# Optimize Cell-Site Deployments

## CellAdvisor BBU Emulation

Mobile operators continue to face an insatiable demand for capacity, driven by multimedia applications and the ever-increasing number of devices connecting to the network. These challenges require operators to quickly and efficiently deploy cell sites to remain competitive. However, the cell-site deployment process is complex, involving multiple parties such as tower builders and radio manufacturers. And, there is network commissioning that creates delays and operational costs due to interaction, verification, and conformance activities at each stage of the process.

In general, the installation process has three main phases:

1. Installation — installing cell-site infrastructure including power, cabling, remote radio heads (RRH), and antenna mounts.
2. Commissioning — configuring the base band unit, its interface with the core network, and initial turn-up of the cell site as well as service verification.
3. Site tuning — tuning antennas and resolving any installation issues.

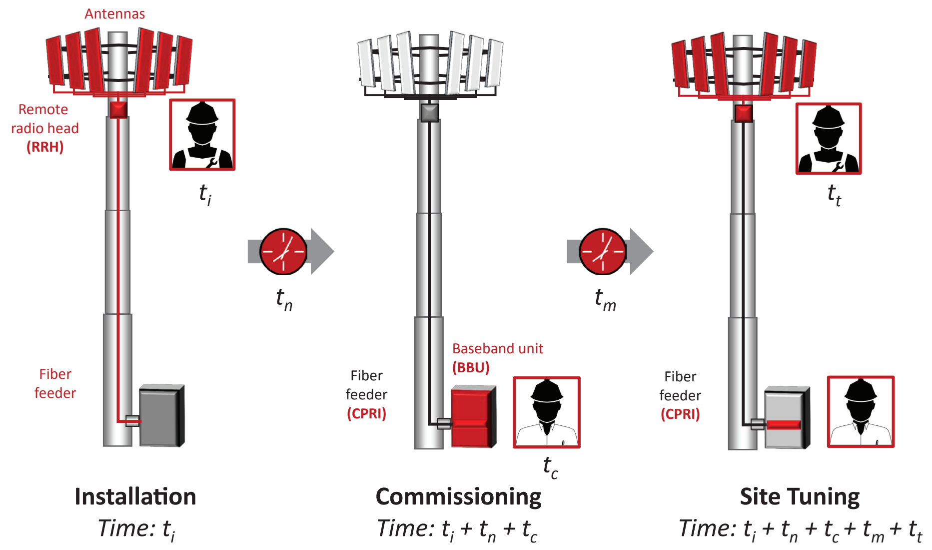


Figure 1. The installation process in three phases

A major challenge facing mobile service providers is the overall time that this installation process takes. Providers need to realize service revenues quickly and minimize customer churn. Figure 2 shows a basic time assessment of this cell-site deployment process.

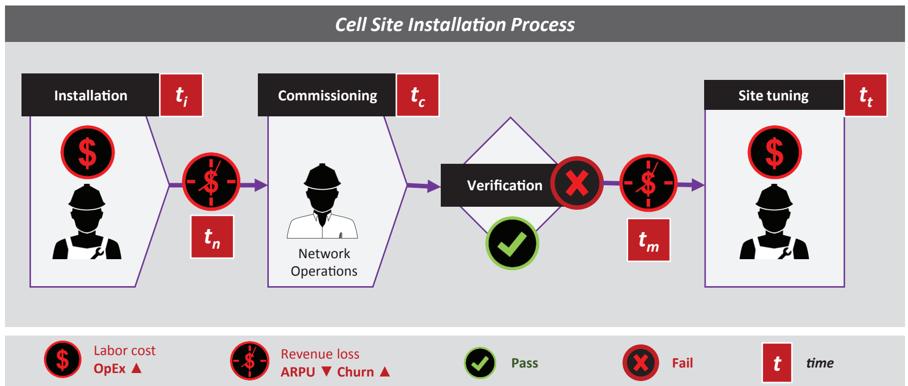


Figure 2. The cell site installation time flow

Total installation time depends on a number of factors:

- Installation time ($t_i$) varies from weeks to months based on permissions, construction, and complexity of the cell-site
- Time between installation and commissioning ($t_n$) averages 15 to 30 days: installers and network commissioning have different schedules and priorities
- Commissioning time ($t_c$) requires a few days to a week based on backhaul performance and potential troubleshooting issues
- Time between commissioning and site tuning ($t_m$) averages 15 to 30 days
- Site tuning ($t_t$) varies from a few days to weeks based on repairs and availability of replacement parts

The total installation time ($T$) adds up to several months: $T = t_i + t_n + t_c + t_m + t_t$. This extended time can drastically affect mobile operators financially. They cannot provide or charge for services, and they risk churning existing customers to other mobile service operators.

