1.0 INTRODUCTION

The MDS TransNET-SF9 (Figure 1), is a modular spread spectrum transceiver designed for use in the license-free 902-928 MHz band. The unit is designed for use inside data equipment to provide reliable connectivity in wireless networks.

The SF9 employs a closed-loop power control circuit, ensuring that the RF output never exceeds +30 dBm at the antenna connector. The module is designed for **OEM use only**. Host systems, if used with antennas having standard connectors, must be professionally installed. Host systems using integrated antennas or unique antenna connectors must be factory configured by the OEM to operate at the correct output power setting. Refer to the table at the end of this guide to determine applicable antenna types and the RF output power allowed.

Electronic copies of this document and other GE MDS user guides are available free of charge at **www.gemds.com**.

1.1 Transceiver Features

The SF-9 maximizes performance and flexibility in wireless networks, offering the following key features:

- 128 frequencies over 902–928 MHz, divided into 8 zones
- User-selectable option to skip sub-bands with interference
- 65,000 available network addresses
- Network-wide configuration from the Master station, eliminating most trips to Remote sites
- Data transparency ensures compatibility with virtually all asynchronous SCADA system terminals.
- Peak-hold RSSI averaged over eight hop cycles
- Operation at up to 115,200 bps continuous data flow
- Store-and-Forward repeater operation
- Data latency typically less than 10 ms
- Same hardware for Master or Remote configuration
- Supports RS/EIA-232 and RS/EIA-485 user interface
- Low current draw; typically less than 8 mA in sleep mode
- Operates at 3.3 Vdc at the power connector

Figure 1. SF9 Transceiver Module
(J3 Data/Power and J200 Antenna Connectors on other side)

NOTE: Some features may not be available on all units, based on the options purchased, or regulatory constraints in the country of operation.

1.2 Accessories

GE MDS offers an *Accessories Selection Guide* listing additional items that may be used with our products. Contact your factory representative or visit **www.gemds.com** for the latest copy.

2.0 INSTALLATION

The transceiver is designed for installation in existing electronic equipment. It mounts to any flat surface using screws through the four holes provided in the corners of the PC board.

Only two cable connections required to the radio; J3, the Power/Data connector, and J200, the Antenna connector. It is recommended that the module be installed in a manner that permits viewing the four status LEDs (CR3, 4, 5, and 6) during operation. These LEDs provide important information that is useful during startup and optimization of the radio link.

Antennas used with the radio can be either a Yagi directional type (often used at remote sites) or an omni-directional type used for short range applications or at Master stations. Contact your sales representative for information on available antennas.

Follow these steps to install the transceiver module:

1. Select a suitable mounting location for the module. This should be a flat surface close enough to the power/data and antenna cabling so that these will reach their respective connectors.

2. Secure the module to the surface using suitable screws through the mounting holes in each corner of the radio's PC board. Use spacers as necessary to achieve required height. (Mounting hardware is not supplied.)

3. Select and install an appropriate antenna and feedline for your system coverage requirements.

4. Connect the antenna coaxial lead to J200 on the module. It accepts a Type-UMC female coaxial connector.

5. Prepare the power/data cabling for connection to J3 on the module. It accepts a Molex SlimStack™ 20 pin receptacle. Use only the required data pins for the application (see Table 1 for pin information). The input power applied to J3 must be **3.3 Vdc** (-0/+0.2 V). Connect the plug to J3.

Table 1: J3 Power/Data Connector Pinouts

Pin(s)	Description
1, 2, 7, 8	**Signal Ground**—Connects to ground (negative supply potential) on the radio's PC board and chassis
3, 4, 5, 6	3.3 Vdc Input
9	Alarm
10	DCD_LED
11	Serial Configuration
12	**CTS (Clear-to-Send)**—Goes "high" after the programmed CTS delay time has elapsed (DCE), or keys an attached radio when RF data arrives (CTS KEY). CTS_N-485_DE
13	**RXD (Received Data)**—Supplies received data to the connected device
14	RTS (Request-to-Send)
15	**TXD (Transmitted Data)**— Accepts TX data from the connected device
16	Power Supply Shutdown PS_SHDN
17	Sleep
18	DIAG_RXD
19	DIAG_TXD
20	*Reserved. Do not connect.*

