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Introduction

LTE offers a valuable last mile access option for remote locations, kiosks, temporary sites, vehicle communications and machine-to-machine applications. Benefits of 4G wireless access include reach, mobility, cost (depends on usage and plan) and performance. This document is focused on Cisco ISR LTE performance based on signal quality due to antenna type and placement. The information is appropriate for Cisco 1900, 2900, 3900 with EHWIC-4G-LTE-V, C819G-4G-V, and CGR2010 with GRWIC-4G-LTE-V. This document is organized in the following fashion:

- Very brief guidelines for antenna selection and placement
- General guidelines for antenna selection, placement and installation
- Detailed guidelines for antenna selection, placement, installation, and confirmation
- Sample configuration for retrieving LTE status, radio signal and ping results via text message
- Frequently Asked Questions

Very Brief Guidelines for Antenna Selection and Placement

1. All platforms ship with quantity 2 4G-LTE-ANTM-D indoor dipole antennas. Always connect both antennas.
2. Antennas should always be placed more than 17" apart. The only way to do this is to use an antenna cable with at least one of the antennas. At least one 10' cable with base (4G-AE010-R) ships with every Cisco LTE device. (C819G-4G-V units shipped before October 2013 may not include a cable; one can be purchased separately)
3. If after confirming a correct software image, software configuration, a properly enabled SIM, and connected antennas, there is no LTE connection or low performance, review the general guidelines that follow. For software image and configuration recommendations, see the Verizon LTE deployment guides at www.cisco.com/en/US/products/ps5949/products_installation_and_configuration_guides_list.html
4. Use of a separate "bridge" LTE device added to an ISR (instead of an ISR LTE interface with good antenna placement) is not recommended. LTE bridges connect to an ISR via Ethernet and have these characteristics:
    a. Allow the use of inexpensive unshielded twisted pair cabling instead of a low loss antenna cable
    b. Negatively affect the ability of the ISR to know the actual status of LTE WAN connection
    c. Impair remote site management (visibility into the LTE specifics: RSSI, RSRP, RSRQ, SINR)
    d. Impair troubleshooting (no remote DM Logging, no output detail from IOS LTE modem status)
    e. Disallow LTE modem tuning and control from the ISR (e.g. no automation of those functions)

    ISRs have indoor and outdoor antenna options/SKUs that allow the antenna to be placed up to 75 feet away, while still providing the advantages of a single integrated solution.

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General Guidelines for Antenna Placement, Selection, and Installation

There are some common issues for not achieving an LTE connection or for poor LTE performance. These should be checked, and if needed, corrected:

1. The appropriate IOS version is not installed, or the configuration used is affecting data connection. Please see the appropriate deployment guide at www.cisco.com/en/US/products/ps5949/products_installation_and_configuration_guides_list.html

2. An Internet LTE connection becomes active for less than a minute, then disconnects, reconnects, disconnects again, continuously (log messages such as "Cellular interface is up"…down…up…down). All packets leaving the ISR onto the Verizon LTE network must have the ISR cellular interface's IP address as the source address. Non-conforming packets are IP packet violations and the LTE network will disconnect the ISR cellular interface. This is a configuration issue resolved by using the appropriate guide from the link above (all traffic NAT'd, or encapsulated in a VPN tunnel).

3. The SIM is not seated properly. Checked with "show cellular x hardware", to ensure that the MSISDN and ICCID are seen. If not seen after 10 minutes after bootup: Power off ISR, remove and reinstall SIM, power on ISR, await boot-up, and check again.

4. The SIM is not provisioned properly or is not enabled. One way to check to so put the SIM in a working 4G device. Another check is to review the output from "show cell x network" and ensure that "no service" is **not** seen (shown below, means no attach to the IMS APN, which is needed before the data APN attach can occur. The Current Service Status should be "Normal").
   Network Information
   ==========
   Current System Time = Tue May 13 15:11:20 2014
   Current Service Status = **No service**

5. The LTE service is MPN or Public/Static, and the appropriate APN is not set on the LTE modem. The value is seen via IOS enable mode command "show cell 0/x/0 profile" (x = eHWIC slot #0) or "show cell 0 profile (for C819G-4G-V). Please see the MPN planning guide or Public/Static IP guide for how to correct. www.cisco.com/en/US/products/ps5949/products_installation_and_configuration_guides_list.html

6. The IMS profile is set to IPv4 (see profile 1 from "show cell x profile" command). For instructions to reset to IPv6, open a Cisco TAC service request. The proper output is shown below.
   Profile Information
   ==========
   Profile 1 = INACTIVE **

   PDP Type = **IPv6**
   Access Point Name (APN) = vzwims

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7. A single antenna is connected, and that antenna connected to the M1/DIV port instead of the M0/MAIN port. An LTE connection will usually not be made. Both antennas should be installed.

