Cellular Phone Functional Test Platform

Using the HP TS-5500 in the Manufacturing Test of GSM Cellular Phones

Product Note

HP's TS-5500 Platform

- Decreases Test Cost Per Phone
- Speeds Time-to-Market
- Integrates Software and Hardware
- Tests Up to Four Phones at a Time
- Can Be Customized For Calibration or Radio Protocol Tests
- Configures to Any Functional Test Stage
- Includes Cellular Phone-Specific Software
  - Powerful Test Executive Functions
  - GSM Tests, Measurements and Utilities
  - Fast, Comprehensive Audio Measurements
  - Easily Customized Operator Interface

GSM

Cellular Phone Manufacturing

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Industry Challenges

Cellular and PCS phone manufacturers are in a dynamic industry. Volumes are increasing at dramatic rates, with new phones being introduced every few months. As a result, the pressures to significantly reduce costs per phone are on the rise. These factors add even more pressure to the manufacturer's margins. What's more, new cellular phone technologies, such as PCS, dual-band and dual-mode, are causing considerable changes in the design and manufacturing processes. To obtain regional market access and off-load the main factories, many manufacturers are pursuing significant globalization. In short, factory efficiency, manufacturing costs and time-to-market promise to be key factors in determining success or failure.

Manufacturing Goals

The main goal of manufacturing is to produce quality phones better than the competition. That means getting to market quicker, while reducing the cost per phone by increasing throughput, reducing capital costs on equipment and potentially reducing floor space. However, in this fast-paced industry, many manufacturers simply can't build phones fast enough. Couple this increased pressure to perform with reducing costs per phone, while building and maintaining test systems and software, and the stage is set for competitive change.

Many manufacturers are building more flexible lines to accommodate the rapid introduction of new technology and respond to increasing market demands. At the same time, many test engineering departments are trying to build-in flexibility, even though their time is valuable and not always available.

Cell Phone Manufacturing Pressures
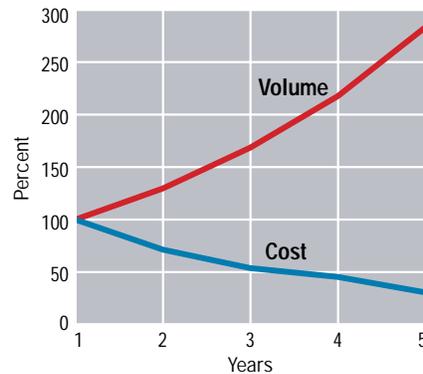
When a new cellular phone is being developed, a test system and production line must be built without delaying the introduction of the new phone. Test engineering is under tremendous deadline pressure to get the manufacturing test process set up on time. Test systems are a critical element of this process to guarantee production of quality phones. As you can see, reducing test development time can significantly impact time-to-market.

Test Engineering Trade-Offs

Manufacturing has traditionally optimized and worked on at least three key parameters to reduce the test cost per phone: equipment cost, test time and floor space. In the past, this was accomplished internally in the cellular phone manufacturing company, simply because the test equipment manufacturer offered little help with the exception of providing quality measurements.

Equipment cost is an obvious area to begin economizing, but there's a point of diminishing returns. Once you consider the less visible costs of equipment, such as maintenance, training, and support, the total costs become more difficult to compare.

Reducing test times is also a key parameter in reducing test costs per phone. Once you can significantly impact test times per phone, you produce more phones with the same equipment, thereby reducing the test cost per phone. Test engineering departments will optimize tests and instrument I/O, eliminate tests, trade-off test coverage, use faster computers and instruments – even overlap tests in an effort to reduce test times. However, there's a trade-off in this effort since you're forced to sacrifice engineering resources to improve test systems. And, of course, the schedule on the new test systems still remains the same.

Furthermore, many manufacturing situations are limited by the amount of floor space equipment can occupy. Some factories are already at full capacity, so space is at a premium. Traditionally, test engineering has been challenged to put more equipment in each test rack, test multiple phones per test stand, or use automation to reduce floor space requirements. Some of these improvements may actually decrease flexibility to re-use test stations or re-configure the manufacturing process. Again, manufacturers are often forced to trade-off test engineering resources to improve the test stands and get the new cell phone to market.

HP's Solution

With the introduction of HP's TS-5500 Functional Test Platform manufacturers can lower test times, decrease floor space, and lower test equipment costs, and still get their product to market faster. The HP TS-5500 is the third member of HP's functional test platform family, which includes successful test platforms for automotive electronics and SONET.

The HP Platform concept provides a universal test system core of both hardware and software, which can be easily modified to suit various test situations. Test system developers can customize the use of instruments and test routines to create a test stand for a specific manufacturing stage.

HP TS-5500 Platform Meets the Needs of Cellular Phone Manufacturers

HP TS-5500 Platform Overview

Measurement-Ready for Cellular Phone Testing

Cellular phone production lines require different types of testing at various stages. Testing GSM cellular phones necessitates certain instruments for the specific tests and integration of this equipment into the manufacturing line. The HP TS-5500 features superior measurement equipment integrated with the software to get the job done.

Turn-on tests of the cellular phone at board-level include emulating the battery requirements, testing battery-charging circuitry, probing points on the board and phone communication. The HP TS-5500 features specific power supplies, a DMM and multiplexer, and RS-232 capabilities to handle these needs.

The standard VXI architecture for switching, DMM and phone communication offers a flexible method for configuring different test stands. VXI is the most cost-efficient architecture, reducing equipment space when used to test multiple phones per test stand. HP's Dynamic Measurement Power Supplies are designed for cellular phone battery emulation and testing.

Calibration tests involve adjusting power levels in the phone circuitry to make a phone call. To gather these RF measurements, the HP TS-5500 uses one HP 8922M/P for each phone. Today, the HP's 8922 family of RF test sets is a crucial part of the system, producing quality phones at the best throughput and lowest cost.

Call processing may be verified in a final test station. This sequence of standard GSM tests uses the HP 8922M/P as the core measurement instrument. Other final tests include audio tests of the microphone and speaker. With the HP TS-5500, audio tests are performed with the VXI Audio Source and Digital Signal Processor.

