

Radio Function Test for Telematics Control Unit

SSM Test PKG Telematics Connectivity MX847503A-TL660

SSM Test PKG Telematics Throughput MX847503A-TL661

SSM Test PKG Telematics Mobility Basic MX847503A-TL662

Table of Contents

1. What is a Telematics Control Unit?	2
2. TCU Functional Performance Test	2
2.1 Problems Which are Likely to Occur with Wireless Communication	3
2.2 Issues Affecting the TCU Performance Test.....	4
2.3 Anritsu's Solutions	5
3. Test Procedure.....	6
3.1 Test Flow	6
3.2 Measurement System	6
3.3 Acquiring UE Capability Information	7
3.4 Creating the Test Case.....	7
3.5 Test Execution and Results.....	8
4. Product Information.....	9

1. What is a Telematics Control Unit?

A vehicle equipped with a communications device that allows it to communicate with servers and other systems via the Internet is called a “connected car.” The services provided by connected cars will include automatic emergency calling in the event of an accident, tracking of stolen cars, etc.

A telematics control unit (TCU) is a wireless device which receives information from units in the vehicle (such as the electronic control unit (ECU)) and transmits that information to external systems. With the expansion of the connected car market, wireless communication is becoming more and more important.

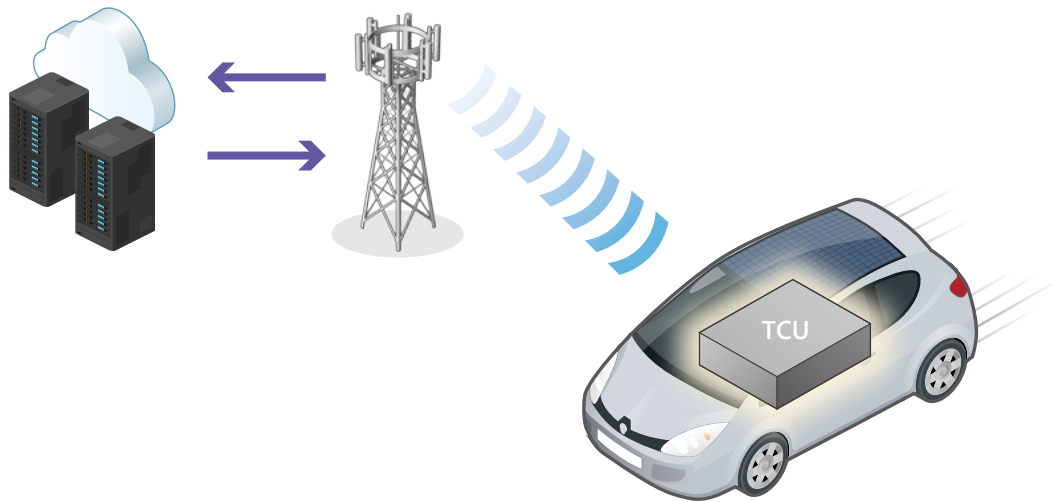


Figure 1 Telematics Control Unit in Connected Car

TCUs are able to connect to 4G or 5G mobile networks and maintain a network connection while the car is moving. To ensure that the customer is provided with a satisfactory service, the manufacturer should check that the TCU can establish a stable connection with a mobile network.

Related link: [5G Connectivity](#)

2. TCU Functional Performance Test

The most common method of testing a TCU’s wireless performance is to verify its functions through on-the-road tests with the TCU installed in the vehicle. This method has poor repeatability because radio propagation may differ due to weather and traffic conditions, even when the vehicle drives the same route. To check the TCU’s functions and performance, car manufacturers need to execute numerous test patterns repeatedly using a test method which offers repeatability.