6. Set the radio's basic configuration with a PC terminal connected to J3. The three essential settings for all transceivers are:

- **Mode:** Master, Remote, or Extension
- **Network Address:** A unique number from 1 to 65000
- **Data Interface Parameters:** bps, data bits, parity, stop bits

7. Observe the transceiver LED status panel for proper indications (see Table 2).

Table 2: LED Indicator Descriptions
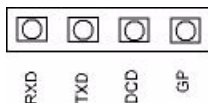
LED Name	Description
RXD (CR3) **Receive Data**	Serial receive data activity. Payload data from connected device.
TXD (CR4) **Transmit Data**	Serial transmit data activity. Payload data to connected device.
DCD (CR5) **Data Carrier Detect**	Continuous—Radio is receiving/sending synchronization frames On within 10 seconds of power-up under normal conditions
GP (CR6) **General Purpose**	• Continuous—Power is applied to the radio; no problems detected • Flashing (5 times-per-second)—Fault indication. See *Troubleshooting* • Off—Radio is unpowered or in Sleep mode

8. In a normally operating system, you will see the following indications within 16 seconds of start-up:
- **PWR** lamp lit continuously
- **SYNC** lamp lit continuously
- Remote radio(s) transmitting data (**TXD**) and receiving data (**RXD**) with the Master station.

9. Optimize the installation by checking:
- Antenna aiming and SWR check
- Data buffer setting (applicable to Modbus protocol)
- Hoptime setting
- Optimal baud rate setting
- Radio interference checks

3.0   RADIO PROGRAMMING

There are no manual adjustments on the radio. All programming and control is performed through a PC connected to the radio's J3 connector.

3.1   User Commands

The following tables provide descriptions of the various user commands for the transceiver. For additional detail refer to the *TransNET OEM Integration Guide* (05-3946A01). (This material is referenced as a resource for command details only. Other material in the guide pertains to a different TransNET model.)

Table 3: Network Configuration—Master Station

COMMAND	DESCRIPTION
AT [ON, OFF]	Enables Master station to emulate a modem and respond to AT commands
BUFF [ON, OFF]	ON = Seamless data OFF = Fast byte throughput.

COMMAND	DESCRIPTION
FEC [ON, OFF]	Sets/disables FEC (Forward Error Correction) setting.
HOPTIME [7, 28]	Displays hop-time or sets it to 7 or 28 ms.
LPM [1, 0]	Used at Master to set all associated stations in an energy-conservation mode. 1 = Low-power mode enabled network-wide 0 = Disable low-power mode (Default)
REPEAT	Sets/displays the fixed downstream re-send count.
RETRY [0–10]	Sets/displays the maximum upstream re-send count for ARQ (Automatic Repeat Request) operation
SAF [ON, OFF]	Enables/disables the store-and-forward function for the network controlled by this Master unit.
SKIP [NONE, 1...8]	Skip one or more frequency zones— See note below regarding zone skips.

NOTE: In the USA, a maximum of four zones may be skipped, per FCC rules. Check the regulatory requirements for your region before skipping zones.

Table 4: Network-Wide Diagnostics

COMMAND	DESCRIPTION
DLINK [xxxxx/ON/OFF]	Controls operation of diagnostic link function.
DTYPE [NODE/ROOT]	Set radio's operational characteristics for network-wide diagnostics

Table 5: Operational Configuration

COMMAND	DESCRIPTION
ADDR [1–65000]	Program network address
AMASK [0000 0000–FFFF FFFF]	Alarm response Default: FFFF FFFF
ASENSE [HI/LO]	Sense of the alarm output on Pin 6 of the DATA interface connector in the EIA-232 mode. Default: Alarm present = HI
BAND [A, B, C]	Selects one of three operating bands. *(2.4 GHz Model Only)*
BAUD [xxxxx abc]	Data communication parameters
CODE [NONE, 1...255]	Select the security/encryption setting in the radio
CSADDR [1–65000]	Used on a single Master/Remote network to support TDD-style simulated full-duplex.
CTS [0–255]	CTS delay in milliseconds (A value of 0 returns CTS immediately)
CTSHOLD [0–60000]	"Hold time" that CTS is present following last character from DATA port.
DEVICE [DCE, CTS KEY]	Device behavior: DCE (normal) or CTS Key

