Combine Cell Phone Tests to Manage Cost

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MOBILE phones are complex enough devices, and the continual addition of features further challenges test engineers to prevent test time from creeping higher. In addition, wide-bandwidth, high data-rate transmission techniques require testing to verify the performance of complex modulation schemes. Moreover, RF modes like Bluetooth and WLAN are being added to phones and require verification. And because of short product life cycles, cell phone production lines must be able to manufacture a wide variety of products with a wide variety of features.

As a result, while mobile phones may be approaching a mature market and mature technologies, the test requirements have not gotten any simpler. For starters, testing the basic phone continues to require the following:

- DC tests: current measurements for monitoring standby and transmit power consumption (as well as ensuring no shorts exist on the circuit), and calibration of the A/D converter that monitors the battery voltage.
- Audio measurements: frequency response and distortion measurements of a 20Hz to 4-kHz (typical) audio circuit. Operation of a vibrator must also verified.
- RF transmitter measurements: output power-level calibration at one channel, frequency response over the frequency band of operation, modulation accuracy, spurious power or adjacent channel power measurements.
- RF receiver measurements: calibration of the receiver's automatic gain control circuit at one channel, frequency response over the frequency band of operation, receiver sensitivity (essentially some type of bit error rate test).
- Special features: Bluetooth or Wi-Fi circuitry (or modules) must at least be tested for power output, the ability to perform a communication link, and receiver sensitivity. MP3 players need at least a frequency response or distortion test, and a camera must be verified to capture an image.
- User interface: The phone's display pixels and keypad must be tested to ensure sufficient pixels are operational and all keys are operating
- Finally, the ability to make a phone call must be verified using a base station simulator.

Of these, the RF tests are the most time consuming because the measurements themselves can take a long time and all measurements must be repeated for each (cellular, DCS, or PCS) band and for each cellular standard such as cdma2000 1X and AMPS.

On top of all these tests, it takes time to load the flash memory on the PC board with control and test code. The final control code or customized code may be "flashed in" at final test. Furthermore, the test engineer must contend with 100 percent testing requirements. That is, all phones must be tested and calibrated because a cell's base station controls the mobile phone's power level. Thus mobile transmitter and output power levels must conform to a range defined by the operating standard. Furthermore each phone must be verified to ensure it does not create excessive interference.

As a result, minimizing total test time is a challenging task. Typically test time is in the order of a few minutes. With the huge numbers of phones produced, even reducing seconds can add up to a substantial annual cost savings.

Choose Your Test Strategy

There are numerous different test strategies for building and testing mobile phones. All PC boards are populated in high-speed pick and place machines; and then, a board level test is performed. Boards that successfully pass the board level testing are assembled and subjected to a final test.

Although board level and assembled test are the two major test stages, there are often multiple test stations at each stage. At board level, the DC and RF tests may be combined at one test station. The test firmware may be "flashed in" to the board at a separate test station. Audio tests and vibrator tests may be at a separate test stand.

The final test will include a simulated phone call at a test station; however, the test for a properly installed antenna and functioning speaker and microphone may be at a separate station, as may be the test of the keyboard and display. Yet another test station may be needed to install the final operating and any custom software.

In some cases, PC-board level testing may only be a quick check to verify the board is sufficiently operational to produce an RF signal, with all RF calibration and modulation and demodulation testing performed on an assembled phone. Other manufacturers may perform all the RF tests at board level and just verify an RF output at final test.

Overall assembly processes vary among manufacturers as well. Some manufacturers use automated conveyor systems and automated handling systems to transport phones down a production line and insert the board and assembled phone into a test fixture. Other manufacturers use more labor-intensive schemes that have operators manually inserting boards or phones into test systems and transporting assemblies from one station to the next.

In some cases, production lines are designed to test any type—including GSM, cdma2000, and EDGE—of phone. Other manufacturers prefer to dedicate a line to a type of phone. Still another approach is to use one production cell to build all PC-boards for all the standards, and then have the boards assembled at unique cells for each type of phone. Whatever the test strategy, all phones go through multiple test stands as the phones progress from bare boards to finished units.

Among the largest consumer of test time is the device's own power-up and self-check routine. Another time consuming operation is the handling involved in transporting boards or phones to all the test stations. Whether handling is manual, by a conveyor system, or a robotic system, reducing the number of test stations that a board or phone must be placed can help cut test times. Reducing the number of test stations also minimizes the number of times the phone has to go through its power-up routine.

The test in which the phone connects to a base station simulator to make a simulated call is also a major component of total test time. The multiple signals that must be transmitted and demodulated between the phone and the base station simulator make the call test a multi-minute test. Therefore, if the phone's base station-linking functions can be tested without executing the complete protocol for a phone call, then test time can be saved.

The More the Merrier

In addition, testing multiple phones at a test station can reduce the effective test time per phone. Here, the challenge is to use a configuration that tests all phones simultaneously so that no phones have any significant idle periods. Similarly, the configuration must ensure that the test equipment is being used to the maximum extent possible. Inefficient use of the test equipment, the result of a poorly conceived multi-DUT test system, can extend rather than reduce test time

If RF transmitter and receiver tests are performed at separate test stations, either at board level or at assembled phone level, those stations should be combined. That reduces handling time and cuts the number of power-up cycles. In a typical simple single device test system, calibration of the transmitter and the receiver is performed using a spectrum analyzer (or a RF power analyzer) and an RF source.

If this configuration is used at board level, and only gain calibration and frequency response are performed, the source could be an unmodulated or continuous wave source. If demodulation tests are performed on the receiver, a digitally modulated RF source is required. This configuration could also perform all DC tests at the same station.

