Iridium 9604
End Device Production and Validation Guide

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Revision History

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1.0	May 2026	Initial Release

Documentation Feedback

To provide feedback on this document, open a ticket in the Partner Support portal (Iridium Service Desk) and under Component select Document Feedback.

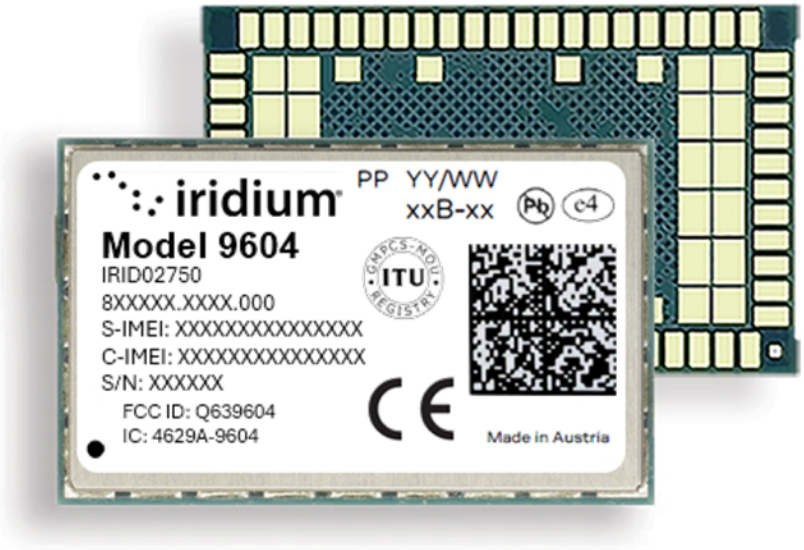
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1. Introduction

This document provides guidelines for effective production testing and prototype validation for hardware applications integrating Iridium® 9604 hybrid cellular + satellite IoT transceivers.



1.1. Document scope and structure

This document covers guidelines for efficient testing in the production line, and for effective prototype hardware design verification and validation of end-devices integrating Iridium 9604 transceivers, with a special focus on the +UTEST AT command.

The production line testing and prototype hardware design validation are crucial steps in the product life cycle process before a device's deployment. Efficient testing in the production line and effective design verification/ validation not only reduces the time to market and device costs, but also ensures a robust product, adhering to the functional and conformity specifications and requirements. As a general rule, identifying an issue earlier makes it easier and more cost-effective to create a solution.

Guidelines for efficient testing in production line of end devices integrating Iridium 9604 transceivers are provided in Section 6.

Guidelines for efficient prototype hardware design verification and validation of end devices integrating Iridium 9604 transceivers are provided in Section 7.

Proprietary AT commands are used to execute testing in production. The +UTEST=0 and +UTEST=1 AT commands, described in Section 2, enable the production non-signaling test mode, for cost-effective testing of the cellular RF interface and the transceiver I/O pins. A brief description of the non-signaling test mode, as compared with the normal operating signaling mode, is included in Section 1.2.

Additionally, the +UTEST=2 and +UTEST=3 AT commands, described in Section 3, allow to set the cellular system of the transceiver in specific transmitting and receiving states. This eliminates the need for live cellular network coverage or costly cellular network simulator equipment. Only basic RF test equipment, such as a spectrum analyzer (or an RF power meter) and, optionally, a signal generator are required, further reducing production time and costs.

For transceivers supporting the dynamic antenna tuning feature, OEMs may wish to configure such feature while applying their settings on the production line. This is achieved with the +UTEST=4 command described in Section 4.

Finally, the +UTEST=10 AT command, described in Section 5 of this document, performs functional testing on the digital pins of the transceiver.

The +UTEST=3 command sets the cellular system of the transceiver to emit RF power ignoring cellular signaling protocol while operating in non-signaling test mode. This emission may generate interference that is prohibited by law in some countries. Only qualified users are allowed to use this feature which is intended for testing purposes in controlled environments only.

None of the commands described in this application note are to be used for product certification approval or RF performance measurements. For certification approval guidelines, see the *Iridium 9604 Hardware Development Guide* [3].

The use of the non-signaling test mode shall be restricted to controlled (shielded chamber/box) environments and for test purposes only. Improper use of the Non-Signaling Test mode and related AT commands on a real network could disturb other users and the network itself.

Iridium and the manufacturer of the Iridium 9604 assume no responsibility for the inappropriate use of the non-signaling test mode.

1.2. Normal signaling mode and Non-Signaling Test mode

Iridium 9604 transceivers have two working modes:

- **Normal operating mode / signaling mode**: the transceiver can access cellular and satellite networks. All the functionalities are enabled according to the normal operation status (idle mode, active mode, connected mode); this is the typical operating mode of the transceiver.
- **Production mode / non-signaling test mode**: the transceiver cannot access cellular or satellite networks. The software providing support to the network signaling protocols is not running. The test interface allows direct access to the basic transceiver and chipset functionalities, but only for functional testing of the hardware and of the transceiver RF subsystem.

After booting, the transceiver starts by default in signaling mode, offering full functionality. Then, to enter non-signaling test mode issue the AT+UTEST=1 command after having disabled the protocol stack with the AT+CFUN=0 command. Refer to the *Iridium 9604 AT Command Guide* [1] for details on the use of AT commands.

Once having entered the non-signaling test mode, the non-signaling transmission can be triggered by issuing the AT+UTEST=2 command, while AT+UTEST=3 allows to retrieve the received signal strength.

If the non-signaling test mode is deactivated by issuing the AT+UTEST=0 command, a reset or a power-off / power-on cycle is performed, the transceiver is reverted into normal mode.

The transitions between normal (signaling) and test (non-signaling) modes are shown in Figure 1.

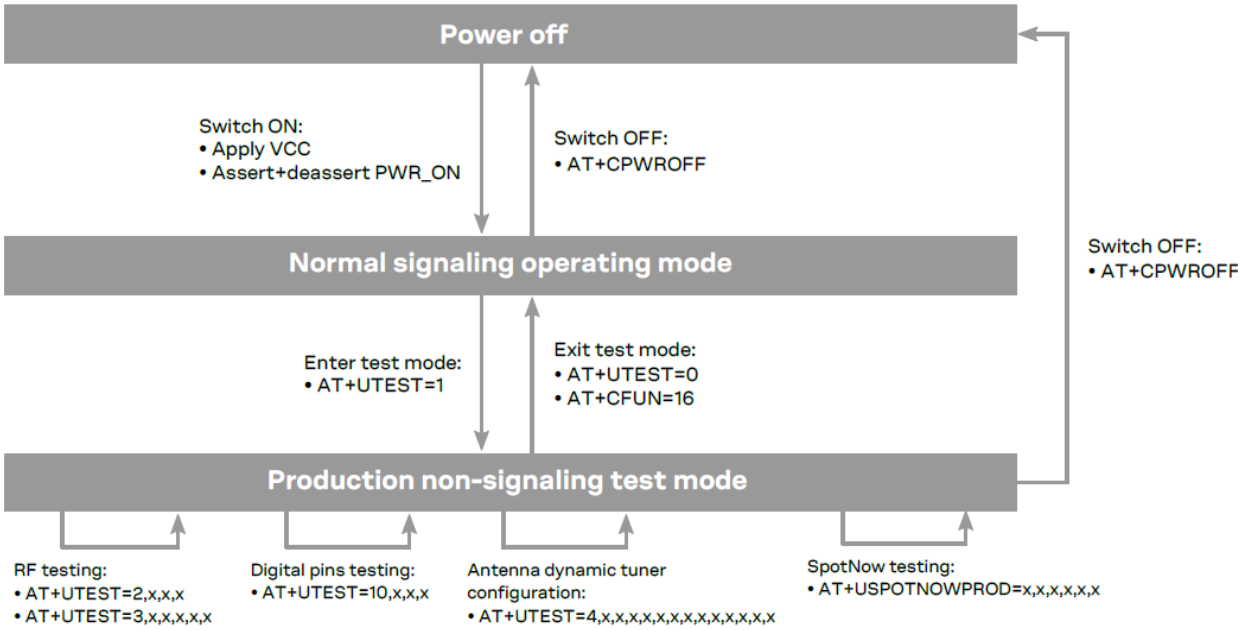


Figure 1. Transceiver State Transition Between Normal Mode and Test Mode

In normal mode the only allowed +UTEST command is the AT+UTEST=1 used to enable the testing interface. All other +UTEST commands return an error result code (+CME ERROR: operation not allowed or +CME ERROR: 3, depending on the +CMEE AT command setting).

In test mode the transceiver only accepts +UTEST commands. Do not send any other command as any other command will either return an error result code or lead to undefined behavior.

1.3. Referenced Documents

For the latest Iridium partner documentation, log in to the Iridium for Partners (IFP) website at https://ifp.iridium.com/login and then go to the Resources section.

No.	Document	Description
1	IRDM-5220-ICD-001	*Iridium 9604 AT Command Guide*
2	IRDM-5220-UDOC-003	*Iridium 9604 Technical Reference Guide*
3	IRDM-5220-UDOC-001	*Iridium 9604 Hardware Development Guide*
4	IRDM-5220-UDOC-002	*Iridium 9604 Software Developer Guide*
5	UBX-21035062	u-blox M10 standard-precision GNSS chip interface manual (contact u-blox)
6	3GPP TS 51.010	Technical Specification Group GSM/EDGE Radio Access Network; Mobile Station (MS) conformance specification
7	3GPP TS 34.121	Technical Specification Group Radio Access Network; User Equipment (UE) conformance specification
8	3GPP TS 36.521	Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification
9	ETSI TS 102 230-1	Smart Cards; UICC-Terminal interface; Physical, electrical and logical test specification
10	UM10204	I2C-bus specification and user manual - NXP semiconductors, https://www.nxp.com

1.4. Abbreviations

See Appendix A.

2. Toggle test mode (+UTEST=0, +UTEST=1)

Table 1. +UTEST=0 attributes

+UTEST=0						
Attributes	**Syntax**	**PIN required**	**Settings saved**	**Can be aborted**	**Response time**	**Error reference**
	partial	No	No	No	Up to 1 s	+CME Error

2.1. Description

Enables the production test (or *non-signaling*) mode, or returns to the normal (*signaling*) operating mode. The AT command +UTEST=0 exits production test mode, while +UTEST=1 enters it.

If the Satellite RAT is active, this command is not supported.

Signaling mode is the default operating state after boot: the protocol stack is operating and the transceiver can connect to the cellular network normally. In non-signaling mode, the transceiver switches off the protocol stack for running tests which could not otherwise be performed.

In signaling mode:

- The only allowed +UTEST command is the AT+UTEST=1 used to enable the testing interface
- All other +UTEST commands return an error result code ("+CME ERROR: operation not allowed" or "+CME ERROR: 3" depending on the +CMEE AT command setting)

To enter production test mode:

- Deactivate the protocol stack issuing the AT+CFUN=0 command before entering the non-signaling mode.

To return to the normal mode, perform one of these actions:

- A transceiver reset
- Power off the transceiver
- Send AT+UTEST=0

When the transceiver returns to the normal mode, the network registration status stored in the profile will be restored. Use the AT+CFUN=1 command to restore the transceiver’s full functionality.

2.2. Syntax

Table 2. +UTEST=0 and +UTEST=1 syntax

Type	Syntax	Response	Example
Generic syntax			
Set	AT+UTEST=<mode>	[+UTEST: <mode>] OK	AT+UTEST=0 OK
Entering normal mode			
Set	AT+UTEST=0	OK	AT+UTEST=0 OK
Entering test mode			
Set	AT+UTEST=1	OK	AT+UTEST=1 OK
Read	AT+UTEST?	+UTEST: <mode> OK	+UTEST: 1 OK
Test	AT+UTEST=?	+UTEST: (list of supported <mode>s) OK	+UTEST:(0-4) OK

2.3. Defined Values

Table 3. +UTEST=0 and +UTEST=1 defined values

Parameter	Type	Description
<mode>	Number	Test mode setting: • 0: the transceiver returns to the normal mode • 1: the transceiver enters the test mode

2.4. Examples

For non-signaling transmission or reception with the +UTEST=2 and +UTEST=3 commands, the transceiver must first enter the non-signaling test mode as described in the current section. The syntax of +UTEST=2 and +UTEST=3 is described in Section 3. Once the non-signaling test phase is completed, the application must restore the normal transceiver functionality.

Unless otherwise specified, the settings and the operations performed with the +UTEST AT commands are not persistent and have no impact on the normal mode transceiver configuration. When returning in normal mode, the transceiver will automatically recover the network registration status saved in the profile and the GPIO configuration. Make sure to also restore the full operational +CFUN mode via AT+CFUN=1.

Only the antenna tuner configuration settings are persistent. For more details, see the section related to +UTEST=4 in the *Iridium 9604 AT Command Guide* [1].

2.4.1. Entering test mode (AT+UTEST=1)

The AT+UTEST=1 command causes the transceiver to enter the non-signaling mode where the transceiver switches off the protocol stack for performing single tests, not available in the normal operating mode.

Only the +UTEST AT commands are available and work as expected in non-signaling mode. Consider issuing the AT+CMEE=2 command before activating the test interface so that the verbose error result codes can be displayed also in non-signaling mode.