Table 1. Overall installation costs

| Cell-Site Installation | Days | Revenue Loss | Churn Cost | Labor | Opportunity Cost |
|---|---|---|---|---|---|
| $t_i$: Time of installation | 7 | $ 11,666.67 | $ 233.33 | | $ 11,900.00 |
| $t_n$: Time of commissioning | 7 | $ 11,666.67 | $ 233.33 | | $ 11,900.00 |
| $t_c$: Time of commissioning | 30 | $ 50,000.00 | $ 1,000.00 | | $ 51,000.00 |
| $t_m$: Time for tower crew | 30 | $ 50,000.00 | $ 1,000.00 | | $ 51,000.00 |
| $t_t$: Time of repair and tuning | 1 | $ 1,666.67 | $ 33.33 | | $ 1,700.00 |
| Tower Crew | | | | $ 3,000.00 | $ 3,000.00 |
| Total Time and Cost | 75 | $ 125,000.00 | $ 2,500.00 | $ 3,000.00 | **$ 130,500.00** |

The considerations for the above model are:

- Revenue loss = daily ARPU x subscribers, where the typical monthly ARPU (average revenue per user) is $50.00 or $1.67 per day for 1, 000 service subscribers
- Churn cost = revenue x 2% churn rate

Site tuning or installation verification is currently done as a third phase of the process, since it requires the baseband unit (BBU) to communicate with the RRH and perform a functional test. However, this process can be eliminated if the BBU can be emulated to conduct the RRH functionality at the installation phase. Turn-up and verification can occur at the time of installation.

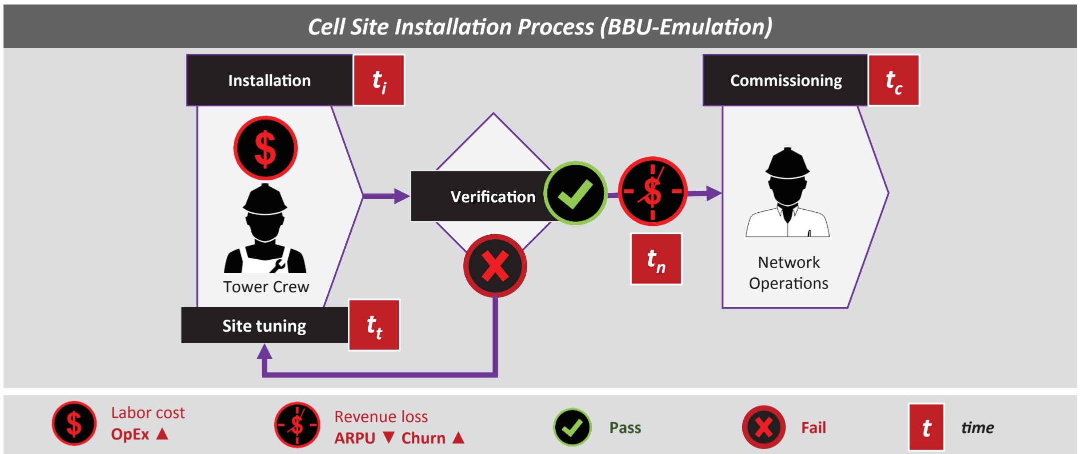


Figure 3. Cell-site installation with BBU emulation

This expedites installation time, eliminating the time between commissioning and site tuning. It also reduces recurring visits of a tower crew for repairs or site tuning. The cost savings achieved with BBU emulation can be significant. Considering the cost model in Table 2, BBU emulation yields a 30-day reduction in deployment time and opportunity cost savings of $54,000 per cell site.

Table 2. Overall estimated costs with BBU emulation

| Cell-Site Installation | Days | Revenue Loss | Churn Cost | Labor | Opportunity Cost |
|---|---|---|---|---|---|
| $t_i$: Time of installation | 7 | $ 11,666.67 | $ 233.33 | | $ 11,900.00 |
| $t_t$: Time of repair and tuning | 1 | $ 1,666.67 | $ 33.33 | | |
| $t_n$: Time of commissioning | 7 | $ 11,666.67 | $ 233.33 | | $ 11,900.00 |
| $t_c$: Time of commissioning | 30 | $ 50,000.00 | $ 1,000.00 | | $ 51,000.00 |
| Total Time and Cost | 45 | $ 75,000.00 | $ 1,500.00 | $ - | **$ 76,500.00** |

