciters when dual and provides interface between exciter pwbs and the other blocks contained in the transmitter

Exciter/Monitor/Generator

Monitors critical RF output parameters

Modulator Driver Pwb

Creates the low level drive signal for the Pulse Duration Modulator which includes line voltage compensation

+24 VDC Supply Output for ATU

Vector 125W/250W Control/Monitor Overview

Liquid Crystal Display

Control/Display Pwb

Performs most of the operations associated with control, monitor, protection and display for the transmitter. It is essentially the “brain” for the Vector.

Site Control/Monitor

Contains 16 optically isolated monitor inputs and 16 control points. The Site Control/Monitor allows the Vector local control or remote control/monitor to control and monitor other site equipment

Sonalert

Provides user capability to configure alarms to be audible

Remote Interface

Contains user interface connections for ATU Control/Monitor and Remote Control/Monitor

NDB Antenna Tuning Units

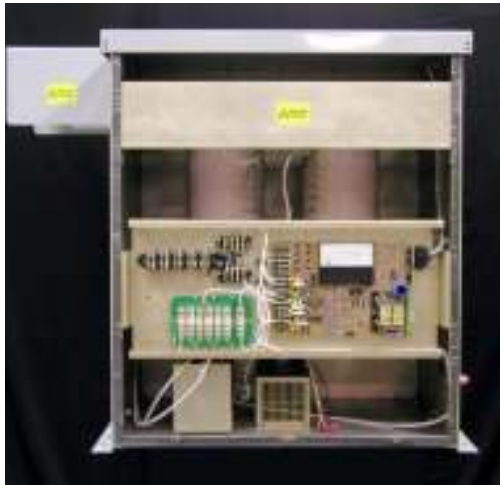
ATU500SR

125 W NDB

ATU-LP

125 W & 250 W NDB
250 W & 375 W DGPS

ATU-HP



500 W, 1000 W & 2000 W NDB
750 W – 3000 W DGPS

Making Digital Radio **Work.**

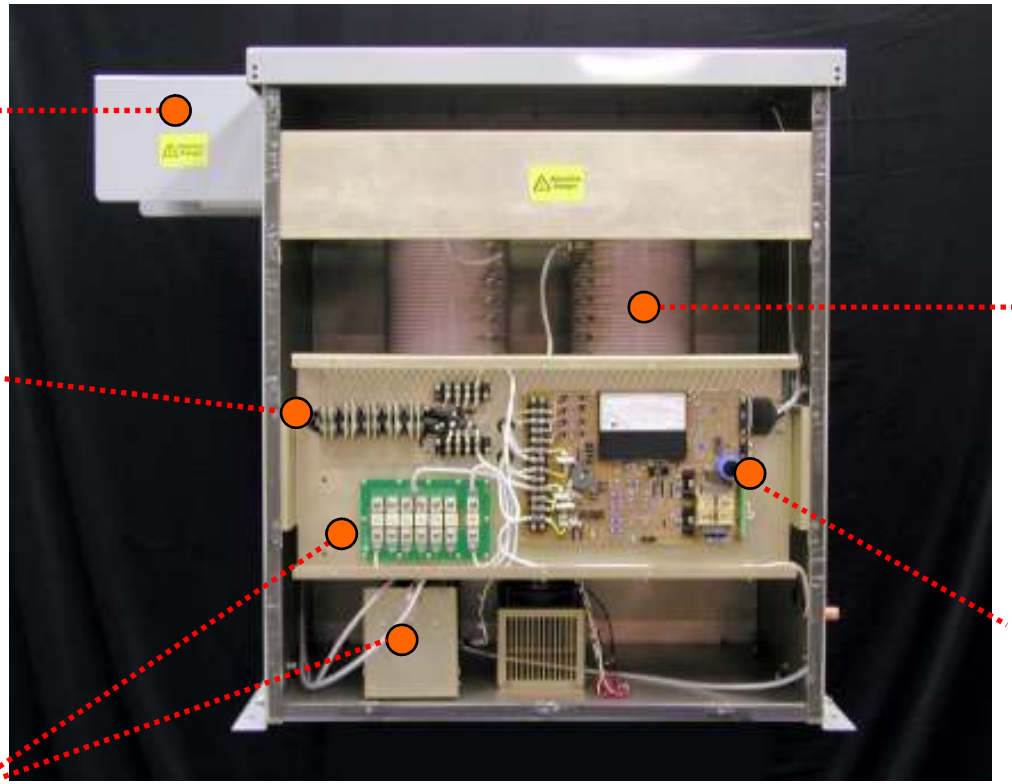
NDB Antenna Tuning Units

ATU-LP

- **<u>Automatic</u> Resistive Matching (ATU-LP & ATU-HP)**
- **The serial data link between the ATU and the Vector transmitter stabilizes the antenna current, and the radiated power, by automatically adjusting the transmitter output power**
- **Remote control and monitor of the ATU limits worker exposure to strong RF fields**
- **An external resistor bank for the ATU adds additional resistance in series with the antenna, optimizing the trade-off between antenna bandwidth and efficiency**