Enter the non-signaling mode from a clean state: if the transceiver has already been used, then reboot it and abort any pending network registration procedure with AT+COPS=2. Before entering non-signaling mode, send AT+CFUN=0 to disable the cellular protocol stack. If AT+UTEST=1 is entered when +CFUN: 0 is not set, an error result code will be issued: +CME ERROR: operation not allowed (the verbose error result code will only be seen if +CMEE has been set to 2 as explained in the previous paragraph).

Table 4. Entering test mode with +UTEST=1

Command	Response	Description
AT+CMEE=2	OK	Enable the verbose error result code
AT+CFUN?	+CFUN: 1,7 OK	Check the transceiver functionality level
AT+CFUN=0	OK	Disable the cellular protocol stack
AT+CFUN?	+CFUN: 0,7 OK	Check the transceiver functionality level
AT+UTEST=1	OK	Set the transceiver in the non-signaling mode
AT+UTEST?	+UTEST: 1 OK	Check the test mode status. The transceiver is in non-signaling mode.

2.4.2. Disabling LwM2M before entering test mode

The LwM2M client may interfere with test mode operations and shall be disabled if it will not be used in the OEM application. After sending the AT+ULWM2M=1 command, the LwM2M client requires 4 s to be completely disabled. During those 4 s the transceiver must not be rebooted or shut down to avoid any damage to the file system. In order not to waste time on the production line, send the command to disable the LwM2M client before entering test mode as shown in the example in the following table.

Table 5. Entering non-signaling mode after disabling the LwM2M client

Command	Response	Description
AT+COPS=2	OK	Abort any pending network registration procedure
AT+CFUN=0	OK	Disable the cellular protocol stack
AT+ULWM2M?	+ULWM2M: 0 OK	Check if the LwM2M client is active. If the client is not enabled (i.e. the command returns +ULWM2M: 1), the next command should be skipped.
AT+ULWM2M=1	OK	Disable the LwM2M client. After sending this command, wait at least 4 s before shutting down or rebooting the transceiver
AT+UTEST=1	OK	Enter test mode as usual

2.4.3. Exiting test mode (AT+UTEST=0)

Send the AT+UTEST=0 command to exit the test mode and restore normal mode as shown in the example in the next table. Other ways to return to the normal operating mode include:

- transceiver switch off
- transceiver reset

Table 6. Exiting non-signaling mode with +UTEST=0

Command	Response	Description
AT+UTEST?	+UTEST: 1 OK	Check the test mode status. Test mode is enabled.
AT+UTEST=0	OK	Exit test mode.
AT+UTEST?	+UTEST: 0 OK	Check the test mode status. The transceiver is in normal mode.
AT+CFUN?	+CFUN: 0,7 OK	Check the transceiver functionality level. Cellular protocol stack is still disabled.
AT+CFUN=1	OK	Restore full transceiver functionality.

3. Non-signaling test (+UTEST=2, +UTEST=3)

Table 7. +UTEST=2 attributes

+UTEST=2						
Attributes	**Syntax**	**PIN required**	**Settings saved**	**Can be aborted**	**Response time**	**Error reference**
	partial	No	No	No	Up to 1 s	+CME Error

3.1. Description

Enables transceiver testing on RF and digital pins.

The use of this command shall be restricted to controlled (shielded chamber/box) environments and for test purposes only. Improper usage of this command on a real network could disturb other users and the network itself.

Iridium assumes no responsibility for the inappropriate use of this command.

If the satellite RAT is active, this command is not supported.

3.2. RF test description

This command requires entry into non-signaling mode. In non-signaling mode, the transceiver switches off the protocol stack for running tests which could not otherwise be performed. See Section 2 for instructions on how to enter or exit non-signaling mode.

Note that, in non-signaling mode:

- Only the +UTEST AT commands are available and work as expected
- The +CMEE AT command cannot be set

Depending on the RATs supported (see the *Iridium 9604 Technical Reference Guide* [2]), in test mode, it is possible to trigger the following actions:

- 4G transmission of an LTE signal in the desired band, channel, and power level
- Receiving signal detection and RF level measurement on the desired 4G (LTE) channel

If an unsupported parameter is issued, an error result code will be provided ("+CME ERROR: operation not supported" or "+CME ERROR: 4" depending on the +CMEE AT command setting).

3.3. Syntax

Table 8. +UTEST=2 and +UTEST=3 syntax

Type	Syntax	Response	Example
Generic syntax			
Set	AT+UTEST=<mode>[,[<param_val1>][,[<param_val2>][,[<param_val3>][,[<param_val4>][,[<param_val5>]]]]]]	[+UTEST:[<param_val1>,<param_val2>][,<param_val3>][,<param_val4>,<param_val5>][,<min>,<avg>,<max>]] OK	AT+UTEST=0 OK
Rx test mode			
Set	AT+UTEST=2[,[<RX_channel>][,[<RX_time_interval>][,[<receiver_path>]]]]	+UTEST:<RX_channel>,<RX_time_interval>,<receiver_path>,<min>,<avg>,<max> OK	AT+UTEST=2,124, 250 +UTEST:124,250,0, -80,-80,-80 OK
Tx test mode			
Set	AT+UTEST=3[,[<TX_channel>][,[<power_control_level>][,[<training_sequence>][,[<modulation_mode>][,[<TX_time_interval>]]]]]]	+UTEST:<TX_channel>,<power_control_level>,<training_sequence>,<modulation_mode>,<TX_time_interval> OK	AT+UTEST=3,32,7,5 +UTEST: 32,7,5,1, 1000 OK

3.4. Defined Values

Table 9. +UTEST=2 and +UTEST=3 defined values

Parameter	Type	Description
<mode>	Number	Test mode setting: 2: RX test mode (measuring the antenna level estimation of the received RF signal) 3: TX test mode (transmission of a test signal in the supported RF bands)
<RX_channel>	Number	For the parameter description and its range, see Section 3.5.
<RX_time_interval>	Number	For the parameter description and its range, see Section 3.5.
<receiver_path>	Number	For the parameter description and its range, see Section 3.5.
<expected_power>	Number	For the parameter description and its range, see Section 3.5.
<measured_power>	Number	For the parameter description and its range, see Section 3.5.
<TX_channel>	Number	For the parameter description and its range, see Section 3.5.
<power_control_ level>	Number	For the parameter description and its range, see Section 3.5.
<training_sequence>	Number	For the parameter description and its range, see Section 3.5.
<modulation_mode>	Number	For the parameter description and its range, see Section 3.5.
<TX_time_interval>	Number	For the parameter description and its range, see Section 3.5.
<param_valx>	Number	Supported content depends on related <mode> (details are given above).

3.5. Notes

- Wait at least 10 ms after issuing AT+UTEST=3 to measure the transceiver Tx power to avoid sampling the initial power transient
- The <expected_power> and <measured_power> parameters are not supported.
- Check the *Iridium 9604 Technical Reference Guide* [2] for the list of supported bands and radio access technologies (RAT).
- **Rx mode setting (<mode>=2)**

Table 10. Rx mode parameters

Parameter	Description	Range	Default	Notes
<RX_channel>	Channel	0 - max value of supported band	(See Notes)	RX channel 4G RAT: the value corresponds to EARFCN with an offset of 100000. See **<RX_channel> range table** below.
<RX_time_interval>	Time	See notes column	1000	Time interval for RX test expressed in milliseconds. The range goes from 10 ms to 600000 ms.
<receiver_path>	Antenna diversity[1]	0 or 1	0	Receiver path: • 0: main / primary antenna • 1: diversity / secondary antenna The parameter is available only if supported, otherwise an error result code will be provided ("+CME ERROR: operation not supported" or "+CME ERROR: 4" depending on the +CMEE AT command setting)
<min>	Minimum antenna RF level estimation	See Notes below tables		Expressed in dBm
<avg>	Average antenna RF level estimation	See Notes below tables		Expressed in dBm
<max>	Maximum antenna RF level estimation	See Notes below tables		Expressed in dBm

<RX_channel> range	LTE band	EARFCN range
[100000-100599]	FDD 1	[0-599]
[100600-101199]	FDD 2	[600-1199]
[101200-101949]	FDD 3	[1200-1949]
[101950-102399]	FDD 4	[1950-2399]
[102400-102649]	FDD 5	[2400-2649]

<RX_channel> range	LTE band	EARFCN range
[102750-103449]	FDD 7	[2750-3449]
[103450-103799]	FDD 8	[3450-3799]
[105010-105179]	FDD 12	[5010-5179]
[105180-105279]	FDD 13	[5180-5279]
[105280-105379]	FDD 14	[5280-5379]
[105850-105999]	FDD 18	[5850-5999]
[106000-106149]	FDD 19	[6000-6149]
[106150-106449]	FDD 20	[6150-6449]
[107700-108039]	SAT B24	[7700-8039]
[108040-108689]	FDD 25	[8040-8689]
[108690-109039]	FDD 26	[8690-9039]
[109210-109659]	FDD 28	[9210-9659]
[109870-109919]	FDD 31	[9870-9919]
[137750-138249]	TDD 38	[37750-38249]
[138250-138649]	TDD 39	[38250-38649]
[138650-139649]	TDD 40	[38650-39649]
[139650-141589]	TDD 41	[39650-41589]
[166436-167335]	FDD 66	[66436-67335]
[168586-168935]	FDD 71	[68586-68935]
[170366-170545]	FDD 85	[70366-70545]

The “+CME Error: Operation not supported” or "+CME ERROR: 4" error result code will be provided in these cases (depending on the +CMEE AT command setting):

- A value not belonging to the above ranges is set
- The Rx channel parameter value belongs to a non-supported RAT (2G or 3G or 4G) or band.

The default channel is the same as the central channel of the lower LTE band supported by the transceiver.

Notes:

- RF level estimation range: -90 to -20 dBm
- RF measurement bandwidth: 1.4 MHz for LTE Cat M1
- **Tx mode setting (<mode>=3)**

Table 11. Tx mode parameters

Parameter	Description	Range	Default	Notes
<TX channel>	TX Channel	0 - max value of supported band	32	Tx channel 4G RAT: the value corresponds to EARFCN with an offset of 100000. See **<Tx_channel> range table** below.
<power_ control_level>	Power control level	-56 - 24	5	For 4G RAT: absolute output power [dBm]: -40 to 24 for all the bands Only the values indicated in the above ranges are valid, otherwise an error result code will be provided ("+CME ERROR: operation not supported" or "+CME ERROR: 4" depending on the +CMEE AT command setting). The maximum value of the output power level <power_control_level> is 23 dBm in 4G mode
<training_ sequence>	Training sequence	0 - 7	5	Training sequence to be used (to be changed only in case of link with network simulator, else use default). In a 4G RAT the value is unused.
<modulation_ mode>	Modulation mode	1 - 2	0	Modulation mode: • 1: GMSK normal modulation including the training sequence • 2: 8-PSK normal modulation including the training sequence In a 4G RAT the parameter is ignored In LTE Cat-M1 SC-FDMA OFDM modulation, FDD, the modulation mode is automatically set using an EARFCN value for the <TX_channel> parameter.
<TX_time_ interval>	Time	0 - 600000		Time interval for TX test expressed in milliseconds • 0: the signal is transmitted without interruption. In this case, the command will immediately return the information text response and the command line will be available. AT+UTEST=1 stops the transmission, +UTEST=2 or +UTEST=3 commands can be set and the current sequence transmission is stopped.

<TX_channel> range	LTE band	EARFCN range
[118000-118599]	FDD 1	[18000-18599]
[118600-119199]	FDD 2	[18600-19199]
[119200-119949]	FDD 3	[19200-19949]
[119950-120399]	FDD 4	[19950-20399]
[120400-120649]	FDD 5	[20400-20649]
[120750-121449]	FDD 7	[20750-21449]

<TX_channel> range	LTE band	EARFCN range
[121450-121799]	FDD 8	[21450-21799]
[123010-123179]	FDD 12	[23010-23179]
[123180-123279]	FDD 13	[23180-23279]
[123280-123379]	FDD 14	[23280-23379]
[123850-123999]	FDD 18	[23850-23999]
[124000-124149]	FDD 19	[24000-24149]
[124150-124449]	FDD 20	[24150-24449]
[125700-126039]	SAT B24	[25700-26039]
[126040-126689]	FDD 25	[26040-26689]
[126690-127039]	FDD 26	[26690-27039]
[127040-127209]	FDD 27	[27040-27209]
[127210-127659]	FDD 28	[27210-27659]
[127760-127809]	FDD 31	[27760-27809]
[137750-138249]	TDD 38	[37750-38249]
[138250-138649]	TDD 39	[38250-38649]
[138650-139649]	TDD 40	[38650-39649]
[139650-141589]	TDD 41	[39650-41589]
[231972-232671]	FDD 66	[131972-132671]
[233122-233471]	FDD 71	[133122-133471]
[234002-234181]	FDD 85	[134002-134181]

The “+CME Error: Operation not supported” or "+CME ERROR: 4" error result code will be provided in these cases (depending on the +CMEE AT command setting):

- A value not belonging to the above ranges is set
- The TX channel parameter value belongs to a non-supported RAT (2G or 3G) or band.

Avoid channels that would put the TX waveform outside the band due to SC-FDMA modulation bandwidth

The default channel will be the same as the central channel of the lower LTE band supported by the transceiver.

