NOMADIC COMMUNICATIONS

NMX920

OEM Integrators Guide

Version 1.02

December 1999

1. Record of Issue

Issue	Issued by	Date	Nature of Amendment(s)
1.0	BH	17.11.1999	Draft release
1.01	BH	26.11.1999	Added PCB layout dimensions for plug in modem option.
1.02	BH	09.12.1999	Update of Modem I/O for improved performance
1.03	BH	03.01.2000	Added SAR compliance results

2. Contents

3. Scope

The NMX920 Radio Packet Modem is a second generation product providing system integrators access to 900 MHz Mobitex Networks.

This OEM Integrators Guide documents the behaviour and control of the NMX920 to enable OEM designers to correctly and efficiently interface with the modem. This document is concerned with the physical, interface and regulatory issues related to the use of NMX920. It does not address the issues of good wireless application design, or code generation, though references to these issues can be found in section ……

3.1. Standards

The NMX920 operates in the 900 MHz SMR (Specialised Mobile Radio) Band in North America.

The NMX920 is designed to comply with established system and RF standards. The standard documents listed here are for reference only, and are subject to change or revision at any time.

Mobitex
Approval Standards: Mobitex Operators Association (MOA)
Documents: Mobitex Interface Specification, Revision R4A, October 1998
Approval Authority: BellSouth Wireless Data

USA
Approval Standards: Federal Communications Commission, FCC, USA
Documents: CFR47, Parts 2, 15, 90
Approval Authority: FCC

Canada
Approval Standards: Industry Canada, IC, Canada
Documents: RSS-119
Approval Authority: Industry Canada

3.2. Applicability

The content of this document is valid for the Nomadic Communications NMX920 Mobitex Radio Modem, with firmware versions greater than 2.01

4. Interface Notes

- Permanent damage can occur to the NMX920 if operated without a properly connected 50-ohm antenna and cable (eg. RG-174). Care should be taken to ensure that the antenna and cable are correctly matched to the NMX920.

- NMX920 must be properly subscribed with the approved MOBITEX Network Operator in the country of intended operation before use. Care should be taken not to operate an unregistered NMX920.

- When power is applied to the NMX920 power pins it will enter **POWER-OFF MODE** (see section 6 below) waiting to sense a “power on request” via the correct assertion of **DTR** pins (see section 6 below).

- When operated for the first time, via the correct assertion of the **DTR** pin (see section 6 below), the NMX920 may take several minutes as it attempts to become BORN on its’ registered MOBITEX Network. Once BORN, the NMX920 will enter its default mode, Battery Save or Express, as programmed at time of manufacture. The Mode may be changed by the relevant MASC command.

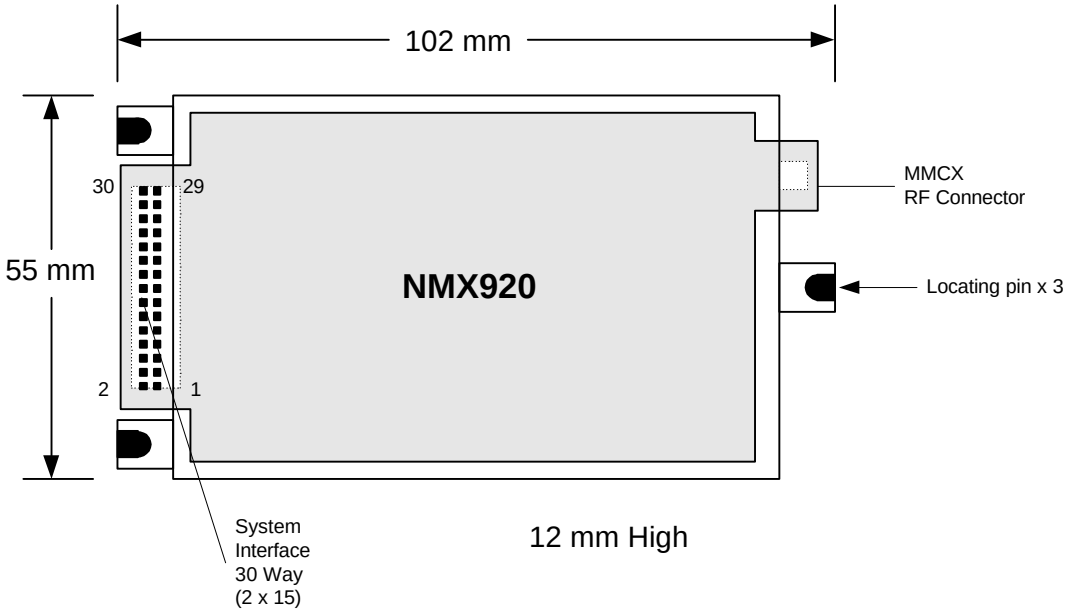
- NMX920 should always be operated as described in this document, special attention should be given to power handling detailed in section 6.

5. Physical Requirements

5.1. Dimensions

The overall dimensions of the NMX920 are provided below. It should be noted that the NMX920 can be ordered with a variety of termination options. It is the integrator's responsibility to specify these options as required and maintain sufficient space around the modem for cable access, if required.

