SXM Edge Node

User's Manual

Version 1.3

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Preface

The intended audience, document organization, and conventions used herein are described. Related documentation is identified, as are instructions for accessing other electronic product documentation.

Audience

This document is intended for technical users who have a basic level of understanding, familiarity and experience with spectrum monitoring and mobile network usage.

Conventions

The following conventions are used in this document.

Convention	Description
Grayed-out Font	Indicates a command or a feature is not available in the current release.
Courier Font	Illustrates an example command or a concept.
Light Blue Font	A clickable hyperlink to a referenced source.
Normal Bold Font	A concept or idea important enough that the reader's attention is being explicitly focused.
Red Font	Additional information for the topic.

Note: This symbol means **take note**. Notes contain helpful suggestions or references for additional information and material.

Caution: This symbol means **be careful**. In this situation, you might do something that could result in loss of settings, data or unintended data behaviour.

Obtaining Latest Documentation and Software

Please visit the thinkRF website at https://thinkrf.com/documentation/ to obtain the latest product documentation. Software and firmware releases are also available on the thinkRF website at https://support.thinkrf.com/support/solutions.

Document Feedback

Please send any comments regarding thinkRF documentation to SXMfeedback@thinkrf.com. We appreciate your feedback.

Obtaining Technical Assistance

For all customers who hold a valid end-user license, thinkRF provides technical assistance 9 AM to 5 PM Eastern Time, Monday to Friday. Contact us at https://support.thinkrf.com/ or by calling **+1.613.369.5104**.

Before contacting support, please have the following information available:

- The Serial Number of the issue SXM node
- LEDs blinking pattern if applicable
- Date and time when the issue occurred, with pictures of the issue if applicable
- Maintenance log information, if applicable
- Phone number to reach you, if applicable
- Any SXM software used and its version

Product Feedback

thinkRF's SXM is constantly evolving to better serve your needs, with new features and enhancements deployed to your network and this dashboard regularly. Submit your input to SXMfeedback@thinkrf.com or use the Dashboard's Feedback box in the Help page.

Overview

thinkRF's Spectrum eXperience Management (SXM) node is the IoT hardware of the SXM solution, which is a revolutionary real-time wireless network monitoring and intelligence platform, providing analytics and insights at the users' fingertips. It empowers wireless network operators and national regulatory agencies to characterize, optimize, manage, and protect RF spectrum assets.

The node operates 24/7 continuously and autonomously to perform spectrum analysis and send data to the SXM Cloud. The data can then be consumed by the users via SXM API for users' own application or with thinkRF's readily available SXM Dashboard. The solution architecture is illustrated in the following picture.
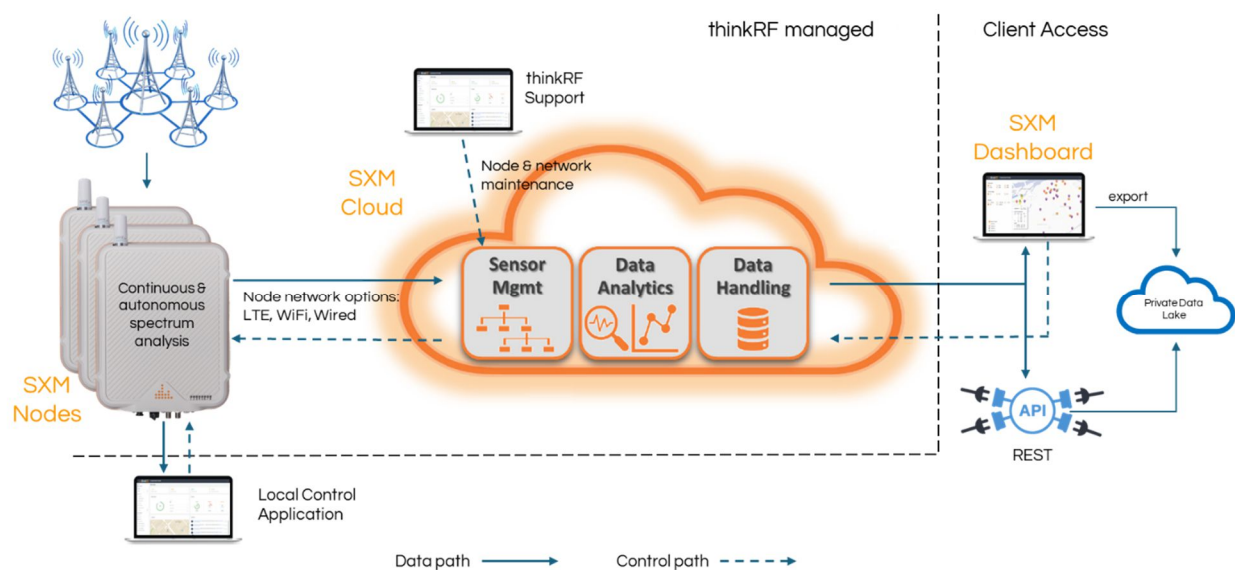
Getting Familiar with the SXM Node

