The smart grid is revamping the electricity delivery network from electrical generation through the end-use customer with improved costing, efficiency, reliability and security. Smart grids leverage the latest in digital and information technology such as microprocessors, communications, advanced computing, and information technologies that provide advanced two-way communications between utility provider and energy consumer. These changes are resulting in a multitude of new smart grid devices with more advanced electronic designs that must seamlessly integrate into the grid. These more advanced designs require new modernized manufacturing test strategies in order to meet the cost, quality, delivery and reliability expectations of smart grid stakeholders.
Agilent offers comprehensive board test solutions that respond to the need for new, modernized test strategies for smart meter manufacturers. Agilent solutions enable manufacturers to perform comprehensive in-circuit test (ICT), functional circuit test (FCT) and combination test (ICT + FCT in a single test) at the assembled PCBA level, with the goal of assuring product quality and greatly reducing costs.

Agilent offers smart meter manufacturers these value propositions:

- Greater volume per tester results in fewer systems and fewer operators
- This means less capital, less maintenance, less labor, less training and less cost
- We simplify your supply chain – whether manufacturing is in the Americas, Europe or Asia, we’re there with local test experts to assist in deployment, train your partners and relocate or repair your Agilent test assets
- We shorten time to volume – by maintaining a large system assembly capacity and by providing a standardized platform that re-uses your hardware and software investments across your test systems
- We ensure high quality test and best-in-class diagnostics for efficient manufacturing repair
- We free up your internal test engineering resources to work other high value projects
- IP protection – your trade secrets are meant to be kept secret and we act in concert with that
Smart Grid technologies can be divided into four segments

1. Distributed energy generation and storage
2. Sensing, measurement and control & communications
3. Communication
4. Transmission lines

This product note addresses the electronic test strategies and requirements within the sensing, measurement and control and communications segments.
Sensing, measurement, and control

Smart meters have been called the backbone of the smart grid and constitute the largest part of the sensing and measurement technology. Smart meters, advanced meter infrastructure (AMI) & advanced meter reading (AMR) allow utility companies to capture electric grid data, transform that data into powerful information and then act on the data to improve overall grid operational efficiency; in addition, smart meters enable consumers to play an active role in energy conservation and cost reduction.

Communication

Advanced communication technologies connect the various smart grid electronic devices into a powerful network to achieve dynamic, two-way, interactive, real time information exchange. Many types of communications technologies enable the smart grid (e.g. copper wire, optical fiber, power line carrier technologies and several varieties of wireless). There is no universally accepted standard for smart grid communication technologies today and multiple technologies must co-exist in today’s grid. However, the smart grid cannot exist without an effective integrated communications infrastructure. Smart grid communications network can be divided into three components.

1. Home area networks (HANs) – HANs connect home appliances to a smart meter
2. Neighborhood area networks (NANs) – NANs connect smart meters to the utility infrastructure or backbone
3. Backbone – this is how a utility company control-center communicates with its service territory
1. **In-circuit Test (ICT)** - This test validates the component assembly process of the board. Smart meter manufacturers typically test for solder & pcb trace shorts, measure all analog components for values within a specified tolerance, test all powered analog devices, exercise all digital devices to verify solder integrity and/or device operation and perform some amount of in-system-programming (ISP) to customize the behavior and function of certain digital ICs. Agilent ICT is a very high-speed and affordable test with excellent diagnostics that identify the precise location of an assembly defect. Since smart meter production can be very high volume, Agilent offers the unique capability to test smart meter boards concurrently – as many as four at-a-time, so a meter manufacturer can produce four times the number of meter boards via a single tester.

2. **Functional Circuit Test (FCT)** - To be consistent with Lean Manufacturing principles, smart meter manufacturers will confirm the operation of smart meter boards with an FCT step prior to the value-added final integration process. Tests include an AMR test plus crystal oscillator frequency, high current measurement and voltage tests during FCT. The most commonly used AMR methods are power line communication (PLC) and RF communication (Zigbee (802.15.4), WiMAX, WLAN, GSM/GPRS and 900MHz Band). Manufacturers may also integrate in-system programming at this step as well for the same cost reduction reasons as ICT. To maximize tester capacity at this test step, Agilent leverages the concurrent test capability and high-speed test actions built into Agilent’s functional test executive.

Most manufacturers want the flexibility to execute whatever is needed to achieve operational excellence: most manufacturers select test strategies to detect failures at the earliest possible stage of the manufacturing process. But smart meter manufacturers often demand more than other electronics manufacturers because the functional test of a final assembled smart meter can take as much as one hour.