8. A single antenna is connected to M0/MAIN port (no antenna connected to M1/DIV port). This will affect downlink performance. Both antennas should be installed.

9. The antennas are not securely tightened. The antennas may not remain vertical (the appropriate position for a dipole) or the loose connection will yield intermittent or lower signal quality all connectors should be tight.

10. Both antennas are directly connected to the ISR. This may reduce LTE performance of the ISR. At least one antenna should be connected via an extension cable (supplied) and antennas separated by 18 inches.

11. Antennas not positioned for optimal reception. Antennas should be placed outside any metal or thick walled (concrete, brick, etc.) enclosure, preferably either close to a window or on a higher floor (e.g. not in a basement). The appropriate antenna installation guide should be reviewed and followed (see next item).

12. The Cisco antenna was not installed as recommended. Please see the following installation guide: www.cisco.com/en/US/docs/routers/access/interfaces/ic/hardware/installation/guide/EHWIC34G3LTEHW.html

13. Antennas used are not 4G-compatible or are non-Cisco. It is possible to obtain reception with 3G antennas or non-Cisco 3G/4G antennas, but the signal strength and/or quality may not be sufficient for a high performing 4G environment. Additionally, 3G and non-Cisco antennas are not supported by Cisco for 4G deployment.

14. The signal strength or quality is insufficient. Please see the next section.

15. Everything seems correct, and still cannot get an LTE connection, or the LTE performance is unacceptable. Gather the following and open a Cisco TAC services request.

    - Brief summary of the design or test setup, List of the issues. The following ISR console output:
    - term len 0, sh flash, sh ver, sh run, sh ip int brief, sh ip route, sh line, sh dialer
    - sh int cell 0/x/0, sh cell 0/x/0 all, sh cell 0/x/0 rad hist all (find x from "sh ip int brief" or just 0 for 819)
    - debug chat, debug dialer, (wait a few minutes), undebug all
    - sh log, sh controller cell 0/x/0 (find x from "sh ip int brief" or just 0 for 819), term len 24

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Signal Strength and Quality:

The effect of LTE signal strength and quality on the ISR performance on Verizon Wireless LTE is considerable. A weak or low quality LTE signal degrades throughput by more than 80%, and can reduce the efficiency of an LTE sector (the 120 degree area around a cell tower) that affects the remote site (and likely other devices nearby).

2 questions: How to know if the LTE signal strength and quality are "good" and what can be done if it's not "good".

Is the LTE signal strength and quality "good"? Cisco ISRs and CGRs with embedded LTE interfaces provide benefits for performance, security, routing and management, which are equivalent across these product lines. As part of management functions, the router provides detailed radio statistics and logs. To check the LTE signal strength and quality, a simple "show" command is used. Sample output is shown below, followed by the meaning of the important values and current suggestions for what may be considered "good" values.

Values are "good"

```
819r6DM#show cell 0 radio
Radio power mode = ON
Channel Number = 5230
Current Band = LTE
Current RSSI = -54 dBm
Current RSRP = -79  dBm
Current RSRQ = -9  dB
Current SNR = 14.4  dB
LTE Technology Preference = AUTO
LTE Technology Selected = LTE
```

Values show need for antenna placement/change

```
819H#show cell 0 radio
Radio power mode = ON
Channel Number = 5230
Current Band = LTE
Current RSSI = -65 dBm
Current RSRP = -100  dBm
Current RSRQ = -16  dB
Current SNR = -4.1  dB
LTE Technology Preference = AUTO
LTE Technology Selected = LTE
```

Different LTE devices types measure RF values differently. A smartphone app may yield different results than an ISR. It is recommended to measure the signal using an actual ISR (all 4G ISRs/CGR use the same LTE modem and will yield similar results). The values below are not absolute. Good performance may be obtained with results outside of the "good" values and vice versa. A speed/performance test should be done over the ISR LTE connection and used in conjunction with the suggestions below to determine if antenna placement/replacement is needed.