COMMAND	DESCRIPTION
MODE [M, R, X]	Operating mode: M = Master, R = Remote, X = Extension
MRSSI [NONE, -40...-90]	Minimum RSSI level required to preserve synchronization with a Master radio for Remotes in mobile service.
OT [ON, OFF]	Enables a 1-second delay on delivery of RXD serial data.
OWN [xxxxx]	Owner's name, or alternate message (30 characters maximum)
PORT [RS232, RS485]	Data port (DATA connector) interface signaling mode: RS232 or RS485
PWR [20–30]	Power output in dBm
RXD [0–255]	Set RXD delay time for virtual seamless mode with low latency
RXTOT [NONE, 0–1440]	Maximum duration (in minutes) before time-out alarm. Default is OFF.
RTU [ON, OFF, 0–80]	Enable or Disable unit's built-in RTU simulator. Default is OFF. Set RTU address between zero and 80.
SLEEP [ON, OFF]	Enable or Disable the radio's energy-conservation Sleep mode function.
UNIT [10000–60000]	Unit address used for network-wide diagnostics. (Unique within associated network.)
XADDR [0–31]	This unit's Extended address. Typically, the Master is set to zero (0).
XMAP [00000000–FFFFFFFF]	Included Extended units in MODE X. (Extensions and Remotes only)
XPRI [0–31]	Address of the primary Extended radio unit (Extension).
XRSSI [NONE, -40...-120]	Minimum RSSI level required to preserve synchronization with a non-primary radio. (Only meaningful when XPRI is not NONE)
ZONE CLEAR	Reset zone data statistics

Table 6: Operating Status—**Display Only**

COMMAND	DESCRIPTION
ADDR	Network address
AMASK	Alarm mask (response)
ASENSE	Current sense of the alarm output.
BAUD	Data communication parameters. Example: BAUD 9600 8N1
BUFF	Data buffering mode: ON = seamless data, OFF = fast byte throughput
CODE	Security/encryption operational status. "NONE" (Inactive), or "ACTIVE"
CTS	CTS delay in milliseconds (0–255 ms)
CTSHOLD	"Hold time" that CTS is present following last character from DATA port.

COMMAND	DESCRIPTION
DEVICE	Device behavior. Alternatives: DCE and CTS KEY
HOPTIME	Hop-time value in milliseconds (ms).
LPMHOLD	Time (0-1000 ms) provided to give an RTU time to respond before the radio goes to sleep.
MODE	Current operating mode: M = Master R = Remote X = Extension (Repeater)
MRSSI	Minimum RSSI level required to preserve synchronization with a Master radio for Remotes in mobile service.
OWM	Owner's message or site name
OT	Status (ON/OFF) of the 1-second delay on delivery of RXD serial data.
OWN	Owner's name or system name
PORT	Current data port (DATA connector) interface signaling mode: RS232 or RS485
PWR	Forward power-output setting in dBm
REPEAT	The fixed downstream re-send count.
RETRY	The maximum upstream re-send count for ARQ (Automatic Repeat Request) operation.
RSSI	Received signal strength indicator (in dBm). Unavailable at Master unless SETUP is enabled.
RTU	RTU simulator's operational status (ON/OFF)
RXTOT	The amount of time (in seconds) to wait before issuing a time-out alarm.
SAF	Store-and-forward mode status in this unit. (ON/OFF)
SER	Serial number of radio
SHOW CON	Display virtual modem connection status
SHOW PWR	RF output power. Measured RF power in dBm.
SHOW SYNC	Information on synchronization source
SKIP	Frequency zones that are skipped
SLEEP	Radio's Sleep Mode setting. (At Remotes Only)
SREV	Transceiver firmware revision level
STAT	Current alarm status
TEMP	Transceiver's internal temperature (°C)
UNIT	Programmed unit address for network-wide diagnostics
XADDR	This unit's Extended address
XPRI	Address of the primary Extended radio unit (Extension).

