RF Device High-Volume Production Test Station

Challenge

Good Technology, Inc. designed a product that would revolutionize wireless corporate messaging. In order to take the market by storm they needed to minimize their manufacturing costs and produce extremely high quality devices. The design allowed for lower cost components by using internally stored correction factors to maintain high tolerances of the end product.

Solution

Good Technology, Inc. selected Larson Automation to provide a custom test station that would perform all the alignments required, store the values internally, and verify the functionality of all aspects of the board. This station combines traditional instrumentation, high performance data acquisition products, custom mechanical fixturing, and custom electrical interface circuitry. These are all tied together using custom software to create one virtual instrument.

Overview

The Larson Automation RF Device High-Volume Production Test System performs the board level alignment and functional testing of a text message radio unit. The Test System can either be used for production testing or as an invaluable debugging station with the ability to perform each test manually.

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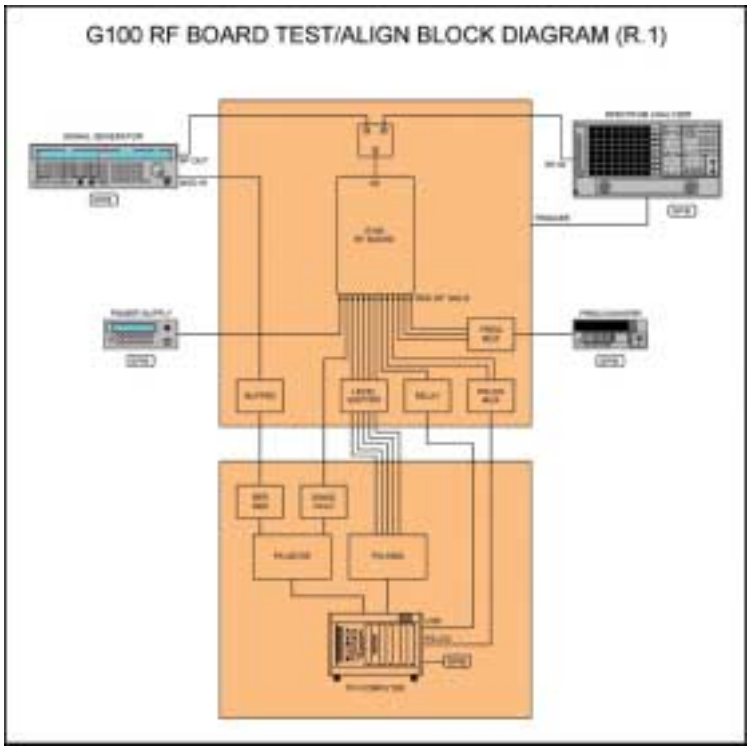
Device Under Test (DUT)

The Good™ G100 wireless handheld from Good Technology is a powerful, compact and sophisticated handheld that pioneers a new category of Synchronized Messaging Devices. Small enough to be carried or belted at all times, G100 provides mobile professionals with a highly portable handheld for robust wireless access to a wealth of corporate information.

The G100 uses the Cingular Wireless[SM] Mobitex packet data network to send and receive data. Mobitex is packet switched technology that makes efficient use of the radio spectrum. It only takes 8 kHz of bandwidth to transfer data. No end-to-end connection is required and there is no call-connect time.

Mobitex protocol is based on a NRZ Gaussian filtered FM modulation at a link speed of 8000 bits/s in a 12.5 kHz channel. The G100 communicates using two-frequency simplex operation, transmitting in the range of 896-902MHz and receiving between 937-941MHz.

Test System



The Test System is composed of 4 main components:

- National Instruments PXI Data Acquisition system that performs system control and all data acquisition functions
- Larson Automation custom fixture. This performs mechanical and electrical interface from the DUT to the instrumentation
- Equipment rack. This houses all the GPIB test equipment, fixture, and computer monitor.
- Custom Software. This ties the system together and provides the user a single "Virtual Instrument" to perform testing of the G100 RF board.