- **RSSI**: Received Signal Strength Indication – a generic radio receiver technology metric for signal strength. Measures both usable signal and noise. Rated in dBm
  - **"Good" value is greater than -80 dBm** (e.g. -79 is greater than -80)
- **RSRP**: Received Signal Reference Power – the average of the power received of all radio resource elements that carry cell-specific reference signals. Measures usable downstream signal. Rated in dBm
  - **"Good" value is greater than – 105dBm** (e.g. -104 is greater than -105)
- **RSRQ**: Reference Signal Received Quality – the ratio of usable signal usable+noise signal (RSRP-RSSI). Measures how close the usable signal is to usable+noise. Rated in dBm.
  - **"Good" value is greater than -12dBm** (e.g. -11 is greater than -12)
- **SNR**: Signal to Noise (Interference) Ratio – The ratio of usable signal to noise (plus interfering) signal. Measures how much of the total signal is usable by comparing usable to noise. Rated in dB
  - **"Good" value is greater than 5 dB** (e.g. 6 is better than 5)

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If the output of the "show cellular 0/x/0|0 radio" command is different than above and shows the "Technology Selected" is eHRPD, only RSSI will be provided. This means that the LTE signal received is not present, or the LTE signal was not good and the 3G signal was better and selected for use. The remediation is the same as not getting a "good" LTE signal, but with an additional caveat listed in the Q&A section (LTE reselection). The way to determine which is the case (no LTE signal or LTE signal not "good") is to force the LTE interface to only use LTE. Note that the forcing is "permanent"…an ISR reload will not change the radio "preference" to "auto" (to return it to "auto" issue the command again as shown below). Also, if not LTE signal is present, no cellular connection will be made with this setting, thus this test may affect data transfer.

- Run the following enable-mode IOS command: cellular 0/x/0 lte tech lte (where x is the LTE eHWIC slot number) or cellular 0 lte tech lte (for 819).
- Issue the show cell 0/x/0 radio (for LTE eHWIC, or show cell 0 radio for 819) again and review the values
- To return the setting to its default: cellular 0/x/0 lte tech auto (or cellular 0 lte tech auto for 819)

What can be done if the LTE signal strength and quality are not "good"? There are two common actions that can be taken to improve the signal: Relocate one or both antennas for better reception, and/or use antennas that are more appropriate (meet the needs of that location and use).

Relocating antennas: Placement of the existing 2 antennas can make a significant performance difference due to multipath interference, proximity to walls or structures that inhibit the signal, and proximity to devices emitting interfering radio signals. This is especially the case where the ISR in located in a metal enclosure (kiosk, ATM) or a room that significantly inhibits the signal. In these cases, the antennas should be placed outside the enclosure/room using antenna cables as mentioned below.

Depending on the ISR model and what was ordered, 1 or 2 ten foot extension antenna cables are included with the ISR. The antenna connected to the connector labeled "M0/MAIN" can be extended using this supplied cable (antenna cable connects to antenna cable's base and to ISR, no adapters needed). This allows placement up to 10 feet away. By moving the main antenna to different usable locations, the best location can be determined. The antenna connected to M1/DIV can be left connected directly to the ISR, or if there is a 2nd cable, it can be used.

- Record the radio statistics (from the "show" command) before attaching cable(s) and moving antenna(s)
- Connect the cable(s) and move the antenna(s) to a different location. Wait 1 minute, then record the radio statistics and mark the antenna location(s).
- Repeat the previous step as feasible for various antenna placements.
- Choose the best placement from the above test, and check to see if all the signal values are "good". If so, move the antenna(s) to the location(s) permanently.

What if no nearby antenna location provides "good" LTE signal? The ISR can be moved to another location and the test repeated. This can be done even if the location is not feasible for permanent installation. By determining if there is a better location for reception, longer antenna cables can be ordered for the permanent installation. Up to 75 foot LTE antenna cables are available from Cisco as standard SKUs. Note that for indoor antennas (such as the supplied dipoles) proximity to a window may provide improved signal strength.

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Choosing more appropriate antennas: This option can help overcome issues such as weak signal due to distance from LTE cell towers, signal loss or noise due to physical location, or signal obstruction. The challenge is the availability of various antennas to test with, as these are optional and purchased separately. When there are issues obtaining “good” LTE signal, and placement of the existing dipole antennas does not resolve it, a site survey from a service provider is recommended. If this is not feasible, the following guidance may assist in determining the appropriate antennas to acquire. Again, a site survey from a provider who can bring various antennas is best.