3.6. Rx test mode (+UTEST=2) examples

To avoid transceiver damage during receiver testing, the maximum power level received at the ANT pin must comply with the transceiver specifications (see the *Iridium 9604 Technical Reference Guide* [2]). Do not exceed a power level of -15 dBm at the cellular antenna port.

As described in Section 3, the measurement of the received power level can be done using this command syntax:

```
AT+UTEST=2,<RX_channel>,<RX_time_interval>
```

If a parameter is omitted, the default value is used. See Section 3.3 for the default values implemented by the transceiver.

The information text response provides the receiver measurement report in the following form:

```
+UTEST: <RX_channel>,<RX_time_interval>,0,<min>,<avg>,<max>
```

<min>, <avg> and <max> are respectively the estimated minimum, average and maximum values of the RMS RF power level in dBm received at the ANT pin of the transceiver. The average level is calculated during the whole time interval defined by <RX_time_interval>. The power level estimate (<min>, <avg> and <max>) corresponds to the RXLEV value: the signal strength reported by the mobile in the normal operating mode.

The accuracy and the tolerances specified in 3GPP TS 36.521 [8] are not applicable, since in normal operating mode a correction algorithm is used. Nevertheless the <min>, <avg> and <max> parameters can be assumed to be a good estimate of the average received power.

Modulation settings are not needed on the generator feeding the test signal to the transceiver. When the measurement is performed using a continuous-wave signal, use 100 kHz offset from center frequency of the channel selected on the transceiver for the Tx frequency. For example, to test EARFCN=2525 of LTE band 5, which corresponds to a center frequency of 881.50 MHz, set the signal generator Tx frequency to

```
881.5 + 0.1 MHz = 881.6 MHz.
```

The offset is not needed if the signal generator is feeding a modulated signal.

All the examples below have been recorded with a test setup as shown in Figure 5, using a signal generator connected to the transceiver by a low-loss RF cable.

3.6.1. Entering test mode and setting up a reception test

Table 12. Setting up an Rx test

Command	Response	Description
AT+UTEST?	+UTEST: 0 OK	Check the test mode status. Test mode is disabled.
AT+CFUN=0	OK	Deactivate the protocol stack before entering the non-signaling mode.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST?	+UTEST: 1 OK	Check the test mode status. Test mode is now enabled.
AT+UTEST=2,105060,1000	+UTEST: 105060,1000,0,-21, -20,-19 OK	RX test is executed on B12, channel 5060. RX measurement is on for 1 s.
AT+UTEST=0	OK	Exit the non-signaling test mode.
AT+CFUN=1	OK	Restore full transceiver functionality

The signal generator used during this test is set as follows:

- Carrier frequency: 734.1 MHz (to compensate for the offset described at the end of Section 3.6)
- Power level: 20 dBm
- Modulation: disabled

The transceiver measures the RF level at the expected LTE downlink frequency (734.0 MHz) over 1 s. The received power level is within the measurement uncertainty range for this setup.

After the "OK" final result code, another +UTEST=2 command can be sent. This is demonstrated in the following example.

3.6.2. Sequence of reception tests

Table 13. Executing a sequence of Rx tests

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack before entering the non-signaling mode.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST=2,105060	+UTEST: 105060,1000,0,-21, -20,-19 OK	RX test is executed on B12, channel 5060. RX measurement is on for 1 s (default value).
AT+UTEST=2,100300	+UTEST: 100300,1000,0,-20, -20,-19 OK	RX test is executed on B1, channel 300. RX measurement is on for 1 s (default value).
AT+UTEST=0	OK	Exit the non-signaling test mode.
AT+CFUN=1	OK	Restore full transceiver functionality

3.6.3. Reception test with signal generator switched off or with wrong settings

The signal generator was switched off or was transmitting a carrier at a different frequency.

The transceiver response is -90 dBm as the lower-level limit.

Table 14. Executing +UTEST=2 with the generator switched off or set at the wrong carrier frequency

Command	Response	Description
AT+UTEST=2,105060,1000	+UTEST: 105060,1000,0,-90, -90,-90 OK	

3.7. Tx test mode (+UTEST=3) examples

The use of this command shall be restricted to controlled (shielded chamber/box) environments and for test purposes only. Improper usage of this command on a real network could disturb other users and the network itself.

Iridium and the manufacturer assume no responsibility for the inappropriate use of this command.

To avoid transceiver damage during transmitter test, a proper antenna according to transceiver specifications or a 50-ohm termination must be connected to the **ANT** port.

As described in Section 3.7, the transceiver is instructed to transmit a test signal using the following command syntax:

```
AT+UTEST=3,<TX_channel>,<power_control_level>,<par1>,<par2>,<TX_time_interval>
```

<par1> and <par2> are ignored. If a parameter is omitted, the default value is used. If no <TX_channel> is specified, the default channel will be the central channel of the lowest LTE band supported by the transceiver, if no <power_control_level> is specified, 5 dBm will be used as the Tx signal power. Finally, if no <TX_time_interval> is specified, the default time interval is set to 1000 ms while if <TX_time_interval> is set to 0 the test signal will be transmitted without interruption. To stop the transmission, issue any other AT+UTEST command.

The accuracy and the tolerances specified in 3GPP TS 36.521 [8] are not applicable, since in normal operating mode a correction algorithm is used. Nevertheless the <power_control_level> parameter can be assumed to be a good estimate of the peak transmit power of the test signal.

The RF output resulting from the AT+UTEST=3 command is a QPSK modulated signal with a bandwidth of 1.08 MHz and a duty cycle (actual time spent transmitting over frame duration time) of 0.3. This corresponds to a typical LTE Cat-M half-duplex transmission using 6 resource blocks. Given that the actual transmission is not continuous (even if the <Tx_time_interval> parameter is set to 0), the power read by a power meter connected to the ANT pin will be lower than the requested value. Since power meters report the average power received at their input port, in the presence of pulsed signals a correction factor equal to

$$10 \cdot \log_{10}\left(\frac{1}{duty_{cycle}}\right) = 5.23dB$$

must be added to the reading to recover the actual TX power value. With the aforementioned signal parameters such factor amounts to 5.23 dB.

Wait at least 10 ms after issuing +UTEST=3 to measure the transceiver Tx power to avoid sampling the initial power transient.

3.7.1. Entering test mode and setting a transmission test

A transmission test can be either:

- **single-shot** (Table 15) when the duration of the test signal is finite
- **persistent** (Table 16) when the duration of the Tx test signal is infinite

Table 15. Example of single-shot +UTEST RF Tx testing

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack before entering the non-signaling mode.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST?	+UTEST: 1 OK	Check that UTEST is in non-signaling mode
AT+UTEST=3,119200, 23,,,1000	+UTEST: 119575,23,5,1,1000 OK	The transceiver transmits in channel 19200 (frequency 1710 MHz LTE band 3) for 1 s with 23 dBm output power, after which the "OK" final result code is returned. After the "OK" final result code, another +UTEST command can be sent.
AT+UTEST=0	OK	Exit the non-signaling test mode.
AT+CFUN=1	OK	Restore full transceiver functionality

Table 16. Example of persistent +UTEST RF Tx testing

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack before entering the non-signaling mode.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST=3,119200, 23,,,0	+UTEST: 119200,23,5,1,0 OK	The transceiver transmits in channel 19200 (frequency 1710 MHz LTE band 3) with 23 dBm output power. The "OK" final result code is returned immediately after the transmission is started.
AT+UTEST=1	OK	Any +UTEST command stops the transmission.
AT+UTEST?	+UTEST: 1 OK	The transceiver is still in non-signaling mode.
AT+UTEST=0	OK	Exit the non-signaling test mode.
AT+CFUN=1	OK	Restore full transceiver functionality.

The following plots have been obtained by connecting the **ANT** pin of the transceiver to a spectrum analyzer by means of a low-loss RF cable, as shown in Figure 5. The transceiver is powered on, and it is set in non-signaling mode to persistently output a 23 dBm LTE RF test signal, centered around 1710 MHz, using the AT command sequence in Table 16.

Figure 2 shows the shape of the transmitted signal in the frequency domain (a) and in the time domain (b) using the zero-span function of the spectrum analyzer. The peak power measured (highlighted by marker 3) is 12.56 dBm and the signal bandwidth (frequency difference between marker 1 and marker 2) is roughly 1 MHz.

The figure has been obtained by setting the spectrum analyzer as follows:

- Reference level = 25 dBm
- Center frequency = 1710 MHz
- Frequency span = 10 MHz (a) / zero span (b)
- Resolution bandwidth (RBW) = 100 kHz
- Video bandwidth (VBW) = 1 MHz
- Sweep time (SWT) = 250 ms (a) / 30 ms (b)
- RBW filter type = Normal 3 dB
- Trace mode = MAX hold (a) / clear write (b)
- Trace detector = RMS
- Trigger = free run (a) / video, trigger level 50 % (b)

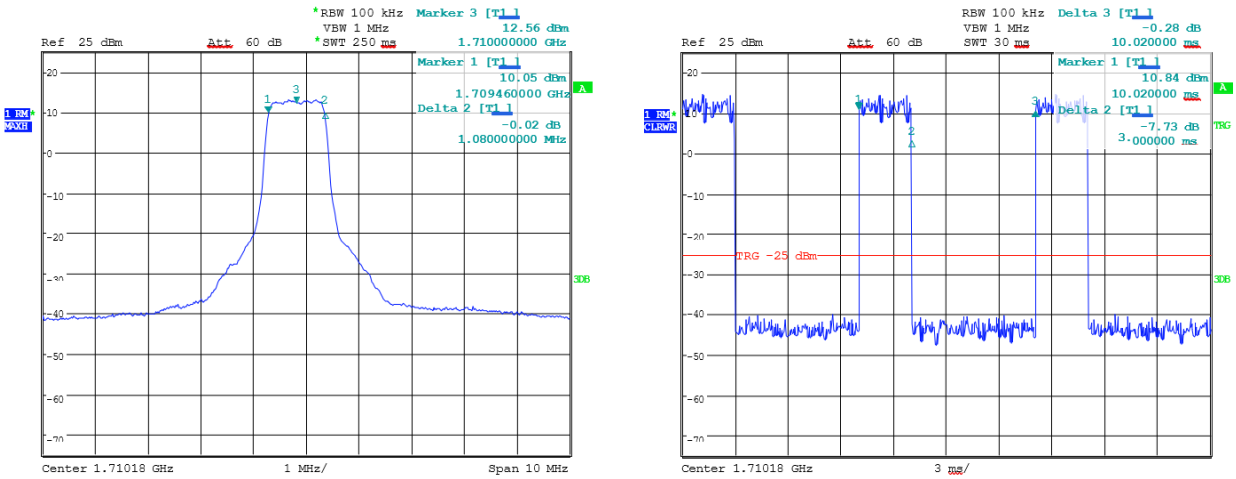


Figure 2. Power level measurements on an LTE test signal on a spectrum analyzer: (a) frequency domain power and (b) time-domain power using the zero-span function

The peak power value reported by the instrument is lower than the expected 23 dBm. This is due to the spectrum analyzer behavior with modulated noise-like signals: i.e., the power reading is influenced by the resolution bandwidth (RBW) of the instrument. To recover the actual power transmitted over the whole signal bandwidth, the following formula must be used:

$$P_S^{(dBm)} = P_M^{(dBm)} + 10 \bullet \log_{10}\left(\frac{SignalBandwidth}{RBW}\right)$$

where P_S is the signal power in dBm and P_M is the spectrum analyzer peak power in dBm. By applying this formula to the measurements, we obtain the expected peak power value within measurement uncertainty.

Another approach to recover the actual transmitted RF power is to set the RBW of the spectrum analyzer to a value larger than the signal bandwidth and observe the peak power. Make sure to use a sweep time long enough to properly average the signal power and/or turn on the averaging feature of the instrument. Note that, by substituting the spectrum analyzer with a power meter, there is no need to change the RBW since a power meter behaves like a spectrum analyzer with a very wide RBW (as wide as the bandwidth of the instrument).

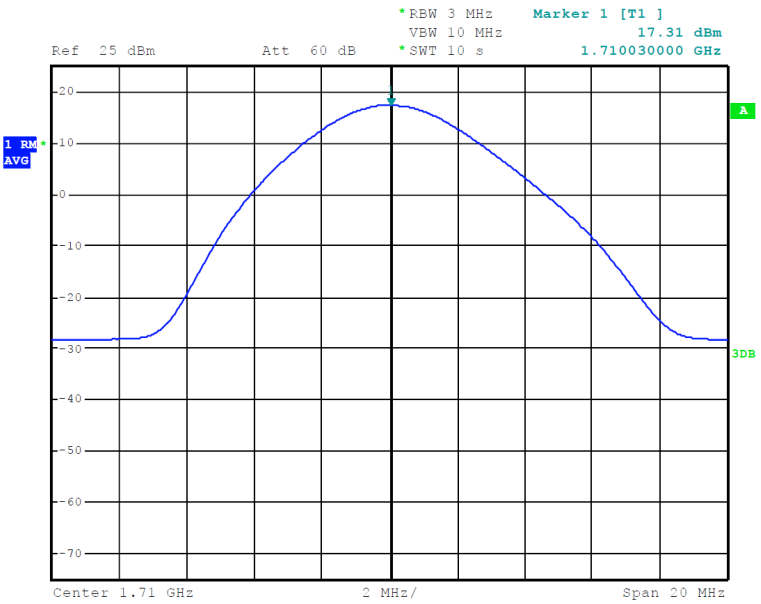


Figure 3. Power level measurements on an LTE test signal with a spectrum analyzer using a resolution bandwidth wider than the signal bandwidth.