PXI Data Acquisition System

The PXI data acquisition system contains the system controller as well as modules for controlling instrumentation and performing data acquisition and control.

- NI-PXI-8174 controller
  - USB communications with the DUT
  - Serial port communications / monitor of DUT
  - Program storage
  - Data storage
  - User interface
- NI PXI-6508 Digital I/O module
  - Provides 96 bits of digital Input or Output (I/O) configurable in eight bit ports.
  - Drives the custom interface circuitry to control and monitor digital signals on the DUT
  - Drives the RF switches
  - Selects frequency counter inputs
- NI PXI-6070E Multi I/O module
  - Provides 16 12-bit analog input channels and two 12-bit analog output channels operating up to 1.25 MS/s
  - Monitor current consumption
  - Monitor FM demodulation signal and perform SINAD measurements
  - Provide a pattern to FM modulate the signal generator to support BER testing (see details) and Packet Detection testing (see details)
- NI PXI-8212 GPIB Card and Ethernet
  - Provides remote control of the traditional instrumentation including power supply, signal generator, and frequency counter
  - Network communications

Larson Automation Custom Fixture

The custom fixture provides the mechanical, electrical, and RF interface to the DUT

- Mechanical
  - Designed to provide a quick and accurate interface to the DUT utilizing an RF probe to access the antenna and pins to interface to test points
  - Tooling pins ensure proper and consistent alignment
  - Mechanically assisted mechanism to provide a smooth operation over many cycles minimizing operator strain

- Electrical
  - Custom Interface Boards (CIBs) route signals to and from the instrumentation
  - Analog Interface Board (CIB1)
    - Route onboard voltages to the MIO card for current measurements and other analog measurements
    - Route and condition analog output signals from the analog output DAQ interface to the FM demodulation input of the signal generator to support BER testing and pattern detection testing

  - Digital Interface Board (CIB 2)
    - Two CPLDs provide custom logic
    - Multiplexing signals for serial port control and monitoring
    - Multiplexing DUT oscillator signals for frequency counter measurements
    - Routing trigger signals from the DUT for spectrum analyzer measurement

- RF
  - High frequency probe ensures proper RF connection
  - RF switches route signals to the proper instrumentation

Equipment Rack

- All the components of the test system are enclosed within a standard 19” wide equipment rack. This provides a compact platform to provide the most powerful system utilizing the minimum amount of space at your contract manufacturer’s facility.
- Agilent E4402B Spectrum Analyzer;
    - Capture the RF signals from the DUT to perform measurements of the transmitter
- Agilent E4420B ESG Signal Generator
    - Generate RF stimulus to the DUT to simulate receive signals
    - Modulated by the MIO card DAC output to produce BER waveforms and pattern detection circuitry waveforms to support the testing
- Agilent E3642A Power Supply
    - Provide bias for the DUT
- Agilent 53181A Frequency Counter
    - Monitor the 32 kHz, 16 MHz, and 22.5 MHz signals during the test process
- Power Distribution
    - Provide AC signal routing throughout the rack to the individual instruments
- RF cable routing
    - Secured within the rack to minimize any wear. This ensures no RF degradation over the life of the test station
- User Interface
    - Barcode reader
        - Conveniently located to reduce operator strain
        - Reduces errors entering serial numbers
    - Keyboard and mouse
        - Integrated into the rack for operator convenience
    - Monitor
        - Provide user with feedback during test process

Software

Software can run in two different modes: production testing mode for operator use and engineering evaluation mode for technician/engineer use.

Production Testing Mode

This interface is kept as simple as possible making operation of use easy and keeping training of new personnel to a minimum.

Both of these factors are essential in a manufacturing environment. The operator GUI consists of two panels, where one provides control over the start and stop buttons, while the other panel shows a data sheet report. The start and stop buttons are duplicated on the fixture to provide a 'mouse free' environment if desired.