The node comes with

- An IoT modem with a physical SIM card (supporting LTE/UMTS and GSM).
- a pre-installed RF Antenna or an external antenna,
- an Ethernet access
- a -48V DC Power supply
- a ground terminal lug, optional
- an external RF antenna, optional
- an external GNSS/GPS antenna, optional

Front View   *Back View*

The antenna shown here is available with the SXM node "integrated antenna" for the standard option. Note: If the SXM Node is optioned with an FR1 3GPP antenna, attempting to remove the antenna will damage the unit, If a new antenna configuration is required, please contact ThinkRF.

The Front View

The front of the node consists of a series of LEDs, providing quick visual information about various hardware and software status. See LEDs Status section for more information.

The Back View

The back of the node has pre-drilled mounting holes for the ground lug and pole/wall mounting.

The Bottom View – Standard Option

Bottom View

At the bottom of the node are the input ports for the power supply (-48VDC) and Ethernet connection. The Ethernet connection can be used for LAN network connection to provide internet to the node or for a direct node's access with the Local Control Application.

The Bottom View – External Antenna Option

Bottom View - Optional Antenna Ports

At the bottom of the node, from left to right, are the input ports for the power supply (-48VDC), Ethernet connection, RF antenna input, and GNSS antenna input. The Ethernet connection can be used for LAN network connection to provide internet to the node or for a direct node's access with the Local Control Application.

Device Operation

Hardware Installation

Whether deploying within an enclosed environment or out in the field, please read and follow the included "SXM Installation Guide" for unpacking, installation, usage, and safe operation of the node.

If the node is to be deployed in a location with poor cell reception or without access to the internet via a local Ethernet network, it should first be powered on in a location with internet access. This will allow the necessary update, initial setup and configuration with the latest software as well as ensuring the node is functional. See SXM Node Software section.

LEDs Status
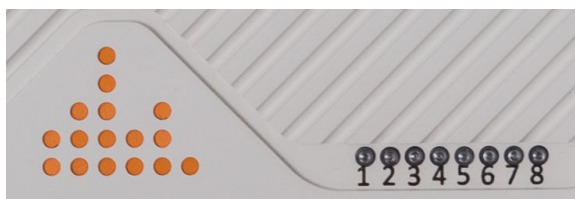
The meaning of the LEDs at the front of the node is as described in the following table.

Normal, Cold & Hot refers to the temperature operation condition. The Cold Operation refers to when the node is operating approximately below -5°C ambient operating temperature, the internal temperature monitoring system will shut down the key hardware modules to protect and prolong the life of these modules. The heater system (which is turned on at ~3°C) will be running to keep the system's ambient operating temperature above 0°C.

Similarly, the Hot Operation refers to the shutdown at an internal ambient temperature of 70°C or higher. The fan system will kick in to help speed up the cooling.

