Ultra High Spectral Efficiency, Very Low Latency
UHF Radio for Mission-Critical Applications

NETWORK DIGITAL LINK (NDL)
DATA SHEET
RADIO SPECTRUM IS FINITE AND THEREFORE SHOULD BE PRESERVED THROUGH HIGH-PERFORMING, ULTRA SPECTRALLY EFFICIENT LINKING SOLUTIONS. PUBLIC SAFETY, TRANSPORT, UTILITIES AND GOVERNMENT ORGANIZATIONS ALL REQUIRE EFFICIENT AND LOW LATENCY BACKHAUL COMMUNICATION LINKS IN ORDER TO CONNECT NETWORK LOCATIONS AND TO HAVE FASTER ACCESS, INCREASED RELIABILITY AND SPECTRAL EFFICIENCY.

With this in mind, the MiMOMax team has designed a seriously smart, point-to-point, ultra spectrally efficient, very low latency digital radio for deployment in critical network infrastructure. **Network Digital Link (NDL)** by MiMOMax aims to provide intelligent wireless linking solutions for SCADA and backhaul applications.
The MiMOMax NDL is a long range point-to-point wireless linking solution for backhaul and SCADA applications. Utilizing the Multiple Input Multiple Output (MiMO) technology and operating in full-duplex mode, the NDL maximizes system throughput by enabling raw data rates of up to 320 kb/s in 25 kHz channel and up to 160 kb/s raw data rate in 12.5 kHz channel.

The NDL is designed to provide high reliability, fixed linking solutions to a number of mission critical industries. Apart from servicing SCADA applications primarily, the NDL can also be used for linking conventional and trunked and digital and radio sites. Multiple links can be cascaded to cope with difficult terrain and very long paths. Mounting options (including wall, pole and rack) provide much-needed flexibility for varied network requirements.

Utilising licensed spectrum ensures that the link operates in an interference-free environment and is capable (under the right conditions) of providing a reliable low-error data transport service (<10^-7 bit error rate). Very high system gains and good receive sensitivity makes it possible to achieve industry-leading long range in excess of 100kms from high radio sites at full throughput.

A number of internal interfaces are available to support various SCADA applications and also multichannel, conventional, analogue, simulcast, MPT, P25 or TETRA digital networks in trunked and simulcast configurations. For PMR applications, a separate high quality Network Interface Box (NIB) with up to 6 x 32 k ADPCM audio channels plus a 9k6 RS232 signalling channel, supports analogue networks.

Optional MiMOMax proprietary protocols including software feature enablers support network robustness, integrity, security and faster transmission while overcoming adverse environmental challenges. These protocols include MiMOMax Data Acceleration Protocol (M-DAP), MiMOMax Routing Adaptation Protocol (M-RAP), MiMOMax Cognizant Adaptive Modulation (M-CAM) & MiMOMax Power on Demad (M-PoD).

Furthermore, sophisticated network management, monitoring and over-the-air configuration options enable remote monitoring, diagnostics, configuration and software upgrades. The MiMOMax NDL also supports the generic system management standard, Simple Network Management Protocol (SNMP) & DNP3. A comprehensive suite of security options further ensures that mission critical operations remain highly secure.

Being fully compatible with the rest of the MiMOMax products, NDL can be incorporated into MiMOMax point-to-multipoint Multiple Digital Link (MDL)⁴.

---

1. For more information regarding MDL, please visit the “products” section of our website: www.mimomax.com.
2. For more information regarding 4 Wire Audio Interface Box, please visit “products” section of our website: www.mimomax.com.

---

**SYSTEM OVERVIEW**

![Four Wire Audio Interface connected to MiMOMax NDL](image)

---

MiMOMax Four Wire Audio | MiMOMax Link-End Radio Unit
**Product Performance**

**Ultra High Spectral Efficiency**
MiMOMax NDL is capable of achieving up to 16b/s/Hz in both 25 kHz and 12.5 kHz channels.

**Very High Data Throughputs**
The NDL utilizes MiMO technology to achieve industry leading spectral efficiency of up to 320 kb/s raw data rate in a 25 kHz channel & up to 160 kb/s in a 12.5 kHz channel. Additionally, optional proprietary Data Acceleration Protocol can boost the effective data rate even higher.

**Very Low Latency**
In X-21 mode, 16 QAM, the MiMOMax NDL offers very low latency of 5.05 ms in 25 kHz and 9.8 ms in 12.5 kHz channels respectively and even lower latency when using higher available modulations.

**Very Low Jitter**
The nominal inter-symbol jitter rate for MiMOMax NDL is typically <50ns in X-21 mode.

**Adaptive Modulation**
The MiMOMax NDL supports an optional, intelligent adaptive modulation protocol (M-CAM), which enables the system to always optimise the modulation modes for maximum data throughput even in fading environments. Supported modulations include QPSK/16/64/256 QAM.