ATU-HP

Vector ATU-HP Overview



High Voltage Output Insulator

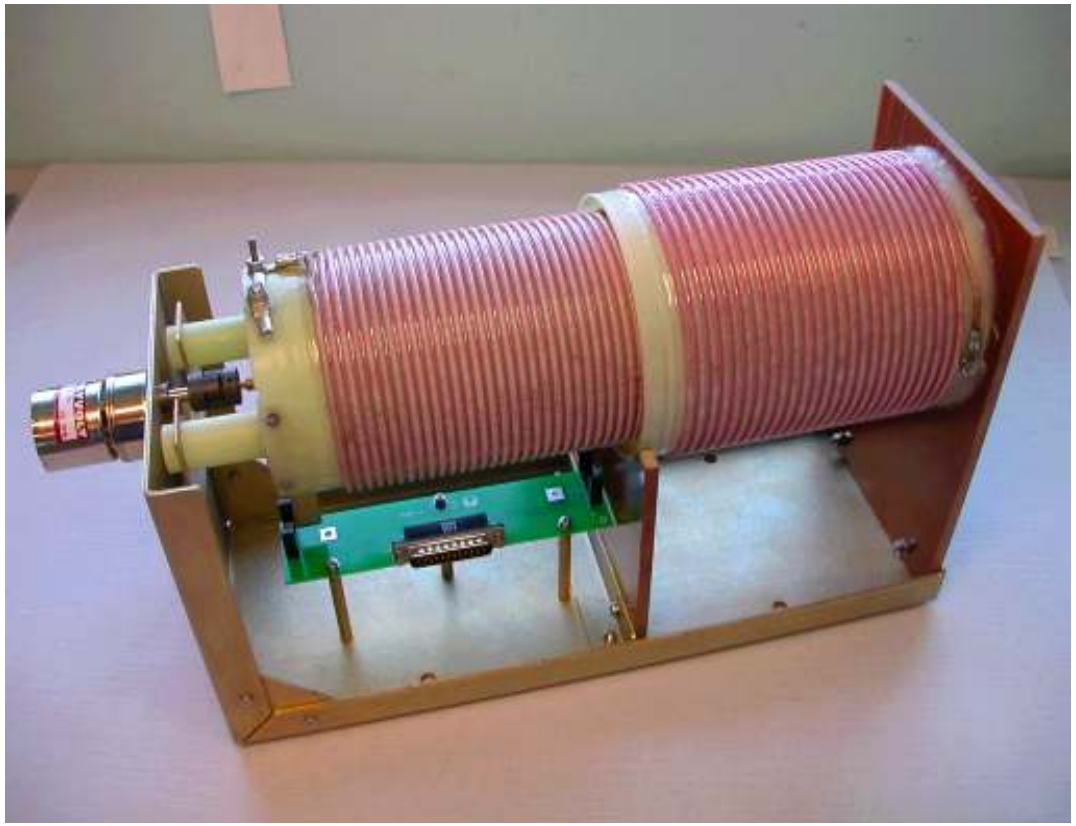
Fixed Resistive Matching Transformer

Automatic Servo Controlled Resistive Matcher

Automatic Servo Controlled and Low Loss (Q1000) Astatic Inductors for Reactive Tuning

ATU Control/Monitor Pwb contains status leds to ensure correct tuning and matching is achieved