With the dramatic increase in high volume cellular phone manufacturing, computer-aided-testing is more valuable than ever. The HP TS-5500 uses a single embedded VXI Pentium PC for controlling the instruments, running the tests, and interfacing to automation equipment. A software test executive, GSM measurement routines, software utilities, and an operator interface panel are also included.
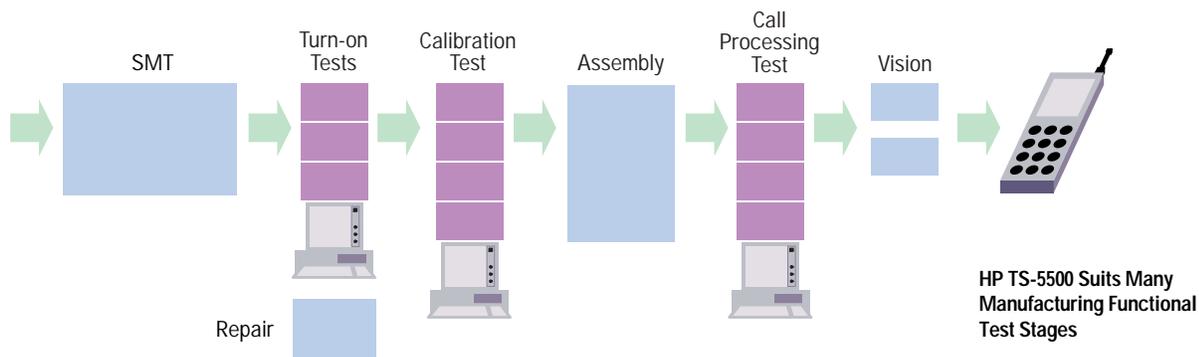
Lower Integration Costs

Because HP standardizes the racking, cabling and mass interconnect, the functional system is totally integrated to lower your costs. These HP economies of scale provide a lower cost than one-of-a-kind integration by each test engineering project team. It's a more comprehensive solution that eliminates steps in test development while lowering costs. Since one TS-5500 handles up to four phones with one rack of equipment, integration costs are dramatically reduced versus building separate racks for each phone.

All of the low frequency resources for testing up to four phones with the HP TS-5500 are available through the HP ExpressConnect interface panel. Pinouts are documented allowing you to swap fixtures by changing the interface – all in a matter of minutes. As a result tests can be designed and debugged using a simple fixturing system, while a more advance fixture is being developed. Since the system interface is defined and documented, the fixture developer can design and build the fixture concurrent with the test system development, thus saving valuable development time.

HP TS-5500 Software Increases Productivity

As a result of its hierarchical environment, the HP TS-5500 software delivers maximum re-use. This code is further optimized for fast execution of each routine. The test software consists of both developer- and test-execution environments.

The test system developer uses the hierarchical environment for creating the test program. In addition, HP provides a test plan template for typical radio protocol tests on a GSM phone. It's a template that's easily modified to get a phone test up and running quickly. Or, manufacturers can easily build their own test plan from the HP-provided software building blocks. The HP-supplied library of tests, measurements and utilities for GSM cellular test are finely-tuned for measurement performance.

SMT · Turn-on Tests · Calibration Test · Assembly · Call Processing Test · Vision · Repair

HP TS-5500 Suits Many Manufacturing Functional Test Stages

Test operators view a panel for running tests on specific phones – a panel created by the test developer. HP provides a sample operator interface that's easy to change or upgrade. Or, developers can use Visual Basic® to quickly develop a custom operator interface

Documentation, Training, and Support

Documenting a system can be difficult when test engineering's primary job is to keep production up and running. HP's TS-5500 provides complete documentation of its unique capabilities: cabling, mass interconnect, power distribution and software. HP also offers system platform training to augment its extensive curriculum. Worldwide support on the hardware components and the unique platform features is provided by HP's team. When a system is deployed, there are virtually no hassles or headaches. Manufacturers need only worry about documenting and supporting the customization of their specific platform.

Depending on a manufacturer's production situation, there may be numerous reasons to adopt the platform concept. Take a look at some of the following reasons as they relate to an upcoming project ...

1. Reduce Your Test Cost per Phone

Test cost is only one factor in reducing the total cost of manufacturing a phone; however, it's a tangible cost that can be reduced by test engineering. As mentioned, test engineers are often forced to make costly time trade-offs. They're not only keeping the lines running, they're pressured to constantly improve the processes while creating new production lines. To reduce test costs, test engineers focus on reducing test times, capital equipment costs and floor space. And HP's TS-5500 delivers, reducing test times, capital equipment costs and floor space. In fact, in many instances, reducing costs can impact time-to-market and/or flexibility of manufacturing.
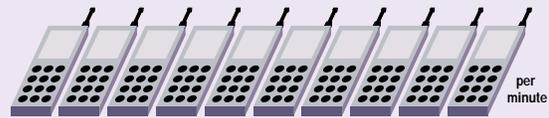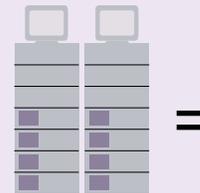
Today's Final Test Stage
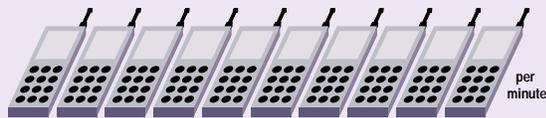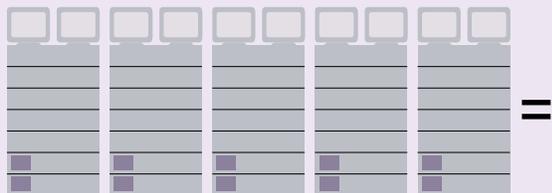
5 test stands
2 phones each
10 phones/minute
$98K/phone ($196K/test stand)
= **$980K for 10 phones/ minute**

Final Test Stage with HP TS-5500

2 test stands
4 phones each – *Density Doubled*
10 phones/minute – *20% reduction in test times*
$75K/phone ($300K/test stand) – *23% reduction in capital cost*
= **$600K for 10 phones/ minute**

Just Take a Look at the Savings...

The cellular phone manufacturer shown in Figure 1 has ten test stands for testing radio protocol. The cost of those stands is approximately $98k per phone tested - for a total of $980k. Costs include the test equipment (power supplies, PC, switching, radio test set), racks, system integration and cabling – everything but the software. This test stage is capable of handling ten phones per minute. Contrast that with the HP platform-based solution shown in Figure 2, reducing the test cost per phone by >35%, and achieving the ten phones per minute rate.