**Low Error Rate**
The MiMOMax NDL has a very low bit error rate of less than $10^{-7}$ (signal level dependant on modulation rate).

**High Levels of Security**
The MiMOMax NDL supports a range of advanced, industry compliant, security features that prevent both deliberate and inadvertent attacks on the network.

**RF Performance**
High system gain enables the MiMOMax NDL to transmit data over paths spanning up to 100 kilometers in length from high sites with some non-line-of-sight and near-line-of-sight capability over shorter distances.

**Built-in Micro-Duplexers**
The NDL transmits an average power of 1W average per transmitter (for 2x2 MIMO). The receive sensitivities and transmit powers are measured at the output of the duplexers.

**Power Consumption**
The typical active power consumption for the MiMOMax NDL is 72 W with a standby power consumption of <10 W when using optional Power on Demand (PoD). Optional low power radios are also available which reduce power consumption to <55 W @ +26 dBm & <40 W @ +23 dBm.

---

1 For complete details on security features, please view both “Product Features” and “Product Options” sections.

---

**MiMOMax Linking in a 5 + 1 Channel P25 Trunking System**

The diagram illustrates the system setup where 6 portables are trunked together using MiMOMax NDL technology to communicate between Remote Site and Local Site. The Site Controller coordinates the communication process, while FTP Server, WireShark Monitoring Station, and RFFS Server are integrated into the system for data management and monitoring.

This is provided by the IP transport service (via Ethernet) under appropriate link conditions.
MIMO
In true MIMO format, each MiMOMax radio unit has 2 internal transmitters and 2 internal receivers. This enables a single radio link to produce high performance, pattern-diverse MIMO signals and to increase both signal quality and path resilience.

Data Throughput
The MiMOMax NDL utilises true 2×2 MIMO technology which is capable of operating in QPSK/16/64/256QAM to achieve industry-leading full-duplex data throughputs of 80/160/240/320 kb/s (raw data rates) in a 25 kHz channel bandwidth (40/80/120/160 kb/s in a 12.5 kHz channel).

Operating Frequencies
The MiMOMax NDL operates in a range of licensed UHF frequency bands including 369-390MHz, 420-470MHz and 806-960MHz and operates in both 12.5 kHz and 25 kHz narrowband channels¹. Please refer to the “Product Specifications” section for details on specific frequency band splits.

Interfaces
The MiMOMax NDL is a fully integrated solution that transmits both packet-based IP and serial data (RS232, V24, RS422, V11, V35 and X21 between 32 & 128kb/s) via internal Ethernet.

► Ethernet Interface
Ethernet connectivity is provided via RJ45 socket, configurable to provide connectivity to other IP enabled networked devices. The network connectivity provided by the NDL is at layer II (IP). Layer III is also available as an option. Bandwidth not used by the synchronous serial interface will be available for IP traffic.

Built-in Multiplexer
The NDL has a built-in multiplexer, supporting a mix of traffic from synchronous & asynchronous serial and Ethernet interfaces. The synchronous serial connection takes service priority with any remaining link bandwidth being used for IP data transport via the Ethernet port. Additionally, optional M-DAP and QoS can be utilized for efficient Ethernet traffic management.

MiMOMax Configuration, Control & Monitoring Software (CCMS)
The MiMOMax NDL supports connection of an HTTP type web browser which allows customers to have access to a field level of configuration, control, monitoring and alarm functions².

1 For information on alternative operational channel bandwidths, please contact MiMOMax Wireless directly.

2 MiMOMax offers a pre-ship configuration service, which will configure a radio unit to a user’s documented requirements, prior to shipping, to expedite implementation.

The CCMS has two access options including:

► Local CCMS
This allows local access to the CCMS web application via the Ethernet port of the local radio modem link. It enables restricted control of the local radio modem.

► Remote CCMS (Over-the-Air Configuration--OTAC & Over-the-Air Programming--OTAP)
Optional remote CCMS enables the CCMS web application to be accessible via local Ethernet port and over-the-air link. This allows remote configuration (OTAC) and programming (OTAP) of the remote radio unit (RRU) and often replaces the need for the user to travel to radio sites, saving both time and cost.

Standard Security³
The MiMOMax NDL system has the capability of protecting the wider SCADA network from either deliberate or accidental breach or denial of service. The following security features are included in the NDL radio unit:

• Licensed Spectrum: ensures that the spectrum licensee is the only authorised user for that channel.
• Proprietary MIMO Protocol: avoids any over-the-air interception or manipulation of data, as only MiMOMax radios can reassemble the coded MIMO data.
• Software Image Protection: prevents determined interceptors from making unauthorised software changes or mimicking MiMOMax radio software.
• Directed Traffic Control: only MiMOMax radios registered on the system will be recognised by the system. Radios must be either paired or part of a system to participate in that system. Prevents “Man in the Middle” intercepts.
• Transparent Payload Encryption: transparent to Encrypted packets for all data types. Supports “end to end” encryption schemes.
• Management Interface Protection: SSL/TLS & AES 256 provide “end to end” management system interface protection for both directly connected and over-the-air CCMS.
• Audit Logging: CCMS user passwords are logged so that past history of system CCMS users can be interrogated.