The integrator is also required to maintain adequate ventilation about the NMX920. The amount of ventilation required will be dependent on the worst case transmit duty cycle that could be expected from the wireless application. Failure to provide adequate ventilation will not damage the NMX920, but if power amplifier temperature exceeds safe operating limits, the NMX920 will perform a controlled shutdown.



5.2. System Interface

The System Interface port on the NMX920 provides power, serial communication and status indicators between the OEM device and the modem. In addition to the user signals, there are a number of signals that are used for manufacturing purposes. Only the signals listed below may be used for system interconnection. All other signals should be 'no connects'.

The standard system interface connector is a 2 x 15 x 2 mm pitch connector. The NMX920 may be ordered with this connector mounted on the top for cable interface, or underneath for board to board connection. Refer to the Ordering Information.

The NMX920 is available with either a RS-232 serial interface, or a TTL (5V) serial interface. This is an order time option, and is not retrofitable in the field. Refer to the Ordering Information

Host Interface Connector

Pin#	Pin Name	Type/Direction[1]	Description
1-4	PWR	VBAT	Main power supply input
5-8	GND	GND	Ground (Reference ground for all host interface signals)
9	RXD	TTL/RS232 output	Main serial data receive (optional 5V TTL or RS-232 DCE compatible output)
10	TXD	TTL/RS232 input	Main serial data transmit (optional 5V TTL or RS-232 DCE compatible input)
11	DTR	TTL/RS232 input	System power-on control (optional 5V TTL or RS-232 DCE compatible active edge triggered input)
12	RFU	No Connect[2]	Reserved for Future Use
13	RFU	No Connect	Reserved for Future Use
14	RFU	No Connect	Reserved for Future Use
15	/RADIO_LED	Output	Radio-on indicator (active low 5V TTL output)
16	/RX_LED	Output	Receive packet indicator (active low 5V TTL output)
17	/MODE_LED	Output	Network mode indicator (active low 5V TTL output)
18	/TX_LED	Output	Transmit packet indicator (active low 5V TTL output)
19	/NET_LED	Output	Network contact indicator (active low 5V TTL output)
20	/PWR_LED	Output	Power-on indicator (active low 5V TTL output)
21	NC	No Connect	
22	NC	No Connect	
23	SYSON	+5V_IN	System power-on indicator (active high, high impendence digital output)
24	EXTBAT	-	(Optional) Standby power supply input (4.75-5.5VDC @ 100mA maximum)
25	NC	No Connect	
26	NC	No Connect	
27	NC	No Connect	
28	NC	No Connect	
29	NC	No Connect	
30	NC	No Connect	

[1] Direction with respect to the Modem
[2] All No Connects must be left Open Circuit

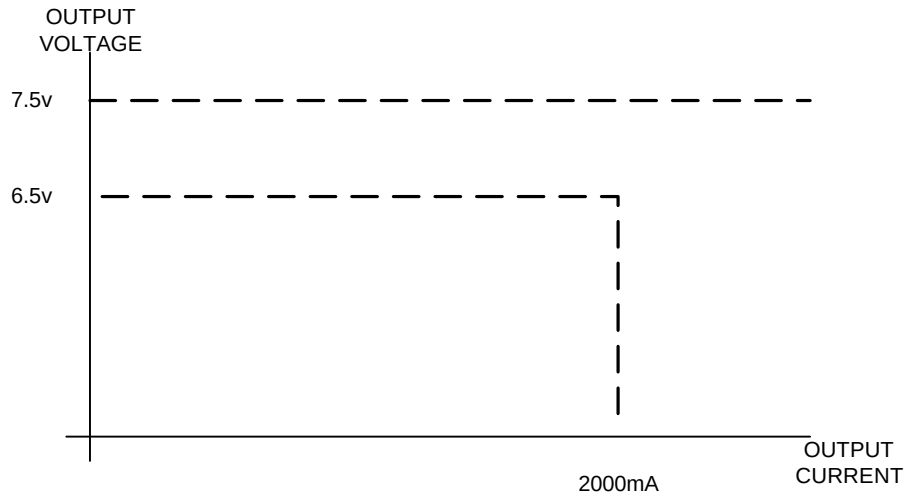
5.3. RF Port

The NMX920 is designed to operate with a 50 ohm antenna system. It is fitted with a MMCX miniature RF connector. As an order time option, the RF connector may be a straight connector mounted on the bottom of the modem for board to board connection, or a right angle connector on the top of the board pointing out, or sideways. See Ordering Information for details.

5.4. Power Supply

Careful consideration must be given to the power supply design for the NMX920. Whilst receive current is in the order of 100 mA, the transmitter requires 1.7 A

during transmission. This current must be available instantly; the modem has less than 15 msec to change from receive mode to transmit mode, and at this point the power amplifier has finished its startup sequence. Additionally, the power supply must be able to provide this current without voltage sag for a maximum length transmission, about 980 msec. The OEM power supply should fall within the following template for reliable modem operation.