3.7.2. Sequence of transmission tests

After the "OK" final result code, another +UTEST command can be sent. This allows to perform a sequence of transmission tests while the transceiver is in non-signaling test mode as shown in Table 17.

Table 17. Entering test mode and issuing a sequence of transmission tests

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack before entering the non-signaling mode.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST?	+UTEST: 1 OK	Check that UTEST is in non-signaling mode
AT+UTEST=3,119200, 23,,,1000	+UTEST: 119575,23,5,1,1000 OK	The transceiver transmits in channel 19200 (frequency 1710 MHz LTE band 3) for 1 s with 23 dBm output power, after which the "OK" final result code is returned. After the "OK" final result code, another +UTEST command can be sent.
AT+UTEST=3,123095, 23,,,1000	+UTEST: 123095,23,5,1,1000 OK	The transceiver transmits in channel 23095 (frequency 707.5 MHz LTE band 12) for 1 s with 23 dBm output power, after which the "OK" final result code is returned.
AT+UTEST=0	OK	Exit the non-signaling test mode.
AT+CFUN=1	OK	Restore full transceiver functionality

[1] Diversity is not supported in LTE Cat M1

4. Antenna dynamic tuner configuration (+UTEST=4)

+UTEST=4						
Attributes	**Syntax**	**PIN required**	**Settings saved**	**Can be aborted**	**Response time**	**Error reference**
	Full	No	NVM	No	Up to 1 s	+CME Error

4.1. Description

Allows enabling, disabling and customizing the antenna dynamic tuner settings. The antenna dynamic tuner control setting is stored in the NVM, and its configuration is effective after exiting the test mode. Enter the test mode to enable or disable the antenna dynamic tuner control (see Section 4.5 for configuration examples). Upon enabling the antenna dynamic tuner function by means of the AT+UTEST=4,1 command, the dedicated pins are automatically configured as antenna dynamic tuning outputs. Therefore, their value is controlled by the RF driver and changes according to the RF band used by the transceiver. The relation between the dedicated pins output value and the RF frequency band in use, is reported in Section 4.4.

If the transceiver has not been set into non-signaling mode (with AT+UTEST=1) prior to using +UTEST=4, this command will return "+CME ERROR: operation not allowed" or "+CME ERROR: 3" error result code, depending on the +CMEE AT command setting.

For more details on signaling and normal mode, see Section 2.4.1.

4.2. Syntax

Table 18. Syntax for antenna dynamic tuning test configurations

Type	Syntax	Response	Example
Generic syntax			
Set	AT+UTEST=<mode>[,<param_ val1>]	[+UTEST: [<param_val1>] OK	AT+UTEST=0 OK
Entering normal mode			
Set	AT+UTEST=0	OK	AT+UTEST=0 OK
Entering test mode			
Set	AT+UTEST=1	OK	AT+UTEST=1 OK
Antenna dynamic tuner control disabling			
Set	AT+UTEST=4,0	OK	AT+UTEST=4,0 OK

Type	Syntax	Response	Example
Antenna dynamic tuner control enabling			
Set	AT+UTEST=4,1	OK	AT+UTEST=4,1 OK
Antenna dynamic tuner write configuration table			
Set	AT+UTEST=4,2,<atun_0_lte_bitmask0>,<atun_0_lte_bitmask1>,<atun_0_gsm_umts_bitmask0>,<atun_1_lte_bitmask0>,<atun_1_lte_bitmask1>,<atun_1_gsm_umts_bitmask0>,<atun_2_lte_bitmask0>,<atun_2_lte_bitmask1>,<atun_2_gsm_umts_bitmask0>,<atun_1gsm_umts_bitmask0>,<atun_2_lte_bitmask0>,<atun_2_lte_bitmask1>,<atun_2_gsm_umts_bitmask0>	OK	AT+UTEST=4,2,0,64,0,134232064,1048576,0,34472080,0,0,16777231,2,0 OK
Antenna dynamic tuner read configuration table			
Set	AT+UTEST=4,3	+UTEST:<ant_tuner_enable>,<atun_0_lte_bitmask0>,<atun_0_lte_bitmask1>,<atun_0_gsm_umts_bitmask0>,<atun_1_lte_bitmask0>,<atun_1_lte_bitmask1>,<atun_1_gsm_umts_bitmask0>,<atun_2_lte_bitmask0>,<atun_2_lte_bitmask1>,<atun_2_gsm_umts_bitmask0>,<atun_1_gsm_umts_bitmask0>,<atun_2_lte_bitmask0>,<atun_2_lte_bitmask1>,<atun_2_gsm_umts_bitmask0> OK	AT+UTEST=4,3 +UTEST:1,0,64,0,134232064,1048576,0,34472080,0,0,16777231,2,0 OK
Read	AT+UTEST?	+UTEST: <mode> OK	+UTEST: 1 OK
Test	AT+UTEST=?	+UTEST: (list of supported<mode>s) OK	+UTEST: (0-3) OK

4.3. Defined values

Table 19. Antenna dynamic tuning configuration parameters

Parameter	Type	Description
<mode>	Number	Test mode setting: • 0: the transceiver returns to the normal mode • 1: the transceiver enters the test mode • 4: antenna dynamic tuner configuration mode (enable, disable antenna dynamic tuner control, write and read NVM configuration table)

Parameter	Type	Description
<ant_tuner_enable>	Number	Enable/disable antenna dynamic tuner control. Allowed values: • 0 (factory-programmed value): antenna dynamic tuner control disabled • 1: antenna dynamic tuner control enabled • 2: antenna dynamic tuner control write configuration table (enable flag and all LTE/UMTS/GSM bands in use) inside NVM • 3: antenna dynamic tuner control read configuration table from NVM
<atun_0_lte_bitmask0>	Number	ATUN signal patch value 0 (ATUN2=0, ATUN1=0) bitmasks: it indicates the bandmask for LTE bands 1 through 64. It is created using the same procedure described for the +UBANDMASK AT command
<atun_0_lte_bitmask1>	Number	ATUN signal patch value 0 (ATUN2=0, ATUN1=0) bitmasks: it indicates the bandmask for LTE bands 65 through 128. It is created using the same procedure described for the +UBANDMASK AT command.
<atun_0_gsm_umts_bitmask0>	Number	ATUN signal patch value 0 (ATUN2=0, ATUN1=0) bitmasks: it indicates the bandmask for GSM and UMTS bands. The bit number 1 to 22 are dedicated for GSM, and, 23 to 64 are dedicated for UMTS according to the list, which is available in the description of +UBANDMASK AT command.
<atun_1_lte_bitmask0>	Number	ATUN signal patch value 1 (ATUN2=0, ATUN1=1) bitmasks: it indicates the bandmask for LTE bands.
<atun_1_lte_bitmask1>	Number	ATUN signal patch value 1 (ATUN2=0, ATUN1=1) bitmasks: it indicates the bandmask for LTE bands.
<atun_1_gsm_umts_bitmask0>	Number	ATUN signal patch value 1 (ATUN2=0, ATUN1=1) bitmasks: it indicates the bandmask for GSM and UMTS bands.
<atun_2_lte_bitmask0>	Number	ATUN signal patch value 1 (ATUN2=1, ATUN1=0) bitmasks: it indicates the bandmask for LTE bands.
<atun_2_lte_bitmask1>	Number	ATUN signal patch value 1 (ATUN2=1, ATUN1=0) bitmasks: it indicates the bandmask for LTE bands.
<atun_2_gsm_umts_bitmask0>	Number	ATUN signal patch value 1 (ATUN2=1, ATUN1=0) bitmasks: it indicates the bandmask for GSM and UMTS bands.
<atun_3_lte_bitmask0>	Number	ATUN signal patch value 1 (ATUN2=1, ATUN1=1) bitmasks: it indicates the bandmask for LTE bands.
<atun_3_lte_bitmask1>	Number	ATUN signal patch value 1 (ATUN2=1, ATUN1=1) bitmasks: it indicates the bandmask for LTE bands.
<atun_3_gsm_umts_bitmask0>	Number	ATUN signal patch value 1 (ATUN2=1, ATUN1=1) bitmasks: it indicates the bandmask for GSM and UMTS bands.

4.4. Notes

- The same band cannot be active for more than one ATUN signal patch value at the same time.
- The antenna tuner configuration persists after updating the firmware version or restoring the NVM to the factory-programmed configuration by means of the +UFACTORY AT command.
- 2G and 3G bands are not supported in Iridium 9604 transceivers; the corresponding GSM and UMTS bitmasks (<atun_0_gsm_umts_bitmask0>, <atun_1_gsm_umts_bitmask0>,

<atun_2_gsm_umts_bitmask0>, <atun_2_gsm_umts_bitmask0>) must be 0.

- The factory-programmed value of <ant_tuner_enable> is 0 and all other default values are highlighted in Table 20.

Table 20. Default antenna dynamic tuner configuration table

ATUN signal patch value X = 0,1,2,3	ATUN2 - transceiver pin 34	ATUN2 - transceiver pin 35	atun_X_lte_bit mask0	atun_X_lte_bit mask1	atun_X_gsm_u mts_ bitmask0	LTE bands
0	0	0	0	64	0	LTE Cat M1 bands: B71, which corresponds to bit 7
1	0	1	134232064	1048576	0	LTE Cat M1 bands: B12, B13, B14, B28 and B85, which corresponds to bit 21
2	1	0	34472080	0	0	LTE Cat M1 bands: B5, B8, B18, B19, B20 and B26
3	1	1	16777231	2	0	LTE Cat M1 bands: B1, B2, B3, B4, B25 and B66, which corresponds to bit 1

4.5. Antenna dynamic tuner configuration examples

Table 21. Antenna dynamic tuner mode test configuration examples

Command	Response	Description
Disabling antenna tuner control		
AT+CFUN=0	OK	Disable the protocol stack.
AT+UTEST=1	OK	Enter the test mode.
AT+UTEST=4,0	OK	The transceiver disables the antenna dynamic tuner feature.
AT+UTEST=0	OK	Enter the normal mode.
AT+CFUN=1	OK	Restore full transceiver functionality.
Enabling antenna tuner control		
AT+CFUN=0	OK	Disable the protocol stack.
AT+UTEST=1	OK	Enter the test mode.
AT+UTEST=4,1	OK	The transceiver enables the antenna dynamic tuner feature.
AT+UTEST=0	OK	Enter the normal mode.
AT+CFUN=1	OK	Restore full transceiver functionality.
Reading antenna tuner control table		
AT+CFUN=0	OK	Disable the protocol stack.
AT+UTEST=1	OK	Enter the test mode.
AT+UTEST=4,3	+UTEST:1,0,64,0,134232064,1048576,0,34472080,0,0,16777231,2,0	The transceiver reads the antenna dynamic tuner configuration table from NVM.

Command	Response	Description
	OK	For an explanation of the bit masks see Table 20.
AT+UTEST=0	OK	Enter the normal mode.
AT+CFUN=1	OK	Restore full transceiver functionality.
Writing antenna tuner control table		
AT+CFUN=0	OK	Disable the protocol stack.
AT+UTEST=1	OK	Enter the test mode.
AT+UTEST=4,2,0,64,0,134232064,1048576,0,34472080,0,0,16777231,2,0	OK	The transceiver writes the antenna dynamic tuner configuration table inside NVM.
		For an explanation of the bit masks see Table 20.
AT+UTEST=0	OK	Enter the normal mode.
AT+CFUN=1	OK	Restore full transceiver functionality.

5. Digital pins testing (+UTEST=10)

Table 22. +UTEST=10 attributes

+UTEST=10						
Attributes	**Syntax**	**PIN required**	**Settings saved**	**Can be aborted**	**Response time**	**Error reference**
	Partial	No	No	No	Up to 1 s	+CME Error

5.1. Description

Performs functional testing on the digital pins of the transceiver.

The transceiver pins can be considered as generic digital input / output pins; it is possible to configure one pin as a digital output with "high" logic level and then verify the voltage level present. Conversely, it is possible set a pin as a digital input, externally apply a "high" or "low" logic level, and then check if the transceiver is able to correctly measure the voltage level applied.

This command is intended for production or prototype testing: to check the correct digital pins behavior and to detect possible soldering or functional problems. The execution of these actions is performed only in non-signaling mode. If the transceiver has not been set into non-signaling mode (with AT+UTEST=1) prior to using +UTEST=10, this command will return "+CME ERROR: operation not allowed" or "+CME ERROR: 3" error result code, depending on the +CMEE AT command setting.



Do not exceed the values reported in the Generic Digital Interface section of the *Iridium 9604 Technical Reference Guide* [2] when testing a pin as a digital input pin, since stressing the device above the listed ratings may cause permanent damage to the transceiver.



The command only accepts the parameter set supported by the specific transceiver version. When an unsupported parameter is issued, an error result code will be provided ("+CME ERROR: operation not supported" or "+CME ERROR: 4" depending on the +CMEE AT command setting).

For more details on test command examples, guidance about test equipment setup and more information on transceiver reboot see the *Iridium 9604 Application Development Guide* [4] and the *Iridium 9604 Technical Reference Guide* [2] for pins levels characteristics.