LED Number	Function	Description	Normal Operation	Cold Operation	Hot Operation
1	-48V DC	48V DC power indicator. Stays ON with an available external power.	ON	ON	ON
2	SBC STS	Status indicator of the on-board computer.	ON	OFF	OFF

LED Number	Function	Description	Normal Operation	Cold Operation	Hot Operation
		- Flashes as a continuous heartbeat (45bpm) for normal functioning of the SBC. - Off if no power to the SBC or it is not functioning.			
3	SBC PWR	Power status of the on-board computer.	ON	OFF	OFF
4	APP STS	Status indicator of the applications running in the SBC. - Flashes as a continuous heartbeat when healthy. - Flashes on a long cycle to indicate an application is not running. - Flashes a pattern to indicate an error code.	ON	OFF	OFF
5	RTSA PWR	Power status of the on-board RF receiver.	ON	OFF	OFF

6	LINK STS	Status indicator of the network connectivity.
		- Flashes as a continuous heartbeat if
		  + LTE-4G is running and has signal >60% reporting.
		  + With LTE signal <60%, will indicate with a brief series of flashes for different signal strength detected, ex 1 flash per second = 10%, 2 flashes per second = 20% etc.
		- A solid LED ON if ethernet or Wi-Fi is used.
			ON	OFF	OFF

7	INT PWR	Power status of the internal peripherals.	ON	ON	ON
8	HEATER	Power status of the heater.	OFF	ON	OFF

Network Connectivity

The node supports 3 types of network options:

- An integrated LTE IoT modem and SIM, which supports 4G, 3G and limited 2G mobile network access. This allows nodes to be deployed globally, wherever there is a supported mobile network available.
- Ethernet connection to LAN for fast internet access. The Ethernet connection also allows direct access to the node using the Local Control Application.

- Wi-Fi connection. However, to configure the node to a Wi-Fi network, another means of internet connection must be available first. Contact thinkRF's support if this method is desired.

To check for the node's online status, you could either

- check the LINK STS LED as mentioned in the LEDs Status section, or
- use SXM Dashboard to see the Node's status on its map, or
- the Local Control Application, when available.

Node Reboot

The node could be rebooted by unplugging the power cord if accessible or remotely by a thinkRF staff.

The node will also go through a regular reboot interval of 3 days to prevent it from being stuck in an unknown state.

Node Troubleshooting

Should the node not function normally, see the following steps to resolve or narrow down the issue. If the issue persists, reach out to thinkRF support along with the information as indicated in Obtaining Technical Assistance section.

To minimize issues with the nodes, please follow the Node Maintenance Plan.

System Issue	Action
No LEDs on or no power	- Verify the 48V DC power supply used is the one provided by thinkRF. - Ensure that the power supply is connected to a valid power source and the node is properly grounded. - Check the -48VDC power connector is properly attached to the node. - If the issue persists, please contact thinkRF support.
One or more status LEDs are off (LED #1, 3, 5, or 7)	- Verify the power supply used is the one provided by thinkRF. - Ensure that the power supply is connected to a valid power source and the node is properly grounded. - Unplug the power supply then connect again. - If the issue persists, please contact thinkRF support. - If the temperature is sub -5 Celsius and these LEDs are off, check if HEATER LED is on as the heater is working to heat up the node to the operational temperature. - If the issue persists, please contact thinkRF support.
SBC, LINK or APP STS LEDs does not flash as indicated in the LEDs Status section	- Unplug the power supply then connect again. - If the issue persists, please contact thinkRF support.
LINK LED is off while other LEDs are on	- Ensure the site has a good cell reception. - Unplug the power supply then connect again. - If the node is online and working normally, notify thinkRF support with the LINK LED issue for record keeping. - If the issue persists and the node is not online, contact thinkRF support.
All LEDs are blinking together at same rate	- Verify the power supply used is the one provided by thinkRF. - Ensure that the power supply is connected to a sufficient power source. - If the issue persists, please contact thinkRF support.
A connector or part damaged or cannot be used	Please take a picture and contact thinkRF support.
Missing part(s)	Please contact thinkRF support.

Data Issue	Action
Node is verified to be online, but no measured data is seen on the Dashboard, via SXM API, or Local Control Application	- Check the APP LED for the flashing pattern as indicated in the LEDs Status section. - Ensure there is no strong RF interference affecting the node by following the "Site Selection" instructions of the "SXM Installation Guide" document. - Ensure the external RF and GPS antennas are properly connected to the node. - Note that measured data typically takes 5 minutes or longer to be available on the cloud, depending on the availability of the spectrum signals of interest. If the users are uncertain that the signal of interest is available at the measured site, contact thinkRF support. - Note that if the node is in a location with poor cell reception, the data may not get uploaded to the cloud until a good internet connection is established.
Node is verified to be online, but less than normal data seen on the Dashboard, via SXM API, or Local Control Application	- Check the APP LED for the flashing pattern as indicated in the LEDs Status section. - Ensure there is no strong RF interference affecting the node by following the "Site Selection" instructions of the "SXM Installation Guide" document. - Ensure the external RF and GPS antennas are properly connected to the node. - Check 3GPP configuration is correct (if applicable)
Node data showing at wrong GPS location	Please contact thinkRF support for proper node configuration for your application.