Automatic Resistive Matcher

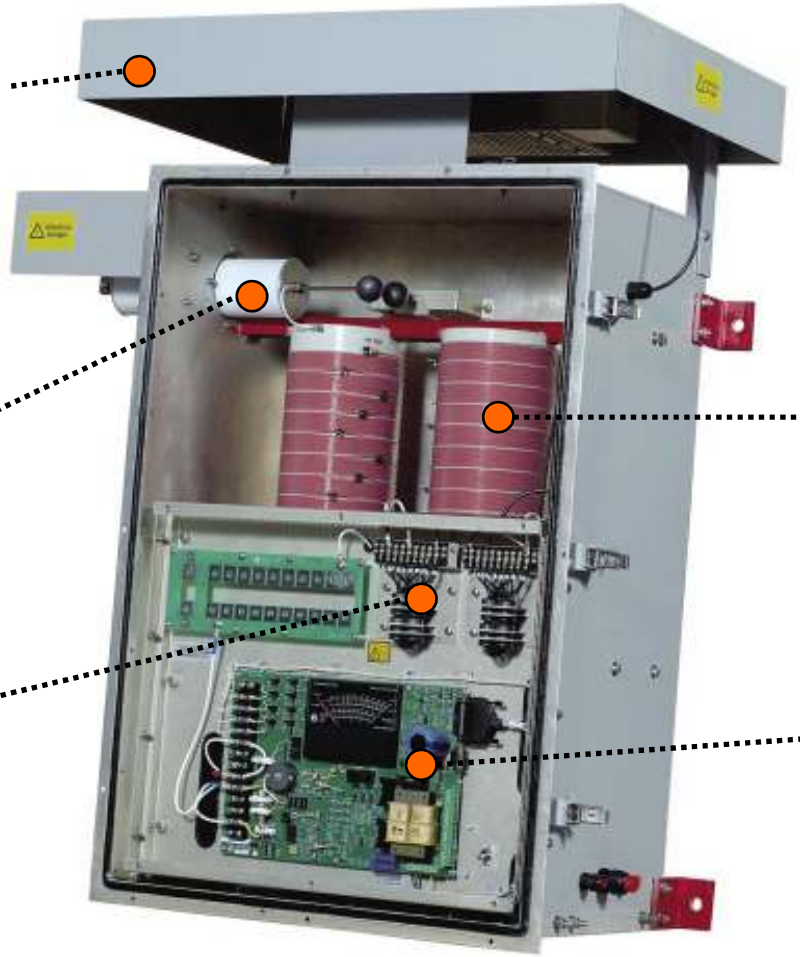


Servo Controlled

Mutually Coupled Inductors

±2:1 change in resistive load (or 4:1) overall

Vector ATU-LP Overview



Optional Sunshield or Optional External Series Resistor

High Voltage Output Insulator and Adjustable Graphite Spark Balls

Fixed Resistive Matching Transformer

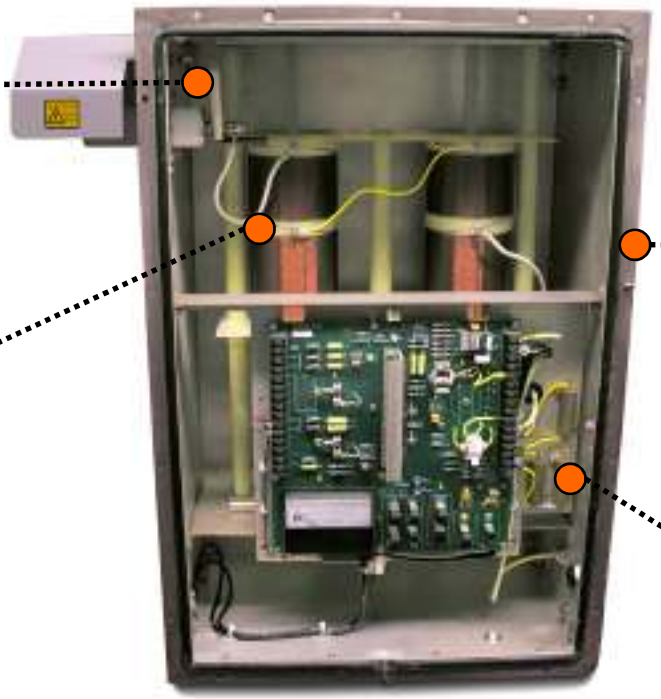
Automatic Servo Controlled, Astatic & Low Loss Inductors (Q of 600) for Reactive Tuning

ATU Control/Monitor Pwb contains status LEDs to ensure correct tuning and matching is achieved

ATU500SR 125W Antenna Tuning Unit

ATU500

Adjustable Spark Gap with intrinsic static drain



125 W Antenna Tuning Unit

Servo Controlled and Automatic Fine Tuned Astatic pair of Loading coils which can be connected series or parallel for maximum agility

IP66 Compliant Cabinet manufactured from Marine Grade Aluminum with protective finish suitable for global environments

Bandwidth Optimization to minimize VSWR, sideband attenuation and distortion as compromise between bandwidth and range

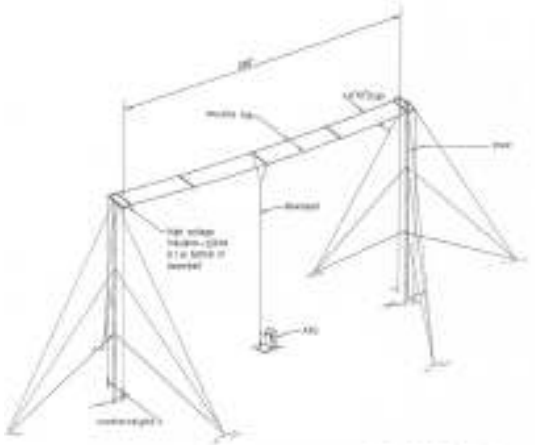
NDB Antennas

Whips
(Vendor Item)

CL-40
(Nautel Manufactured)

Base Insulated Monopoles
(Vendor Item)

T-20/T-35/T-50
(Nautel Manufactured)



Antenna Performance Notes

- The minimum bandwidth required for 400 Hz modulation should be in excess of 800 Hz and for 1020 Hz modulation should be in excess of 2040 Hz.