- The included dipole antennas are sufficient for most locations. Placement near a window, on upper floors may assist with signal reception. The thin low-loss extension cables with Cisco SKUs may be needed.
- Where an indoor antenna cannot be placed near a window, use of the indoor ceiling mount antenna in an open area may assist in achieving better signal. The thin low-loss extension cables with Cisco SKUs may be needed.
- If there is no location within the building where “good” signal can be obtained. External antennas can be used. Use of external antennas greatly reduces physical obstruction, allowing a stronger signal received. If there are multiple cell towers nearby and the signal is weak, an omnidirectional antenna with higher gain can be used. If there is only 1 cell tower nearby and the signal is weak, a directional antenna can be used.
    - Outdoor LTE antennas and cables available for CGR 2010 function with ISR LTE eHWIC/819.
- All Cisco LTE antennas and cable also operate with 3G and 2G

Resolving fallback from 4G to 3G: Locations may experience fallback from 4G LTE to 3G EVDO. This can be caused by the LTE signal being below a certain level (even for a moment), and the EVDO signal being above a certain level. The radio access technology (RAT) chosen by an LTE device is based on 3GPP specification and the radio signal reception of the device's LTE modem. The RAT value can be seen from the ISR "show cell x radio" enable-mode command. LTE 3G-to-4G reselection requires the connection to be dormant for 7-10 seconds in the Verizon LTE network. For a mobile phone, return to LTE is feasible. For a router with multiple devices behind it, the user traffic, keep-alives, and normal protocol messages may keep a dormancy period from occurring for hours or days. Another factor is that even a transient condition can cause the LTE modem to choose 3G. Below are two mitigation options:

- Confirm that the ISR is at a stationary location and has consistently acceptable LTE signal. If so, lock the connection to LTE (IOS enable-mode command "cellular x lte tech lte"). The modem will only connect to LTE. If there's no LTE signal, no connection will be made. This setting is permanent (until overridden by setting "tech" back to "auto").
- Either manually or via EEM, check RAT. If on 3G, power off/on the modem's radio. This will cause a brief disconnect (IOS config: "controller cell x", "lte radio off", "no lte radio off").

Information on Cisco LTE antennas as cables can be found at these locations:
www.cisco.com/en/US/docs/routers/access/interfaces/ic/hardware/installation/guide/EHWIC-4G-LTEHW.html

- LTE installation guide for ISR

www.cisco.com/en/US/docs/routers/connectedgrid/antennas/installing/Multi-purpose_Integrated.html

- CGR antenna installation guide

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Detailed Guidelines for Antenna Selection, Placement, Installation, and Confirmation

This section will be added to over time. Understanding the output of the "show cell x radio" command along with the performance test results can be used to determine if the performance is acceptable. Assuming that the performance testing is done so as it minimize the influence of the test server and LTE network congestion, and that the RF values are tracked and mapped to the performance test instance, valuable insight can be gained to determine antenna placement and type.

If RSSI is high but RSRP is low (more than 30dBm less), there is potentially strong signal but with significant interference. If a different inside antenna placement does not resolve (e.g. antenna near window, on a high floor), then the interference may be from inside the building. An outdoor antenna may improve the RF signal quality.

If RSSI is low, there is potential that the LTE signal is weak. If a different inside antenna placement does not resolve, an roof-mounted outdoor antenna may increase the signal strength. If the building/site location is simply far from the LTE cell tower, a directional outdoor antenna may yield a stronger signal. Outdoor antennas on buildings are best installed above the roof line, or as high up on an exterior wall as is feasible (preferably above the roof line).

If RSRQ and SNR are relatively low, the amount of usable signal is relatively low. How low depends on the RSSI and RSRP levels. If all are low, then the signal is weak, and also not of sufficient quality. Better inside antenna placement may still yield good results (especially if the ISR is on a ground or below-ground level, via placement on a higher floor). If this doesn't yield acceptable results, an outdoor antenna (omni-directional or uni-directional) may yield improvement.

Changes in data throughput/performance on different days or at various times during the day can have different causes. There may simply be increased use by other LTE devices in the cell sector. This can be confirmed by viewing RF results in times of good and less-than-good periods, and comparing them. If the RF results are not significantly different, this points to LTE congestion in the geographic area. Unless the RF results are not "good", antenna placement/replacement may not yield substantial improvement. If the RF results are significantly different, then a temporary obstruction or interference source may be affecting performance. Look for sources such as nearby cable or over-the air broadcasting sites, cable TV set-top-boxes close to antennas, Femto-cells or cable tv distribution enclosures in the same or nearby building, a vehicle with a "cell jammer" that is near the building at certain times, nearby 700mhz wireless microphones turned on at certain times, garage door openers and other equipment with 700mhz remote controllers, some types of fluorescent bulbs that emit 700mhz frequencies, etc.