Node Maintenance Plan

Please follow the following maintenance plan to ensure the proper and longevity of the node's operation.

Daily Maintenance – Powered on Node

Power and Connectivity

- If the node is powered up and running, check the node's online status using the SXM Dashboard or the Local Control Application (when available) with direct network access.
- If the above step is not feasible, perform the following manual checking
  - o Verify that the hardware is powered on.
  - o Check LEDs status for any issues (see the LEDs Status section).
  - o Check connectivity by looking at the LINK STS (#6 LED).

Weekly Maintenance

Visual Inspection

When possible,

- Check external antenna(s) for damage or wear and tighten as necessary.
- Ground Cable Inspection for rust or corrosion.
- Secure all connections, check for damage, and clean/tighten as necessary.

Monthly Maintenance

Power-Up for Over-the-Air Update

- If the node has not been used for one month in a good cell coverage area, power up the node for at least one hour in an area with good cell reception to ensure it can receive over-the-air updates. The update could also be done faster with a direct Ethernet connection to a LAN network with internet.

Winter Maintenance

During the winter months, it is recommended to clear snow and ice off from the external antenna for optimal performance.

Calibration and Ongoing Maintenance

The ThinkRF SXM Edge Node does not require routine annual calibration.

Certain maintenance practices should be followed to keep the hardware in optimal working condition. These practices include routine checks to ensure there is no water leakage, animal damage, or other environmental issues.

ThinkRF is committed to providing the best service and products to its customers. If users observe any service degradation or have concerns about hardware performance, please contact ThinkRF Support by email to support@thinkrf.com

Decommissioning Procedure

ThinkRF SXM Edge Node users should contact ThinkRF before decommissioning the devices. This ensures all data is uploaded and the Node is properly deactivated on the SXM Dashboard. Notify ThinkRF of the Node serial numbers to be decommissioned.

No data is permanently saved on the SXM Node. However, if the Node has had no internet access during recent usage, it must be connected to the internet to upload all recent data to the cloud. All data is stored in the cloud for a period of 2 years, so there is no data to erase from the SXM Node.

When removing the equipment, Use appropriate safety measures and power it down and disconnect it from all power sources, networks, and peripherals. Clearly label the equipment as decommissioned to avoid accidental reuse.

For environmental considerations, follow proper recycling and disposal procedures for electronic equipment and utilize certified e-waste recycling facilities.

SXM Node Software

The Edge Node has a host of software, running 24/7 to deliver seamless operation, ranging from automatic recovery of applications or network loss to advanced signal analysis and sending measured data and metrics to the cloud.

When a node is powered up or has been successfully configured to perform a signal analysis, the data will typically be available in the cloud for approximately five minutes or longer. For 3GPP signal analysis, the measured data availability depends on the availability of the RF/spectrum signals of interest at the monitoring site. Data upload time depends on the availability of the internet or the configuration of the analysis (such as the 'integration time' of the Channel Occupancy analysis). When there is internet, this typically will not be longer than 1hour (in the case of Channel Occupancy).

The node's measured data is timestamped the moment the receiver's raw data is captured, not when the analysis is done on the raw data.

System Operation

Ensuring Continuous Operation

System Self-Test

The node has a system self-test tool that can be run on demand via an application available to the users or by thinkRF's node support staff as needed. This test checks and reports:

- the overall health and the status of various node's hardware, network connectivity, software and services,
- the device's uptime and temperature, and
- any error and a meaningful message, which often consists of a suggested action if possible.

Watchdog and Autorecovery

Beside the Operating System's watchdog, the node's software system has various watchdog/heartbeat monitoring and auto-recovery services to ensure the recovery of these services or applications to a good state:

- Network connectivity
- AWS IoT applications
- Signal analysis applications
- SSH service
- Various node's logging and monitoring services

For signal analysis applications, where desired, the application might start from the last known configuration after a recovery or device's reboot.