Many cell phone manufacturers are moving towards "multi-up" or multiple phones tested per test stand. This is often extremely difficult to create in an asyn-

chronous, simultaneous test environment. Yet, HP's platform has this capability and it's easy to configure a four-up test stand for radio protocol tests.

To illustrate, let's assume that these improvements can be executed 20% faster than your typical systems. To test ten phones per minute, the platform concept reduces the amount of testers required. Since these new testers are 20% faster, manufacturers actually require two less testers to achieve the same rate.

For every four phones tested, only one PC is needed; one VXI mainframe for all switching, DIO, and RS-232, and one rack, cabling and system integration. Capital costs are reduced by 23% to $600k for the testing stage, with all equipment placed in two 2m racks to save space.

A test platform features a specific instrumentation set, so HP can optimize throughput by tuning the hardware and software for faster execution. Since many of the tests involve communicating with the radio, specific hardware such as buffered RS-232 has been developed to off load the computer and speed test execution. Should a manufacturer require comprehensive audio phone measurements, the VXI DSP module can contribute to decreasing test times.

2. Significantly Reduce Test Development Time

Because the HP TS-5500 represents a majority of a test system solution, it's never been easier to keep pace with demand. HP's successful experience with other functional test platforms has produced phenomenal results in reducing test software development time. Automotive electronics manufacturers have used HP's platform concept - going on record to say they've developed tests in one-third the time. In fact, using HP's platform concept, test development was reduced from three months to one month for some automotive electronics modules. Plus, HP's Solution Services team has delivered numerous test stands and automation lines to cellular phone manufacturers.

The software development productivity of the HP TS-5500 results from a hierarchical approach to test development that maximizes the reusable code in a structured process. HP's high quality software environment, tests, measurements and utilities are a direct result of thorough design and testing. In addition, HP provides software documentation, training and support.

HP's unique platform approach also saves steps in developing the complete system. Because the HP TS-5500 has a pre-defined architecture, system design and planning steps are reduced. The mass interconnect, cabling and racking are specific activities performed by HP, while test engineering focuses on interfacing the mass interconnect to the phone and other special requirements.

3. Save Space

When a factory has little room for more equipment or new lines, HP's platform for testing multiple phones is a real space-saver! Referring to the previous example, phones can be tested in half the floor space, by reducing test times and economizing on PC's, VXI mainframes, racks and system integration costs. By adding HP's compact fixturing solution to the platform, multiple fixtures can be positioned next to each other without RF interference.

4. Worldwide Deployment

Many companies are operating in a global business environment. For test departments, this sets up many complications, including setting up new production lines overseas and in other countries. Typically, production lines are duplicated with local people trained to run the manufacturing process. However, there's often a heavy burden imposed on the central test engineering department to support the test stands. Any software changes or questions concerning operation eventually makes its way back to the engineer. Software and test systems may be difficult to troubleshoot and maintain, especially when test engineers are short on time and short handed. With HP's test platform approach, stable test results are readily achieved worldwide – without the hassles and headaches. Because the software, hardware and integration are standardized to a large degree, HP can support the platform worldwide, with customization provided via local support.

5. Built-in Growth Path

More often than not, test stands are created in a schedule-driven environment. It's difficult to take the time to design and create a system that's both upgradeable and leverageable for an extended period of time. Most systems are simply not upgraded – ignored as production matures on a particular model.

HP's goal is to upgrade the HP TS-5500 annually to keep systems up to date. In fact, the HP TS-5400 platform for automotive electronics has already been upgraded three times in its first two years to meet user needs. This built-in upgradeability not only preserves the initial investment, it offers the flexibility to grow to a multi-up tester and/or the latest instruments and computers. In other words, manufacturers can start with the HP TS-5500 configuration that fits their needs, then upgrade the configuration as production volumes increase. And the results? Production improvements as well as a reduction in start-up risks.

HP TS-5500 System Architecture

The HP TS-5500 provides an integrated platform of hardware and software. With standard systems, HP optimizes the measurements and tunes the performance to suit the application. For explanation purposes, the following sections review the key components of the HP TS-5500. However, it's important to realize that the complete system, rather than individual components, provides the features and benefits mentioned previously.

HP TS-5500 Hardware Subsystems

The HP TS-5500 hardware can be divided into subsystems for the various measurements and capabilities:

- RF measurements
- Low Frequency Measurements
- I/O Subsystem
- Power Subsystem
- System Controller

RF Measurements

The HP 8922M GSM Test Set provides the crucial measurements needed for GSM phones. The HP 8922P is used for GSM, DCS and PCS phones. It's an instrument that provides all of the RF measurement capabilities, phone call initiation and protocol handling. One HP 8922 is dedicated to each phone tested in the system. In addition to making accurate and repeatable measurements for the production of quality phones, HP's RF instrumentation maximizes production throughput while minimizing the cost per test.

Low Frequency Measurements

The Digital Multimeter (DMM), frequency counter, audio signal source and audio digital signal processor (DSP) in the HP TS-5500 provide all DC and low frequency measurements.

The HP E1412A is a 6.5 digit VXI DMM for basic measurements made on cellular phones. For instance, at board level tests, it provides probes for basic functionality including continuity and power. The HP E1412A is a C-size VXI module delivering high accuracy and wide functionality. This DMM can measure AC/DC volts, amps, 2- and 4-wire ohms and frequency/period. A 16-channel multiplexer connects it to the HP ExpressConnect.

The HP E1420B High Performance Universal Counter is a C-size VXI module providing a full set of traditional universal counter measurements (frequency, period, time interval, totalize and ratio), plus the automatic measurements of rise/fall time, pulse width and phase. It features a 200 MHz frequency range and 2nS time interval

resolution for accurate measurements of clocks and bus signals. Of course, it's ideal for automated applications due to its high speed measurement set-ups, measurements and result outputs.

Audio Measurements

Users of cellular phones are growing increasingly discriminating concerning the quality of voice transmissions. As a result, testing of the speaker, microphone and audio circuits is becoming evermore important.