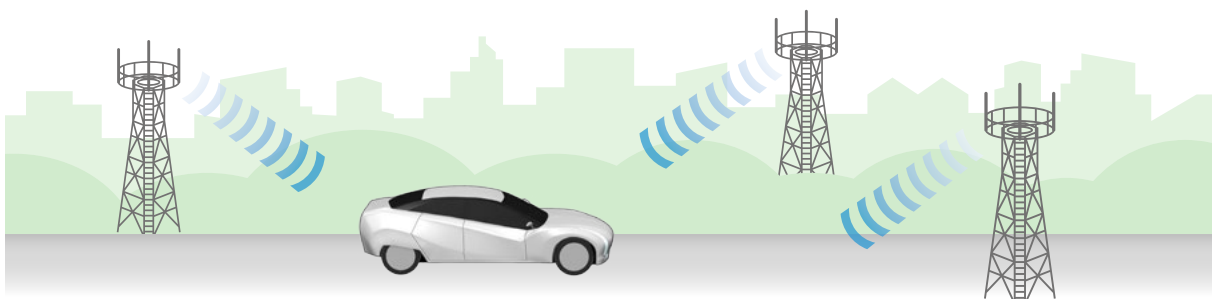


Figure 2 TCU’s On-the-Road Wireless Performance Test

2.1 Problems Which are Likely to Occur with Wireless Communication

The TCU's radio performance testing cannot include all the wireless communication conditions which arise during actual driving. Therefore, communication issues may arise while the vehicle with the TCU is on the road, even if the TCU performance satisfies the specifications set by the car manufacturer. Problems which are likely to occur include unstable connections and throughput drops.

2.1.1 Unstable Connection

An unstable connection occurs as a result of the TCU disconnecting from the network. The TCU switches from one base station to another as the vehicle drives through their coverage areas. The switching from one base station to another is called "handover." Communication standards for mobile networks have continued to evolve, through 3G, 4G, to the current 5G. Globally, mobile networks of each generation of standard operate in tandem, and the frequency bands used vary from country to country. TCUs need to be able to guarantee the quality of their wireless communication functions regardless of the operational status of the mobile networks in the countries in which they are operating.

There are two types of 5G base stations: non-stand-alone (NSA) base stations, which provide wireless connectivity in conjunction with 4G base stations, and stand-alone (SA) base stations, which provide stand-alone wireless connectivity. When a wireless connection is made using a multiple frequency band method called "carrier aggregation", the TCU performs handover over multiple frequencies.

Therefore, the following two aspects of the mobile network conditions affect the handover conditions:

- Status of Radio Access Technology (RAT) development from 2G to 5G
- Frequency utilization of bands, etc.

The following three points should be considered when determining the method of connection to the base station:

- Process of signaling to the mobile network until location registration is complete
- For 5G, the NSA base station or SA base station
- The use of carrier aggregation

To realize connected car services, it is important to check the handover function of TCUs under these very diverse conditions.

2.1.2 Throughput Drop

A drop in data throughput means that the data transmission speed slows down even though you are connected to the network.

To realize the connected services offered by car manufacturers, such as location information services, emergency calls, and infotainment, it is essential that the TCU provides stable, high-speed data transmission and communication functions.

The mobile network sets the following communication parameters for the TCU depending on the on-the-road communication environment, such as the signal strength and data error rate.

- Bandwidth: The radio frequency bandwidth to be used. Just like the width of a road, the wider the bandwidth, the higher the data speeds can be. On the other hand, when multiple devices communicate at the same time, the available bandwidth is limited.
- Modulation and coding scheme: Communications standards define the Modulation and Coding Scheme (MCS). The amount of data sent per modulation varies depending on the modulation and coding scheme. When the signal strength from the base station is strong, a scheme with a larger data capacity can be used.
- MIMO: A method of simultaneous communication using multiple transmitters, receivers, and antennas is called multi-input multi-output (MIMO). This technology has been used in networks since 3G.
- Carrier aggregation: A method of communication that combines multiple bands specified by the standard. The bands to use and the number of bands are decided by negotiation between the TCU and the base station.

2.2 Issues Affecting the TCU Performance Test

As described in the previous section, the test parameters for TCUs include different communication standards for different generations and many different parameters that determine the data rate.

Therefore, the number of test conditions can become huge, considering the many frequency bands used for communication and the combinations of frequency bands, along with handover and parameter changes.