Detail information is available on cisco.com, including these links:

CGR-2010 detailed antenna guide with 6 different antenna use cases and SKUs, usable for ISRs:
www.cisco.com/en/US/partner/docs/routers/connectedgrid/antennas/installing/Overview.html

Cisco 4G LTE Antenna Guides:

www.cisco.com/en/US/docs/routers/access/wireless/hardware/notes/4G3G_ant.html
www.cisco.com/en/US/docs/routers/access/wireless/hardware/notes/antcm4gin.html
www.cisco.com/en/US/docs/routers/connectedgrid/antennas/installing/4G_LowProfile_Outdoor_Saucer.html
www.cisco.com/en/US/docs/routers/connectedgrid/antennas/installing/Outdoor_Omni_for_2G_3G_4G_Cellular.html
www.cisco.com/c/en/us/td/docs/routers/access/wireless/hardware/guide/antenna/4glteantmo3.html

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LTE Site Survey via SMS: Overview

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LTE Site Survey via SMS: Details

survey

survey says

LTE Site Survey via SMS: Requirements

3.

4.

5.

6.

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LTE Site Survey via SMS: Installation

https://supportforums.cisco.com/document/12316801/commands-over-sms

commandoversms.tcl

event manager directory user policy "flash:/"

event man pol commandoversms.tcl type user

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LTE Site Survey via SMS: Sample Installation and operation

```
VZW-SP-MPN-1#sh ver | i IOS
Cisco IOS Software, C800 Software (C800-UNIVERSALK9-M), Version 15.3(3)M2, RELEASE SOFTWARE
(fc1)
```

```
VZW-SP-MPN-1#copy tftp flash:
Address or name of remote host []? 172.21.12.3
Source filename []? commandoversms.tcl
Destination filename [gps_geofence.tcl]? <hit enter>
Accessing tftp://172.21.12.3/gps_geofence.tcl...
Loading gps_geofence.tcl from 172.21.12.3 (via Vlan1): !
[OK - 8206 bytes]

8206 bytes copied in 0.672 secs (12211 bytes/sec)
```

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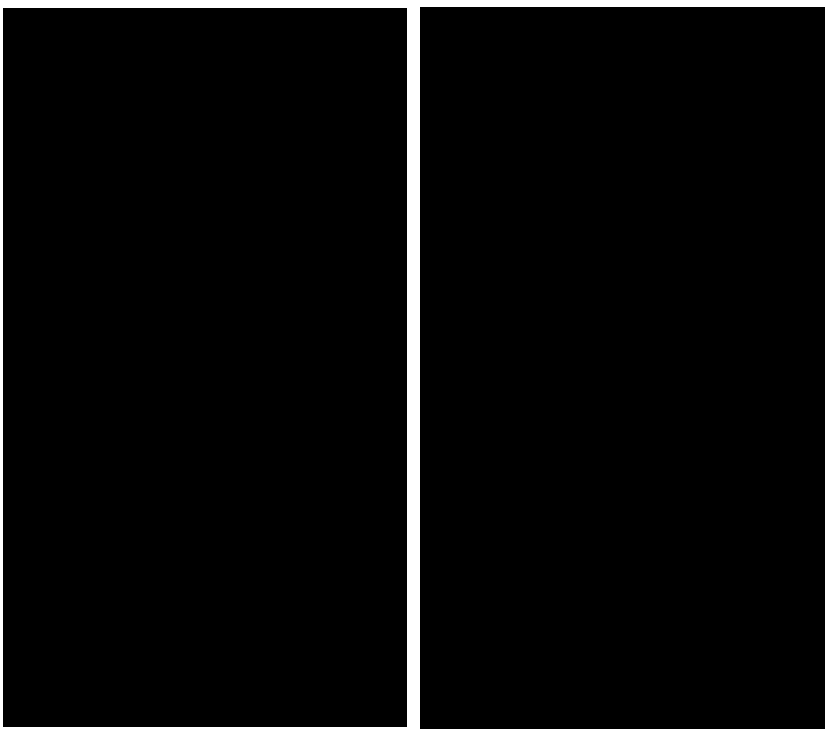
```
VZW-SP-MPN-1#sh cell 0 hardware
Modem Firmware Version = SWI9600M_03.05.10.06
Modem Firmware built = 2012/11/12 15:07:45
Hardware Version = 10
International Mobile Subscriber Identity (IMSI) = 311480039221159
International Mobile Equipment Identity (IMEI) = 990000820118364
Integrated Circuit Card ID (ICCID) = 89148000000386223318
Mobile Subscriber International Subscriber
IDentity Number (MSISDN) = 14082067973
Current Modem Temperature = 29 deg C
```

```
VZW-SP-MPN-1#copy running startup
Destination filename [startup-config]?
Building configuration...
WLAN_AP_SM: Config command is not supported
[OK]
```