## RFoCPRI BBU Emulation

Distributed cell sites with fiber links between the BBU and remote RRH provide the necessary bandwidth for multi-carrier, multi-standard, and multi-antenna transmission; however, this architecture creates challenges for cell-site installation and maintenance:

- Installation — the verification of the installation should be made performing RF tests at the RRH since the BBU is not yet commissioned. This significantly increases installation costs, and in some cases, RF tests are omitted until the BBU is commissioned. In most cases, this creates a series of unnecessary cycles of installation verification and commissioning. This increases operational costs and excessively delays network deployment.
- Maintenance — regular maintenance procedures ensure service availability and quality, including proper RF emissions verifying reflections on feed-lines, intermodulation (PIM) products causing interference, and real-time analysis to detect external interference; however these tests are performed at the RRH increasing maintenance cost and extending time for resolution.

Proper installation and maintenance practices can overcome these challenges without incurring prohibitive expenses or delaying deployments. However, it is important that these practices:

- Effectively perform RF testing from the BBU (RF over CPRI)
- Perform RRH functional tests by emulating the BBU

### Overview

Distributed cell-site installation and maintenance testing with BBU emulation covers two main areas:

- The configuration profile of the RRH
- The transmission characteristics of the RRH

The RRH configuration profile should include:

- Optical power transmission, reception, and CPRI link status
- Model number and technology supported
- Operational frequency band for transmission and reception
- Carrier information and transmission signal type
- Attributes of its optical interface or small form-factor pluggable transceiver (SFP)
- Firmware loaded, version, and serial number
- The RRH RF reception and transmission profile should include:
- Spectrum clearance or interference analysis in the mobile's transmission frequency
- Radio transmission for coverage range testing including:
  - RF cable reflections or voltage standing wave ratios (VSWR)
  - Verification and adjustment of antenna tilts
- Passive intermodulation analysis

These installation and maintenance tests with BBU emulation are applicable to any type of cell site, including but not limited to macrocells, microcells, small cells, and distributed antenna systems.

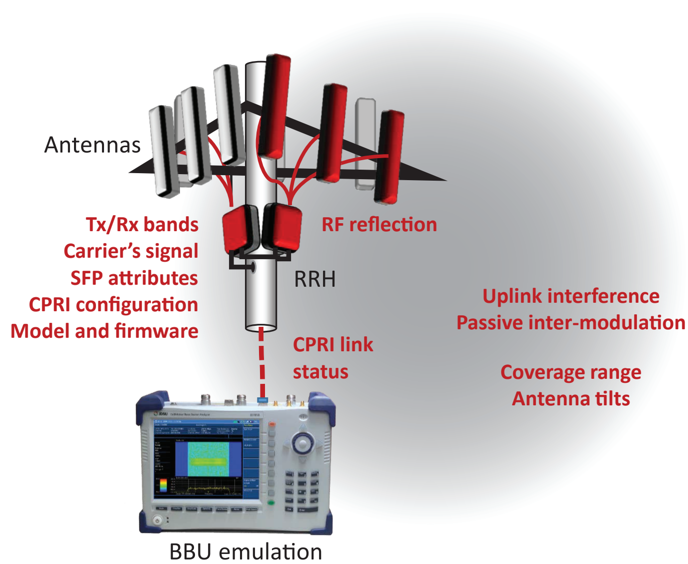


Figure 4. RRH installation and maintenance aspects

## RRH Configuration Profile

An RRH configuration profile test ensures proper equipment is installed in the cell site. A BBU emulation operation starts with the verification of optical power and CPRI communication status, then establishes a communication session with the radio retrieving its hardware characteristics including radio type, operating frequencies, optical transceiver, and its configuration including carrier's information and firmware loaded.

### *Optical Power and CPRI Link Status*

CPRI link status performs Layer-1 and Layer-2 verification tests. These include optical power levels as well as CPRI digital alarms and errors corresponding to loss of signal due to low power levels and loss of frame due to lack of synchronization.