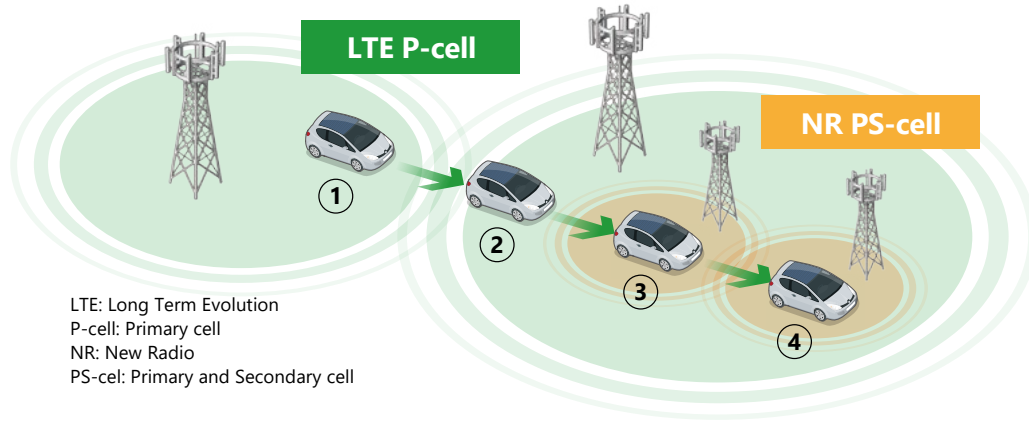


Figure 3 Handover from LTE Base Station to 5G Base Station

Figure 3 shows a vehicle moving and handing over from a 4G (LTE) base station to a 5G (NR) base station.

At position ①, the TCU is connected to the LTE base station.

When the vehicle moves to position ②, the signal from the base station to which it was previously connected becomes weaker, and the TCU detects the signal from another LTE base station. Here the TCU performs handover between the LTE base stations.

When the vehicle moves to position ③, the TCU detects the 5G base station (NSA). The TCU maintains the radio connection to the LTE base station and performs handover to the 5G base station (NSA), but only for the portion of the connection used for data transmission.

A scheme that uses multiple frequency bands to connect to both LTE and 5G base stations (NSA) is called EUTRA-New Radio Dual Connectivity (EN-DC). With this scheme, the frequency band of the LTE base station may change.

When the vehicle moves to position ④, the TCU detects another 5G base station (NSA) and performs handover to that 5G base station. For example, if a TCU supports five frequency bands for LTE and two for 5G, there are 500 possible combinations of frequencies that could be used for handover from 1 to 4.

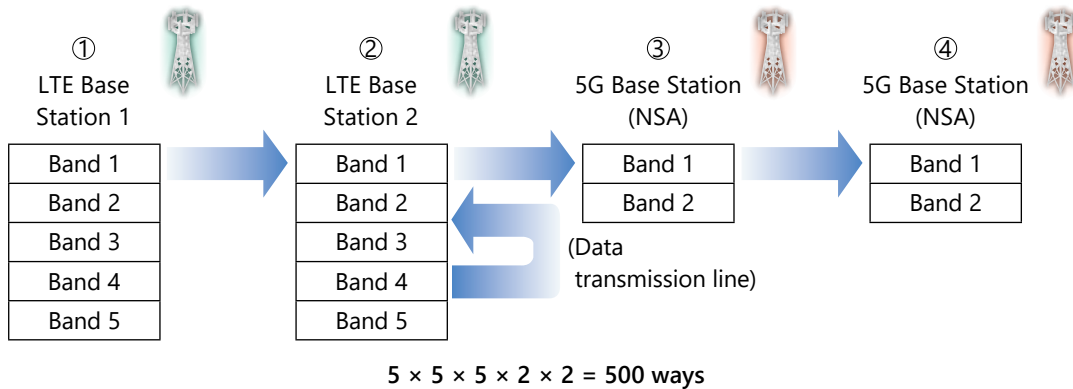


Figure 4 Frequency Band Combinations Used for Handover

It is not practical to perform tests with every possible combination of parameters such as frequency bandwidth, carrier aggregation, MIMO, MCS, etc.