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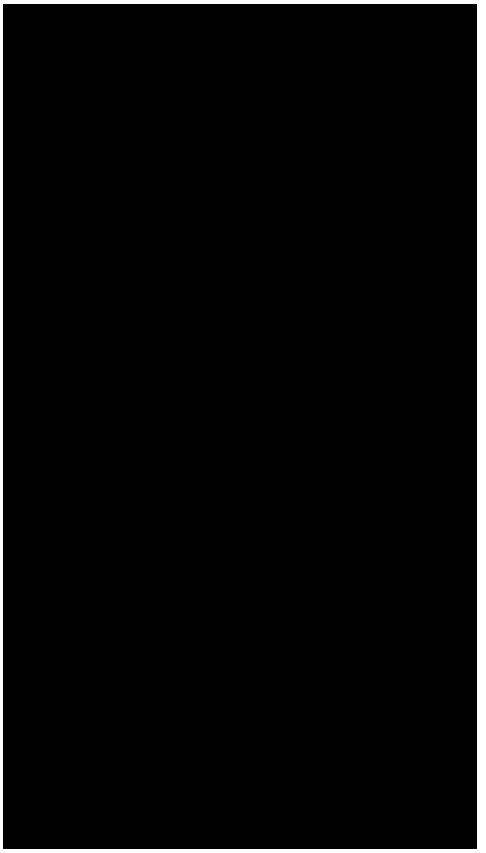