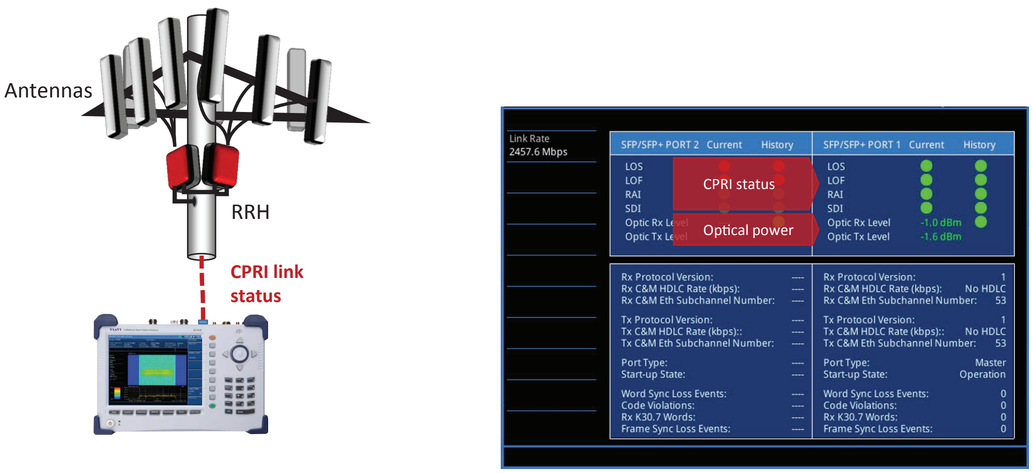


Figure 5. BBU emulation with CPRI status and optical power measurements

### *RRH Description and Optical Transceivers*

An RRH description includes the hardware characteristics of the radio including the radio's model, cellular technology supported, operating band, and transmitting power limits. The information of the optical transceiver (SFP) is also retrieved, confirming its type and rate as well as the port where it is installed.

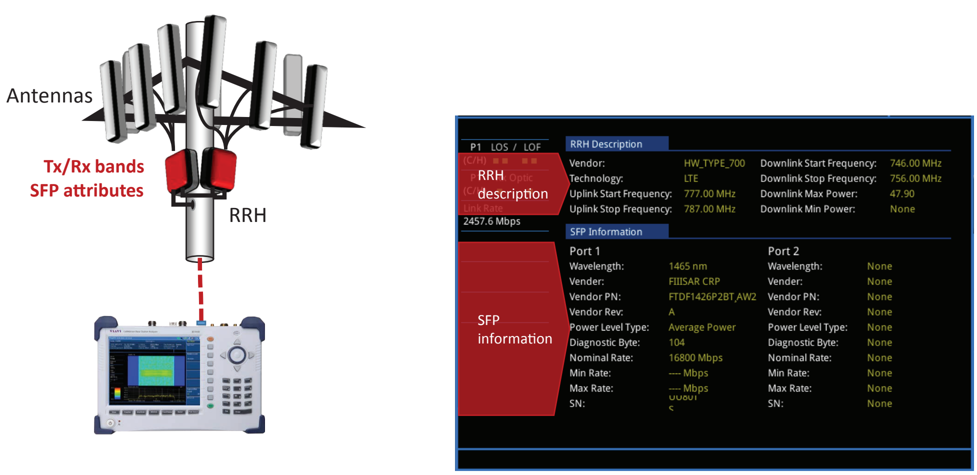


Figure 6. BBU emulation with RRH description and SFP information measurements

### *Carrier Information*

Carrier information provides the configuration of the cellular signal of the radio, including transmission's (downlink) center frequency, and reception (uplink) center frequency, a signal's technology and bandwidth, and power limits.

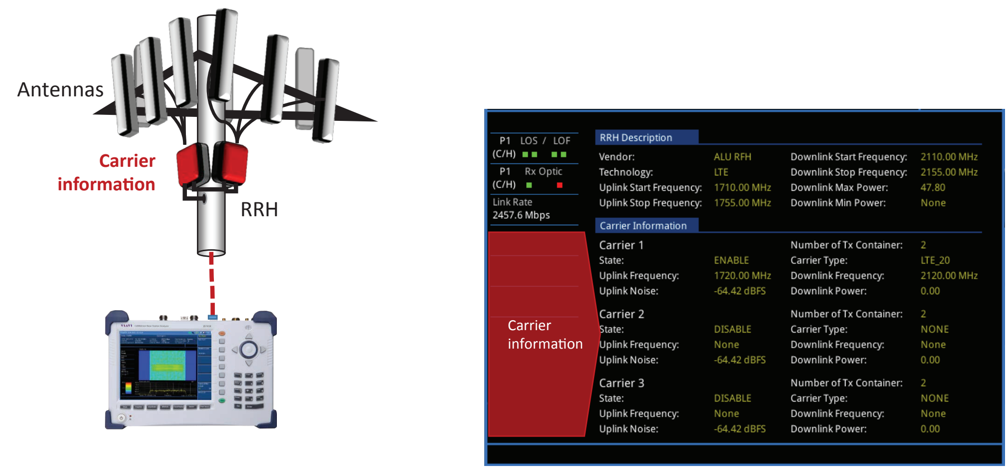


Figure 7. BBU emulation with carrier information

### *CPRI Configuration and Firmware*

CPRI configuration ensures the alignment of active ports with optical transceivers and provides the CPRI line rate set on the radio. In addition, it provides the active software loaded in the radio to verify consistency among the different sectors of the cell site.