Therefore, a smart meter manufacturer needs to avoid defects that escape to final unit test. Agilent systems are known for their best-in-class test coverage that give manufacturers confidence in assuring low defect rates at final test.
Smart Meter ICT:
Using the Agilent Medalist i3070 Series 5

The Agilent Medalist i3070 Series 5 is the newest and fastest system in the Agilent i3070 Family. Like its many predecessors, the Series 5 will run tests and fixtures designed for older generations of 3070 test systems – an investment preservation business model that has saved our users hundreds of thousands of dollars and distinguished Agilent from other test system suppliers.

Agilent’s new i3273 Series 5 ICT system is small-footprint tester sufficient to provide excellent coverage to test up to 8 smart meter boards in a panel, tested sequentially at high speed. Other versions of the Series 5 test system will test two, three or as many as four boards in a panel concurrently, giving the manufacturer maximum volume in a minimum of space with a single operator. All i3070 Series 5 test systems include an infrastructure to flexibly add, control and connect external electronics or instruments. The Series 5 system accepts the new Agilent utility card which includes three slots to add external electronics such as commercial device programmers, boundary scan test engines or your own custom electronics in addition to supporting external instrument switching.

Smart meter manufacturers face ICT test access and density issues like all electronics manufacturers. Agilent i3070 systems provide a unique suite of limited access test tools – from access restoration tools like Agilent Bead Probe to virtual access solutions like Cover-Extend and boundary scan – to make your dense designs testable at ICT so you can take advantage of the speed and defect diagnostics found only at ICT.
## Key i3070 Specifications

Read more about the i3070 Series at [www.agilent.com/find/i3070](http://www.agilent.com/find/i3070)

<table>
<thead>
<tr>
<th>Features</th>
<th>Analog Plus (Mux)</th>
<th>Access Plus (Mux)</th>
<th>Hybrid Plus (Mux)</th>
<th>Hybrid 144 (Unmux)</th>
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<tbody>
<tr>
<td>Test nodes per card</td>
<td>144</td>
<td>8 x High Frequency</td>
<td>144</td>
<td>144</td>
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<tr>
<td></td>
<td></td>
<td>10:28 instrument ports</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 x GP Relays</td>
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<td></td>
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<tr>
<td>Digital channels per card</td>
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<td>144</td>
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<tr>
<td>Max pattern rate/frequency</td>
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<td>HF: 100 MHz</td>
<td>6/12/20 MPS</td>
<td>6 MPS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inst Ports: 25 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>GP Relays: N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum cards per backplane/system**</td>
<td>9/9</td>
<td>9/9</td>
<td>9/9</td>
<td>9/9</td>
</tr>
<tr>
<td>Analog voltage range</td>
<td>0-100V</td>
<td>0-100 V</td>
<td>0-100 V</td>
<td>0-100 V</td>
</tr>
<tr>
<td>Digital Drive/Receive range</td>
<td>N/A</td>
<td>N/A</td>
<td>-3.5 to 5.0 V</td>
<td>0 to 4.75 V</td>
</tr>
<tr>
<td>Edge Placement Accuracy</td>
<td>N/A</td>
<td>N/A</td>
<td>+/- 10 nS</td>
<td>+/- 10 nS</td>
</tr>
</tbody>
</table>

** ** NOTE: Total pin cards cannot exceed 9 pin cards/backplane. Model 3273 contains a single 9-pin card backplane. Other models contain two, three or four backplanes to support larger panels and concurrent test.

## Extend ICT to In-System Programming and Functional Testing:

Using the N1807A-001 Agilent Utility Card

![Utility Card Image]

Agilent ICT users can benefit from cost avoidances, less net loading time, floor space reduction, less staged product and overall better product yield by extending the ICT to include in-system programming and/or selected functional tests.

Innovative manufacturers tend to implement more requirements at the ICT stage, such as in-system programming of flash or microcontrollers (ISP), low voltage testing & frequency measurement. Agilent provides the flexibility to extend traditional ICT with these applications. Agilent’s new utility card complements our standard Flash RAM & CPLD RAM programming by offering users the ability to program thousands of serial devices. Performing ISP programming at the ICT step means the manufacturer no longer needs to pay for pre-programmed parts saving from between $0.05 and $0.90 per part. And programming parts at ICT means that inventory is less perishable because a programming change can be easily implemented at ICT.

The utility card also provides a switching mechanism to integrate additional instruments. Its three card slots allow users to design & install their own custom electronics for added functional test or functionality during ICT. External instruments and signals can be connected to the two balanced 1:4 multiplexed signal ports for added flexibility.

Read more about the Utility Card at [www.agilent.com/find/utility](http://www.agilent.com/find/utility)
The Agilent TS-5020 and TS-5040 functional test systems are part of the Agilent TS-5000 Family of standardized functional test systems. Standardization results in less effort to modulate your test strategy, less time to develop new test applications and greater supportability in remote manufacturing locations. The Agilent functional test family allows smart meter manufacturers to create a fast, robust, reliable and upgradeable test system that gives you a surprisingly low cost of ownership.