5.2. Syntax

Table 23. Digital pins testing syntax

Type	Syntax	Response	Example
Digital pins testing generic syntax			
Set	AT+UTEST=10,<op_code>[,[<bit_padding>]<pin_seq>]	OK	AT+UTEST=10,3,"0000001000000300" OK
Restoring original configuration			
Set	AT+UTEST=10,0	OK	AT+UTEST=10,0 OK
Pins set definition			
Set	AT+UTEST=10,2,[<bit_padding>]<pin_seq>	OK	AT+UTEST=10,2,"0000000C300000003000" OK
Pins configuration			
Set	AT+UTEST=10,3,[<bit_padding>]<pin_seq>	OK	AT+UTEST=10,3,"0000000420000000 1000" OK
Output pins definition			
Set	AT+UTEST=10,4,[<bit_padding>]<pin_seq>	OK	AT+UTEST=10,4,"0000000010000000 2000" OK
Digital testing execution			
Set	AT+UTEST=10,5	OK	AT+UTEST=10,5 OK
Digital value measurement			
Set	AT+UTEST=10,6	<bit_padding>]<pin_seq> OK	AT+UTEST=10,6 000000041000000030 00 OK

5.3. Defined values

Table 24. Digital pins testing defined values

Parameter	Type	Description
<op_code>	Number	Test mode setting: • 0: restores the pins to the original configuration • 2: defines and initializes a set of pins to be tested. The original pins configuration is kept for final restore. In the [<bit_padding>]<pin_seq> parameter use this notation to represent each transceiver pin with its binary digit: ◦ 0: the pin will not be tested ◦ 1: the pin will be tested (as digital input or output) • 3: configures the logical pins previously enabled for testing as output or input; the command has effect only if AT+UTEST=10,2 has been issued. If a non-enabled pin is set as digital input or output, the command does not return an error and the setting is not applied. In the [<bit_padding>]<pin_seq> parameter use this notation to represent each transceiver pin with its binary digit: ◦ 0: the pin will be set as an output ◦ 1: the pin will be set as an input • 4: configures the value of the output pins under testing; the command has effect only if AT+UTEST=10,3 has been issued; The command is not mandatory if there are no output pins to configure. In the [<bit_padding>]<pin_seq> parameter use this notation to represent each transceiver pin with its binary digit: ◦ 0: the pin will output a "low" logic level ◦ 1: the pin will output a "high" logic level • 5: applies the setting change defined with <op_code>= 2 / 3 / 4 and triggers the execution of the digital testing. Digital testing of the pins is possible only after the execution of the AT+UTEST=10,5 command. • 6: returns the logic value of pins under testing (both input and output); in the [<bit_padding>]<pin_seq> parameter use this notation to represent each transceiver pin with its binary digit: ◦ 0: "low" logic digital level measured at the transceiver pin ◦ 1: "high" logic digital level measured at the transceiver pin
[<bit_padding>]<pin_seq>	Number	Sequence of hexadecimal digits containing the pin information and the action to execute. See Section 5.4.

5.4. Notes

- The <op_code>, <bit_padding>, <pin_seq> parameters setting is not stored in the NVM.
- Follow these steps to construct the [<bit_padding>]<pin_seq> sequence:
  1. Consider the number of bits available to select the transceiver's pins: 96 bits
  2. The status of the n-th pin is represented by the corresponding n-th bit; see the <op_code> description for the notation of each mode setting
  3. Convert each group of four binary digits into its hexadecimal representation
- When a non-testable pin is selected, the command returns an error result code, and the value is not considered and not applied.

5.5. Setting testable pins

This section describes how to perform verifications on the digital pins of the transceivers with the +UTEST AT command. Use this command to configure a specific group of pins such as:

- Digital input: once configured, it is possible to apply a voltage level to the pin
- Digital output: the pin can be used to output a digital "high" or "low" voltage level

Pins enabled for digital testing can be considered as generic digital input / output pins; the customer may configure a pin as a digital output with "high" logic level and then verify the voltage level present at the pin. Conversely, it is possible to apply a "high" or "low" logic level on a pin set as a digital input, and then check if the transceiver can correctly measure the voltage level applied.

After the execution of the AT+UTEST=10,5 command, it is possible to externally apply a voltage level to the enabled input pins and / or measure the voltage level on the pins configured as digital input.

These commands are intended for production to check the correct digital pins behavior, detect possible soldering or functional problems, and can be executed only in non-signaling mode (otherwise the "+CME ERROR: operation not allowed" or "+CME ERROR: 3" error result code - depending on the +CMEE AT command setting - is issued without performing any operations).

Do not exceed the values reported in the Generic Digital Interface section of the *Iridium 9604 Technical Reference Guide* [2] when testing a pin as a digital input pin, since stressing the device above the listed ratings may cause permanent damage to the transceiver. See the *Iridium 9604 Technical Reference Guide* [2] for the pin levels characteristics.

Table 25 reports number and type of pins available for digital testing via the +UTEST AT command. For a detailed description of the input / output levels characteristics of the pins and the actual pins supported, see the *Iridium 9604 Technical Reference Guide* [2].

Table 25. List of pins available for +UTEST digital pins testing

Pin number	Name	Interface
6	DSR	UART
7	RI	
8	DCD	
9	DTR	
10	RTS	
11	CTS	
16	GPIO1	GPIO
18	RESET_N	System functions
19	GPIO6	GPIO
23	GPIO2	
24	GPIO3	
25	GPIO4	
26	SDA	I2C
27	SCL	
34	RFCTRL1	RF GPIO
35	RFCTRL2	
36	GPIO7	GPIO
37	GPIO8 / ANT_ON	
42	GPIO5	
44	SDIO_D2	SDIO
45	SDIO_CLK	
46	SDIO_CMD	
47	SDIO_D0	
48	SDIO_D3	
49	SDIO_D1	

If the UART port is used as the AT interface, disable the hardware flow control before entering test mode for digital pin testing.

When testing the GPIO pins, consider the following notes:

- The **RESET_N** pin can be set as an input only. If this pin is enabled for testing, asserting it will not trigger a transceiver reset. Use AT+CFUN=16 instead.
- The **I2S_WA** and **I2S_TXD** pins are not available for testing if the dynamic antenna tuning feature is enabled.

If supported by the application, enable the dynamic antenna tuning feature after digital pins testing is complete.

Only the transceiver pins in use by the OEM application need to be verified. Before configuring the pins listed in Table 25 as digital input or output, select the pins to be tested by:

```
AT+UTEST=10,2,[<bit_padding>]<pin_seq>
```

where [<bit_padding>]<pin_seq> is a sequence of hexadecimal digits (0,1,…,E,F).

As outlined in Section 5.4, to construct the [<bit_padding>]<pin_seq> sequence, first represent each transceiver pin with a binary digit (0 or 1) having this meaning:

- 0: the pin will not be tested
- 1: the pin will be tested (as a digital input or output)

Out of the total pins available on the transceiver, only the pins reported in Table 13 can be set to 1. Note that the **GND** pins are not considered by the AT+UTEST=10 command.

In case a non-testable pin is set to 1, the AT+UTEST=10,2 command returns an error result code and the whole [<bit_padding>]<pin_seq> value is not considered and not applied.

Figure 4 shows a possible sequence of binary digits where the 6th and the 11th digits are set to 1; these enable pin 6 and pin 11 for testing. There is no limit to the maximum number of pins that can be enabled.

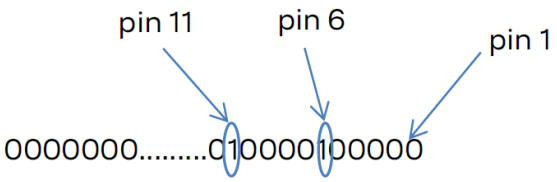


Figure 4. Example binary representation of pins; '1' identifies an enabled pin

Once the binary sequence has been defined, the number of binary digits must be the same as the total number of testable pins (see Section 5.4). Finally, convert each group of four binary digits into its hexadecimal representation where the leftmost digit is the most significant one.

5.5.1. AT+UTEST=10,2 example

For Iridium 9604, 96 binary digits can be used to set the testable GPIO pins. Since a group of four binary digits can be represented by a single hexadecimal digit (0, 1, …, E, F), the resulting length of the sequence will be equal to 24 hexadecimal digits.

Analyzing the sequence 000000000000180000008400 in Table 26, its binary representation is equal to:

0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 **1**000 0**1**0**1** **1**000 0000

The digits set at '1' are the 8th, 9th, 11th and 16th, so comparing with Table 25, the enabled pins for digital testing are: **DCD, DTR, CTS** and **GPIO1**.

Table 26. AT+UTEST=10,2 example

Command	Response	Description
AT+UTEST=10,2,"0000000000000000 0008580"	OK	Pins enabled for testing: **DCD, DTR, CTS** and **GPIO1**

5.6. Digital pins configuration

With this command, it is possible to configure a previously enabled pin as a digital output or a digital input. Enabled pins can be set as digital input or digital output using the following command:

```
AT+UTEST=10,3,[<bit_padding>]<pin_seq>
```

where [<bit_padding>]<pin_seq> is a sequence of hexadecimal digits (0, 1, …, E, F). It is constructed using the same procedure outlined in Section 5.5.

When representing each transceiver pin with its binary digit, use this notation:

- 0: the pin will be set as an output
- 1: the pin will be set as an input

The command has effect only if AT+UTEST=10,2 has been previously issued. In case a non-enabled pin is set as digital input or output, the command does not return an error result code and the setting is not applied.

5.6.1. AT+UTEST=10,3 example

Continuing the example introduced in Section 5.5.1, the following command sets:

- **DTR** and **CTS** as digital input**, DCD** and **GPIO1**as digital output.

Therefore, the hexadecimal sequence 000000000000000000000500 in Table 27 when converted into its binary representation, results in:

0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
000**0 0**000 0000 0000 0000 0000 0000 0000 0000 0**10**1 0000 0000

Where digits 9 and 11 are set to 1, digits 8 and 16 are set to 0.

Table 27. AT+UTEST=10,3 example

Command	Response	Description
AT+UTEST=10,3,"0000000000000000 00000500”	OK	Pins enabled for testing: • **DTR** and **CTS** as input • **DCD** and **GPIO1** as output

5.7. Setting voltage levels

This command sets the logic value of the pins under test configured as digital output. Use this command to define the logic value of the output pins:

```
AT+UTEST=10,4,[<bit_padding>]<pin_seq>
```

where [<bit_padding>]<pin_seq> is a sequence of hexadecimal digits (0, 1, …, E, F) constructed using same procedure outlined in Section 5.5.

When representing each transceiver pin with its binary digit, use this notation:

- 0: the pin will output a "low" logic level
- 1: the pin will output a "high" logic level

This command has effect only if AT+UTEST=10,3 has been previously issued.

See the Generic Digital Interface section of the *Iridium 9604 Technical Reference Guide* [2] for a detailed description of the input / output levels characteristics of the pins.

If there are no output pins to be configured, AT+UTEST=10,4 command execution can be avoided.

5.7.1. AT+UTEST=10,4 example

Proceeding with the example described in Section 5.5.1 and Section 5.6.1, the command in Table 28 sets: a "high" logic value on the **GPIO1** pin and a "low" logic value on the **DCD** pin.

In fact, converting the hexadecimal value 00000000000080000000000 into its binary representation, results in:

0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 **1**000 0000 0000 0000

where digit 16 is set to 1 ("high" output logic value), whereas digit 8 is set to 0 ("low" digital output level).

Table 28. AT+UTEST=10,4 example

Command	Response	Description
AT+UTEST=10,4,"00000000000000000008000"	OK	Digital logic value of the output pins: • **GPIO1** set to "high" • **DCD** set to "low"

5.8. Execution of the digital testing

This command applies the settings defined with commands AT+UTEST=10,2 followed by AT+UTEST=10,3 and AT+UTEST=10,4 triggering the actual digital pins test execution.

Before sending AT+UTEST=10,5 the intended pins must be enabled for testing (with AT+UTEST=10,2), configured as digital input or output (with AT+UTEST=10,3) and, for digital output pins, the logic value must be defined (with AT+UTEST=10,4).

Digital testing of the pins is possible only after the execution of the AT+UTEST=10,5 command.

After the execution of the AT+UTEST=10,5 command, it is possible to externally apply a voltage level to the enabled input pins and/or measure the voltage level on the pins configured as digital output.

See the Generic Digital Interface section of the *Iridium 9604 Technical Reference Guide* [2] for a detailed description of the input / output levels characteristics of the pins.

Do not exceed the values reported in the Generic Digital Interface section of the *Iridium 9604 Technical Reference Guide* [2] when testing a pin as a digital input pin, since stressing the device above the listed ratings may cause permanent damage to the transceiver.

Use this command to trigger the execution of the digital testing on the enabled pins:

```
AT+UTEST=10,5
```

An example is shown in Table 29.

Table 29. AT+UTEST=10,5 example

Command	Response	Description
AT+UTEST=10,5	OK	Configurations made by AT+UTEST=10,2; AT+UTEST=10,3 and AT+UTEST=10,4 are executed.

5.9. Digital value measurement

This command returns the logic digital value, "high" or "low", measured on all the enabled pins (with AT+UTEST=10,2 followed by AT+UTEST=10,3 and AT+UTEST=10,4 commands) after the AT+UTEST=10,5 command execution. The command returns the measured logic voltage level for both input and output pins.