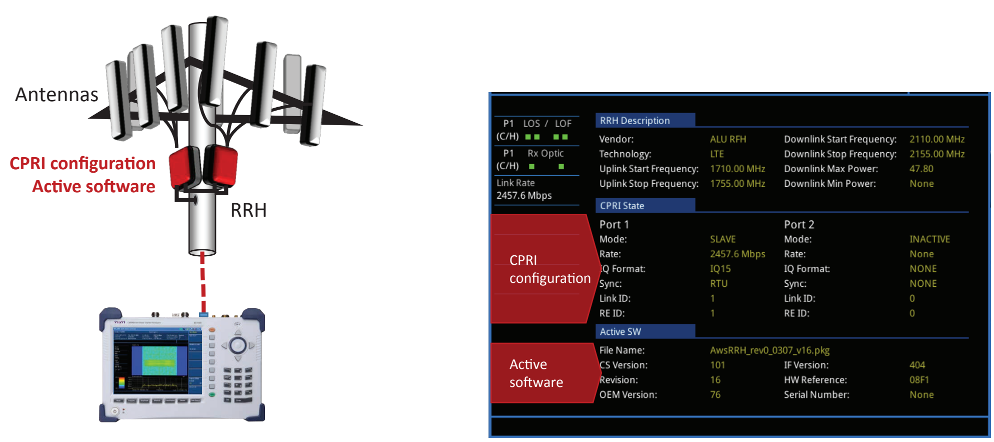


Figure 8. BBU emulation with CPRI configuration and active software information

### RRH RF Reception and Transmission Profile

The RRH radio frequency profile is set by the BBU emulation function, controlling how the radio will receive and transmit RF signals to assess interference and the radio's coverage.

### *Radio RF Reception*

The BBU emulation function sets the radio's RF reception profile and performs the following RF tests:

- Configures the radio's profile to enable a carrier and open its RF path to perform interference analysis of the mobile transmission band (uplink)
- Retrieves RF reflection measurements (VSWR) of the coax cables and antenna
- Retrieves antenna tilts and permits setting a different degree value