Table 6: Operating Status—Display Only *(Continued)*

COMMAND	DESCRIPTION
XMAP	Included Extended units in MODE X. (Extensions and Remotes only).
XRSSI	Minimum RSSI level required to preserve synchronization with a non-primary radio. (Only meaningful when XPRI is not NONE)

Table 7: Diagnostic and Test Functions

COMMAND	DESCRIPTION
KEY	Enables the transmitter test. (must be in Setup mode).
DKEY	Turns off the transmitter test (must be in Setup mode).
TX [xxxx]	Set/display transmit test frequency (must be in Setup mode).
RX [xxxx]	Set/display receive test frequency. (must be in Setup mode).
SETUP	Enables Setup mode. Times out after 10 minutes. Press "Q" to quit.
ZONE DATA	Zone data statistics
ZONE CLEAR	Clears the Zone Data log

4.0   TROUBLESHOOTING

Successful troubleshooting is not difficult, but requires a logical approach. It is best to begin troubleshooting at the Master site, as the rest of the system depends on the Master for polling instructions and synchronization data. If the Master has problems, the operation of the entire network will be affected.

Begin by checking the basics. All radios in the network must meet these requirements:

- Adequate and stable primary power (3.3 Vdc) at J3.
- An efficient and properly aligned antenna system
- Secure connections (RF, data & power)
- Proper programming of the radio's operating parameters, especially Operating Mode (MODE), Network Address (ADDR), and interface Baud Rate (BAUD).
- The correct interface between the radio and the connected data equipment (proper cable wiring, data format and timing).
- In store-and-forward systems these additional areas should be checked or evaluated:
    - Look for duplicate XADDR values on MODE M and MODE X radios. Duplicates will cause failures (unless the radios are too far apart to hear each other).
    - Check for errors in the synchronization qualifiers, XPRI and XMAP, on corresponding Remote radios.
    - Verify SAF is enabled at the Master radio.

4.1   LEDs

Table 8 describes the functions of the LEDs on the transceiver board.

Table 8: LED Indicator Descriptions

Name	Description
RXD	Receive data activity on the J3 interface connector
TXD	Transmit data activity on the J3 interface connector
SYNC	Continuous—Radio is receiving/sending synchronization frames. Normally on within 10 seconds of power-up.
PWR	• Continuous—Power applied to radio; no faults • Flashing (5 times-per-second)—Fault indication. See *Troubleshooting* above, as well as chart below. • Off—Radio is unpowered or in Sleep mode

Table 9 provides suggestions for resolving system difficulties that may be experienced in the radio system. If problems persist, contact the factory for further assistance.

Table 9: Troubleshooting Chart

Difficulty	Recommended System Checks
Unit is inoperative	a. Check for the proper supply voltage (3.3 Vdc) at the power connector. b. The transceiver's internal fuse may have opened.
Interference is suspected	a. Verify that the system has a unique network address. Nearby systems with the same address will cause interference. b. Check for interference by locking out affected zone(s) using the **SKIP** command. c. If omnidirectional antennas are used on Remote stations, consider changing to directional antennas. This will often limit interference to and from other stations.

Table 9: Troubleshooting Chart *(Continued)*

No synchronization with Master, or poor overall performance	a. Check for secure interface connections at the radio and the connected device.
	b. Check the antenna, feedline and connectors. Reflected power should be less than 10% of the forward power reading (SWR » 2:1 or lower).
	c. If the Remote radio is in synchronization, but performance is poor, check the received signal strength using the RSSI command. If RSSI is low, it may indicate antenna problems, or misalignment of directional antenna headings.
	d. Verify proper programming of system parameters: mode, network address, data interface baud rate, transmitter power, CTS delay, etc. For store-and-forward applications, also verify the following: **SAF** is **ON**; extended address is properly programmed at each extension; Remotes are using the proper values for **XPRI** and **XMAP**.
	e. Check for alarms using the **STAT** command.
BER is too high. Data throughput is spotty	a. The **RETRY** and **REPEAT** commands may be increased to deal with interference, or decreased to increase throughput and reduce latency.
	b. Try turning on FEC. FEC on gives some coding gain, but comes at the cost of reduced throughput.
Latency is too high	a. Reduce the **REPEAT** count.
	b. Turn **BUFF OFF**. **BUFF ON** ensures that no gaps occur in the data, but this comes at the cost of increased latency.
	c. Make sure **HOPTIME** is set to 7.