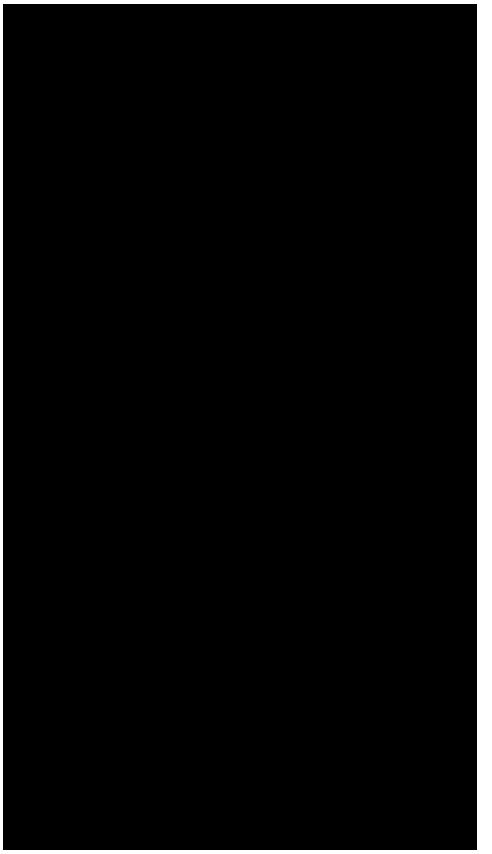

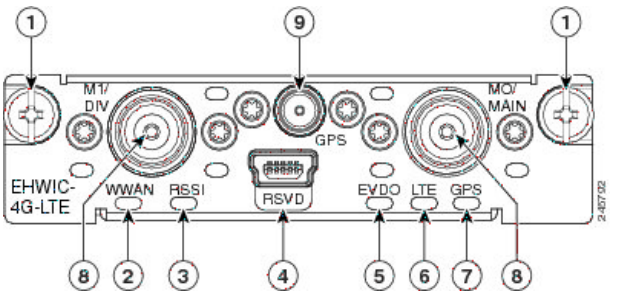

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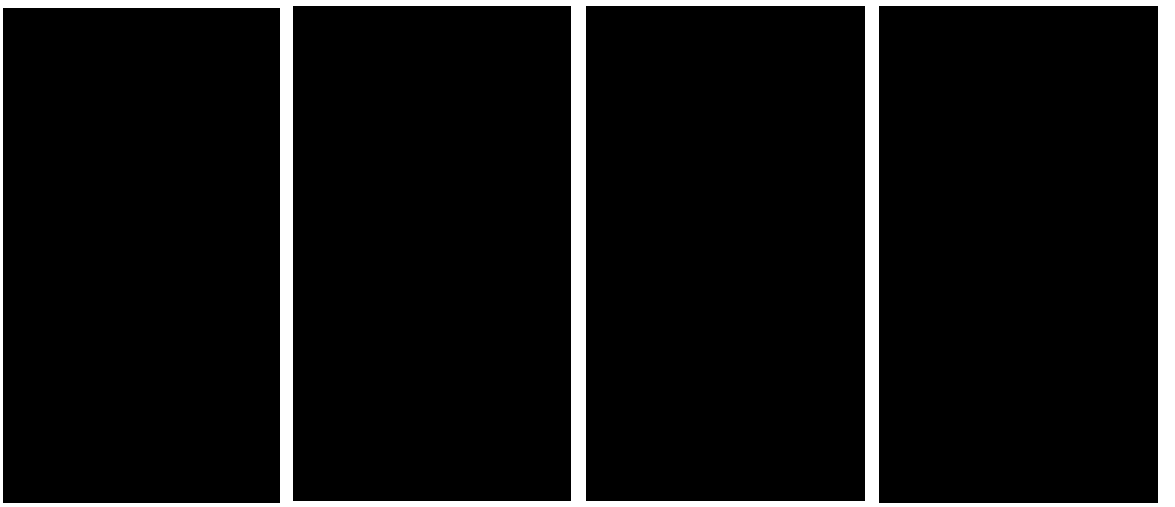
ISR Status via SMS: Overview

ISR Status via SMS: Details

ISR Status via SMS: Sample Installation

ISR Status via SMS: Sample Operation



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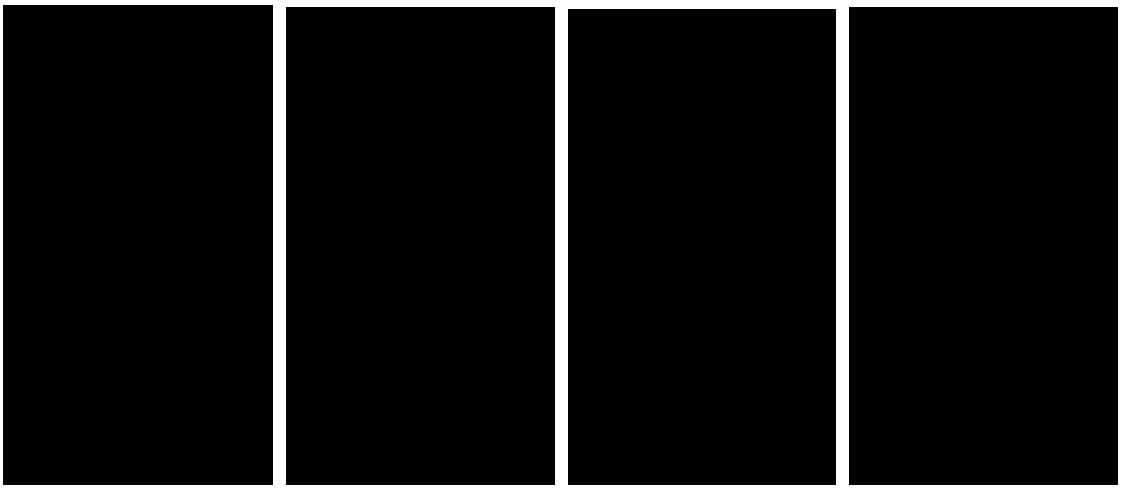