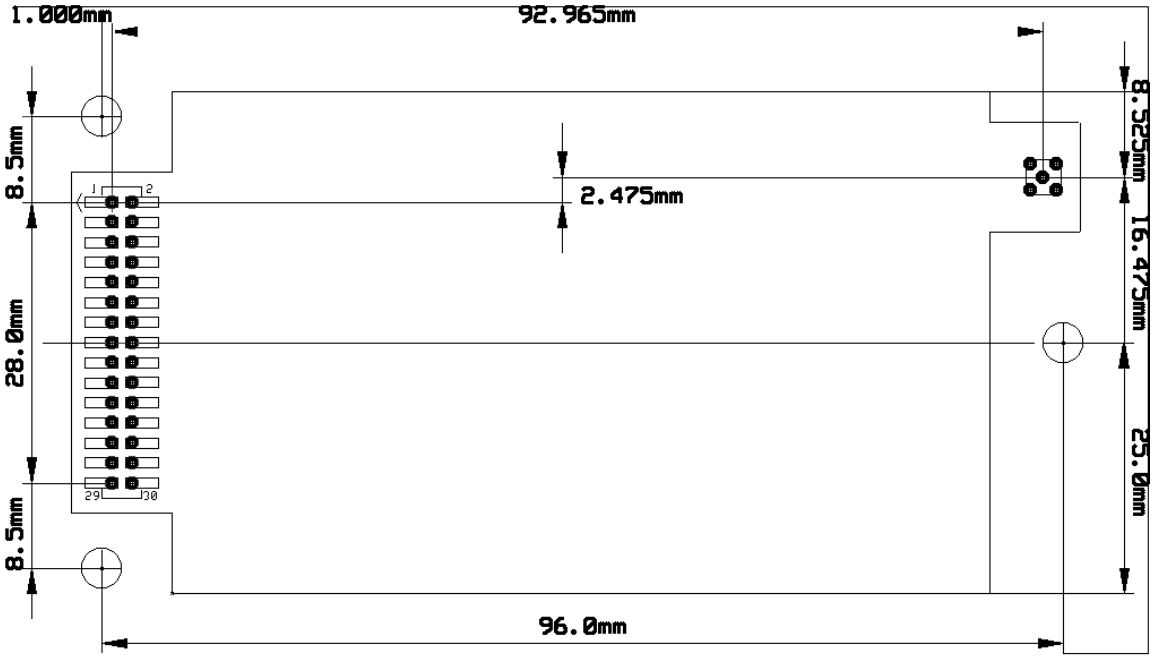


The output voltage must stay within these limits for any transient load change greater than 10uS.

5.5. Board to Board Connection

The NMX920 is available in a direct board to board configuration. In this configuration, the NMX920 mates directly with system interface and RF connectors in on the OEM system. This configuration eliminates all modem cabling, resulting in significant cost savings, and ease of assembly. This option is available at time of ordering.

The dimensions of the required layout on the host unit are shown below. Additionally electronic versions of this layout in CADINT format ise available from Nomadic Communications for import into the system integrator's CAD system.



Recommend Interface Connectors for Board to Board configuration

RF connector is a PCB surface mounted MMCX male, Part No. Johnson 135-3801-201 straight plug receptacle or equivalent.

System Interface Connector is a surface mounted 2 x 15 x 2mm plug, Part No. Samtec TMMH-115-01-S-DV-ES, or equivalent.

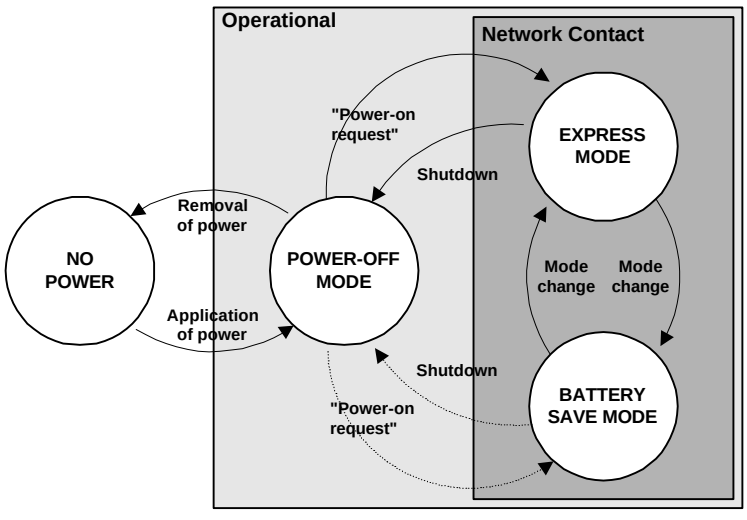
6. Modes Of Operation

The NMX920 is a microprocessor controlled, hybrid electronic device with special requirements for power quality and application. The NMX920 is designed to operate with power applied to the **External Interface** at all times, and provides the ability to power itself on and off under software and hardware control. Because of the nature of radio transmissions, and the MOBITEX network, the NMX920 needs to be able to control its own powering down to ensure that certain time–critical processes are completed and the system is left in a known state. If possible, OEM designers should provide for this behaviour by powering the NMX920 from a constant power source, or the same source as the OEM equipment.