To measure the logic digital value of the enabled pins, send:

```
AT+UTEST=10,6
```

The information text response has the following syntax:

```
[<bit_padding>]<pin_seq>
OK
```

where [<bit_padding>]<pin_seq> is a sequence of hexadecimal digits (0, 1, …, F) which can be decoded using the same procedure outlined in Section 5.5.

When representing each transceiver pin with its binary digit, use this notation to read the command response:

- 0: "low" logic digital level measured at the transceiver pin
- 1: "high" logic digital level measured at the transceiver pin

5.9.1. AT+UTEST=10,6 example

See the example of Section 5.5.1, Section 5.6.1, Section 5.7.1, and Section 5.8; the voltage level at the enabled pins is measured using the following command:

Table 30. AT+UTEST=10,6 example

Command	Response	Description
AT+UTEST=10,6	000000000000000000008400	Logic digital value measured at transceivers pins:
	OK	• **CTS** and **GPIO1**: "high" level detected • **DCD** and **DTR**: "low" level detected

Converting each hexadecimal value of the received sequence 000000000000000000008400 into its binary representation, results in:

0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 **1**000 0**1**00 0000 0000

Where digits 16 and 11 are set to 1 ("high" output logic value), whereas digits 8 and 9 are set to 0 ("low" digital output level).

The sequence results in the following voltage levels at the previously enabled pins:

- **CTS**: "high" logic level (input pin configured in Section 5.6.1)
- **GPIO1**: "high" logic level (input pin configured in Section 5.6.1)
- **DCD**: "low" logic level (as defined in Section 5.7.1)
- **DTR**: "low" logic level (as defined in Section 5.7.1)

5.10. Example GPIO test sequence

To summarize the sequence outlined in this section, Table 31 provides an example AT command sequence to test the **CTS** pin. This sequence can be adapted to test additional pins as needed. Finally, the command AT+UTEST=10,0 is used to restore the pins to their original configuration.

Table 31. AT+UTEST=10 example sequence

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack.
AT+UTEST=1	OK	Enter non-signaling mode.
AT+UTEST=10,2,"00000000000020"	OK	Select **CTS** pin for testing.
AT+UTEST=10,3,"00000000000000"	OK	Configure **CTS** pin as output.
AT+UTEST=10,4,"00000000000020"	OK	Configure **CTS** to output a "high" logic value.
AT+UTEST=10,5	OK	Apply changes to selected pins.
AT+UTEST=10,4,"00000000000000"	OK	Configure **CTS** pin to output a logic "low" value.
AT+UTEST=10,5	OK	Apply changes to selected pins.
AT+UTEST=10,0	OK	Restore transceiver pins to their original configuration.
AT+UTEST=0	OK	Exit test mode.

6. End-device production testing

6.1. Production testing procedure

Thanks to the 100% coverage testing performed in the factory on the transceivers before shipment, manufacturers do not need to repeat firmware tests, RF performance tests, or tests over analog and digital interfaces of the transceiver itself in their assembly line. OEMs need only to verify proper assembly of the transceivers in the final application.

For functional verification of end devices after production, the +UTEST AT command provides OEMs a straightforward interface to:

- Set the transceiver in transmitting and receiving states, while ignoring the cellular signaling protocol. This is especially useful during customer production tests to verify the proper soldering of the transceiver RF interface pins by using simple RF test equipment, such as a spectrum analyzer (or an RF power meter), and optionally a signal generator.
- Set some of the pins of the transceiver as generic digital input or output pins. This is especially useful during customer production tests aimed at verifying the proper soldering of the transceiver digital interfaces pins.

During the production process, an OEM manufacturer should focus on:

- Correct transceiver assembly on the end device; it should be verified that:
  - Soldering and handling processes did not damage the transceiver components
  - All transceiver pins are well soldered on the device board
  - There are no short circuits between pins
- Correct component assembly on the end device; it should be verified that:
  - Communications with host controller can be established
  - The interfaces between the transceiver and device are working
  - Overall RF functional test of the device including the antenna

On a typical application, to assess whether the soldering process completed successfully, OEMs may exercise the following transceiver interfaces when powering on their device for the first time:

- transceiver power supply
- **V_INT** voltage output
- AT commands interfaces and serial port(s)
- SIM interface
- RF antenna interface (see Section 6.3)
- GPIO pins
- GNSS subsystem for integrated GNSS (see Section 6.4)

Taking the assumptions above into account, we can envision a simplified example production test process to be used by OEMs as a basis to develop their own according to their specific requirements:

1. After applying power to the circuit and turning on the transceiver according to the *Iridium 9604 Hardware Development Guide* [3], the **V_INT** voltage should rise after a few milliseconds. If the **V_INT** does not go high after ~100 ms the unit must be discarded for further inspection.
2. By default, the UART interface has hardware flow control enabled. To verify that the transceiver has successfully completed its first boot, wait for a high to low transition on the **CTS** line starting from at least 500 ms after **V_INT** has reached its high level. Now the transceiver should be ready to answer to AT commands. If the transceiver does not respond to AT commands or no transition is observed on the **CTS** line the unit must be discarded for further inspection. **DTR** input of the UART port can be verified by setting a greeting text with AT+CSGT and rebooting the transceiver with **DTR** asserted. When the boot phase is complete, the transceiver must output the greeting text.
3. If the transceiver is answering to AT commands, then the power supply, V_INT and serial port are working. To verify that the transceiver is communicating with the SIM card (or SIM chip) use the +CPIN read command. If such command returns +CPIN: READY the SIM interface is working correctly. For more details on the +CPIN AT command, see the *Iridium 9604 AT Command Guide* [1].
4. If the earlier steps are successful, the transceiver RF interface can be tested. The minimum recommended RF verification during production consists in forcing the transceiver to transmit in a supported frequency (AT+UTEST=3), and then checking that some power is emitted from the antenna system using any suitable power meter or equivalent equipment, as well as checking if the transceiver receives some power from a suitable signal generator while forced to receive in a supported frequency (AT+UTEST=2). RF interfaces are bidirectional: i.e., if Tx works fine, Rx is expected to be working too, and vice versa. Moreover, there is no need to test every supported RAT and frequency band since many of them overlap in frequency and share the same RF paths. Spot checking of some RAT, band, and channel combinations is sufficient. It is up to the OEM to test as many Tx/Rx scenarios as they see fit, depending on the confidence level requirements and the time allowed for production testing.
5. If used in the final product, I2C interfaces can be tested with the related AT commands. See the *Iridium 9604 AT Command Guide* [1] for more details.
6. Eventually, to assess the functionality of the transceiver digital pins used in the application, run the command AT+UTEST=10 as described in Section 4 and in the *Iridium 9604 Software Developer Guide* [4]. Since there is no dependency between steps 4, 5 and 6, they can be executed in no particular order.



The use of the +UTEST AT command must be restricted to controlled RF environments (i.e., shielded chamber/box), and is confined to validation and production tests only. Iridium assumes no responsibility for inappropriate use of the command.

If the production tests are performed in signaling mode on a network simulator, it is suggested to use test SIM cards (or SIM chips supporting simulated networks) to connect to the test instrument. If a test SIM card is not available, disable authentication and integrity checks on the tester side (by proper setting) and on the transceiver (by using the AT+UDCONF=81,0 command). LwM2M and security features might interfere with simulated network measurements and should be disabled with the AT+ULWM2M=1 command. For the +UDCONF=81 and +ULWM2M AT commands description, see the *Iridium 9604 AT Command Guide* [1].

6.2. Persistent configurations

After the application has passed the required production tests, the OEM is responsible for configuring the transceiver according to their requirements. To increase flash memory lifetime, there is no need to repeat the configuration of persistent settings at each transceiver boot since they are saved to and automatically restored from NVM.

What follows is a list of settings that may be set the first time the transceiver boots:

- **Mobile network service parameters**: depending on the mobile network operator of choice, the OEM may, for example, set the radio access technology using the +URAT AT command. Moreover, +UMNOPROF allows to select between different MNO profiles. The +UBANDMASK AT command enables or disables cellular network bands, its default value depends on the selected MNO profile.
- **GPIOs**: the GPIO configuration, set with +UGPIOC, is also saved to the transceiver NVM.
- **Antenna dynamic tuning**: can be enabled or disabled with +UTEST=4. The same AT command allows to change the antenna tuner truth table.
- **UART settings**: by default, Iridium 9604 transceivers have autobauding enabled. Depending on the application, OEMs may need to set the default baud rate to a different value using the +IPR AT command. The frame format settings are changed with +ICF instead.
- **Greeting text**: enabled with +CSGT, can be used to inform the application processor that the transceiver is ready to accept AT commands.
- Any other configuration option different than the default value (e.g., LwM2M, security, etc.).

See the *Iridium 9604 AT Command Guide* [1] for more details about the commands mentioned above.

If some features are never used during the application lifetime, they should be disabled or properly configured to minimize their impact on the overall performance. One of such features is the LwM2M client, which should always be disabled if not required. Also consider that, at new SIM card detection, LwM2M will need about 20 s to populate its database (triggering uplink data transmission) and be ready to operate: this can be done in the production phase or once the device is deployed in the field.

For more details and guidelines regarding persistent configuration of user settings, see the *Iridium 9604 Software Developer Guide* [4] and the *Iridium 9604 AT Command Guide* [1].

6.3. Cellular RF antenna interface production testing examples

6.3.1. Cellular RF antenna interface production test sequence example

To verify proper assembly of transceivers, there is no need to test every supported RAT and frequency band. It is enough to test a single channel in a single frequency band to ensure that the **ANT** pin is properly soldered. The example in Table 32 shows how to set the transceiver to transmit in LTE band 12 with a Tx power of 23 dBm.

Table 32. Example Tx production test sequence

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST=3,123095,23,,,0	+UTEST:123095,23,5,1,0 OK	Enable persistent LTE Tx signal output in LTE band 12, channel 23095, with 23 dBm output power.
AT+UTEST=0	OK	Stop the previous transmission and exit test mode.
AT+CFUN=1	OK	Restore full transceiver functionality.

6.3.2. Tx mode testing of the main internal RF paths

Testing more bands than needed extends the production time with dubious benefits. Since many bands overlap in frequency, the transceiver internally has a limited number of distinct RF paths both for Tx and Rx mode. Therefore, if the production time allows it, the sequence in Table 33 shows how to test the main internal RF paths in Tx mode for extra confidence.

Internally, Iridium 9604 transceivers have two cellular RF paths:

- Low frequency: active when the transceiver is transmitting or receiving at frequencies below 1400 MHz
- High frequency: active for bands above 1700 MHz

As a result, even though not strictly needed for production testing, to exercise the main internal cellular RF paths in Tx mode, test a single channel of LTE B1 and of LTE B12, as described in Table 33.

Table 33. Example Tx production test sequence to verify the main cellular RF paths of the transceiver

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST=3,118300,23,,,1000	+UTEST: 118300,23,5,1,1000 OK	Transmit in B1 channel 18300 for 1 s with 23 dBm output power.
AT+UTEST=3,123095,23,,,1000	+UTEST: 123095,23,5,1,1000 OK	Transmit in B12 channel 23095 for 1 s with 23 dBm output power.
AT+UTEST=0	OK	Stop the previous transmission and exit test mode.
AT+CFUN=1	OK	Restore full transceiver functionality.

6.3.3. Rx mode testing of the main internal RF paths

As explained above, testing all the RF paths of the transceiver provides a negligible increase in the production test confidence and prolongs substantially the production test time. Moreover, for the transceiver, RF interfaces are bidirectional: if the transceiver passes the Tx test sequence, likely the Rx path would also, and vice versa. As an alternative to the example in Table 33, the commands in Table 34 test the main transceiver internal RF paths in Rx mode. To record the example, the transceiver **ANT** pin is connected to a signal generator outputting a CW signal with a power of -20 dBm at each test frequency.

Table 34. Example Rx production test sequence to verify the main cellular RF paths of the transceiver

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST=2,100300,1000	+UTEST: 100300,1000,0,-21, -20,-19 OK	Reception test in B1 channel 300 for 1 s.
AT+UTEST=2,105060,1000	+UTEST: 105060,1000,0,-20, -20,-20 OK	Reception test in B12 channel 5060 for 1 s.
AT+UTEST=0	OK	Stop the previous transmission and exit test mode.
AT+CFUN=1	OK	Restore full transceiver functionality.

6.3.4. Reception test with bad solder joint

If the transceiver or any series component along the **ANT** transmission line are improperly soldered or damaged because of the production step, the estimated RF power level will usually be more than 20 dB lower than expected, depending on the extent of the damage. To simulate such a scenario, a broken RF cable connects the transceiver with a signal generator outputting -20 dBm. The following response has been recorded:

Table 35. Executing +UTEST=2 with a damaged RF path (simulated using a bad RF cable)

Command	Response	Description
AT+UTEST=2,105060	+UTEST: 105060,1000,0,-68, -68,-68 OK	A bad solder joint introduces 48 dB of signal loss.