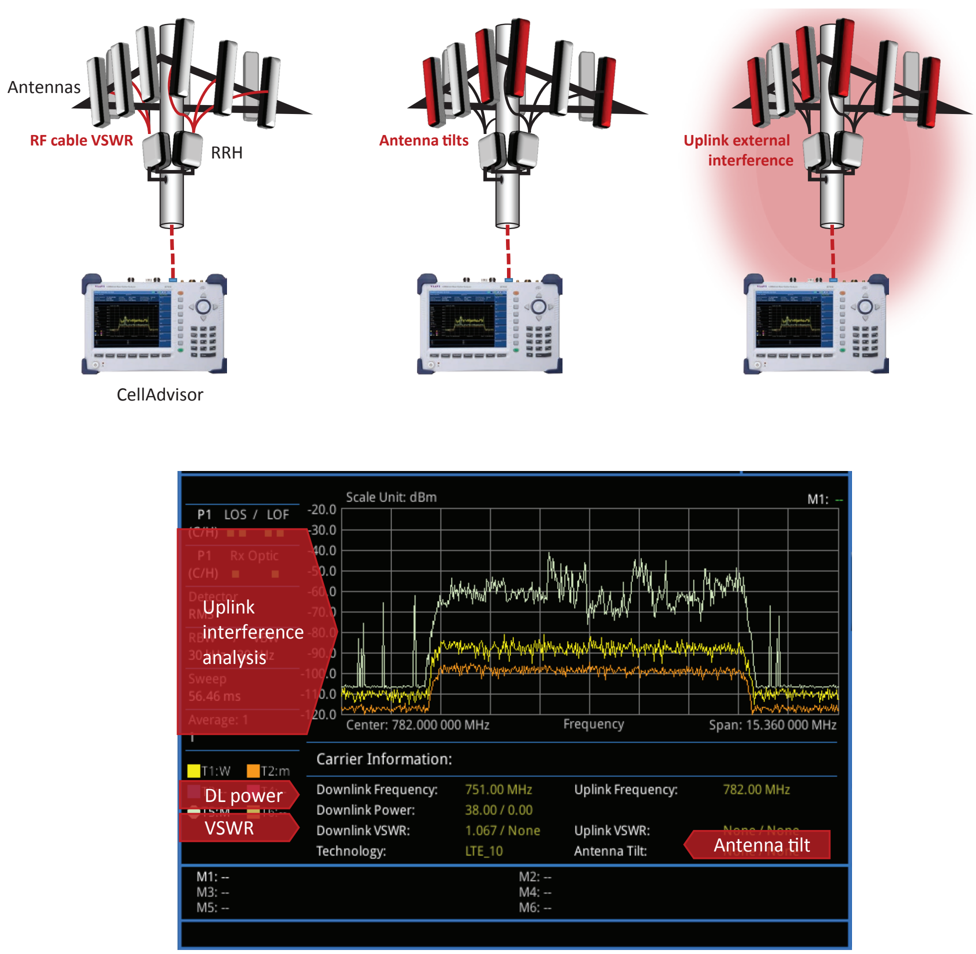


Figure 9. Uplink interference analysis, VSWR, and antenna tilts

### *Radio RF Transmission and PIM Analysis*

The BBU emulation function configures the radio's transmission profile and generates a 3GPP standard LTE signal with all of the resource block active with 64 QAM modulation via CPRI. This enables performing passive intermodulation (PIM) tests on the uplink.

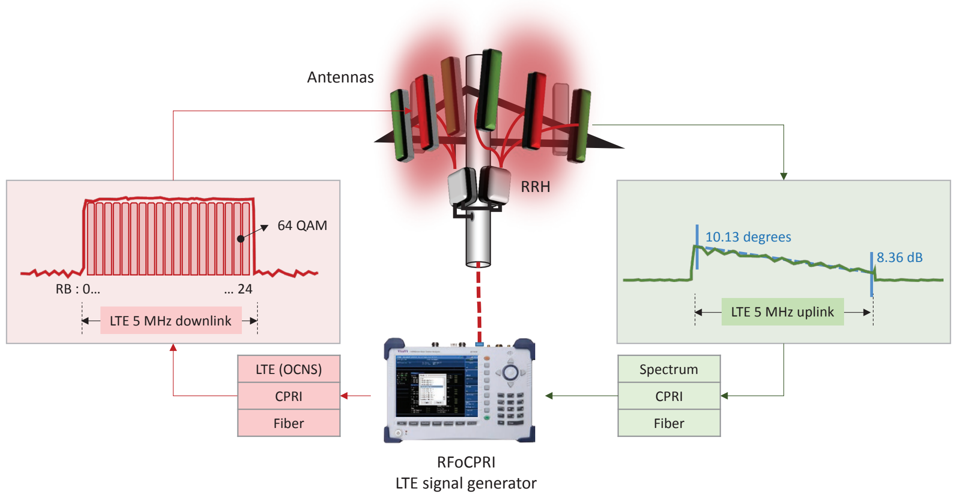


Figure 10. LTE signal generation and PIM detection

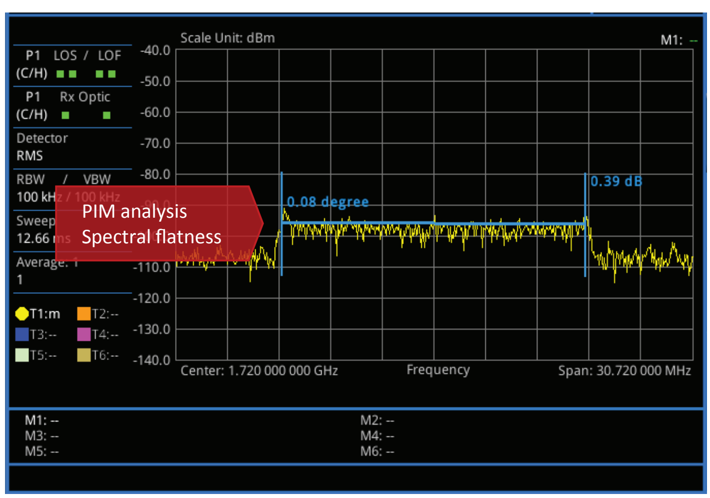


Figure 11. PIM analysis (uplink) with spectral flatness

### *Radio RF Transmission and Modulation Analysis*

BBU emulation configures the radio's transmission profile and generates a 3GPP standard LTE signal with all of the resource block active with 64 QAM modulation via CPRI. This enables performing a modulation quality test to identify distortion created by the RRH or DAS remote units. It also verifies proper connectivity on multiple antennas or branches present in MIMO systems.