IMPORTANT!
Care should be taken not to remove power from the External Interface without properly shutting down the NMX920 via the MASC FO command. For further information see section "Power Sequencing"

If power is removed from the **External Interface**, without correctly shutting down the NMX920, the MOBITEX network will become unaware of the modem's Active/Inactive state. This situation is recoverable, however the sudden loss of power could result in loss of buffered messages. This section outlines the procedures necessary to properly power and control the NMX920.

The following diagram outlines the relationship between the three power modes and the mechanisms for changing between them.



The NMX920 operates in one of three distinct power modes while power is applied to the **External Interface**; **POWER-OFF MODE**, **BATTERY SAVE MODE** and **EXPRESS MODE**. To provide control over the operational state, and power consumption of the NMX920, the OEM can change between these modes by issuing certain MASC commands and/or electrically activating the **DTR** line on the **External Interface**.

- **POWER-OFF MODE** – this mode is selected when the NMX920 is not required to communicate with the MOBITEX network to send and/or receive messages, or the NMX920 is to have its power disconnected. Power consumption is reduced to a minimum in this mode by switching off most internal devices, including the microprocessor and MASC interface. The NMX920 is waiting to sense a "power on request" via the correct assertion of the **DTR** pin (see section **….** above). This will cause the NMX920 to enter its last known operational state (ie. either **EXPRESS** or **BATTERY SAVE MODE**, whichever mode was active when **POWER-OFF MODE** was entered.)

- **EXPRESS MODE** – in this mode the NMX920 the radio is always powered. Radio conditions permitting, the NMX920 will contact and register with the MOBITEX network and is able to send and/or receive messages. The NMX920 will enter **BATTERY SAVE MODE** when the MASC FY command or MODE MPAK is issued. Alternatively, the NMX will return to **POWER-OFF MODE** by issuing the MASC FO command.

- **BATTERY SAVE MODE** - this mode is functionally similar to **EXPRESS MODE** except that the Radio Module runs on about 10% duty cycle to reduce the average power consumption.

6.1. Application of power

Electrical power must be applied to the NMX920 via the **PWR** pins of the **External Interface**. The NMX920 will power-up, run internal diagnostics and then enter **POWER-OFF MODE**. The designer should allow at least 2 seconds between the application of power and the first attempt to communicate with the NMX920 to change out of **POWER-OFF MODE**.

6.2. Network Contact

Once power has been applied according to Section 6.1 the NMX can be brought into Network Contact (ie. either **EXPRESS** or **BATTERY MODE**) by toggling **DTR** to it's active state.

The NMX920 will issue a MASC B frame to initialise the MASC interface, and begin MOBITEX network roaming and contact. From this point on the MASC interface is active and controls the behaviour of the NMX920.

NOTE: Application of DTR for duration less than 1000ms will initiate internal diagnostics and return to POWER-OFF MODE.

6.3. Mode Change

The NMX920 can toggle between **EXPRESS MODE** and **BATTERY SAVE MODE** while in network contact using one of the following mechanisms:

1. MASC FY command is issued.
2. MODE MPAK issued at MASC interface.

The NMX920 will contact the network to toggle modes, this operation involves packet transmission and can take up to two seconds.

6.4. Shutdown

The NMX920 can be placed back into **POWER-OFF MODE** by issuing the MASC FO command.

The NMX920 will terminate MOBITEX network activities, send an INACTIVE to the network, issue the MASC FO reply and shut down power to internal devices to enter **POWER-OFF MODE**. It is important that the correct shutdown procedure be used each time the modem is shutdown to prevent lose of buffered messages, and to keep the network informed of the modem's status.

The NMX920 can toggle between **EXPRESS/BATTERY SAVE MODE** and **POWER-OFF MODE** by repeating sections 6.3 and 6.1.

6.5. Removal of power

The NMX920 controls the internal distribution of power from the PWR pins using digitally controllable switches and regulators. While there is no mechanism for completely disconnecting power from the NMX920 without externally removing the power source from the interface, the NMX920 can enter a very low power state (**POWER-OFF MODE**) under direct control. It is preferable to use this low power mode rather than disconnecting power from the **External Interface**.

If power must be removed from the **External Interface** the following procedure should be followed to ensure data integrity and network compatibility:

1. Shut down NMX920 via the MASC FO command.

2. Wait for MASC FO response from the NMX920 to indicate that it has shut down.

3. Remove electrical power from the interface

Following this procedure will ensure that the network is properly notified and no buffered messages are lost.

7. Notes for Integrators

Application developers should be aware of the following hardware firmware and operational issues prior to commencement of integration of the NMX920. These issues impact hardware design, application software and application certification by the network operator.

7.1. Antenna

The NMX920 requires a 50 Ω matched antenna with a VSWR no greater than 1.5:1 over the transmission band.