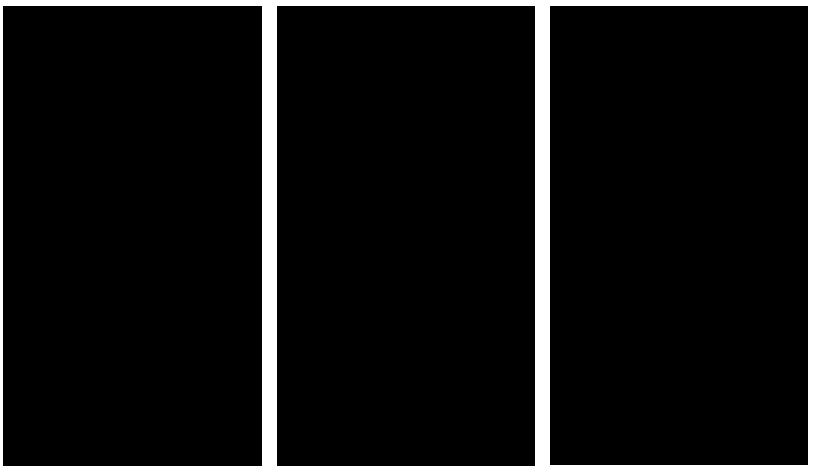

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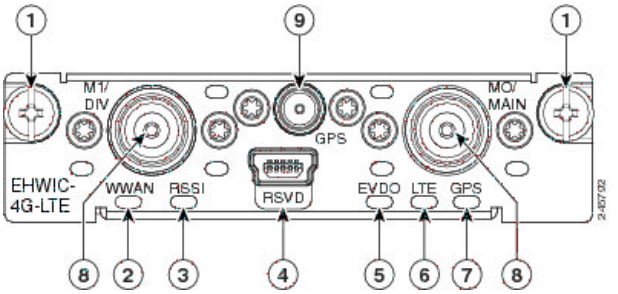
LTE Antenna Frequently Asked Questions



1	Mounting Screws	2	LED—WWAN
3	LED—RSSI[1]	4	RSVD (reserved) port, USB 2.0 mini type B
5	LED—EVDO[2]	6	LED—LTE
7	LED—GPS[3]	8	Antenna Connectors—M1/DIV, M0/MAIN
9	Antenna Connector—GPS		

[redacted]

1	4G Antenna connector—M0/MAIN	8	GE WAN port
2	LEDs	9	Console/Aux port
3	Reset button	10	Power input
4	4G/3G port	11	Power switch
5	4G Antenna connector—M1/DIV	12	Active GPS antenna connector
6	Serial port	13	Ground
7	FE ports		

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Cisco Part Number	Description	Maximum Gain and Frequency Ranges	Notes
4G-LTE-ANTM-D	Indoor 4G dipole omnidirectional	2 dBi • 698-806 MHz • 824-894 MHz • 925-960 MHz • 1710-1885 MHz • 1920-1980 MHz • 2110-2170 MHz • 2500-2690 MHz	Multiband dipole antenna. For more information, see Cisco 4G/3G Omnidirectional Dipole Antenna (4G-LTE-ANTM-D).
4G-ANTM-OM-CM	Indoor ceiling-mount omni-directional	698 MHz-2690 MHz	Multiband omnidirectional ceiling-mount antenna. For more information, see Cisco 4G Indoor Ceiling-Mount Omnidirectional Antenna (4G-ANTM-OM-CM).
4G-AE010-R	Extension base with integral 10-foot cable	0.7-6.0 GHz	This is the default antenna extension base. For more information, see Cisco Single-Port Antenna Stand for Multiband TNC Male-Terminated Portable Antenna (Cisco 4G-AE015-R, Cisco 4G-AE010-R).
4G-LTE-ANTM-O-3	Outdoor omni-directional combination LTE/GPS	698-960 MHz 1710-2700 MHz	Dual LTE-Single GPS Multi-band Indoor/Outdoor Antenna (when used indoors, for GPS signal to be received, there must be line of sight to the sky or a separate in-building GPS signal repeater.

Includes DUAL multi-band swivel faceplate mount dipole 4G-LTE-ANTM-D antennas and DUAL 10ft base extender 4G-AE010-R

1	**EHWIC-4G-LTE-V**	4G LTE EHWIC for Verizon, 700 MHz Band 13 / CDMA Rev A
0	**4G-LTE-ANTM-D**	4G LTE articulating dipole antenna 700MHz-2600MHz bands
0	**4G-ANTM-OM-CM**	Multi-Band Indoor Omni-Directional Antenna - Ceiling Mount
0	**4G-CAB-LMR240-25**	25-ft (7.5M) Low Loss LMR-240 Cable with TNC Connector
0	**4G-CAB-LMR240-50**	50-ft (15M) Low Loss LMR-240 Cable with TNC Connector
0	**4G-CAB-LMR240-75**	75-ft (22.5M) Low Loss LMR-240 Cable with TNC Connector
0	**4G-AE010-R**	Single Unit antenna Extension Base (10 foot cable included)

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Item	Specification
N	Outdoor Use

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N	Outdoor Use
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Item	Specification
N	
N	

www.cisco.com/en/US/prod/collateral/routers/ps10967/ps10977/datasheet_c78-696807_ps10984_Products_Data_Sheet.html

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