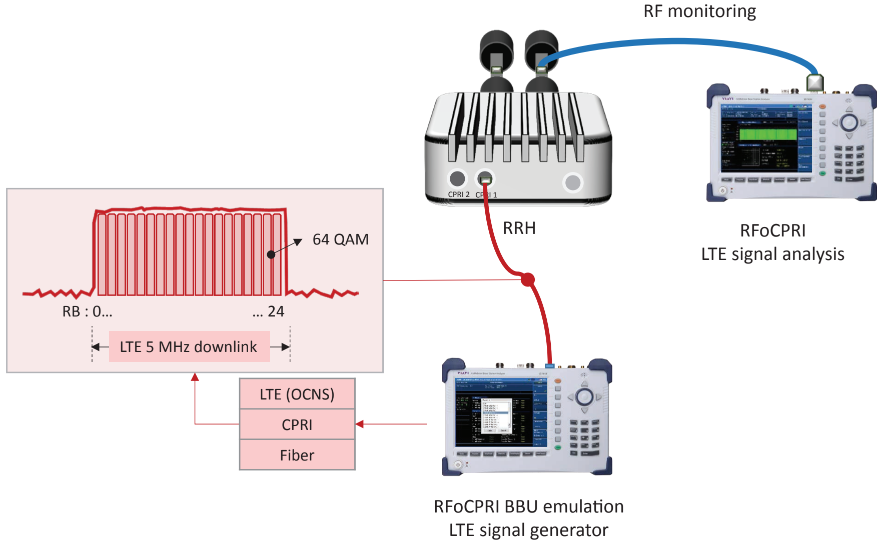


Figure 12. RRH modulation quality test (connected mode)

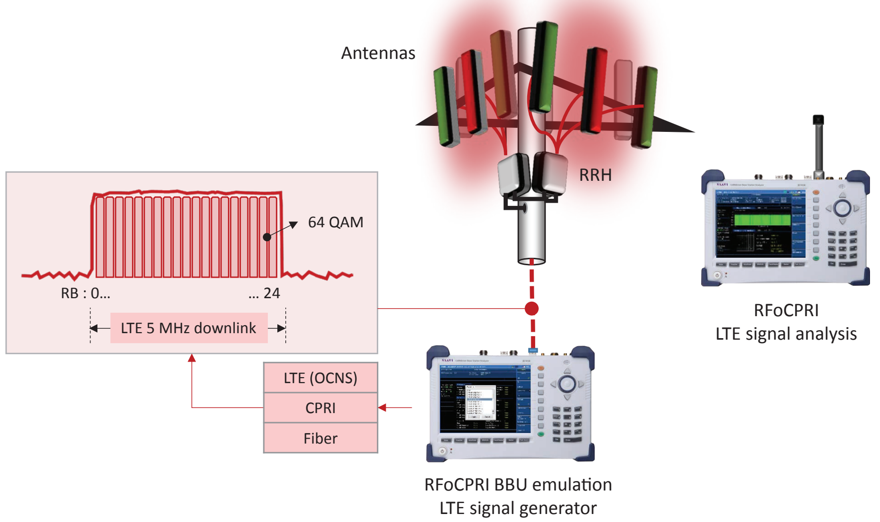


Figure 13. RRH modulation quality test (over-the-air-mode)