The provision of the antenna system is the responsibility of the system integrator. The design and location of the antenna system will be largely dictated by system requirements, and may have system implications with respect to RF exposure, see regulatory issues below. During certification testing, the NMX920 was tested using a unity gain (dipole), ground independent antenna, and a printed circuit antenna of proprietary design.

The unity gain (dipole), ground independent antenna used was manufactured by ZCG Scalar has the following characteristics, but these characteristics are common to both ground independent and ground referenced antennas from a number of manufacturers.

Frequency	890 – 960 MHz
Gain	Unity, (0 dBd)
Mounting	Straight Connection TNC
Power	5 Watts
Impedance (Nom.)	50 Ohm
Polarisation	Vertical polarisation
Construction	Delrin, brass and steel
Tuning	Factory

7.2. Human Exposure Issues

The NMX920 has been evaluated for human exposure to RF radiation under Specific Absorption Rate (SAR) guidelines by APREL Laboratories. The NMX920 was battery powered, and utilised the antenna detailed above. The NMX920 was run with development firmware which restricted the maximum transmit duty cycle to 9%. All production with firmware above R2.00 are limited to a maximum of 9% transmit duty cycle. This parameter is not alterable in the field. The configuration used for SAR testing was

- NMX920, pre-production sample (DUT)
- 7.2 V Li-Ion battery pack
- DYNMAST A-409T 800-900 MHz vertical handheld antenna (described above)

The results of the SAR testing are summarised as

“The maximum Specific Absorption Rate (SAR) averaged over 1 g, determined at 901MHz (high channel), of the Nomadic Communications OEM radio modem, NMX920, is 1.41 W/kg when operating with an 9 % duty factor. The overall margin

of uncertainty for this measurement is ± 16.2 % (Appendix C). The SAR limit given in the FCC 96-326 safety guideline is 1.6 W/kg. This unit as tested, and as it will be marketed, is found to be compliant with this requirement"

The complete SAR report is available on request from Nomadic Communications.

If the final integration uses a different antenna configuration, the entire system will need to be re-evaluated for human exposure to RF radiation. Human exposure to RF radiation is a very complex system issue. It is affected by parameters (but not limited to) such as

- Antenna
- Power Supply
- Application
- Case
- Accessories
- Antenna placement.

If the complete system is operated in a fixed location, mobile application or portable application with a unity gain (0 dBd) antenna and a guaranteed minimum separation of at least 20 cm between the antenna and any body then the NMX920 can be used in the system without further evaluation.

If a higher gain antenna is used then Maximum Permissible Exposure guidelines must be checked, and application possibly made for change in licence conditions.

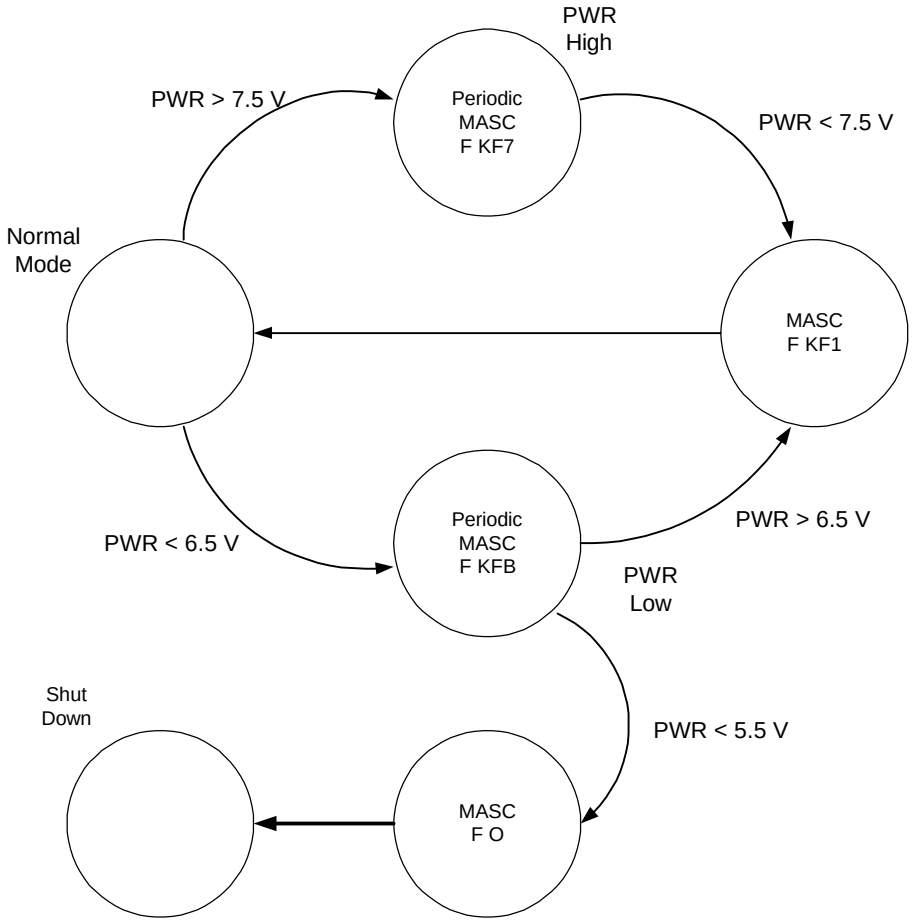
If the NMX920 is to be used in a body worn application, or if a 20 cm separation between antenna and body cannot be guaranteed by obstruction, then the entire integrated system must be re-evaluated for SAR. SAR evaluation will need to be done for all available options for the final systems – all different battery packs, cases, antennas, power supplies, attached peripherals, after market accessories etc.