Today, manufacturers generate single audio tones with the RF test set, audio analyzers and/or other instrumentation. This signal is applied to the microphone, then the RMS voltage is measured at the speaker or decoded from the phone's transmitted RF signal. This type of testing offers an effective functionality check, but may take considerably longer if a more comprehensive test of the audio circuits is performed, e.g. multiple frequencies and different voltage levels.

In contrast, the HP TS-5500 employs the HP E1432A DSP for comprehensive, efficient audio testing. The HP E1432A is a 16-channel, 20kHz bandwidth C-size VXI module with alias protection that performs FFT's and averaging on the input signals. What's more, it contains a function generator that can be programmed for sine, noise or arbitrary waveforms. Since the HP E1432A measures all frequencies at once with an FFT, the traditional single tone tests can be replaced with multiple tone within the same time constraints. Plus, distortion measurements can easily be performed if needed. Add to that the fact that this audio measurement capability is a shared system resource, and the benefits continue to grow. Only one E1432A is needed for testing up to four phones!

HP E1432A VXI DSP Module
for Audio Measurements on
Microphone and Speaker

I/O Subsystem

The I/O Subsystem includes the switching, phone communications and fixture control functions in the VXI M-module format. These M-modules are ideal for the multiple functions needed in testing cellular phones. Because M-modules provide needed user functionality in smaller increments, test costs are reduced. M-modules are an open-industry standard that debuted as computer interface products.

The compact C-size Carrier occupies a single VXI slot and holds up to five M-modules. Each M-module is programmed as a separate device. Any of the following M-modules can be added to the carrier:

- Dual RS-232 and Parallel Interface M-module
- Quad RS-232 M-module
- Digital I/O M-module
- Multiplexer Switching M-module
- Matrix Switching M-module
- General Purpose Switching M-module

HP E2260A Dual RS-232 and Parallel Interface M-module

- Two buffered RS-232 channels for phone communication and automation control
- One buffered bi-directional Centronics parallel port

The HP E2260A is used to program individual cellular phones over RS-232 or other phone interface devices with a parallel port. Input and output buffering reduces communication overhead and lowers test time.

VXI M-Module Functionality in Small
Increments for Reduced Test Cost

HP E2261A Quad RS-232 M-module

Built-in data handshaking and internal 2K data buffers per channel reduce communication overhead for lower test times. These shared-system RS-232 resources are used to drive strip printers, bar code readers and other serial devices.

HP E2290A Digital I/O M-module

- 16 data/actuator lines for independent inputs or outputs
- Open collector outputs: 30V max

The Digital I/O M-module is used for versatile digital sensing and control of devices and special purpose circuitry within a system. The 16 data lines can be TTL compatible I/O, or TTL compatible inputs and open collector outputs up to 30V. Each I/O line provides switchable current sinks for actuation of external devices, including high voltage/current relays, switches, high frequency coax relays, microwave and RF switches and programmable attenuators. One bit of the digital I/O in the HP TS-5500 system drives the relay to control the charger power supply.

HP E2272A Multiplexer Switching M-module

- Dual 8x1 Two-wire or Single 16x1 Two-wire (DPST)

This multiplexer has 16 DPST latching relays organized as two separate 8-to-1 banks. They can also be easily configured as a two-wire 16-to-1 multiplexer. In the standard configuration of the HP TS-5500, one HP E2272A is used to switch the DMM inputs and another is used to multiplex the audio output of the HP E1432A DSP.

HP E2271A Matrix Switching M-module

These 16 DPST relays are configured as a 4x4 two-wire signal switching matrix for connecting a group of instruments to several points on a device under test. Flexible switching systems can be developed with multiplexers and general-purpose relays connected to matrix switching.

HP E2270A General Purpose Switching M-module

These 16 SPST relays are for general purpose signal switching and control of external devices.

Power Subsystem

The HP TS-5500 contains phone power supplies that emulate a cellular phone battery, a battery charging power supply and utility power supplies for fixture power and factory automation power.

The HP 66312A and 66332A Dynamic Measurement DC Sources are ideal for testing battery powered devices such as cellular phones. These power sources not only provide the power for testing the device, but also perform the peak current measurements required to characterize the pulsed current demands of battery powered devices. Since battery life is of utmost importance, the HP power supplies offer 0.1% + 2.5 microamp measurement accuracy.

These dynamic DC sources solve three challenges facing digital cellular phone manufacturers. First, many digital wireless telecommunications products transmit in short bursts to conserve power between transmissions, thereby improving battery-operating time. As a result, current is drawn from the battery in pulses causing voltage dropout on typical supplies. These current pulses are digitized by the HP power supply. Utilizing the HP power supply, transmit-, standby- and off-current waveforms can be sampled every 15.6 microseconds.

Second, lower phone operating voltages provide more efficient circuitry and smaller batteries. However, since transmit power remains the same, currents increase with the lower voltage. The HP 66312A supplies 2A and 40 watts to each phone; whereas, the HP 66332A provides up to 5A and 100 watts for the increasing capabilities of GSM phones. That's another reason why HP power supply outputs are optimized for cellular phone requirements.

And finally, high volume manufacturing dictates that the programmable power source is located several meters from the fixture. The path from the source to the phone may have significant resistance and inductance. The HP 66312A and 66332A tackle each of these, providing the proper voltage/current ratings, local sensing to maintain the proper voltage and transient response – all in one small package at one low cost.

The HP 6612B Power Supply is used as the cellular phone's battery-charging supply in the HP TS-5500 system. This 40 watt DC Power Supply maintains a constant voltage supply that provides programmable current down to the microamp level. That makes it the perfect source for production test application because of its high-speed programming with under 4 millisecond response time.

For utility power in the HP TS-5500, an AC-DC power supply with one- to four-outputs is provided. Output voltages are user-defined with up to four 60-120 watt modules. Each output can be independently turned on/off, paralleled, remote-sensed and voltage adjusted. These power supplies provide +3.3V DC at 25A, +5V DC at 20A, +12V DC at 9A and +24V DC at 5A.