2.3 Anritsu's Solutions

Increasing the number of communication conditions during TCU performance evaluation and acceptance testing will improve the reliability of the TCU operation, but will also increase the cost of testing. Anritsu can provide a solution to determine the frequency band to be tested and reasonable handover conditions, and create a program to execute the tests (this program is called a test case) based on the communication capability information recorded in the TCU.

In this way, the solution can optimize the test parameters and items for TCUs.

UE Capability Information Acquisition and Analysis

UE Capability Information is installed in the TCU and is sent from the TCU to the network when registering its location. The purpose of this is to inform the network of the communication capabilities of the TCU and to optimize the communication conditions within those capabilities. The UE Capability Information contains many parameters, especially for NR, which is much more diverse than LTE due to the complexity of the NR system.

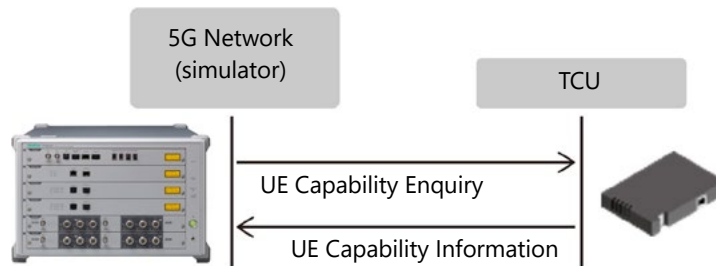


Figure 5 Acquiring Capability Information

Executing a test case that queries the TCU for UE Capability Information acquires the following information:

- LTE bands
- NR SA bands
- NR NSA bands
- LTE Carrier Aggregation
- NR Carrier Aggregation
- MIMO for each band
- Downlink bandwidth
- Uplink bandwidth
- Modulation scheme
- Sub-carrier spacing

Therefore, we need to create scenarios to perform functional performance tests based on UE Capability Information after analyzing the acquired LTE and NR band UE information to determine the tests to perform.

Changing from the communication performance testing of TCUs that run vehicles to the communication performance testing in a simulation environment using measuring instruments enables the improvement of the test reproducibility and reduces the number of test man-hours, due to the use of automated testing. Since communication performance tests in a simulation environment allow users to execute a single test repeatedly, they are very effective for the acceptance testing of TCUs and operation checks during software updates, etc.

3. Test Procedure

3.1 Test Flow

Figure 6 shows the functional performance test flow of the TCU.