7.3. Power Supply

The NMX920 firmware monitors it's power supply. If the modem's power supply falls outside the specified operating limits, the transmitter will be disabled and the DTE notified. MASC packets appropriate to power supply management are

- F KF7. Power Supply voltage above safe operating limits. No transmission possible (and also receive unable to complete), but MASC port still active.
- F KFB. Power Supply voltage below specified operating limits. No transmission possible (and also receive unable to complete), but MASC port still active.
- F KFB followed by F O. Power Supply voltage so far below specified operating limits that the entire modem shuts down.
- F K F1. Modem's power supply has been returned to nominal voltage.

The following diagram outlines the relationship between the voltage monitoring states, the mechanisms for changing between them, and the MASC traffic generated.



7.4. Operational Notes.

- In the case of abrupt power outage, the modem does not save buffered messages. It does, however, preserve all system parameters allowing the modem to return to the network contact once power has been restored
- The NMX920 fully complies with the BellSouth Wireless Data requirements for network delivered Lethal Injection. If the NMX920 is operating on the BellSouth network, receipt of a Lethal Injection will render the modem inoperable, requiring reactivation at a service centre or factory. Changing networks (F R or F 03) does not reset this condition
- MASC frames exceeding 1150 bytes are ignored by the modem

8. Mobitex Compliance

The NMX920 is in conformance with the Mobitex Interface Specification (MIS) R4A. When operated on the BellSouth Mobitex network it also meets the BellSouth Mobitex extensions for Wireless Subscription Management (WSM). The NMX920 has been validated against the BellSouth test specification 'Radio Modem Certification Test Specification, Version 5.1 BellSouth Wireless Data USA, December 11, 1998 (Doc. No. BSWD-031-RMC-TS).

The MASC packets supported by the NMX920 in Production and Engineering versions are summarised below.

	Description	**Production R2.01**	**Engineering V2.01**
B	MASC protocol parameters	Full	Full
M	Send and receive MPAK	Full	Full
E	Error packet	Full	Full
N	Return of MPAK not sent to network	Full	Full
R	Return of incorrect MPAK	Full	Full
T	Request or set alert text	Full	Full
U	Issue alert MPAK	Full	Full
X	User command	Not used	Not used
Y	User command	Not used	Not used
Z	User command	Not used	Not used
F A	Power save mode functions	Full	Full
F B	Change to Mobitex operation mode	Not supported	Not supported
F C	Set up Mobitex line connection	Not supported	Not supported
F D	Set up telephone line connection	Not supported	Not supported
F E	Disconnect the line connection	Not supported	Not supported
F F	Modem is in network contact	Full	Full
F G	Modem is out of network contact	Full	Full
F H	MPAK has been sent to network	Full	Full
F I	Cancel MPAK	Full	Full
F J	Print current MANs	Not supported	Not supported
F K	Error packet	Full	Full
F L	Activate external call indication	Not supported	Not supported
F M	Transmitter on/off	Full	Full
F N	Change to manual radio mode	Not supported	Not supported
F O	Close down radio modem	Full	Full
F P	Terminal MAN	Full	Full
F Q	MASC device identity	Full	Full
F R	Change network identifier	Full	Full
F S	Change of traffic area	Full	Full
F T	Change the temporary channel list	Full	Full

F U	Power control for separate radio module	Not supported	Not supported
F X	Change MASC communication parameters	Full	Full
F W	RLSD control signal	Not supported	Not supported
F Y	Battery saving mode control	Full	Full
F Z	Product information	Full	Full
F 01	Network contact status	Full	Full
F 02	Subscription information	Full	Full
F 03	Change network by name and ID	Full	Full
QA01	Area list information	Full	Full
QA02	Roaming parameters information	Full	Full
QA03	Lock on channel pair	Full	Full
PA01	Radio protocol parameters	No	Full
PA02	Modem identity parameters	No	Full
PA03	Default channel list parameters	No	Full
PA04	Power control parameters	No	Full
PA05	Channel numbers evaluated and scanned	Full	Full
PA06	Radio parameters and tests	Qualified: Loudspeaker and speech commands not supported	Qualified: Loudspeaker and speech commands not supported
PA07	Battery-saving protocol parameters	No	Full
PA09	Invalid list report	No	Full
PA10	MODE/SKIPNUM parameters	Full	Full
KAB	Lock on FBI	Full	Full
KAM	Lock on down channel	Full	Full
KAS	Lock on up channel	Full	Full