HP ExpressConnect

The TS-5500 HP ExpressConnect is a common, standardized connection point for the test fixtures, as well as system resources and instrumentation. While it is designed for up to four DUTs on the multiple-up testers, the HP ExpressConnect scheme is used on all configurations. Benefits include lower integration costs and fixturing costs. All the system's non-RF resources are brought to the HP ExpressConnect; however, once fixtured to the HP TS-5500, there's only the need to connect the resources/instrumentation required for that particular test. The HP ExpressConnect includes connectors, cables and pc board interconnects for the following HP TS-5500 system resources:

- Audio DSP and Multiplexing
- Digital Multimeter and Multiplexing
- Digital I/O
- General Purpose Switching, Multiplexers, and Matrices
- RS-232 and Parallel Interfaces
- Power/Measurement for DUTs
- Power Supply for Battery Charging
- Utility Power Supplies

Customization flexibility is further provided with optional M-module connection points and customer-specific inter-module wiring in the mating connectors. For optimum measurements, RF connections should be routed directly to the RF equipment.

System Resources and Non-RF Instruments for up to Four Phones with HP TS-5500 ExpressConnect
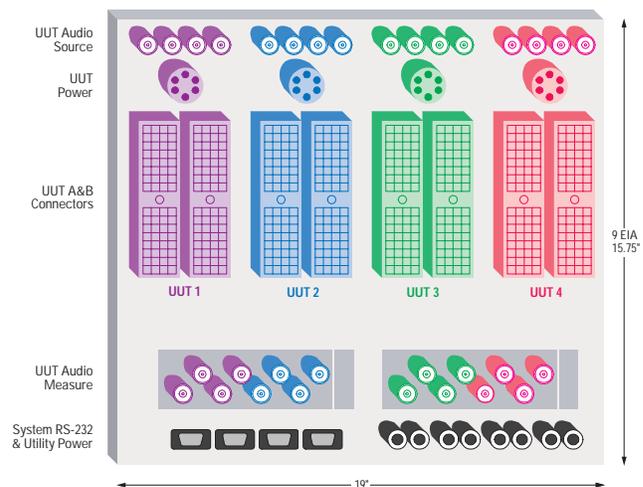
System Controller

The system controller for the HP TS-5500 is a C-size, VXI-embedded Pentium PC. An embedded VXI PC allows direct computer access to VXI devices, system memory and triggers devices as though they were part of the controller hardware. Each test stand supports one controller, running software that controls up to four sets of hardware for testing up to four phones simultaneously.

System Software Reduces Development Time

The HP TS-5500 software is a complete test development and test execution environment for the entire software development job. This test executive environment is tuned for functional testing of electronic devices in manufacturing. The software runs on a PC with Windows NT 4.0 for optimum performance. Plus, it's pre-installed and ready to use.

The HP TS-5500 Software Development Environment is ideal for test development of cellular phones. It consists of re-useable tests, measurements and utilities for performing specific functions related to GSM phone testing. Templates and examples are provided to serve as a starting point for creating tests. The HP test executive allows you to organize and order tests, reconfigure the test stand, profile the execution speed and debug tests.

The HP TS-5500 Software Test Execution Environment allows an operator to test up to four phones simultaneously and report test information back to the operator. Using the software utilities, the test executive can be easily linked with factory automation, bar code readers and printers.
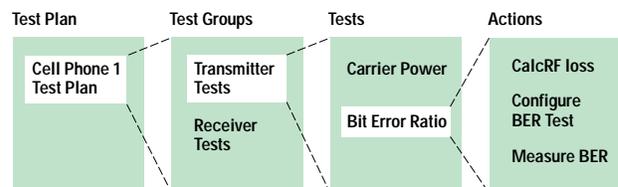
HP TS-5500 Software Development Environment

This hierarchical test development encourages reuse, to decrease development time on upcoming projects. The HP TS-5500 software provides an efficient and effective structure for developing the test plan and sequencing for functional test of cellular phones. In fact, many measurements, tests and utilities needed are already provided as building blocks. These routines are of the highest HP quality and provide maximum performance. A test engineering software team need only create the test plan and sequencing from these integral building blocks of software, add customization for the phone communications and create any custom test and/or measurements.

The developer's interface is used to create and debug tests. HP's software is used in the complete development process, thus shortcutting many traditional steps in developing test software. Get started by writing tests using the building blocks HP provides. The HP TS-5500 lets you develop test groups, tests, measurements and utilities according to the hierarchical method. The test plan template provided can even be used for radio protocol testing, editing or modifying it to meet specific needs. Once a good pass at a test plan and sequence has been accomplished, debug tools and a speed profiler are included.

If similar models of phones are tested on the same system, writing and running similar tests becomes much faster utilizing the test plan variants capability. It's easy to duplicate similar product tests or test plan segments then edit them for the specific product tests performed.

HP TS-5500 Hierarchical Test Development Environment for Maximum Re-use

Test Plan	Test Groups	Tests	Actions
Cell Phone 1 Test Plan	Transmitter Tests	Carrier Power	CalcRF loss
	Receiver Tests	Bit Error Ratio	Configure BER Test
			Measure BER

HP TS-5500 Tests, Measurements and Utilities

HP has created tests, measurements and utilities for making measurements and controlling and configuring system components common in cellular phone test systems. The HP TS-5500 software provides a test plan containing a number of GSM phone tests. It's a test plan containing tests, sample limits, looping constructs and variables. And it's an excellent point to start building a final test plan for your phone.

More than 120 measurements and utilities provided can be used in calibration and final testing of GSM phones. Specific examples of HP TS-5500 phone calibration and GSM protocol software routines are outlined in Table 1. These action routines include GSM call processing functions, configuring the GSM instrument and GSM measurements. The C utilities are used in creating custom phone calibration actions or routines due to the proprietary nature of phone calibration techniques. In addition to the action routines outlined in the tables, HP provides greater than 1000 re-useable C-utilities as .dll's for use in building user-specific actions.