Activities Logging

The services and activities mentioned in the previous section as well as regular logging of connectivity information are logged as well, both for debugging analysis and the node's statistics.

Access and Data Security

To ensure security of a node whether remote access or data transmission, SXM Solution, as a whole, supports encryption of data when in-transit and at-rest such as HTTPS, SSL/TLS 1.2/1.3, and AES256bit.

In addition, in making use of AWS services, the node leverages AWS security as mentioned in https://docs.aws.amazon.com/iot/latest/developerguide/transport-security.html#tls-policy-table.

Signal Analysis' Data Operation

The signal analysis applications are configured directly from the SXM cloud's applications or via direct access to the node using, for example, the ethernet port. Once configured and started, the analysis will run with or without internet.

Signal Analysis at First Power Up

During the factory installation, the node will be programmed to a default 3GPP signal analysis with a default configuration of these following 3GPP bands for both 4G and 5G blind scan:

- 3,7,8,12,13,20,25,26,28,29,32,34,39,40,41,42,46,48,53,66,70,71,76,77,78

To change this configuration, the user can

- either instruct thinkRF with the desired default application and configuration before shipment, or
- use the SXM Dashboard to submit a new configuration, regardless of the node being online or not.

Node's Data Cache Without Internet

User's configurable offline data cache is available to ensure seamless capturing of data as configured. By default, 1000 records are stored, to a maximum of 1GB. For (which could support approximately 6 months of storage, assuming 5kB per data record and 1000 records per day). Depending on the analysis type, each record could range from 3kB to 500kB. For examples:

- 3GPP Analysis application has an average of 3kB per data record
- Channel Occupancy application with 100 channels per band has approximately 26kB per data record.

The cached data will be uploaded to the cloud at the next internet availability to the node, whether the node is being powered off in the internet offline period.

Data Retention

Once uploaded to the cloud, the data records are retained with the most recent 1 year for fast data retrieving. Beyond 1 year, the historical data will be stored up to 2 years using slower cloud data access means. Should a longer historical data storage be needed, please contact thinkRF.

Note: The data is only accessible to the authorized users, who own the nodes. Upon the users' request, the cloud data might be further segregated into a separated cloud system at a cost.

Software Update

To ensure optimal performance and access to the latest features, it is essential to regularly update the nodes' software. Nodes with internet connectivity will receive automatic updates whenever new versions are available. Users do not need to take any action, as thinkRF manages the software updates seamlessly.

Offline nodes (including nodes in the storage) should be powered on at least once a month for at least one hour in an area with good cell reception to ensure it can receive over-the-air updates. The update could also be done faster with a direct Ethernet connection to a LAN network with internet.

Warning: The node should **not** be idled for more than 3 months without an update.

Note: a node should be updated before bringing the node to a remote site without any internet connectivity.

Accessing SXM API

thinkRF SXM solution provides REST APIs for SXM real-time data collected from the SXM nodes in the field and stored in the cloud.

To use the SXM API with a valid subscription, contact thinkRF Support to receive the client and secret for your token generation, along with the SXM API User Guide. Once the necessary information is obtained, please follow the SXM API User Guide to access the API.
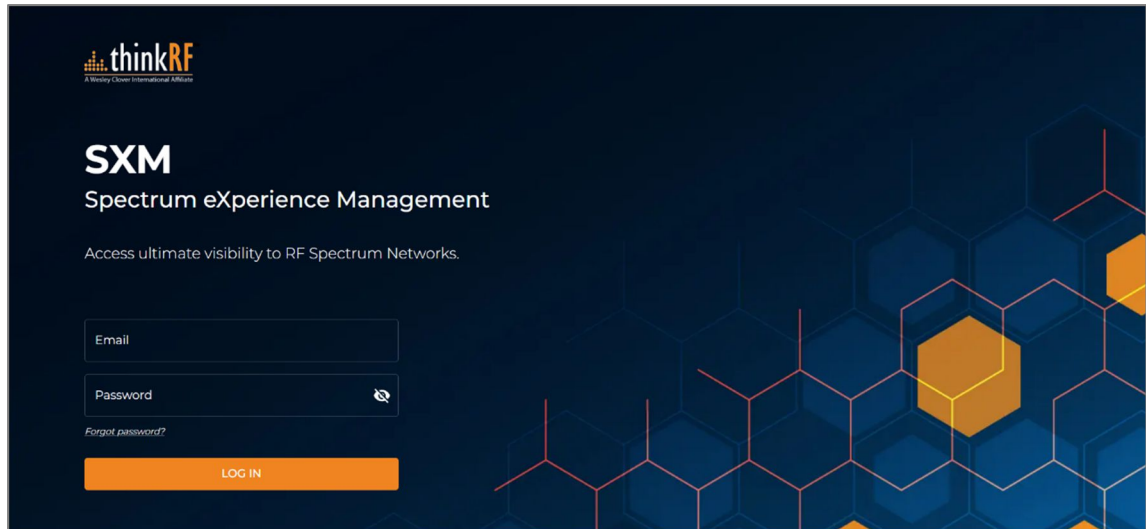
Accessing SXM Dashboard