9. Technical Specification

Radio Transceiver Specification

General	Dual conversion receiver, directly modulated transmitter utilising common antenna and solid state transmit/receive RF switch.
Modulation Technique	NRZ GMSK (BT=0.3)
Transmitter Frequency Range	895 – 905 MHz (800 channels)
Receive Frequency Range	931 – 941 MHz (800 channels)
Channel Spacing	12.5 kHz
Frequency Accuracy	±1.2 kHz over full operating temperature range
Receiver Sensitivity	-116 dBm
Transmitter Power (typical)	2 W @ 6.5 – 7.5 VDC into matched 50Ω antenna load at 20°C
Transmitter Power Control	4 level transmit power control (0, -6dB, -12dB and –18dB)
Antenna Cable Connector	MMCX Female

Environmental Specification

Operating Temperature	-10°C to +55°C
Storage Temperature	-35°C to +80°C
Cooling Method	Convection and thermal conduction of an enclosed environment
Operating Humidity	5% to 95% non-condensing relative humidity at +50°C for at least 8 hours

Physical Specification

Overall dimensions	100 mm x 55mm x 12 mm (standard enclosure) including connectors and mounting lugs
Weight	70 g including standard enclosure
Mounting Method	M2 Screws at 3 positions
Housing	High density metallised plastic and stainless steel
Grounding	Continuous-edge pressure fit grounding from case to PCB

Power Requirements

Supply Voltage	6.5 – 7.5 VDC
Supply Ripple	Less than 35mV rms
All modes – Transmitting high power	1700 mA (typical) @ 7.0 VDC into matched 50Ω antenna at 20°C
Express Mode – Receiving	100 mA (typical) @ 7.0 VDC into matched 50Ω antenna at 20°C
Battery Saving Mode – Receiving	45 mA (ave) (typical) @ 7.0 VDC into matched 50Ω antenna at 20°C
Power-off Mode	250 uA (typical) @ 7.0 VDC

Device Interface

Connector	30-way 0.50 mm pitch FPC socket, or 2 x 15 x 2mm Board to Board Connector, or cable
Data link protocol	Mobitex® Asynchronous Communications Protocol (MASC1)
Data port	RS-232 or TTL (Manufacturing Option)
Data rate	1200 – 9600bps

Specifications Subject to change

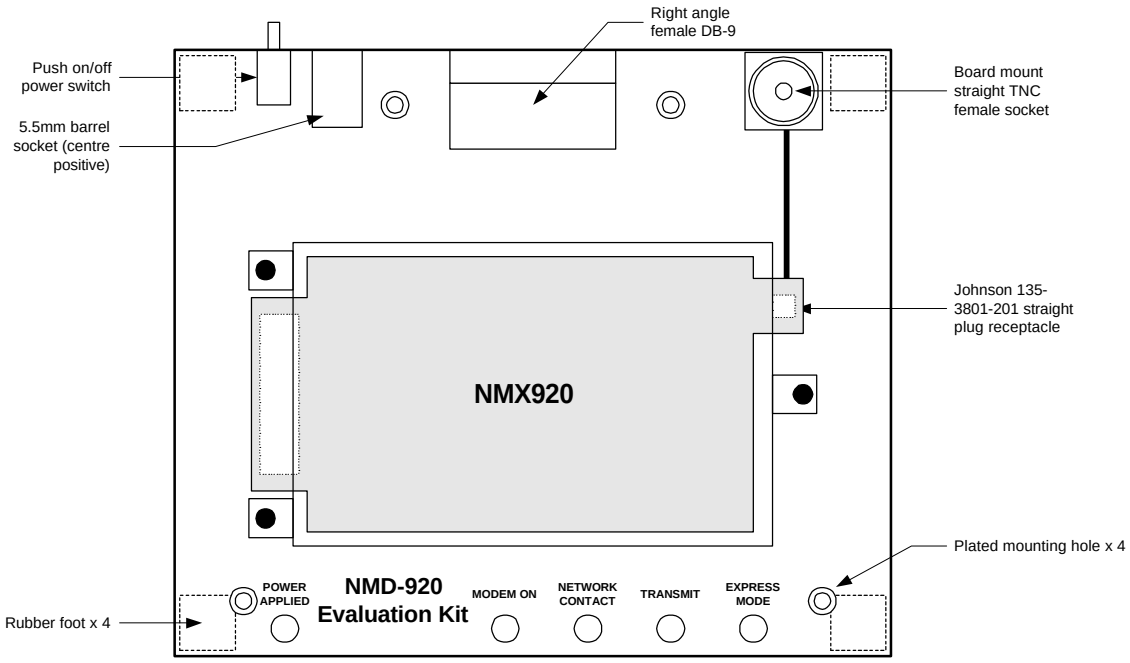
10. Development Tools

10.1. NMD920 Modem Evaluation Kit

The Nomadic Communications NMD920 Development Interface provides the systems integrator a convenient platform from which to evaluate the operation and performance of NMX920 Mobitex® Radio Packet Modems. The NMD920 provides an optimised power supply for the NMX920 series modems, socket for antenna mounting and PC serial interface.