Digital Cartesian Loop
The MiMOMax NDL has a Digital Cartesian Loop that provides very high linearity and low distortion and enables high order modulation. Hence, it helps to achieve very high data throughputs and dramatically reduces the need for regular and ongoing calibration and adjustment.

User Programmable Frequencies
The MiMOMax NDL Tx frequencies can be electronically tuned by the user provided they are within the duplexer tuning range. The programmable frequency step size is 5 kHz or 6.25 kHz. Duplexers will need to be manually tuned if the desired frequency is outside the duplexer bandwidth.

3 For details on further optional protection and security features, please refer to the “Product Options” section.
User Programmable Power
The MiMOMax NDL has transmitter power output that is user configurable to suit specific path requirements. Users can choose either dBm or mW via the CCMS. The programmable power range is greater than 20 dB and includes 10 mW to 1 W power levels.

Internal Power Supplies
The MiMOMax NDL contains an internal switched mode power supply with an input range of 10.5 VDC to 32 VDC. An optional internal isolated (10-64 VDC) power supply is also available. This option eliminates the need for an external isolated power supply.

Form, Factor & Installation (Physical Structure)
All MiMOMax radio units can be pole, wall or rack mounted. Pole and wall mounts come with sunshades and the rack mount option comes with a fan that provides forced-air cooling. In a standard 19in rack, occupying only a 2U panel, rack mount radio units can be installed by technicians with normal industry competency. Additionally, MiMOMax pole or wall mount radio units are designed to meet IP67 waterproofing when deployed outdoors.

Compliances
The MiMOMax NDL conforms to a broad range of international compliances which are detailed in the “Product Specifications” section of this document.

PRODUCT OPTIONS

Additional Security Options
While the MiMOMax NDL has a comprehensive security suite, additional protection options are available to further enhance network robustness and reliability. These include:

► SNMP V3: Management interfaces are password protected and have optional SNMP V3 Authentication & Encryption.
► Firewall: Optional Stateful Packet Inspection provides high level of security to any element on the network by isolating network zones.

Software Feature Enablers (SFEs)
MiMOMax has developed a wide portfolio of SFEs to optimise network performance and meet unique customer requirements. The MiMOMax SFEs that are compatible with the MiMOMax NDL include:

► MiMOMax Cognizant Adaptive Modulation (M-CAM)
► MiMOMax Data Acceleration Protocol (M-DAP)
► MiMOMax Routing Adaptation Protocol (M-RAP)
► MiMOMax Enhanced Security Options (M-SEC)
► Over-the-Air Configuration (OTAC)
► Over-the-Air Programming (OTAP)
► SNMP Support
► Terminal Server Software
► Diversity Enabled (2x4 MiMO) (Future)
► Redundancy Enabled (Future)

PRODUCT ACCESSORIES

Antennas
MiMOMax has developed a range of unique, high performing MiMO antennas that can be connected directly to MiMOMax radio units. All MiMOMax antennas transmit and receive both vertically and horizontally polarized signals. They produce pattern diverse MiMO signals for links that span up to 100 kms (high site) with some near-line-of-sight and non-line-of-sight capability over shorter distances. The MiMOMax NDL is compatible with the complete range of MiMOMax antennas. These include:

► MiMOMax Dual Polarised Loop Yagi Antenna (Single, Dual & Quad Array Variants)
► MiMOMax Ruggardised Panel Antenna
► MiMOMax Collinear Omni Directional Antenna
► MiMOMax 13 dBi Wide Band Antenna

Radio Filters
To ensure high quality and interference-free data transmission, MiMOMax offers two radio filter options specifically for MiMOMax radio units. These include Band Pass Filter and Band Reject Filter. Various configuration options are available to suit specific application requirements.