4.2 Alarm Codes

When an alarm condition exists, the transceiver creates an alarm code. These codes can be helpful in resolving system difficulties.

4.2.1 Major vs. Minor Alarms

Major alarms report serious conditions that generally indicate a hardware failure, or other abnormal condition that will prevent (or seriously hamper) further operation of the transceiver.

With the exception of alarm code 00 (network address not programmed), major alarms generally indicate the need for factory repair. Contact your factory representative for further assistance.

Minor alarms report conditions which, under most circumstances, will not prevent transceiver operation. This includes out-of-tolerance conditions, baud rate mismatches, etc. The cause of these alarms should be investigated and corrected to prevent eventual failure.

4.2.2 Checking for Alarms: STAT command

To check for the presence of alarms, enter **STAT**. If no alarms exist, the message **NO ALARMS PRESENT** appears at the top of the display.

If an alarm does exist, a two-digit alarm code (00–31) is displayed, and it is identified as a major or minor alarm. A brief description of the alarm is also given. Alarm codes and their meanings are listed in Table 10.

If more than one alarm exists, the word **MORE** appears at the bottom of the screen; additional alarms can be viewed by pressing ENTER.

Table 10: Alarm Codes

Alarm Code	Alarm Type	Description
00	Major	The network address is not programmed.
01	Major	Improper firmware detected for this radio model.
04	Major	One or more of the programmable synthesizer loops is reporting an out-of-lock condition.
08	Major	The system is reporting that it has not been calibrated. Factory calibration is required for proper radio operation.
10	Major	The DSP was unable to properly program the system to the appropriate defaults. A hardware problem may exist.
12	Major	Receiver time-out alarm.
16	Minor	The unit address is not programmed.
17	Minor	A data parity fault has been detected on the DATA connector. This usually indicates a parity setting mismatch between the radio and the RTU.
18	Minor	A data framing error has been detected on the DATA connector. This may indicate a baud rate mismatch between the radio and the RTU.
29	Minor	RF output power fault detected. (Power differs by more than 2 dB from set level.) Often caused by high antenna system SWR. Check antenna, feedline and connectors.
30	Minor	The system is reporting an RSSI reading below −105 dBm.
31	Minor	The transceiver's internal temperature is approaching an out-of-tolerance condition. If the temperature drifts outside of the recommended operating range and the transceiver may fail.

4.3 Power Consumption Ratings

The module has the following nominal power consumption ratings when operated at the required input voltage of 3.3 Vdc (-0/+0.2 V tolerance) at the power connector:

Sleep Mode: 5 mA
Shutdown Mode: 2 mA
Receive Mode: 130 mA
Transmit Mode: 1.4 Amperes

4.4 3.3 Vdc Regulation Required

OEM Integrators must regulate the DC voltage applied to the SF9 module at +3.3 Vdc, with a tolerance of -.0/+.2 Vdc. This can be achieved using a voltage regulator similar to the Texas Instruments PTH0407W, which is a precision DC regulator. The transmitter uses a closed-loop power control circuit that ensures the peak RF power will never exceed +30dBm.

The input voltage range of the PTH04070W device is 3 V to 5.5 V, allowing operation from either a 3.3-V or 5-V input bus. Using switched-mode power-conversion technology, the PTH04070W can step down to voltages as low as 0.9 V from a 5-V input bus, with typically less than 1 W of power dissipation. The output voltage must be set to a voltage of 3.3 V, using a single external trim resistor. Operating features of the TI device include an under-voltage lockout (UVLO), on/off inhibit, output overcurrent protection, and over-temperature protection.