Besides GSM test software, HP also includes routines for audio, DMM measurements, counter and the power supplies (See tables 2 - 6). All software routines are optimized to work in the multiple-up environment quickly and efficiently. Furthermore, the HP software frees developers from the details of I/O languages, instrument languages and driver-level nuances.
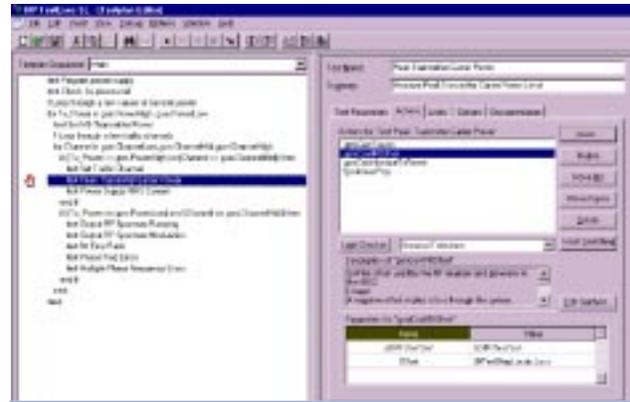
GSM Phone Test Plan Template to Modify

Table 1. Examples of GSM Actions

gsmCalcNominalTxPower	Calculates, in dBm, the nominal power at the GSM MS Test Set.
gsmCallEnd	Terminate a call.
gsmCallOriginate	Originate a call which the phone must then answer.
gsmCallReceive	Receive a call which the phone must have initiated.
gsmCallTrafficChannel	Sets the traffic channel number.
gsmCallTxPowerLevel	Set the Mobile's Tx power level.
gsmConfBitError	Set the number of bits used in a bit error rate measurement and the test type.
gsmConfFastBitError	Set the number of bits used in a fast bit error rate measurement.
gsmConfRadio	Set the radio protocol in the HP 8922.
gsmConfRFCal	Assigns a two-dimensional array of Real 64's.
gsmFetchBitError	Fetches the bit error ratio without triggering a new measurement using the current setup.
gsmFetchFrameErasure	Fetches the frame erasure ratio without triggering a new measurement using the current setup.
gsmFetchPTCP	Fetches a peak transmitter carrier power measurement using the HP 8922 without triggering a new measurement.
gsmMeasBitError	Measure bit error ratio using the current setup.
gsmMeasBurstTimingError	This execute action measures the burst timing error of the Mobile station.
gsmMeasFastBitError	Measure fast bit error ratio using the current setup.
gsmMeasFTCP	Measures fast transmitter carrier power using the HP 8922.
gsmMeasMultiPhaseFreqErrors	Measures frequency, peak phase, and RMS phase error.
gsmMeasOnOffRatio	Measures the Pulse On/Off ratio for both the rising and falling edges of the pulse.
gsmMeasORFSMod	Measures ORFS due to modulation at a set of frequency offsets.
gsmMeasORFSRamp	Measures ORFS due to ramping at a set of frequency offsets.
gsmMeasPhaseFreqErrors	Measures frequency, peak phase, and RMS phase error.
gsmMeasPowerVsTime	Measures power at the various times during the transmit pulse.
gsmMeasPTCP	Measures peak transmitter carrier power measurement using the HP 8922.
gsmMeasSACCHRx	Measure SACCH receiver characteristics: received level and quality.
gsmMeasSACCHTx	Measure SACCH transmitter characteristics: timing advance and transmitter level.

Table 2. Examples of Audio Actions

audioCloseUnlock	Closes and unlocks HP E1432 card so other tasks can use it.
audioConfFFT	Configures the input range and the span, block size, and average count of the FFT.
audioConfSourceFSK	Sets the output to a sine wave alternating between 2 frequencies.
audioConfSourceMultitone	Sets the output to the sum of several sine waves.
audioMeasCMessage	Measures C-message weighted RMS voltage by filtering the FFT spectrum.
audioMeasFFT	Turns on the source and measures a spectrum.
audioMeasMultitone	Measures the RMS voltage at several frequencies.
audioMeasRMS	Measures RMS voltage by averaging the filtered, time sampled waveform.
audioMeasSINAD	Measures the ratio in dB of the signal power at the selected frequency.
audioMeasSine	Measures RMS voltage at the selected frequency.
audioMeasTHD	Measures the total harmonic distortion relative to the RMS voltage.

Table 3. Examples of DMM Actions

ldmmConfCal	Configures autozero and line frequency.
dmmMeasAutoCurrentAC/DC	Measures AC/DC current.
dmmMeasAutoFres	Measures 4-wire resistance.
dmmMeasAutoRes	Measures 2-wire resistance.
dmmMeasAutoVoltageAC/DC	Measures AC/DC voltage.
dmmMeasAutoVoltageDCRat	Measures DC Voltage Ratio.
dmmMeasCurrentAC/DC	Measures AC/DC current.
dmmMeasFres	Measures 4-wire resistance.
dmmMeasRes	Measures 2-wire resistance.
dmmMeasVoltageAC/DC	Measures AC/DC voltage.

Table 4. Examples of Charger Power Supply Actions

chrgConfVoltCurrent	Configure the charger Power Supply's voltage and current.
chrgLockInit	Locks and Resets the charger supply and Closes the charger supply relay.
chrgMeasCurrent	Measures the current sourced by the charger Power Supply.
chrgMeasVoltage	Returns DC voltage measured by the Power Supply.
chrgUnlock	Unlocks charger supply and opens the relay so other tasks can use it.

Table 5. Examples of Power Supply Actions

psConfCurrent	Configure the Power Supply's current.
psConfOutputState	Configure the Power Supply's output on or off.
psConfVolt	Configure the Power Supply's voltage.
psConfVoltCurrent	Configure the Power Supply's voltage and current and enables the output.
psMeasCurrent	Measures the current sourced by the Power Supply.
psMeasMaxCurrent	Measures the maximum current sourced by the Power Supply.
psMeasMaxVoltage	Measures the maximum voltage sourced by the Power Supply.
psMeasRmsCurrent	Measures RMS current level drawn from the Power Supply.
psMeasRmsVoltage	Measures the RMS voltage supplied by the Power Supply.
psMeasVoltage	Returns DC voltage measured by the Power Supply.

Table 6. Examples of Counter Actions

|	
cntConfFrequency	Configures the card to measure frequency.
cntConfVoltageAC/DC	Configures the card to measure AC/DC voltage.
cntInput	Sets the input characteristics.
cntRead	Measures the function configured for the counter.

HP TS-5500 Test Execution Environment

The HP test execution environment enables an operator to test up to four phones simultaneously and report test information back to the operator. The heart of the test execution is the HP TS-5500 operator interface designed for cellular phone testing. This template allows the operator to start and stop tests, while monitoring progress as testing occurs. It also handles operator log-in, loading the test plan and simple operator intervention controls. A test report, including parametric data, can be positioned on the screen or sent to a printer.