1 For comprehensive information on the complete portfolio of MiMOMax SFEs, please refer to the MiMOMax SFE Specification Sheet, located on the MiMOMax website, www.mimomax.com/products/specs-at-a-glance
2 For comprehensive information and specifications on the complete MiMOMax antenna range, please refer to the MiMOMax Antenna Specification sheets, which are available on the MiMOMax website; www.mimomax.com/products/antenna-range
3 For further information on MiMOMax’s Radio Filter options, please refer the MiMOMax Radio Filter Specification Sheets, which are available on the MiMOMax website; www.mimomax.com/products/specs-at-a-glance
## NDL Product Specifications

### Internal Digital Interfaces (Data & Analogue)

**ETHERNET**
- **Format**: 10BaseT (400 MHz) / 10/100BaseT (900 MHz)
- **Connector**: RJ45
- **Supported Bit Rates**: Up to 280 kb/s

**FIBRE**
- **Format**: Fibre Ethernet (Future)
- **Connector**: ST

**ASYNCHRONOUS SERIAL**
- **Format**: Single & Dual(4) RS232
- **Connector**: RJ45
- **Baud Rate**: 300 - 115,200 baud

**SYNCHRONOUS SERIAL**
- **Format**: RS422, V.35, X.21, HSSI, V.11, OR G.703
- **Connector**: RJ45
- **Baud Rate**: 64,000 baud

### External Network Interfaces via Interface Hardware

**FOUR WIRE AUDIO**
- **Format**: 6 x 4 wire 600 Ω ports incl. E & M Signalling
- **Coding**: 32 kbps ADPCM(5)
- **Connector**: RJ45
- **Signalling**: Via RS232 serial port 9600 Baud Rate

### Sub-MUX
- **Format**: 2 x RS422, V.35, X.21, 4 x V.24 (RS232), 1 x C37.94

### RF General

- **RF Bands**: 400 MHz, 900 MHz
- **RF Frequency Range**: 369 to 470 MHz(1) / 806 to 960 MHz(1)
- **RF Frequency Band Splits**: 369-390 MHz, 420-430 MHz, 440-450 MHz, 450-470 MHz
- **Configuration**: 2 x 2 MIMO, 2 x 4 MIMO
- **Supply Voltage**: (Non-Isolated) / (Isolated) 10.5V DC to 32V DC / 64V DC
- **Nominal Channel Bandwidth**: 12.5 kHz & 25 kHz (50 kHz future)
- **Modulation Options**: QPSK/16/64/256 QAM (Software Configurable)
- **Gross Data Rates**: 25 kHz: 80/160/240/320 kb/s, 12.5 kHz: 40/80/120/160 kb/s
- **Maximum Power Consumption**: 92 W Max (at 13.8V), 72 W Typical
- **Standby Power Consumption**: 8 W Typical
- **Ambient Temp Range**: -25°C to +60°C
- **Symbol Rate**: 2 x 20k symbols / second
- **Mounting**: 2U high Rack Mount, Pole Mount Unit, Wall Mount Unit

### Transmitter

- **Modulation**: QPSK/16/64/256 QAM
- **RF Power Output**: 2 x +30 dBm (1 Watt) Average
- **RF Power Control Range**: >20 dB
- **Frequency Step Size**: 5 kHz & 6.25 kHz Adjustable
- **Frequency Accuracy and Stability**: ≤2 ppm at 400 MHz, ≤1.5 ppm at 900 MHz

### Receiver / Diversity Receiver

- **Modulation**: QPSK/16/64/256 QAM
- **Typical RF Sensitivity for 10-4 BER**:
  - 25 kHz: <-109/-103/-97/-92 dBm
  - 12.5 kHz: <-112/-106/-100/-93 dBm
- **Typical RF Sensitivity for 10-7 BER**:
  - 25 kHz: <-108/-101/-95/-89 dBm
  - 12.5 kHz: <-110/-104/-98/-91 dBm
- **Frequency Step Size**: 5 kHz & 6.25 kHz Adjustable
- **Frequency Accuracy and Stability**: ≤2 ppm at 400 MHz, ≤1.5 ppm at 900 MHz

### Duplexer (Internal)

- **RF Bands**: 400 MHz, 900 MHz
- **Bandwidth**: >500 kHz (Stop Band) / >4 MHz (Pass Band)
- **Tx / Rx Split**: 5 MHz minimum at 24-76 MHz
- **Stop Band Attenuation**: >70dB

### Compliances

- **RF Bands**: 400 MHz, 900 MHz
- **Radio Performance**:
  - ACMA: AS/NZS 4768 & AS/NZS 4295-2004
  - FCC: 47CFR part 90: V2.2.3 & IC Canada
- **EMC**: FCC 47CFR part 101: RSS-Gen
- **Safety**: EN 60950 (2006)

### Environmental

- **EN 300 019 Sections 3.3 & 4.2H
- **EN 300 019 Sections 3.3 & 4.2H
- **EN 300 019 Sections 3.3 & 4.2H
- **EN 300 019 Sections 3.3 & 4.2H

---

(1) Other frequencies available on request
(2) NDL configured with MIMO/Mx Power-on-Demand (M-PoD) software
(3) Total aggregate Data Rate is 70, 140, 210, 280 kb/s depending on configuration and path signal
(4) The Dual RS232 does not include hardware flow control
(5) Other CODECS also available on request
(6) Designed to be compliant with listed standards