- Modulating tone which exceeds the bandwidth will result in significant sideband attenuation, inability to achieve 95% modulation and VSWR at the transmitter.

- The addition of series resistance (available as standard in the ATU500 and optionally in the ATU-LP) can be used as a trade off between bandwidth and range if necessary

- The ATU500/ATU-LP will not tune most whip antennas below 250 kHz due to the low capacitance of the antenna.

Extended & Remote Control/Monitoring

VRLINK with ECMP2

Remote Control/Monitor with Extended Control/Monitor Panel

ECMP3

Extended Control/Monitor Panel

NRB4

Beacon Monitor Receiver

NLA/2

Receiving Loop Antenna

Making Digital Radio **Work.**

ECMP3 – Extended Control/Monitor

- Extended control and monitor functions within a maximum distance of 152 m (500 ft) from the Vector NDB.
- 7 visual system indicators (LEDs) and indicator Test switch. LED brightness is adjustable to one of three levels.
- 3 switches for remote command and 1 user configurable spare command switch.
- User configured and enabled timer and audible alarm.
- User configurable to remotely control/monitor any of the Vector System's remote control/monitor points.
- Site control/monitor pwb for Vector NDB required.

ECMP3 – Extended Control/Monitor

SONALERT

The ECMP3 contains a Sonalert, which can be configured to provide an audible indication that a monitor point is asserted.

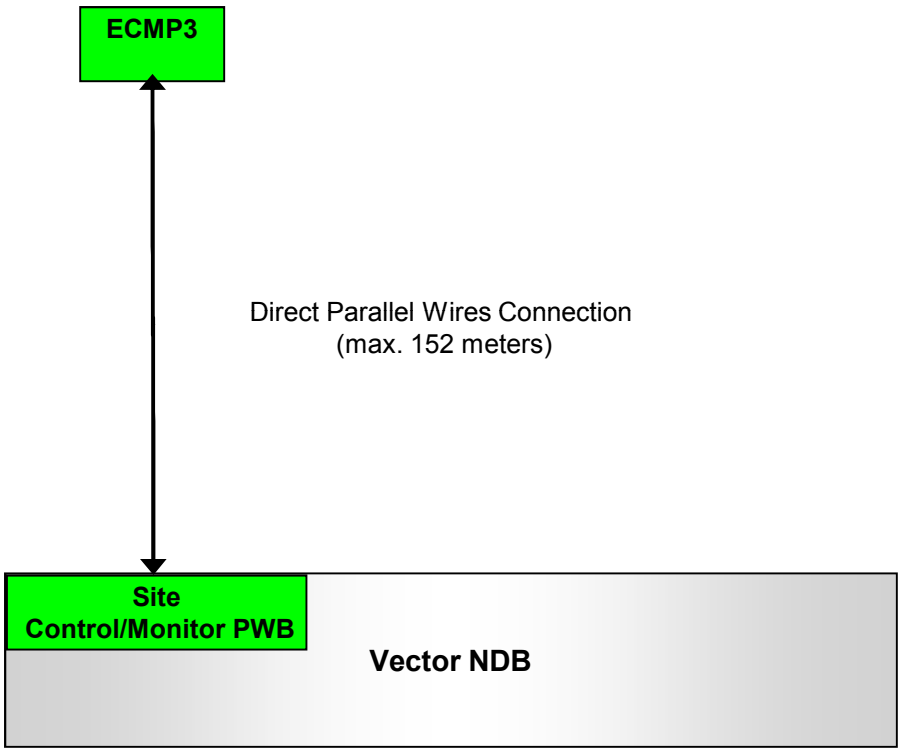
Each monitor point can be configured to independently activate the Sonalert.

Sonalert volume is adjustable to one of three levels.

The Sonalert may be configured to sound when a monitor point activates or when a monitor point activates or de-activates (alarm occurs or alarm disappears).

The Acknowledge momentary push button switch is used for silencing an audible alarm event.