To use the Dashboard, you must have a valid account first, whether provided by thinkRF or by your corporate account's administrator.

Accessing the Web Application

1. Open your preferred web browser.
2. In the address bar, enter the following URL: sxm.thinkrf.com.
3. Press Enter to navigate to the login page of the SXM Portal.
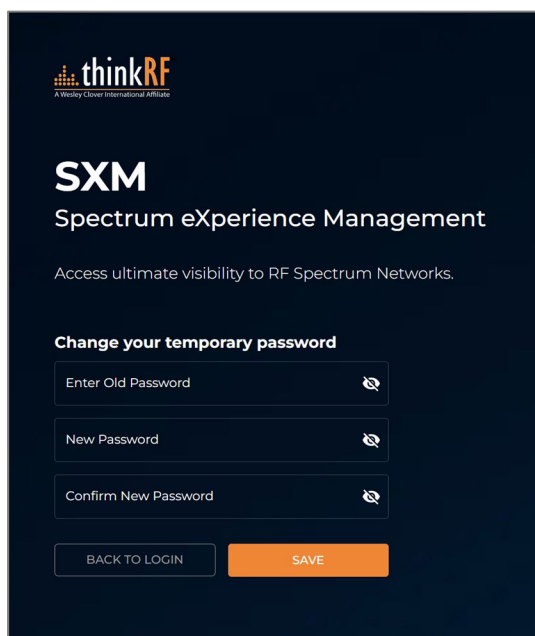
Logging In

4. On the login page, enter your credentials:

- **Email:** Your assigned email address.
- **Password:** Your password is associated with your email. Please ensure the accuracy of the characters entered, as passwords are case-sensitive.

   If you have forgotten your password or need a password reset, use the "Forgot password?" option.

Set a New Password

If it is your first time logging in after your administrator provided your temporary password, you will be taken to a page to change your temporary password.

You will be asked to input your temporary password, followed by your new password. Please ensure your password meets the following requirements:

- Minimum 8 characters long

- At least one uppercase letter
- At least one lowercase letter
- At least one number
- At least one special character

If the password requirements above are not met, an error message will be shown.

Using the Dashboard

After you have successfully logged in, please refer to the Dashboard User Guide, located in the Help section of the Dashboard for more information.

Local Control Application

The Local Control application provides users access directly to the node via the Ethernet connection from the users' computer. With this application, users can check for the node's various status, run the built-in self-test, configure the signal analysis application, or download a copy of the collected data files.

This application will be available in the third quarter of 2024.

Document Revision History

This section summarizes document revision history.

Document Version	Release Date	Revisions and Notes
v1.0	05/30/2024	First document release.

v1.1	06/20/2024	- Added Node Reboot section
		- Added new sections to SXM Node Software:
		  + System Operation
		  + Signal Analysis' Data Operation

v1.2	07/22/2024	- Fixed a link issue in Hardware Installation section and minor update - Removed mentioning of all "In the near future release" - Updated Signal Analysis' Data Operation and added subsections - Updated Node Maintenance Plan section with additional information on End-of-life procedure and calibration - Minor clarification across the document
V1.3	10/01/2024	- Minor updates to align with French language version