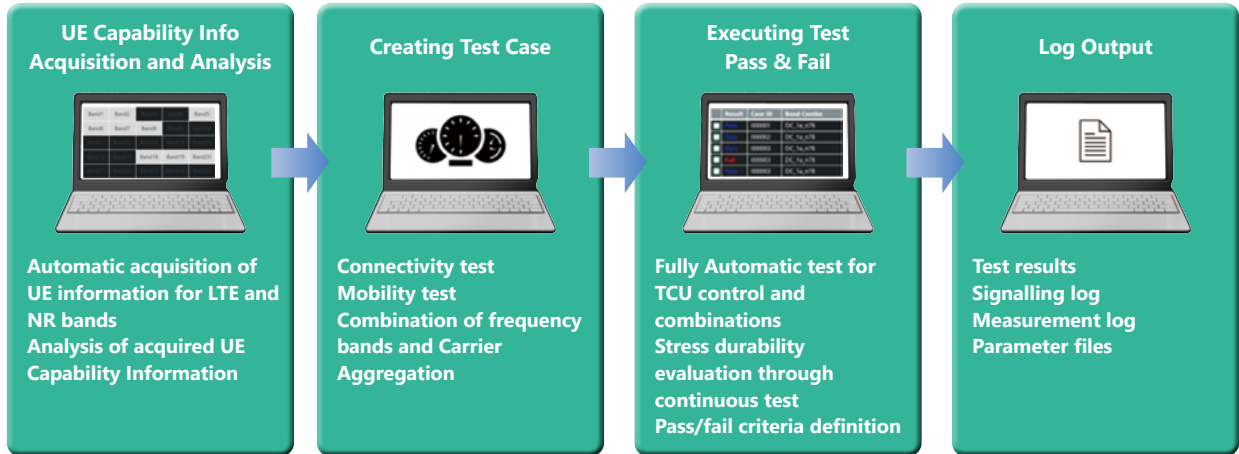


Figure 6 Functional Performance Test Flow of the TCU

UE Capability Information Acquisition and Analysis

Queries the TCU for UE Capability Information and analyzes the acquired data.

Creating the Test Case

It is necessary to describe, to the test case, the test of the connection to the base station, the handover test, or the throughput test based on the UE Capability Information. It should be possible to execute continuous testing with different combinations of frequency bands, carrier aggregation, etc.

Executing the Test Case and Pass/Fail Judgement

The test case is executed to test the radio communication performance of the TCU. The test case produces a pass or fail judgment for each combination of frequency bands, carrier aggregation, etc.

Test Result Output

When the test is completed, the pass/fail results, the signaling log that records the communication details, the measurement log, and the test parameter file are saved.

3.2 Measurement System

Figure 7 shows the measurement system for the TCU. The system consists of Signalling Tester MD8475B which simulates 2G/3G/4G mobile networks, the Radio Communication Test Station MT8000A which also simulates 5G mobile networks, and a computer on which the simulator control software is installed to control each simulator.

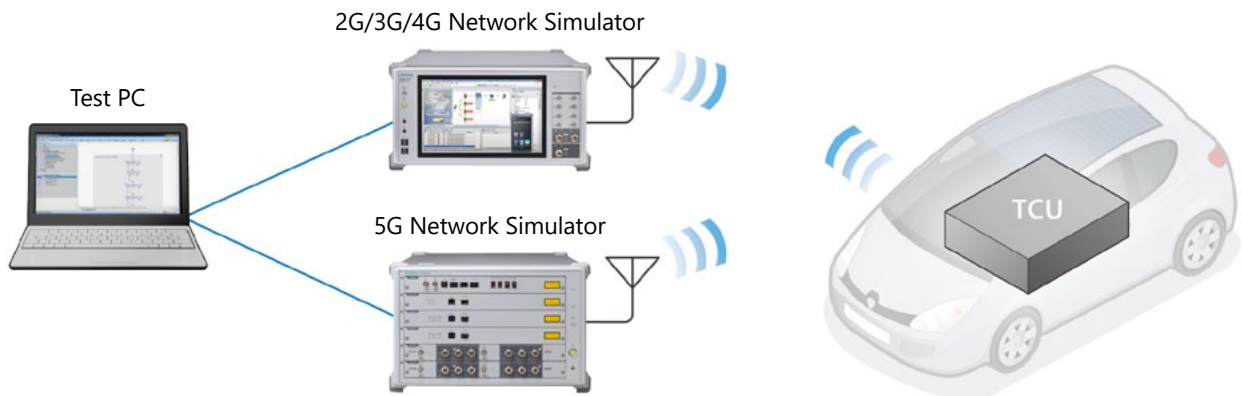


Figure 7 TCU Test Using Simulators

3.3 Acquiring UE Capability Information

A test sequence is executed so that the UE Capability Information is acquired by the software.

Before execution, set the communication parameters according to the TCU being measured and the test sequence conditions at the time of acquisition (RF power, band, etc.).

The screenshot shows the 'Telematics Test (Capability) - LGvelvet_0.2.0_4g' window. On the left, a 'Cell Setting' panel lists steps 1 through 6: Initialize, Setting Condition, Attach DUT, Get DUT Capability, Analyze DUT Capability, and Finalize. The main area displays a log table with columns: N No., Timestamp, Step, Type, and Message. The log contains 17 entries, mostly 'Get DUT Capability' requests and responses for various 4G bands, followed by 'Analyze DUT Capability' and 'Finalize' steps. At the bottom, there is a 'Start' button and a 'Cancel' button, with a checkbox for 'Use Simplified Band Comb'.