6.4. GNSS production testing

After production testing of the cellular parts of the transceiver (see the sequence proposed in Section 6.1), the OEM may also test the GNSS receiver for proper soldering of the related pins. The following flow can be used as a basis to develop the GNSS receiver production test process:

1. Provide a GNSS test signal to the application board. For the production test sequence to be effective, the source must produce reliable and constant signals at every measurement. There is no need for expensive GNSS generators, a single-satellite signal is enough. Such kind of signal can be provided by single-channel GNSS simulators or vector signal generators with a suitable waveform file[1]. The pass/failure criterion is set by comparison with a "golden device" (i.e., a known-good reference GNSS receiver or a working OEM application). The Tx power level of the instrument is set such that the golden device reports a C/No of roughly 42 dBHz.

2. Power on the internal GNSS receiver using the +UGPS=1 AT command.

3. To verify proper operation of the GNSS RF interface, read the satellite C/No value from the NMEA GSV or any UBX message reporting it (e.g., UBX-NAV-SAT). The resulting C/No value should be compared with the "golden device" expected value to conclude a successful production test.

For more details on the GNSS-related AT commands, see the *Iridium 9604 AT Command Guide* [1]. An explanation of the aforementioned UBX messages is available from u-blox in the u-blox M10 standard precision GNSS chip interface manual [5].

[1] Spirent, Rohde & Schwarz and Orolia among other manufacturers offer such devices

7. End-device design validation testing

7.1. Introduction

The design verification and validation phase using a prototype of the product integrating the Iridium 9604 transceiver is crucial to ensure the application meets the OEM requirements before ramping up of the production. Thorough prototype validation reduces unexpected changes once the product is already deployed. Example prototype validation scenarios are available in Section 7.2.

Figure 5 illustrates a typical setup for RF functional testing in radiated mode and conducted mode. Besides specific customer requirements, before mass production it may be valuable to test:

- The application RF performance, since it will affect the device certification phase (see validation testing examples in Section 7.2.1 to Section 7.2.5)
- The transceiver power supply capabilities (Section 7.2.6)
- Device heat dissipation and surface temperature (Section 7.2.6)
- That the correct power on and power off sequences have been implemented (Section 7.2.7)
- SIM card interface rise and fall times (Section 7.2.8)
- UART / USB and other interfaces reliability (Section 7.2.9 and Section 7.2.10)
- Application behavior with various target MNOs
- Cellular network out of coverage scenarios
- Application robustness against unwanted transceiver or MCU hangs and reboots

For further guidelines about software application development, verification and validation, please see the related sections in the *Iridium 9604 Software Developer Guide* [4].

The +UTEST AT command is useful not only for production testing but also for cost and time effective prototype validation since no expensive equipment (such as a cellular network simulator) is involved. However, this procedure is not suitable to perform conformity assessment or RF compliance testing since the Tx and Rx chains are operating open loop and the signals are not representative of an actual transmission. Compared with a similar test scenario, performed on a real (or simulated) network, in non-signaling test mode:

- The protocol stack is disabled. As a result, the actual power consumption of the transceiver will differ as the protocol stack associated circuitry of the transceiver is powered off.
- The Rx and Tx chains are working open loop, i.e., there is no tight control on the received and transmitted power levels. Therefore, deviation in the Tx signal parameters (such as power, EVM, frequency) from the ideal values is expected alongside some error in the reported power values.
- The RF Tx signal is not representative of the actual power dynamic since no network scheduler is instructing the transceiver when to send or receive data. Moreover, a typical application may need to wake up the radio occasionally to send or receive information, while in non-signaling test mode the radio is always enabled and transmits dummy data according to its own repetitive pattern.
- No synchronization signals are sent in Tx test mode nor are decoded by the Rx test mode making the decoding of the Tx signals meaningless.

The +UTEST AT command sets the transceiver to emit RF power ignoring cellular signaling protocol. This emission generates interference that is prohibited by law in some countries. Only qualified users are allowed to use this feature intended for testing purposes in controlled environments.

The +UTEST AT command must not be used outside of the device production line or research and development laboratory. Follow the instructions suggested in this and other supporting documentation. Iridium and the manufacturer assume no responsibilities for the inappropriate use of this feature.

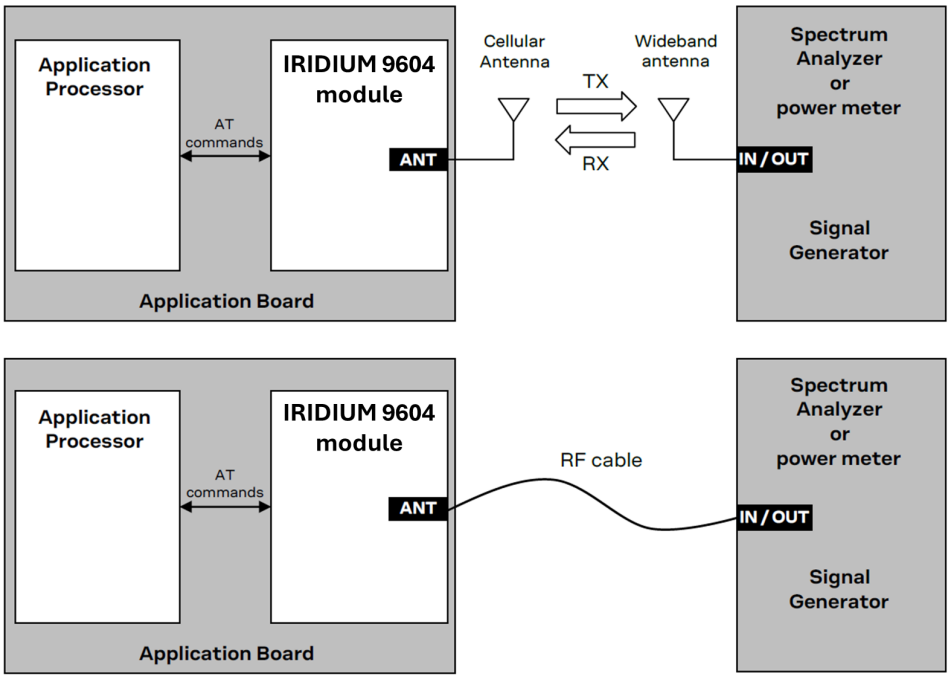


Figure 5. Setup with spectrum analyzer or power meter and signal generator for RF power measurements

7.2. Prototype validation testing examples

7.2.1. Antenna RF design validation using a vector network analyzer

Antenna design validation is a critical step in the development of any antenna system. It ensures that the designed antenna meets the required performance standards and specifications. One of the most widely used tools for antenna design validation is a Vector Network Analyzer (VNA). A VNA is an electronic instrument that is used to measure the RF performance of devices such as antennas and transmission lines. It provides a comprehensive set of measurements that determine the RF characteristics of the antenna, including the impedance matching and frequency response.

As part of the antenna design validation process with configurable tuning capability, OEMs must configure and validate their dynamic antenna tuner implementation. This feature is configured based on the specific performance objectives and system constraints, such as desired frequency range, physical design of the device or antenna type and placement.

The process of antenna design validation using a VNA involves connecting the antenna to the VNA through a coaxial cable. The *Iridium 9604 Hardware Development Guide* [3] reports target requirements for the cellular antenna RF interface the prototype must follow. It is crucial to adhere to the guidelines provided by the antenna manufacturer for the proper installation and deployment of the antenna system, including PCB layout and matching circuitry. Antennas may need tuning to achieve the necessary performance for compliance with all relevant certification schemes. Consulting the antenna manufacturer for design-in guidelines about antenna matching is highly recommended.

7.2.2. Maximum RF Tx power measurement

In the AT command sequence in Table 36, the transceiver is powered on, and it is set to output a 23 dBm LTE RF test signal in non-signaling test mode, centered around 1710 MHz.

Table 36. Example commands for maximum Tx power testing.

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST=3,119200,23,,,0	+UTEST: 119200,23,5,1,0 OK	Enable persistent LTE Tx signal output in channel 19200 with 23 dBm output power.

To measure the maximum output power, the **ANT** pin of the transceiver is connected to a power meter with an RF cable whose loss is 0.6 dB at 1.7 GHz. The instrument peak power reading is 22.3 dBm, corresponding to an output power level of 22.9 dBm as expected.

7.2.3. RF validation testing with network simulators

Full RF validation against cellular networks can be executed by setting up a signaling mode test. These tests can be conducted either through a live network test or by using a telecommunication tester to mimic the behavior of real-world cellular networks. Compliance of the design with RF regulatory rules

defined by the FCC, ISED, RED, etc. can be verified using a radio communication tester (callbox) as the Rohde & Schwarz CMW500, or any equivalent equipment for multi-technology signaling conformance tests.

By default, no AT command or special configuration is needed to trigger the network registration. Make sure the correct SIM card is used for testing against a simulated network (i.e., a SIM card with the specific test profile for the instrument) and the band to test is supported and enabled on the transceiver. When testing is performed over the air, measure the attenuation of the RF path from the instrument antenna to the antenna on the device under test. For a reliable connection, the resulting attenuation value must be compensated for within the instrument's settings.

7.2.4. RF spurious emissions measurement and debugging

Albeit not reliable from a full RF compliance testing perspective, the setup described allows a user to carry out qualitative measurements to debug spurious emission problems. By comparing the results with a reliable, reference measurement obtained from a network simulator, this approach enables faster verification of improvements on the prototype. The +UTEST AT command can also be used to verify whether the application board maintains the transceiver RF performance and if EM interference with the application board electronic components causes spurious emissions outside of the specifications. For this measurement, a spectrum analyzer and an RF high-pass filter are needed.

Spurious emission tests can be performed in two ways: conducted or radiated. Depending on the related regulatory and conformance rules applicable for the radio access technologies supported by the transceivers, spurious emissions may have to be verified up to 12.75 GHz. It has to be considered that the level of the spurious emissions may be more relevant at specific frequencies and/or in particular at frequencies that are multiples of the carrier (harmonic signals). Figure 5 illustrates a typical setup for RF functional testing in radiated mode and conducted mode.

Figure 6 shows a conducted spurious emissions measurement from 800 MHz to 6 GHz. The transceiver under test is set to transmit a LTE signal at maximum power (23 dBm) at 897.5 MHz (band 8 channel 21625). The connection to the spectrum analyzer includes a 10 dB attenuator in series with a 1.4 GHz high-pass filter. The spectrum analyzer settings are as follows:

- Manual attenuation = 0 dB
- Reference level offset = external attenuator + High Pass filter insertion loss + cable loss
- Reference level = 0 dBm
- Start frequency = 800 MHz
- Stop frequency = 6 GHz
- Sweep time = AUTO
- Resolution bandwidth RBW = 3 MHz
- Video bandwidth VBW = 10 MHz
- RBW filter type = Normal 3 dB
- Trigger = FREE RUN
- Trace detector = sample
- Trace = MAX HOLD
- Marker position = peaks

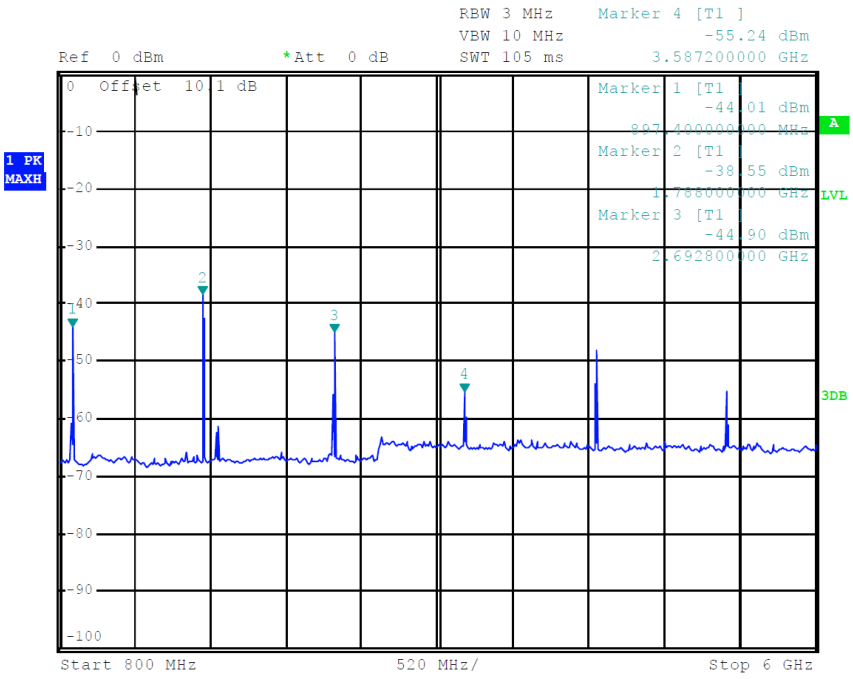


Figure 6. Conducted spurious emission measurement for LTE band 8 channel 21625

The +UTEST AT command is not meant to be used for actual RF compliance testing according to FCC and 3GPP specifications. To correctly test radiated spurious emission, an anechoic chamber, and a precise testing setup (including a cellular network simulator) are needed.

7.2.5. RF receiver validation in the cellular frequency bands

The +UTEST AT command can be used to scan the supported frequency bands with the aim of executing a preliminary basic validation of the cellular receiver capability, while further full validation can only be done using a network simulator (see Section 7.2.3). The cellular receiver will act as a simple spectrum analyzer, allowing detection of any abnormal or unexpected electromagnetic interference sources. This test does not replace a proper signaling-mode Total Isotropic Sensitivity (TIS) test in a real anechoic chamber using a network simulator, however it aids in debugging possible TIS degradations due to external noise coupling into the cellular antenna. Table 37 shows an example AT command sequence to scan the LTE band 12 Rx frequency range (729 - 746 MHz).