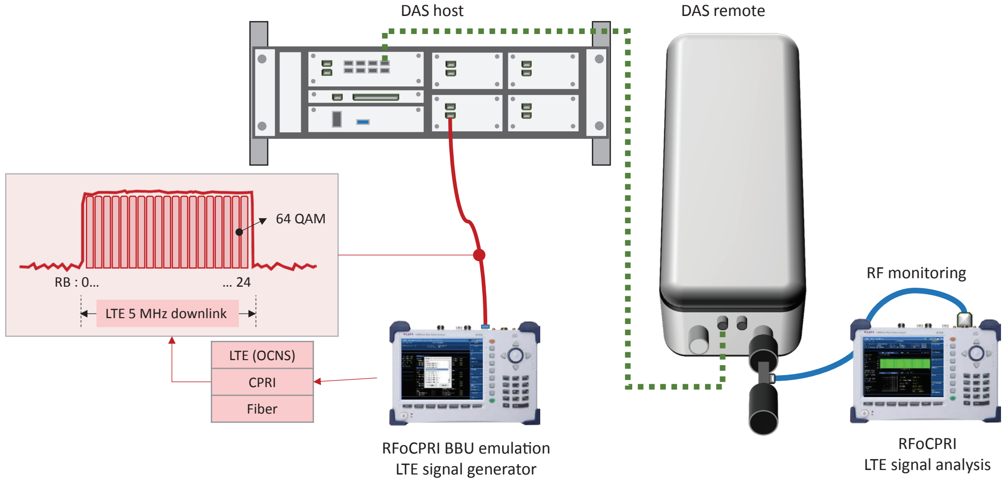


Figure 14. DAS remote modulation quality test

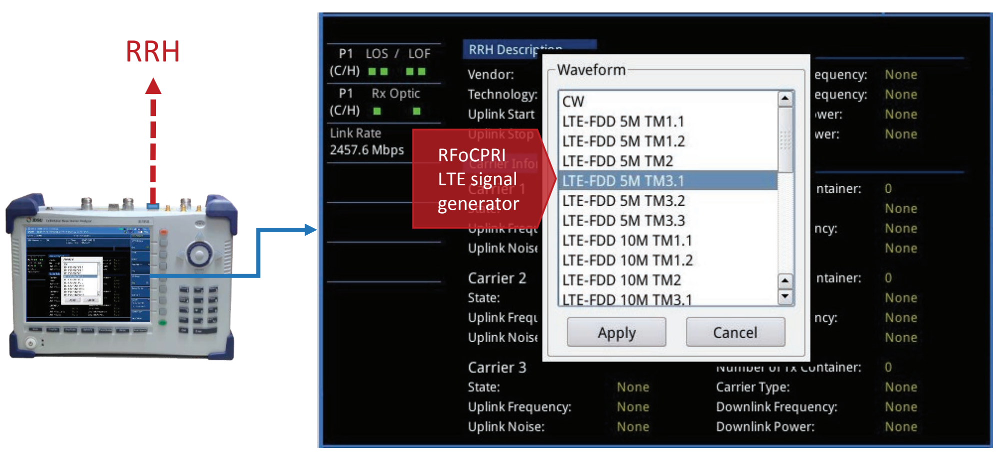


Figure 15. BBU emulation LTE signal generator

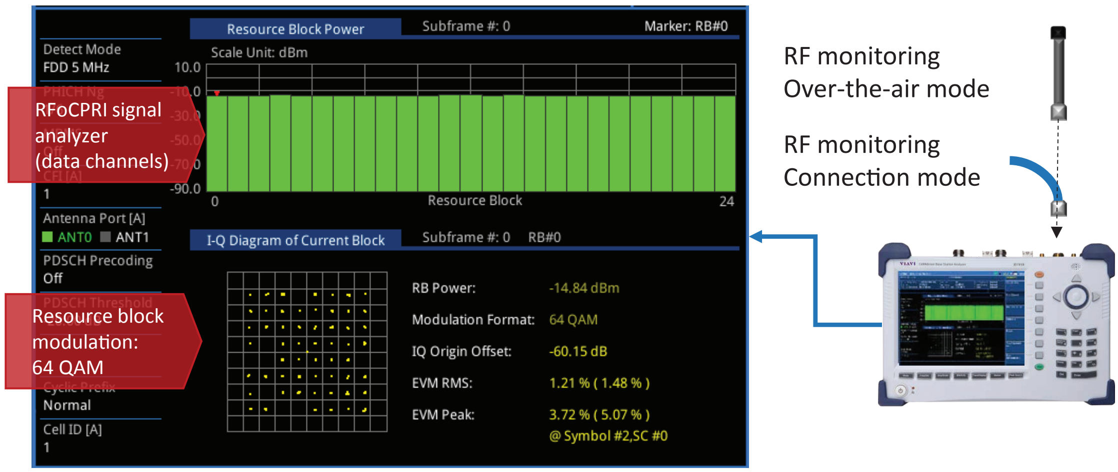


Figure 16. RFoCPRI LTE signal analysis

## Conclusion

Mobile operators are experiencing increasing demands for high-quality mobile services everywhere. They need to deploy cell sites quickly and efficiently to remain competitive.

CellAdvisor with BBU emulation capability simplifies the deployment of cell-sites by verifying radio installation, configuration, and operation prior to commissioning. It verifies the physical infrastructure based on coax or fiber cables, retrieves a radio's model, operating band, and configuration parameters, and controls a radio to transmit over-the-air, ensuring there are no interferences or PIM. It also ensures that modulation distortion is not going to reduce bandwidth to mobile users.

CellAdvisior dramatically reduces OpEx and time-to-market when deploying cell sites.

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