N No.	Timestamp	Step	Type	Message
47	2022/11/17 15:45:27	Get DUT Capability	INFO	Get Band Combination(38/52) 4G Band 5,7,66
48	2022/11/17 15:45:28	Get DUT Capability	INFO	Get Band Combination(39/52) 4G Band 5,40,41
49	2022/11/17 15:45:30	Get DUT Capability	INFO	Get Band Combination(40/52) 4G Band 7,20,38
50	2022/11/17 15:45:31	Get DUT Capability	INFO	Get Band Combination(41/52) 4G Band 8,28,41
51	2022/11/17 15:45:31	Get DUT Capability	INFO	Get Band Combination(42/52) 4G Band 8,39,41
52	2022/11/17 15:45:33	Get DUT Capability	INFO	Get Band Combination(43/52) 4G Band 20,38,40
53	2022/11/17 15:45:34	Get DUT Capability	INFO	Get Band Combination(44/52) 4G Band 25,26,41
54	2022/11/17 15:45:35	Get DUT Capability	INFO	Get Band Combination(45/52) 4G Band 2,17
55	2022/11/17 15:45:36	Get DUT Capability	INFO	Get Band Combination(46/52) 4G Band 4,17
56	2022/11/17 15:45:37	Get DUT Capability	INFO	Get Band Combination(47/52) 4G Band 5,17
57	2022/11/17 15:45:38	Get DUT Capability	INFO	Get Band Combination(48/52) 4G Band 5,25
58	2022/11/17 15:45:38	Get DUT Capability	INFO	Get Band Combination(49/52) 4G Band 5,38
59	2022/11/17 15:45:39	Get DUT Capability	INFO	Get Band Combination(50/52) 4G Band 12,25
60	2022/11/17 15:45:40	Get DUT Capability	INFO	Get Band Combination(51/52) 4G Band 20,41
61	2022/11/17 15:45:41	Get DUT Capability	INFO	Get Band Combination(52/52) 4G Band 39,40
62	2022/11/17 15:45:43	Get DUT Capability	INFO	Finish
63	2022/11/17 15:45:43	Analyze DUT Capability	INFO	Start
64	2022/11/17 15:45:43	Analyze DUT Capability	INFO	Analyze start
65	2022/11/17 15:45:52	Analyze DUT Capability	INFO	Finish
66	2022/11/17 15:45:52	Finalize	INFO	Start
67	2022/11/17 15:46:18	Finalize	INFO	Finish

Figure 8 Example of Acquired UE Capability Information

The acquired UE Capability Information is named and saved in a file for each TCU.

3.4 Creating the Test Case

Create a test case from the acquired UE Capability Information. There are three types of test cases: Connectivity, Throughput, and Mobility. The following explains how to create a Mobility test case for handover testing.

First, generate test patterns based on the UE Capability Information. Next, edit the test pattern of the test case to execute.

After setting the combination of base stations involved in the handover, MIMO, carrier aggregation, etc. on the Mobility test pattern edit screen, the software generates test patterns for the base station based on the UE Capability Information for every combination of frequency bands and base stations for which the TCU can execute tests.

The screenshot shows the 'Telematics Test (Test Pattern) - Test [Mobility]' window. The 'Procedure' section on the left has checkboxes for 'Source' and 'Target' for 2G, 3G, 4G, and 5G (NSA/SA). Below this are tabs for '2G Parameter', '4G Parameter', and '5G Parameter', and a 'Number of Signaling Unit' field set to 2. An orange box highlights this section with a callout 'Set test parameters'. The 'DUT Connection Diagram' shows two devices, MT8000A and MD8475B, connected via cables. Below the diagram is a table of 'Generated test patterns' (No. 00001 to 00011) with columns for Source, Target, 2G Carrier 1, 2G Carrier 2, 3G Carrier 1, 3G Carrier 2, 4G Carrier 1, and 4G. An orange box highlights this table with a callout 'Generated test patterns'. The 'Apply' and 'Cancel' buttons are at the bottom of the parameter section.