In most production environments, the operator interface should be tailored to individual needs. Factory automation utilities are provided to control equipment such as barcode readers for recording serial numbers and strip printers for printing test results. This custom operator interface, including keypads, touchscreen, operator prompts, special screen colors and layout, is developed with Visual Basic methods, properties and events.

Data Logging and Reporting

The HP TS-5500 software logs test results in a comma-delineated file as well as other formats including HP QSTATS II or standard spreadsheet. The system provides a results output file for each phone, parametric data and/or pass/fail of each test. This data may be sent directly from the tester to the main computer system for further analysis by production or R&D. The HP TS-5500 also reports failures to the operator screen in a defined format. If required, failures can also be reported to a system printer and data file.
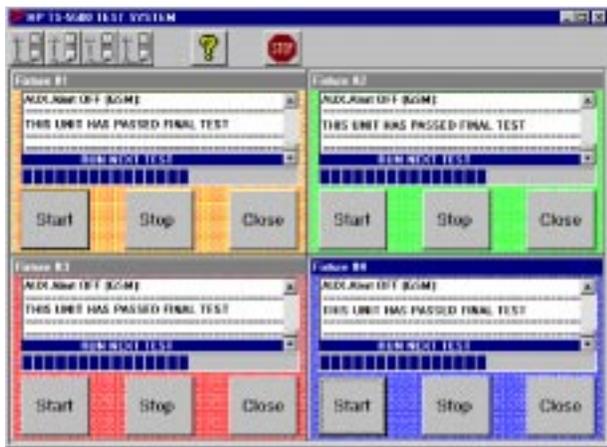
Four-up Operator Interface Shares
Log-in, Barcode Reader and Printer

Creating a Complete System from the Platform

Building test stands from the HP TS-5500 has never been easier. Simply configure the HP TS-5500 system from the list of options, then plan the activities to finish the system's production line deployment.

1. Basic System Components

The HP TS-5500 can be configured with two rack sizes, VXI Instruments, and a choice of power supplies. Configure a four-up radio protocol tester, a multiple-up calibration stand or a single set of equipment for one-up cellular phone testing. Simply select the basic components from the HP TS-5500 options and associated products in the ordering structure. Many of the necessary instruments for interfacing with two phones, such as utility power supplies and RS-232, are included in the base product.

Select HP RF Test Equipment

• GSM or Multi-band Test Sets

Select Low Frequency and I/O Instrumentation

• Digital Multimeter
• Multiplexers
• Matrix Switching
• General Purpose Relays
• Digital I/O
• Buffered RS-232
• Audio DSP and Multiplexer
• Counter

Choose Power Supplies

• Charging Power Supplies
• Phone Power Supplies

Select Utility Power Supply Configuration

• 3.3V, +5V, +12V, -12V and/or +24V

Select Equipment Racks:

• 1.6m or 2.0m

The HP TS-5500 comes completely integrated with the options listed above, as well as the following standard features:

- System Design and Architecture
- Standard Racking
- VXI Module Installation
- Cabling: HP-IB, VXI Modules
- Instrument Power Distribution and Cabling
- HP ExpressConnect for System Resources
- PC with HP TS-5500 System Software:
- Tests, Measurements and Utilities Library for GSM, Audio, Switching and I/O
- Test Executive Functionality
- Windows NT 4.0
- Assembly and System Verification

2. System Customization

To complete the system, the HP TS-5500 can be customized to a particular application. Customization can be provided by a manufacturer's test engineering group, HP's custom services team or a third party. Customizing the HP TS-5500 may include some or all of the following activities:

- Project Management
- Customer-specific Test Development and Test Sequencing
- Phone Fixturing
- Robotics and Automation Handling
- Phone Communication
- Additional Special Instrumentation
- Customizing the Operator Interface
- Database Interface Software

Customization Planning

The test system platform concept significantly shortens development time, leaving more time to plan platform customization. Because every manufacturing situation and new phone may be different, HP's TS-5500 provides all the comprehensive core capabilities needed. Both the software and hardware must first be tailored to individual specifications to get a phone test system up and running.

Typical HP TS-5500 Configurations

The HP TS-5500 platform is easily configured to meet multiple production test situations. For example, you can build a variety of call processing or calibration test stands:

- Four-up to One-up Phone Testing
- Call Processing or Radio Protocol Test Stands
- Board-level Alignment/Calibration Test Stand

The multiple-DUT per test stand configurations provide the best test cost per phone, whereas a single DUT per test stand is flexible and less complex.

HP's TS-5500 is easily configured as a flexible test stand for testing one phone. This configuration can reduce test cost per phone by more than 20% as a result of the test time reductions mentioned previously. Capital equipment costs relative to other options and existing test stands are much the same. Furthermore, this configuration can be moved to various positions in your production line, e.g. move a call processing stand to phone calibration or vice versa.
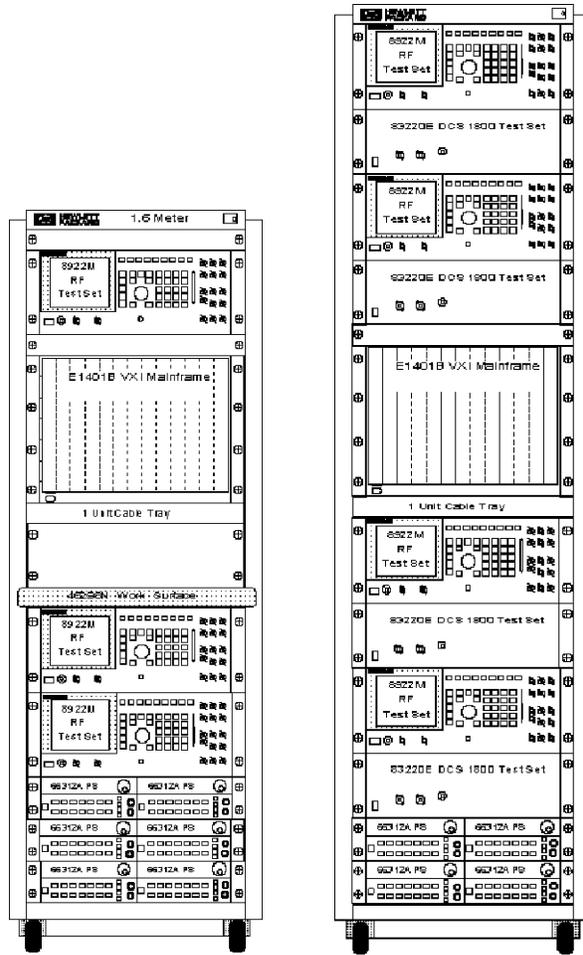
Three-up Final Tester   Four-up Final Tester