Vector NDB & ECMP3 Interconnect

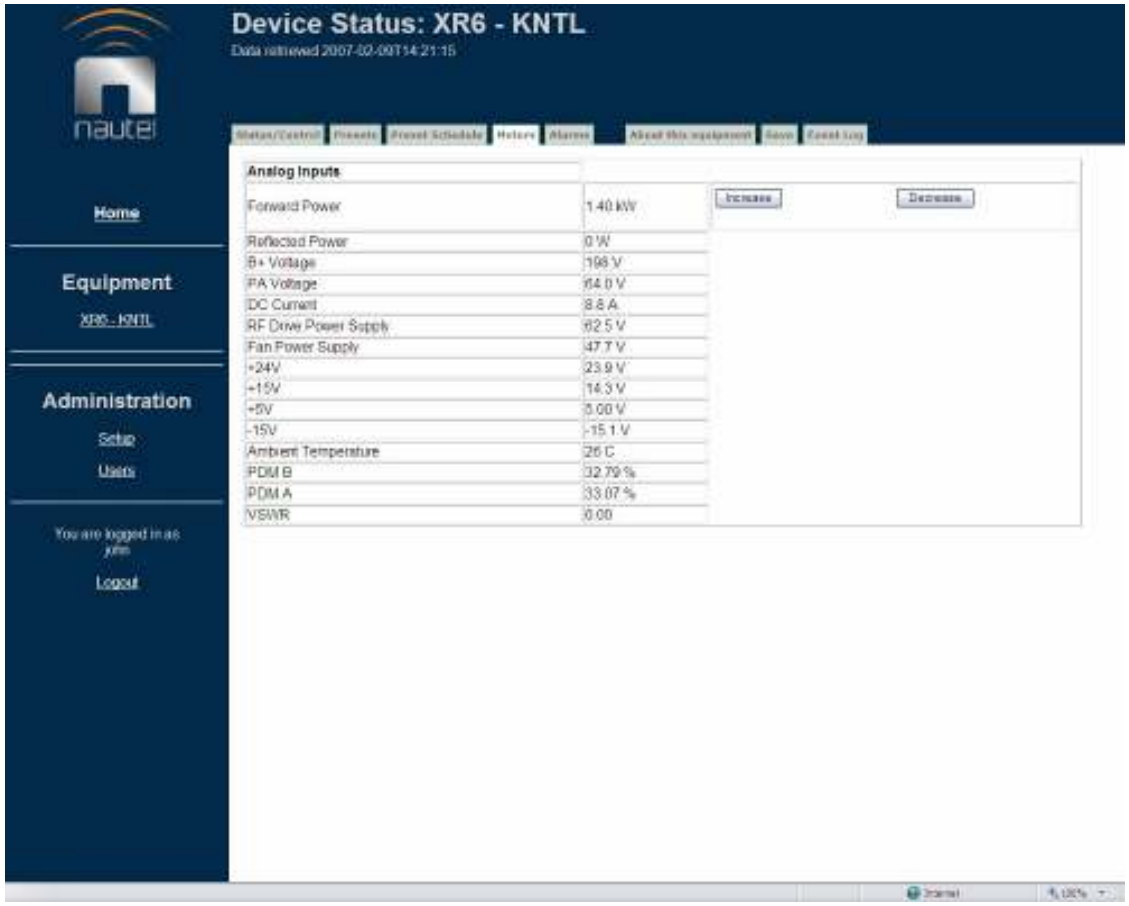


Vector NDB RCMS via VR-Link2

- Economical means of remote control/monitor of one Vector NDB system.
- Standard VR-Link2 connections to the NDB include RS-232, RS-422. Optional leased line/dial-up modems and Wired/Wireless Serial Server connections for network applications are also available.
- Complete control/monitor of the NDB and ATU using a text based display via hosted web page.
- ECMP3 (Extended Control/Monitor Panel) can be integrated into VR-Link2 or a total of 3 ECMP3's can be connected externally to the VR-Link2 via RS-485 serial communication.

VR-Link2 - Web Based RCMS

- Web based remote monitoring and control of Nautel Vector NDB system
- Remote access to alarm/information logs
- Email reporting of critical alarms, upon request
- Data server for integration with existing remote control equipment