No.	Procedure	Cell	DL	UL	Cell	DL	UL	2G Carrier 1	2G Carrier 2	3G Carrier 1	3G Carrier 2	4G Carrier 1	4G
00001	Handover	2G[1]	Gsm850	Gsm850	2G[2]	Gsm850	Gsm850	Gsm850	Gsm850				
00002	Handover	2G[1]	Gsm850	Gsm850	2G[2]	EGsm900	EGsm900	Gsm850	EGsm900				
00003	Handover	2G[1]	Gsm850	Gsm850	2G[2]	Dcs1800	Dcs1800	Gsm850	Dcs1800				
00004	Handover	2G[1]	Gsm850	Gsm850	2G[2]	Pcs1900	Pcs1900	Gsm850	Pcs1900				
00005	Handover	2G[1]	EGsm900	EGsm900	2G[2]	Gsm850	Gsm850	EGsm900	Gsm850				
00006	Handover	2G[1]	EGsm900	EGsm900	2G[2]	EGsm900	EGsm900	EGsm900	EGsm900				
00007	Handover	2G[1]	EGsm900	EGsm900	2G[2]	Dcs1800	Dcs1800	EGsm900	Dcs1800				
00008	Handover	2G[1]	EGsm900	EGsm900	2G[2]	Pcs1900	Pcs1900	EGsm900	Pcs1900				
00009	Handover	2G[1]	Dcs1800	Dcs1800	2G[2]	Gsm850	Gsm850	Dcs1800	Gsm850				
00010	Handover	2G[1]	Dcs1800	Dcs1800	2G[2]	EGsm900	EGsm900	Dcs1800	EGsm900				
00011	Handover	2G[1]	Pcs1900	Pcs1900	2G[2]	Gsm850	Gsm850	Pcs1900	Gsm850				

Figure 9 Test Pattern Edit Window

Third, set the test conditions. These include the transmit power, path-loss, power range during handover handling, etc. Then, select a test pattern to apply from the generated list.

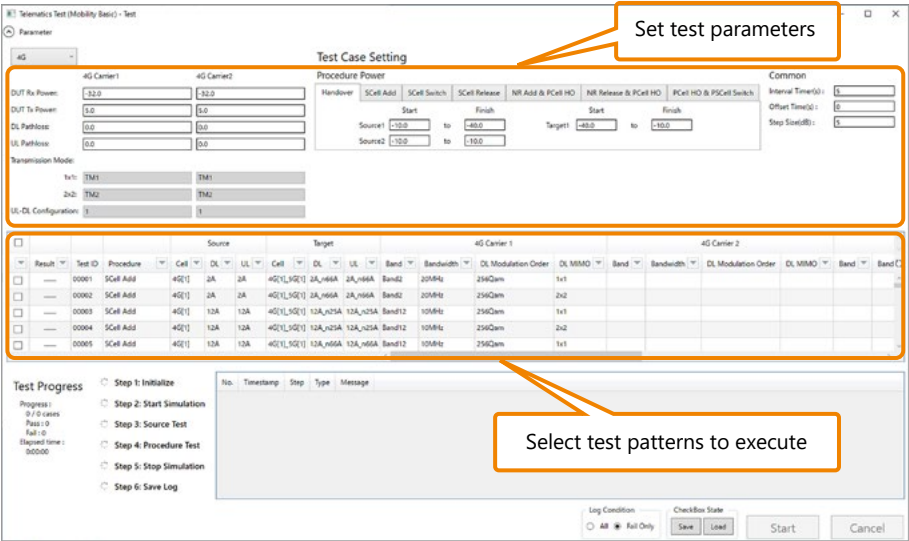


Figure 10 Test Case Edit Window

3.5 Test Execution and Results

Click Start on Figure 10 to start the handover test between the simulator and the TUC according to the test case. Pass/fail results and logs are displayed on the window and saved to files.