Table 37. Scanning LTE band 12 for noise coupled into the cellular antenna

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST=2,105010,200	+UTEST: 105010,200,0,-90, -90,-90 OK	Measure Rx power for 200 ms in channel 5010. Signal strength is -90 dBm, which is the noise floor of the transceiver.
…	…	Repeat the +UTEST=2 command invocation above increasing the channel number at each iteration.

Command	Response	Description
AT+UTEST=2,105030,200	+UTEST: 105030,200,0,-90, -80,-74 OK	Measure Rx power for 200 ms in channel 5030. Maximum signal strength is -74 dBm. The transceiver has detected a spur around 731 MHz.
…	…	Repeat the +UTEST=2 command invocation above increasing the channel number at each iteration.
AT+UTEST=2,105170,200	+UTEST: 105170,200,0,-90, -90,-90 OK	Measure Rx power for 200 ms in channel 5170 (last channel of band 12 is 5179). Signal strength is -90 dBm.
AT+UTEST=0	OK	Exit the non-signaling mode.
AT+CFUN=1	OK	Restore full transceiver functionality.

This functionality can be scripted enabling accelerated and reproducible validation of prototypes. With such a script, a reception test was done on each LTE band 12 channel, revealing unwanted emissions between 730 and 732 MHz (channels 5020 .. 5040), as shown in Figure 7.

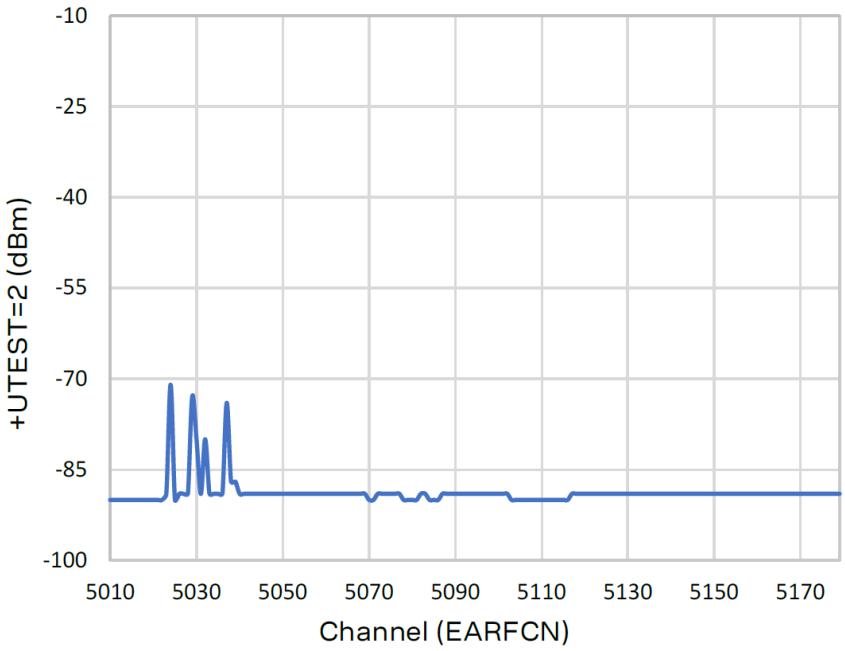


Figure 7. Using the transceiver as a rudimentary spectrum analyzer in LTE band 12 to detect noise

7.2.6. VCC power supply and / or thermal dissipation validation

The **VCC** power supply circuit may affect the RF characteristics and the RF compliance of the device integrating the transceiver with applicable certification regulatory requirements. Therefore, the validation of the **VCC** power supply circuit is important as a preliminary verification of possible degradation in the RF characteristics, aside verifying proper thermal dissipation of the application.

For example, if the power capability of the **VCC** supply circuit is not adequate, the **VCC** voltage drop during transmission at maximum power (see Figure 8) will be larger, and this may increase the level of

the RF spurious emissions, violating applicable RF regulatory requirements (see Section 7.2.4).

As additional example, if the ripple in the **VCC** supply is too large, this noise may be radiated from the **VCC** supply line up to the antenna, affecting the RF receiver performance (see Section 7.2.5).

To validate the application board power supply performance under heavy load, use the +UTEST AT command, setting the maximum transmit power in a channel in one of the lower LTE frequency bands (i.e., LTE B5 or B12).

Using an oscilloscope connected as close as possible to the **VCC** pins of the transceiver, measure the supply voltage drop and ripple during transmission. Make sure that

- the **VCC** voltage pin is within the normal operating range according to the *Iridium 9604 Technical Reference Guide* [2]
- the **VCC** voltage ripple during transmission is minimized

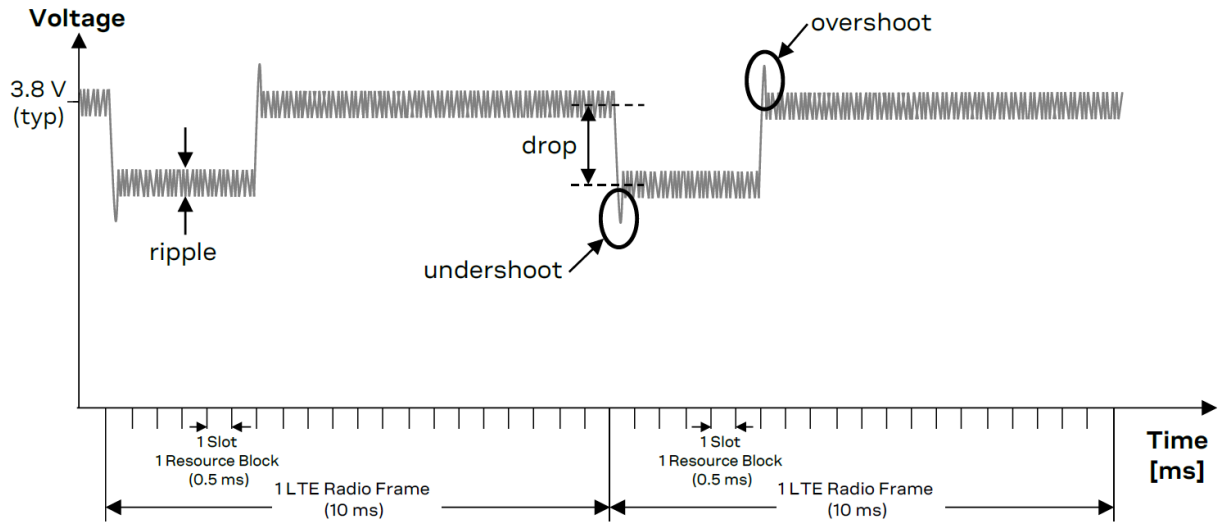


Figure 8. Description of the VCC voltage profile versus time during LTE cat-M transmission

RF power measurement can be executed at the same time while verifying the **VCC** supply circuit. In any case make sure the **ANT** pin is connected to the antenna or to a 50 Ohm termination during the test.

The AT command sequence in Table 38 can be used to perform this **VCC** power supply validation test. The same sequence can be used to evaluate the thermal performance of the application. Leave the transceiver transmitting at maximum power for at least 10-15 minutes then measure its temperature and that of its surrounding components (especially the power supply). The delta between ambient temperature and the transceiver surface temperature will give an estimate of the temperature raise the application may experience.

Table 38. Example commands for VCC ripple testing in LTE B12

Command	Response	Description
AT+CFUN=0	OK	Deactivate the protocol stack.
AT+UTEST=1	OK	Enter the non-signaling mode.
AT+UTEST=3,123095,23,,,0	+UTEST: 123095,23,5,1,0 OK	Enable persistent LTE Tx signal output in channel 23095 (707.5 MHz) with 23dBm output power.

The RF output signal, obtained with +UTEST=3, has a duty cycle of 0.3 (see Section 3.7). As a result, power consumption and thermal measurements may not accurately reflect worst-case scenarios. Nevertheless, this test serves the purpose of putting significant stress on the application's power supply circuitry and evaluating the overall thermal performance.

7.2.7. Power-on and power-off sequence validation

An improper power-on and power-off sequence may damage the transceiver and lead to unreliable application operation when deployed in the field. It is crucial to confirm that those sequences agree with the recommendations available within the *Iridium 9604 Hardware Development Guide* [3]. Care must be taken to also verify the behavior of the application processor in case the transceiver becomes unresponsive.

In addition to following the recommended power-on and power-off sequences, it is important to simulate a crash of the MCU and evaluate the behavior of the processor interfaces during boot. This is especially important for the GPIOs, as their default state can have a significant impact on the functionality of the application. It is crucial to ensure that the GPIOs are configured correctly and that their default state does not interfere with the operation of the application. By carefully simulating a crash and evaluating the behavior of the processor interfaces, developers can identify and address any potential issues, ensuring the reliable operation of the application in the field.

7.2.8. SIM interface rise and fall times measurement

Each line of the SIM interface (**SIM_IO**, **SIM_CLK** and **SIM_RST**) must match the rise / fall time defined by ETSI TS 102 230-1 [9].

- SIM_CLK: 50 ns
- SIM_IO and SIM_RST: 1.0 µs

With the aid of an oscilloscope connected as shown in Figure 9, measure the rise and fall times of the SIM interface lines during transceiver boot.

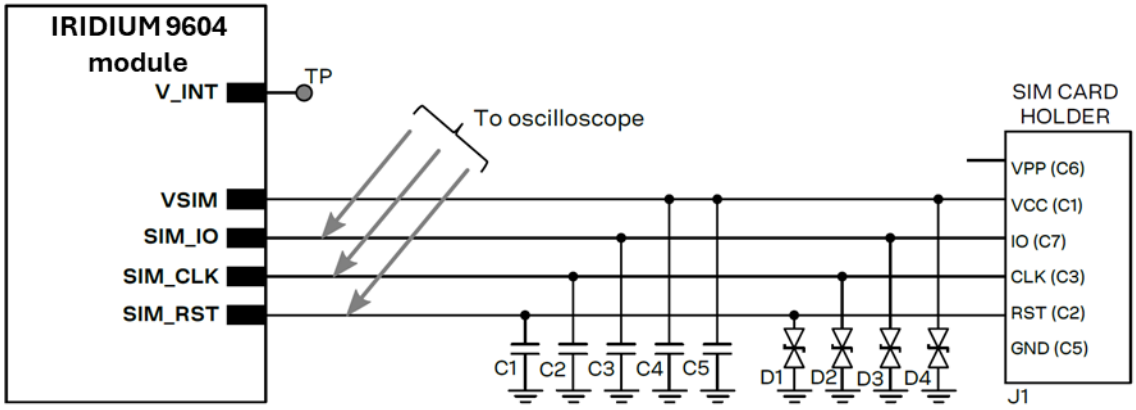


Figure 9. Oscilloscope connection to measure rise and fall times of SIM interface lines

7.2.9. UART interface validation

With a similar setup as in Figure 9, with the oscilloscope connected to the UART pins instead, the UART waveforms can be evaluated. In the *Iridium 9604 Hardware Development Guide* [3], it is recommended to use unidirectional, push-pull voltage translators to ensure maximum signal integrity. When using bidirectional voltage translators with open drain/open collector outputs, OEMs must validate their solution to ensure that the maximum baud rate supported can be reached without signal integrity degradation.

7.2.10. Other interfaces validation

The circuits designed for other interfaces of the transceiver can be validated using the AT commands available to drive the related interface, as for example:

- The GNSS system design can be validated using +UGPS and other GNSS-related AT commands, or using UBX messages sent directly to the GNSS receiver.

Additionally, the circuits designed for any other interfaces of the transceivers can be validated using the AT commands available to drive the related interface, as for example the antenna detection design can be validated using the +UANTR AT command.

Appendix A: Abbreviations

Term	Description
2G	2nd Generation
3G	3rd Generation
3GPP	3rd Generation Partnership Project
4G	4th Generation
APN	Access Point Name
ARFCN	Absolute Radio-Frequency Channel Number
AT	AT Command Interpreter Software Subsystem, or attention
CTS	Clear To Send
CW	Continuous Wave
DCD	Data Carrier Detect
DTR	Data Terminal Ready
EARFCN	E-UTRAN Absolute Radio Frequency Channel Number
EGSM	Extended GSM
EVM	Error Vector Magnitude
FDD	Frequency-Division Duplex
GCF	Global Certification Forum
GMSK	Gaussian Minimum Shift Keying
GPIO	General Purpose Input Output
GSM	Global System for Mobile Communications
LTE	Long Term Evolution
LwM2M	Lightweight M2M
MNO	Mobile Network Operator
MT	Mobile Terminal
NVM	Non-Volatile Memory
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency-Division Multiplexing
QPSK	Quadrature Phase-Shift Keying
PTCRB	PCS Type Certification Review Board
RAT	Radio Access Technology
RBW	Resolution BandWidth
RF	Radio Frequency

Term	Description
RI	Ring Indicator
RMS	Root Mean Square
RTS	Request To Send
Rx	Receiver
SDIO	Secure Digital Input Output
SIM	Subscriber Identity transceiver
TDD	Time-Division Duplexing
Tx	Transmitter
UARFCN	UMTS Absolute Radio Frequency Channel Number
UART	Universal Asynchronous Receiver-Transmitter
WCDMA	Wideband Code-Division Multiple Access