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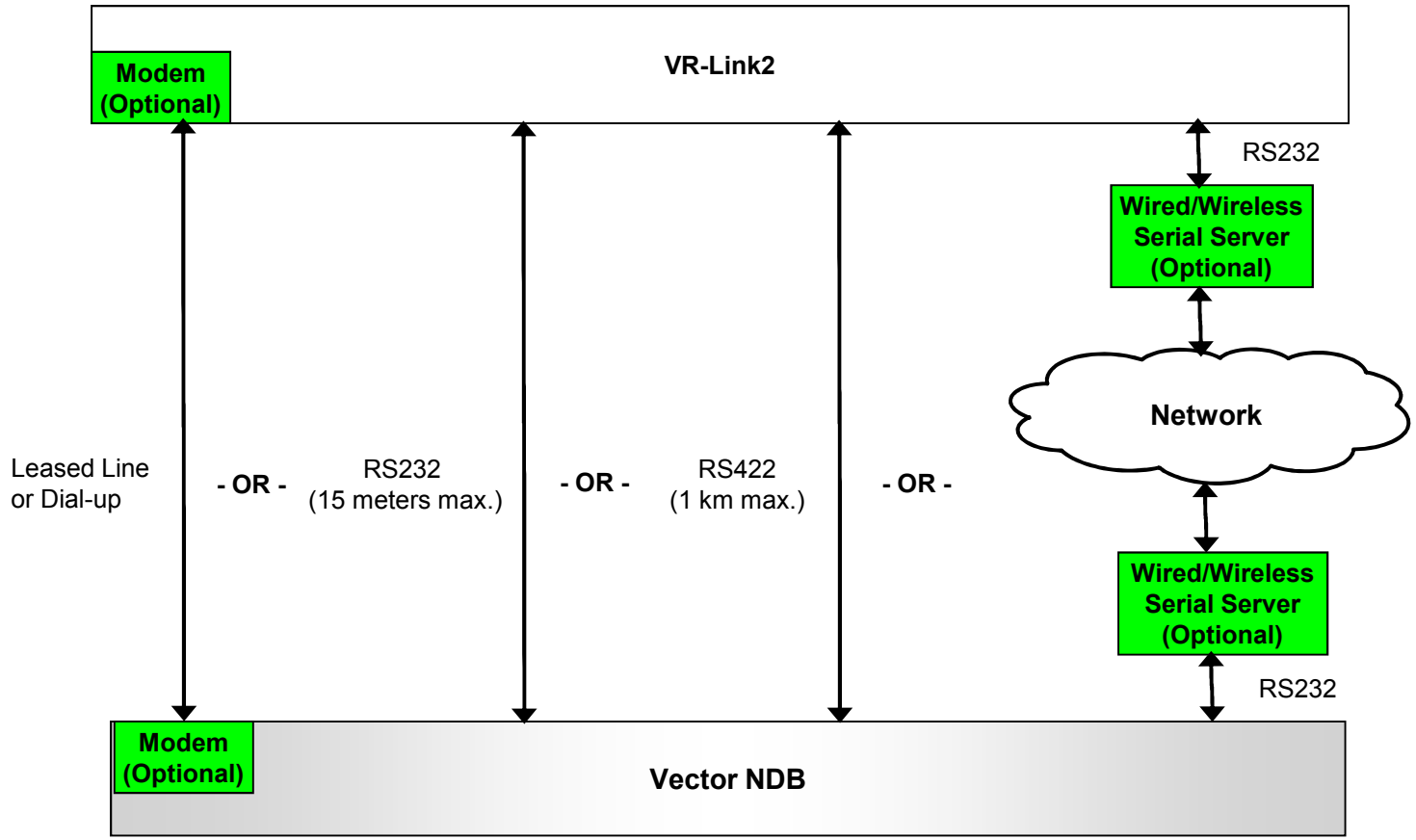
Vector NDB & VR-Link2 Interconnect