For example purposes, a circuit employing this method of regulation is shown below in schematic form.
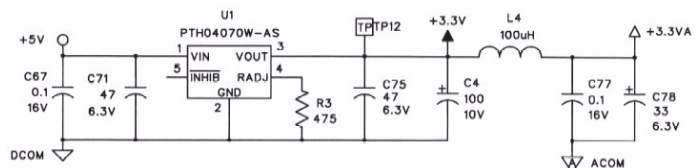
4.5 Technical Assistance

Factory technical assistance is available by contacting GE MDS during business hours (8:30 AM to 6:00 PM Eastern Time). Use one of the following means to contact the factory:

Telephone: (585) 241-5510   FAX: (585) 242-8369
E-mail: gemds.techsupport@ge.com
Web: www.gemds.com

FCC Part 15 and Industry Canada RSS Notice

This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference that may cause undesired operation of the device.

a) Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

b) The radio transmitter described herein (IC ID: 101D-SF9) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Warning: Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

Cet appareil est conforme à la Partie 15 des règlements de la FCC et Industrie Canada exempts de licence standard RSS (s). Son utilisation est soumise à deux conditions: (1) ce dispositif ne peut causer des interférences, (2) cet appareil doit accepter toute interférence pouvant causer un mauvais fonctionnement du dispositif.

a) En vertu des règlements d'Industrie Canada, cet émetteur radio ne peut fonctionner avec une antenne d'un type et un maximum (ou moins) approuvés pour gagner de l'émetteur par Industrie Canada. Pour réduire le risque d'interférence aux autres utilisateurs, le type d'antenne et son gain doivent être choisies de façon que la puissance isotrope rayonnée équivalente (PIRE) ne dépasse pas ce qui est nécessaire pour une communication réussie.

b) L'émetteur radio décrit ci-après (IC ID: 101D-SF9) a été approuvé par Industrie Canada pour fonctionner avec les types d'antennes énumérées ci-dessous avec le gain maximal admissible et nécessaire antenne d'impédance pour chaque type d'antenne indiqué. Types d'antennes ne figurent pas dans cette liste, ayant un gain supérieur au gain maximum indiqué pour ce type, sont strictement interdites pour une utilisation avec cet appareil.

Antenna System Gain (Antenna Gain in dBi[1] minus Feedline Loss in dB[2])	Maximum Power Setting (in dBm)	EIRP (in dBm)
6 (or less)	30	36
8	28	36
10	26	36
12	24	36
14	22	36
16	20	36

1. Most antenna manufacturers rate antenna gain in dBd. To convert to dBi, add 2.15 dB.
2. Feedline loss varies by cable type and length. Consult manufacturer data.

FCC Limited Modular Approval Notice

This device is offered as an FCC Part 15 Unlicensed *Limited Modular Transmitter (LMA)*. The transmitter module is approved for use only with specific antenna, cable and output power configurations that have been tested and approved for use when installed in devices approved by third-party OEMs, or produced by the Grantee (GE MDS). Modifications to the radio, the antenna system, or power output, that have not been explicitly specified by the manufacturer are not permitted, and may render the radio non-compliant with applicable regulatory authorities.

When this device is placed inside an enclosure, a durable label must be affixed to the outside of the enclosure indicating the unit's FCC ID Number.

The antenna(s) to be used with this module must be installed with consideration to the guidelines for RF exposure risk to all nearby personnel, and must not be co-located or operating in conjunction with any other antenna or transmitter.

RF Exposure Notices

Professional installation required. The radio equipment described in this guide emits radio frequency energy. Although the power level is low, the concentrated energy from a directional antenna may pose a health hazard. Do not allow people to come closer than **23 cm (9 inches)** to the antenna when the transmitter is operating in indoor or outdoor environments.

In mobile applications (vehicle mounted) the above separation distance must be maintained at all times. More information on RF exposure is available online at: www.fcc.gov/oet/info/documents/bulletins

L'énergie concentrée en provenance d'une antenne directionnelle peut présenter un danger pour la santé. Ne pas permettre aux gens de s'approcher à moins de 23 cm à l'avant de l'antenne lorsque l'émetteur est en opération. On doit augmenter la distance proportionnellement si on utilise des antennes ayant un gain plus élevé. Ce guide est destiné à être utilisé par un installateur professionnel. Plus d'informations sur l'exposition aux rayons RF peut être consulté en ligne à l'adresse suivante:

www.fcc.gov/oet/info/documents/bulletins