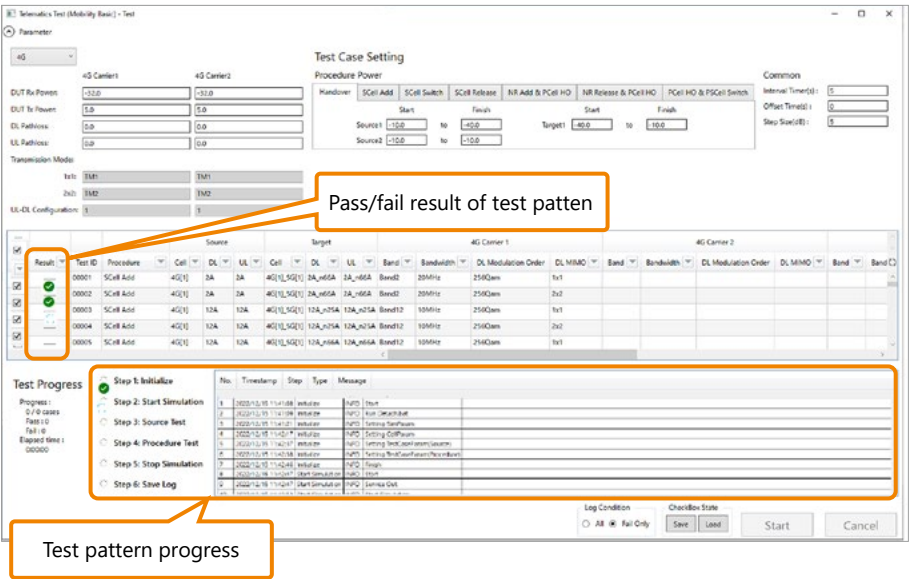


Figure 11 Results of Test Case Execution

4. Product Information

Signalling Tester MD8475B

Signalling Tester MD8475B is a base station simulator which can support communication methods for diverse standards from 2G to LTE-Advance in a single unit.

Leaflet: [For Early Deployment of High-Quality Onboard TCU and Automated Driving System](#)



Radio Communication Test Station MT8000A

The MT8000A is a base station simulator which can support both RF measurement and protocol tests in the sub-6 GHz and millimeter-wave bands for 5G NR.

Leaflet: [Single Box Test Solution for RF and Application Testing of 5G SA/NSA Devices](#)

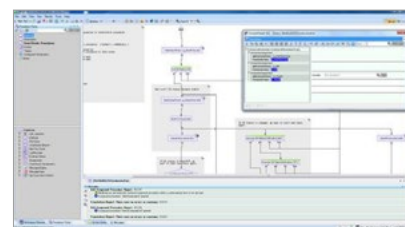


SmartStudio Manager MX847503A

The MX847503A software automates the operation of SmartStudio.

This software allows users to edit and execute tests and also displays the test results.

Leaflet: [Efficient Test Environment for Exponential Increase in Number of CA Band Combinations](#)



SSM Test PKG Telematics Connectivity MX847503A-TL660

This option is a one-year license to use software for confirming the connection of a TCU to a radio base station. The radio access technologies for which this option can confirm the connection are GSM, W-CDMA, LTE, NR (NSA), and NR (SA).

SSM Test PKG Telematics Throughput MX847503A-TL661

This option is a one-year license to use software for confirming the performance of the TCU communication throughput (UDP downlink) to a radio base station.

The radio access technologies for which this option can confirm the throughput are LTE, NR (NSA), and NR (SA).



SSM Test PKG Telematics Mobility MX847503A-TL662

This option is a one-year license to use software for confirming handover between multiple base stations.

The radio access technology combinations for which this option can confirm handover are GSM/W-CDMA/LTE, LTE/NR (NSA), and LTE/NR (SA).

MX847503A-TL660 1year Technical Support MX847503A-TS120

This option provides one year of e-mail-based technical support for SSM Test PKG Telematics.

* Support is not available for test cases which users have edited.