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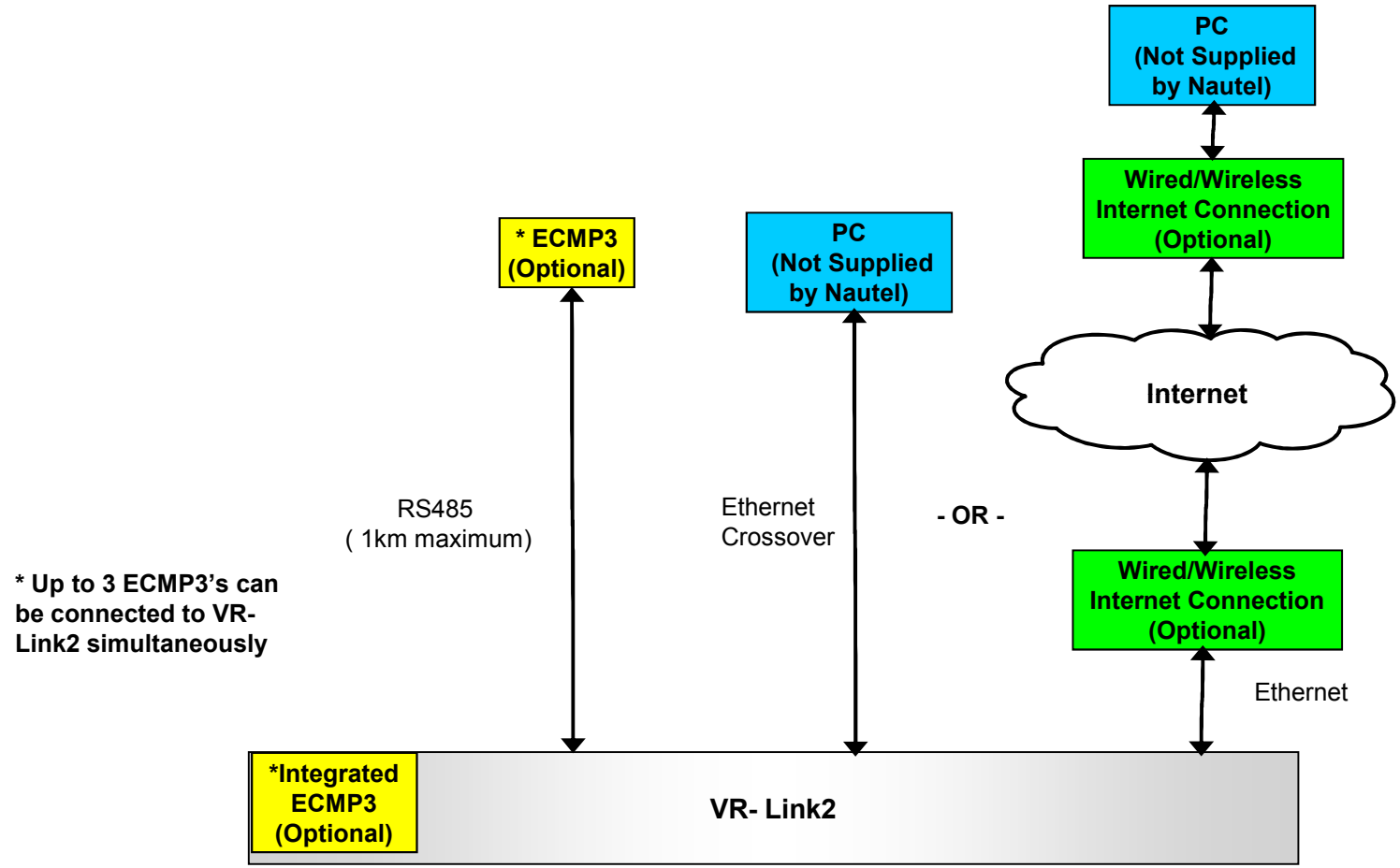
Vector NDB RCMS via VR-Link2



*** Up to 3 ECMP3's can be connected to VR-Link2 simultaneously**

NDB Site Remote Control/Monitoring

Vector Site Control/Monitor Pwb (optional)

- Provides site control and status monitoring capability at the Vector NDB site and via the Remote Control/Monitor system, if connected to the NDB
- 16 optically isolated inputs
- 16 form C relay contact outputs
- can be used to control and monitor the status of ancillary equipment located at the NDB site (air conditioning units, exhaust fans, building temperature alarms, smoke alarms, intrusion alarms, etc.)

SPU1 Surge Protection Unit

SPU1 Surge Protection Unit

The SPU1 surge protection unit prevents lightning induced voltage/current transients from flowing through the transmitter. Isolation of the transmitter and the desired lightning protection is accomplished by:

- Inserting a 1:1 isolation transformer in the RF feed cable. This ensures there is no dc connection between the transmitter's RF output and the antenna system.