Our systems are based on proven instruments and measurement methods that meet smart meter customer requirements for capability, quality and throughput. They are scalable and upgradable to meet the dynamic market requirements while protecting the owner’s investment. The system architecture is designed to adapt to future requirements for new and next generation products with minimum upgrade cost and maximum reusability and utilization. For example, a smart meter may use power line communications today, but next year’s model might be wireless. Finally, Agilent has designed an open architecture test executive, Test Exec SL, with high speed test sequencing and the ability to leverage your software development in a variety of environments like LabView, C++, .net, Visual Basic and more.

Common smart meter application requirements

- Concurrent test mode or single unit sequential test mode
- Single or multi-up panelized boards
- Robust and open architecture test sequencer for manufacturing test
- Fast voltage and current measurements
- Frequency measurements for oscillators, waveforms etc.
- Pulse width measurements
- Single or multiple DC input
- Single or three phase AC input
- RF communication: Zigbee, Mesh RF, Wimax (transmitter and receiver test)
- Serial communications: Power line or optical communication
- DC and RF fixtures
- Automated vision inspection for LCD & LED displays
Key Agilent TS-5000 specifications

- Software: TestExec SL 7.0 multithreading sequencer & TS-5400 system software 7.0
- Measurement: 6.5 digit DMM, 2-channel 225 MHz counter
- Signal switching: Up to 4 MUX card with 4 : 40 channels 0.5 Amp
- Load switching: Up to 64-ch x 2 A and 20-channel x 5 Amp
- DC power sources: Up to 400 W modular power supply
- AC power sources: Single phase 375V A
- Stimulus: 4-channel 16 bit DAC
- RF communication: Vector signal generator and signal analyzer for RF standards

Standard Fixtures and Interface

Agilent’s smart meter functional test solution offers standardized fixtures and wiring for quick line changes.

Fixture Options

There are two fixture options available: the DC fixture and an RF fixture, which are primarily used together with the TS-5020 system.

DC Fixture:

This is the normal test system fixture which comes in the form of the standard “bed of nails” setup. This fixture is then connected to the DUT interface with a standard wiring setup which enables quick line changes.

RF Fixture:

The TS-5020 & TS-5040 platform offers RF testing capability that comes with optional RF shield box. The RF fixture and shield box come in a 305 mm x 203 mm x 660 mm dimension (H x W x D) with the following RF isolation capability.

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 - 1,000</td>
<td>&gt; 65 dB</td>
</tr>
<tr>
<td>1,700 – 2,200</td>
<td>&gt; 60 dB</td>
</tr>
<tr>
<td>2,400 – 2,700</td>
<td>&gt; 55 dB</td>
</tr>
<tr>
<td>5,150 – 5,800</td>
<td>&gt; 40 dB</td>
</tr>
</tbody>
</table>
RF fixture configuration:

The standard DC fixture setup has the ability to support a single-DUT conventional configuration which employs a manual loading and unloading process. Improvements can be made to enable the support of up to six DUTs at one time. With speed and throughput in mind, the configuration can be further enhanced using a Dual Well/Ping Pong setup for elimination of loading and unloading time.

To take it a step further, the multi-DUT fixture configuration can be constructed in a more automated fashion, where six DUTs can be loaded into an optional tray and the fixture can isolate the testing from the loading and unloading phase. Add concurrent test using Agilent latest test executive and imagine the capacity that can be gained in a single system.

As mentioned, the RF fixture setup comes with a shield box that supports up to 2 DUTs. Throughput is enhanced by using a Dual Well/Ping Pong configuration where loading and unloading time can be saved.
Automated Vision Inspection Automatically Detects Display Defects

LCD display modules are an integral part of most smart meters. Manual visual inspection of these displays has been a manufacturing norm but it becomes impractical with today’s growing volumes, high speed manufacturing lines and operator fatigue. But preventing display defects from spilling over into the final unit assembly process remains critical.

Agilent has attacked this paradox with an optional automated vision inspection unit that can be mounted onto test fixtures and integrated directly into the automated functional test system. Throughput increases are dramatic, escapes are greatly eliminated and operator fatigue is avoided.

Using a machine oriented inspection instead of the conventional manual visual inspection, the solution targets key areas like:

• Human error elimination – visual inspection is no longer an operation that fits human operators. Machines don’t tire or fatigue, inspection thresholds remain robotically consistent, and training is minimal
• Increasing speed and consistency – while a well trained operator can do the inspection job, there is no guarantee that the inspection is at an optimal pace and since every human does not work the same way, consistency is always an issue. Using automated inspection, testing is guaranteed to be the same and the speed is constant & optimized, therefore high throughput is the result.
• Adaptability – Considering that production operators can change at anytime, training and learning curve can become a challenge. Product revisions/changes compromise an operators effectivity, however a machine performs the same way every time
• Multiple cameras can be integrated to provide higher throughput in a single machine
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