Key Features

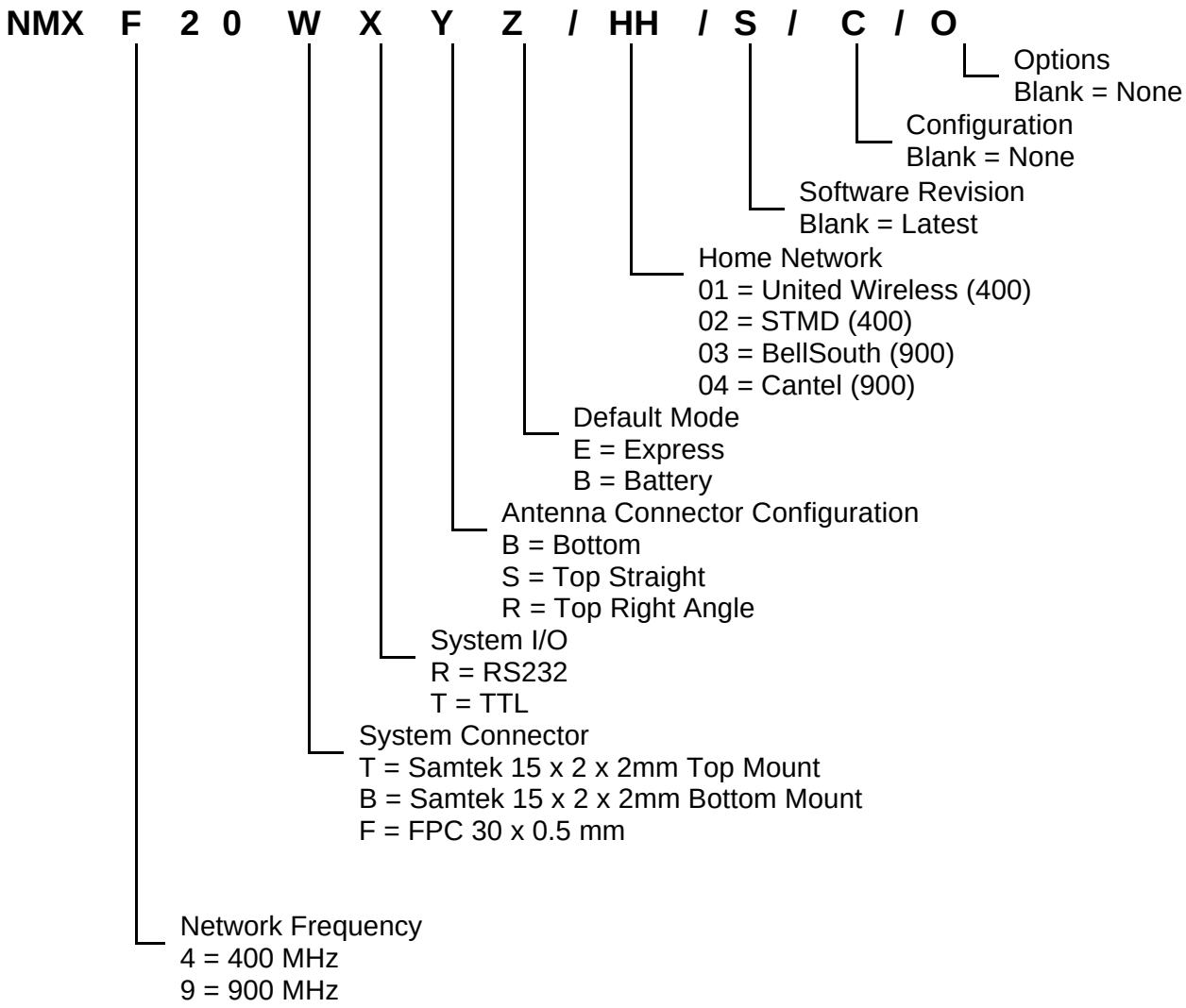
- Power control and regulation for the modem
- Modem plugs directly onto NMD920.
- Connection to PC via 9 pin 'D' connector.
- TNC connector for mounting antenna, or coaxial cable to external antenna or test instruments.
- LED indicators for modem status and power integrity.



10.2. ModmTest

Radio Modem Test Utility, Version 8.30. Copyright© RAM Mobile Data (May 1995)

11. Ordering Information



12. References

– Mobitex Interface Specification (MIS), Revision R4A, October 1998.
– Mobitex Interface specification (MIS) R4A, Chapter 6, Revision G October 1998
– Technical Specification, WSM Modem Requirements, Rev A BellSouth Wireless Data USA July 1998 (Doc. No. 98TR0021)
– Radio Modem Test Specification, Version 5.1 BellSouth Wireless Data USA December 1998 (Doc. No. BSWD-031-RMC-TS)
– Federal Communications Commission (FCC) 47cfr, parts 2, 15, 90
– Industry Canada (IC) RSS-119 Issue 5, August 1996
- Certification Report on Specific Absorption Rate (SAR) Experimental Analysis Nomadic Communications NMX 920 OEM Radio – Modem Date: 30 November, 1999. Aprel Laboratories