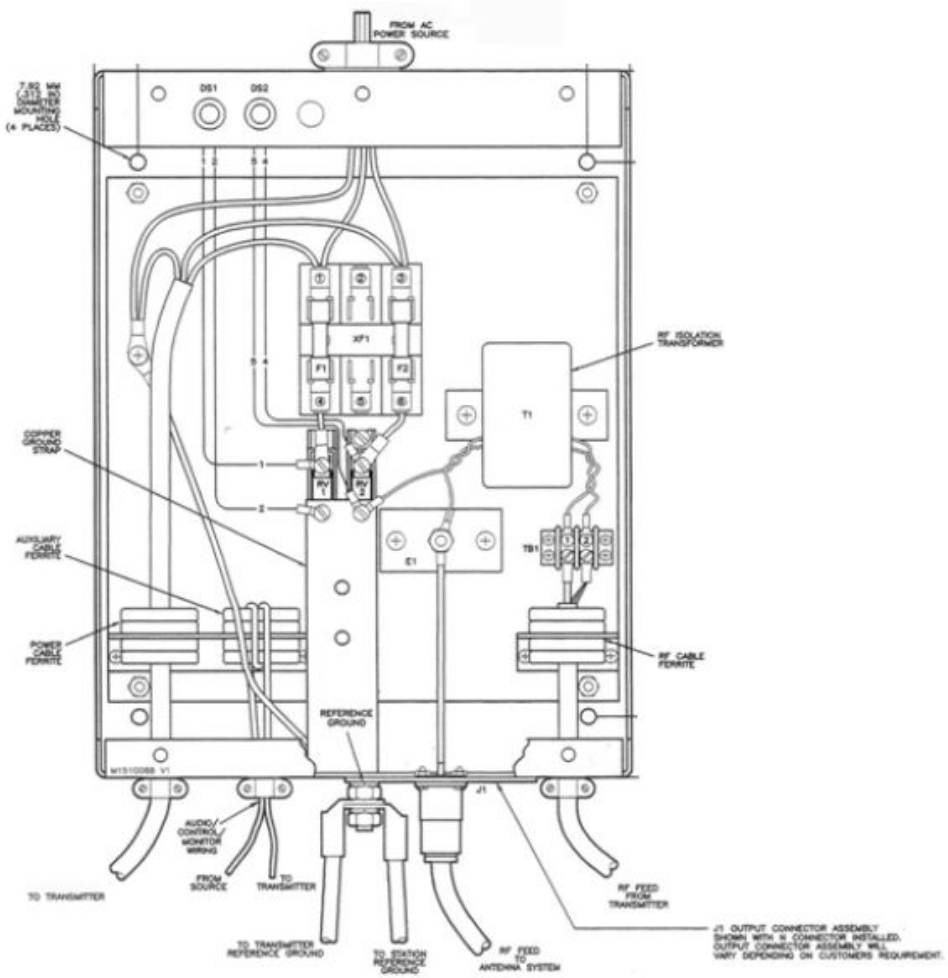
- Connecting suitably rated varistors between the ac line and the station reference ground.

SPU1 Surge Protection Unit

- Passing all wires and their shields, through ferrite toroids. The ferrite
forms an inductance which is transparent to normal signals/voltages
but presents an impedance to lightning induced transients.

- Connecting the shield of the coaxial cable from the antenna directly to the reference ground.

SPU1 Surge Protection Unit



Making Digital Radio **Work.**

NRB4 & NLA/2 “OFF AIR” Monitor

NRB4

Beacon Monitor Receiver

NLA/2

Receiving Loop Antenna

Making Digital Radio **Work.**

NRB4 & NLA/2 “OFF AIR” Monitor

NRB4 Beacon Monitor Receiver

Monitors:

- **Presence of Carrier**
- **Presence of Keyed Tone**

Provides visible alarm if either carrier or modulation fall below thresholds.

NRB4 & NLA/2 “OFF AIR” Monitor

NRB4 Beacon Monitor Receiver

Provides:

- **Transformer coupled audio output sample**
- **Contact closures for external carrier or mod fail alarms – these can be used to activate user supplied audible alarm if required**

NRB4 & NLA/2 Features

Precise and Frequency Agile

- Direct Digital Synthesizer
- No additional parts required for change of frequency
- Excellent selectivity defined by stable IF crystal filter

Off-Air Monitoring of FAA and ICAO requirements

- Adjustable thresholds and Time delays for reduction in carrier power , reduction in modulation depth and loss of keying
- Local and Remote Audio Monitoring
- Calibrated Carrier Level Meter

Vector System Customers

- Airservices Australia – **101** Vector 500 & ATU-LP
- DHMI Turkey – **23** Vector 125 & ATU-LP
- Nav Canada – **6** Vector 500 & ATU-HP; **2** Vector 250 & ATU-LP
- Egyptian Air Force – **8** Vector 500 & ATU-HP
- INFRAERO Brazil – **7** Vector 250 & ATU-LP; **4** Vector 1000 & ATU-HP
- Private Airports South Africa – **6** Vector 125 & ATU500SR
- USCG – **84** ATU-HP
- Offshore – **160+** Vector 125 & ATU500SR on variety of vessels including Oil Platforms and FPSOs

Vector System Customers




Making Digital Radio **Work.**

Customer Service & Training

- Emergency technical support is available 24 hours a day, 7 days a week and is provided by Nautel Customer Service technical staff
- Both facilities house a full inventory of parts, modules, and sub-assemblies to support customer's maintenance needs
- Parts depots also exist in Memphis, TN, USA and in the UK to assist in serving Global customers
- Nautel's first priority is getting customers back on the air, even if the model in question was shipped in 1970
- Installation Supervision and Commissioning Services are available
- RF Basics, System Specific Training and Certified Installer/Maintainer programs, comprised of classroom as well as hands-on practical instruction, are available from Nautel

Nautel User's Group

Membership includes:

- Online access to Nautel's restricted NUG website
  - Technical FAQs
  - Technical manuals
  - Information sheets
  - Field upgrade documents
- Special NUG discounts on select Nautel training programs

Contacts - NDB Products

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Thank You

Making Digital Radio **Work.**