A more efficient test system that can effectively cut test time in half is the four-device test system. This system is very effective for board testing. In this configuration, the receivers of boards one and three and the transmitters of boards two and four are tested at the same time. Because transmitter testing is typically longer than receiver testing, the DC tests can be combined with the receiver tests to minimize any idle time between the end of the receiver tests and the end of the transmitter tests.

More production-focused RF instruments such as mobile phone RF-power analyzers that make extremely fast transmitter power measurements help minimize device idle time and, therefore, test time. Another way to maximize efficiency is to develop an asynchronous test program in which boards are removed as their test sequence is completed and new ones are immediately inserted into the test system.

Combining as many test functions as possible into one system reduces handling time and power-up cycles. One example is a test system that automates the testing of all the user interfaces, the display, the keypad, and the audio circuits, on a phone pc board. Solenoids activate the keys to verify proper operation and a camera verifies that the display has a sufficient number of working pixels. This system also tests the performance of the board's audio circuits. Because in many manufacturing sites, these tests are performed manually, an automated system can quickly pay for itself in improved inspection quality, reduced test time, and reduced labor costs.

Many manufacturers rely on communication test sets; all-in-one instruments that can test a device's RF performance and also perform the call test. Communication test sets are fine instruments, but they are quite expensive and get more so as options are added for testing different frequency bands and mobile phone types. For example, communication test sets with the options to fully test just one type of phone can cost around $50,000.

A way to reduce test time and still efficiently use the communication test set is to test two devices at one time. However, instead of adding a second communication test set, it is possible to enhance the test system with an RF power analyzer optimized for production test speeds and designed to test mobile phone transmitter circuits. With this configuration, the communication test set and the RF power analyzer can interleave the testing of the two devices.

For example the communication test set can test one device's receiver while the RF power analyzer can test the second device's transmitter. With this configuration, test time per phone can be cut by 40 to 50 percent with no more than a 30-percent increase in system equipment cost.

In a two-DUT test system, throughput is doubled with the addition of only a power supply (or the use of the second channel of a two-channel power supply), a transfer switch, and an RF power analyzer. If other RF modes such as Bluetooth or WLAN must be tested, then a more extensive RF switch system can be employed to switch these RF signals to specialized test instrumentation. In any case, the objective is to consolidate all RF testing at a single station for testing the board and the assembled unit.

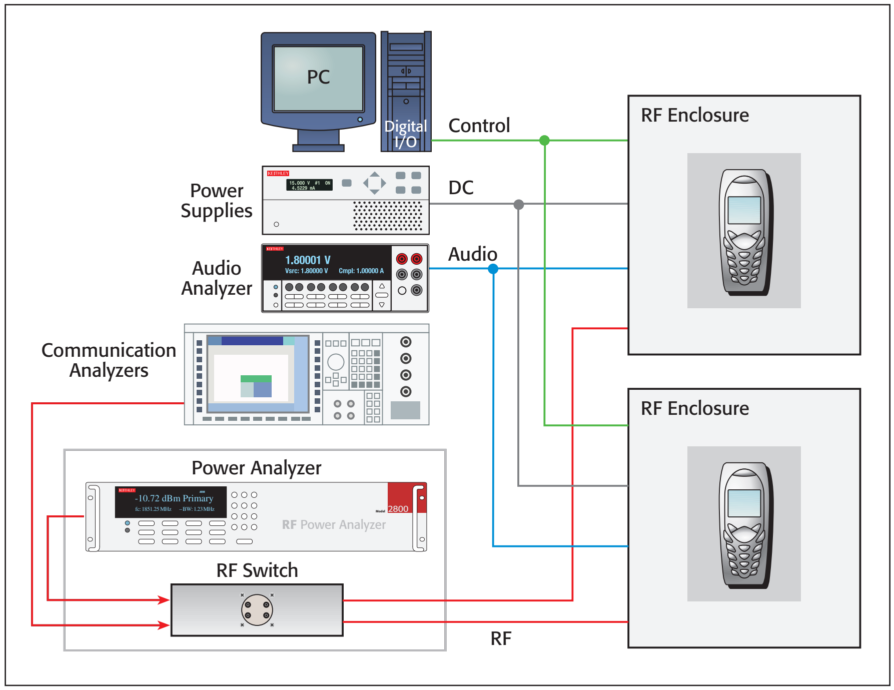
Multifunction and multi-DUT test stations minimize handling, power-up and test time per device by combining as many tests into one station as possible. Another possible test time-saving approach is to eliminate the call test entirely. The call test could be moved to audit stations where a sample of phones are more extensively tested. If the phone passes a set of transmitter and receiver RF power and modulation-demodulation tests, then it should successfully execute a phone call since the key call processing functions are firmware-based.

Design engineering can substantially help to cut test time by providing the test engineers with flexible internal test code that gives test engineering full access to the phone's functionality. If the test engineers have more control over the phone or PC board, they can configure more efficient tests.

For example, transmitter power could be ramped up and down for test purposes independent of how the mobile phone standard operates. In particular, more control of internal device operation can reduce the need for the high-cost communication analyzers as well as minimize the power-up time.

Another potential time saver is to have power on the board or phone even when it is not in a test station. The device could be powered through its charger input using a normally closed switch and a charged capacitor. When installed in a test station, the switch could be opened to disconnect the capacitor and connect it to a power supply.

Certainly the test challenges are extensive for the mobile phone test engineer. Increasing test system functionality, however, as well as increasing the number of devices simultaneously tested will reduce test costs. Moreover, innovative methods such as more accessible test code can further reduce costs to satisfactory levels in the future. KEITHLEY



A dual-DUT system that combines a power analyzer with a communication test set can double test throughput while only slightly increasing test system cost.

About the Author

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