HP TS-5500 Ordering Structure

Product #	Option #	Product Description
E2171A		**TS-5550LX Multi-up Base System includes:**
		HP C-Size VXI Cardcage
		Embedded Windows NT Controller (32MB RAM) Four M-Module carriers, plus Core M-Modules: Two RS-232/Centronics Two 16-bit Digital I/O
		System Resources: One Quad RS-232 M-Module
		Utility Power Supplies (configured with Opts 300-302)
		HP ExpressConnect Interface and Cabling for 2 DUT's
		HP TxSL Software and Cellular Phone Software Library
		Systems Integration of all options and standard instruments, including choice of rack and all racking hardware
		Power Distribution Unit to power instruments and fans

Standard HP TS-5500 Base System Options:

Product #	Option #	Product Description
E2171A	Opt. 200	**Additional set of Core Modules including:**
		One M-Module carrier, plus
		Core M-Modules: One RS-232/Centronics One 16-bit Digital I/O
		HP ExpressConnect Interface and Cabling for one DUT
E2171A	Opt. 210	**RS-232/Centronics M-Module**
		Includes One RS-232 M-Module and HP ExpressConnect Cable
E2171A	Opt. 211	**Quad RS-232 M-Module**
E2171A	Opt. 215	**16 channel GP Relay M-Module**
		Includes One GP Relay M-Module and HP ExpressConnect Cable
E2171A	Opt. 216	**4X4 matrix M-Module**
		Includes One Matrix M-Module and HP ExpressConnect cable
E2171A	Opt. 217	**Dual 8-to-1 Mux M-Module**
		Includes One Mux M-Module and HP ExpressConnect cable
E2171A	Opt. 218	**16 Bit I/O M-Module**
		Includes One Digital I/O M-Module and HP ExpressConnect cable
E2171A	Opt. 310	**0 - 20 V DC Charging Supply**
		Includes One HP 6612 Power Supply, cabling and integration

Racks (Must order one rack option)

Product #	Option #	Product Description
E2171A	Opt. 002	**1.6m Rack**
E2171A	Opt. 003	**2.0m Rack**

Utility Power Supplies (Must order one utility power supply option)

Product #	Option #	Product Description
E2171A	Opt. 300	**3.3V, 5V, 12V and 24V Supplies**
E2171A	Opt. 301	**5V, 12V and 24V Supplies**
E2171A	Opt. 302	**5V, +12V and -12V Supplies**

Standard Instrumentation Supported by the HP TS-5500:

Product #	Option #	Product Description
E2175A		**Digital Multimeter and Mux**
		Includes HP E1412A DMM, One Mux M-Module and cables
E2176A		**Universal Counter includes HP E1420B Counter**
E2177A		**16 Channel Audio Test Module**
		Includes 16 Channel HP E1432A DSP module with ARB, 16 channel Mux, cables, DSP Breakout boxes
E2179A		**M-Module Carrier**

Phone Power Sources

Product #	Option #	Product Description
E8700A		**40W Dynamic Measurement DC Source**
		Includes: HP 66312A Dynamic Measurement DC Source, HP-IB cable, HP ExpressConnect cable and rack mounting
E8701A		**Dual 40W Dynamic Measurement DC Source**
		Includes: Two HP 66312A Dynamic Measurement DC Sources, HP-IB cables, HP ExpressConnect cables and side-by-side rack mounting
E8702A		**100W Dynamic Measurement DC Source**
		Includes HP 66332A Dynamic Measurement DC Source, HP-IB cable, HP ExpressConnect cable and rack mount hardware

Phone Test Sets (Must order one HP 8922 GSM Test Set for each phone tested)

Product #	Option #	Product Description
E8710A		**HP 8922M GSM Test Set** (includes Option 006)
E8711A		**HP 8922P GSM MS Multiband Test Set** (includes Option 006)

System Power Options (Must order one power option)

Product #	Option #	Product Description
E2171A	Opt. 05A	**220V Two Phase, Open Delta; CT of P Neutral; 4-wire**
	Opt. 05B	**220V Two Phase, Open Delta; P Junc Earth; 3-wire**
	Opt. 05C	**220V Three Phase or Wye; 3-wire**
	Opt. 05E	**220V Three Phase Wye with Neutral; 4-wire**
	Opt. 05F	**230V Single-Phase Earthed; 2-wire**
	Opt. 05G	**230V Two Phase, Open Delta; P Junc Earth; 3-wire**
	Opt. 05H	**230V Three Phase Delta or Wye; 3-wire**
	Opt. 05J	**240V Single-Phase Earthed; 2-wire**
	Opt. 05K	**240V Two Phase Open Delta; P Junc Earth; 3-wire**
	Opt. 05L	**400V Three Phase Wye with Neutral; 4-wire**
	Opt. 05M	**220V Single-Phase Earthed; 2-wire**
	Opt. 05V	**200V Single-Phase Earthed; 2-wire**
	Opt. 0E3	**200V (200V to 240V) Power**
	Opt. 0E5	**380V Three Phase Power**
	Opt. 0E6	**240V Three Phase Delta or Wye; 3-wire**
	Opt. 0E7	**415V Three Phase Wye with Neutral; 4-wire**
	Opt. 0EB	**220V Single-Phase Non-Earthed; 2-wire**
	Opt. 0EC	**240V Single-Phase Non-Earthed; 2-wire**
	Opt. 0EF	**208V Three Phase Wye with Neutral; 4-wire**
	Opt. 0EG	**220V Single-Phase CT; 3-wire**
	Opt. 0EH	**240V Single-Phase CT; 3-wire**
	Opt. 0EJ	**230V Single-Phase Non-Earthed; 2-wire**

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Santa Clara, CA 95052-8059
1 800 452 4844

Canada:
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Mississauga, Ontario
L4W 5G1
(905) 206 4725

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European Marketing Centre
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