Using a one-button approach to testing, the operator is prompted to scan the barcode and close the lid of the test fixture to commence testing. Test results are highly visible to indicate testing in process or pass/fail results.

Engineering Evaluation Mode

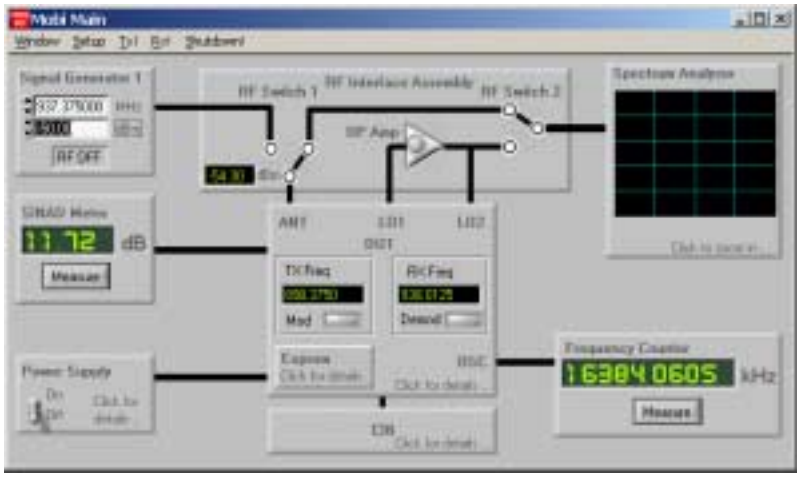
This interface is designed to provide a highly flexible engineering tool for the purpose of debugging and troubleshooting. This mode operates simultaneously with production testing mode. This mode is designed with the engineer in mind. You have full control of the entire station from one central location. All screens are laid out logically, so that you can drill down to whatever level that is necessary to perform whatever operation desired. Every function and control needed to perform any testing is available from these screens.

There are six panels that together provide a complete control over the whole system. This virtual test system allows the engineer to concentrate on evaluating his part, not having to remember how to get to a particular control or indicator. The panels or windows are related in a top-down hierarchy. You start at the top-level panel that represents the overall test station and you drill down as far as you want to operate or view the appropriate control.

All the panels present live information on them throughout any testing or manual operation. This allows the engineer to stop in the middle of a test and view the condition of all the instrumentation at the time he interrupted the test.

Virtual Test Station Inter-relationship (Hardware)

Virtual Test Station Main Panel



This panel shows the structure of the entire RF test station. Each one of the rectangular areas represents one of the major parts of the system, such as Signal Generator, SINAD Meter, Power Supply, CIB, DUT, Spectrum Analyzer and RF Interface Assembly, and Frequency Counter. This panel provides an overview of the entire test station. You can monitor every major function at a glance. Summary information is displayed for each section. If you desire further detail you can "drill down" to each of the major sub-systems.

DUT Control Panel

This panel provides complete control over the DUT. Communications are either through the USB port or RS-232 interface. All the internal settings are adjustable from this panel.

General Functions

In order to establish communications, the modem has to be initialized. This initializes the hardware and downloads a small program to the DUT to enable the internal BIST functionality. A 'READ' button allows you to read the EEPROM data and load all panels with current information. A main power switch takes the unit out of "sleep mode" and allows it to respond to commands.

Transmit Functions

The transmitter has separate power supplies and can be turned on or off. Transmit frequencies and Mobi assigned channel numbers can be set to program the synthesizer to the proper mode. Internal modulation routines (part of the Built-In Self Test) are selected and turned on or off from this panel. The unit operates at either full power, or one of three back-off levels.

Receive Functions

The receiver has separate power controls as well. It can be set to its receive frequency, or a Mobi assigned channel. There are demodulation commands to command the receiver and monitor the assigned channel. During BER testing, the BER level and data quality can be viewed here.

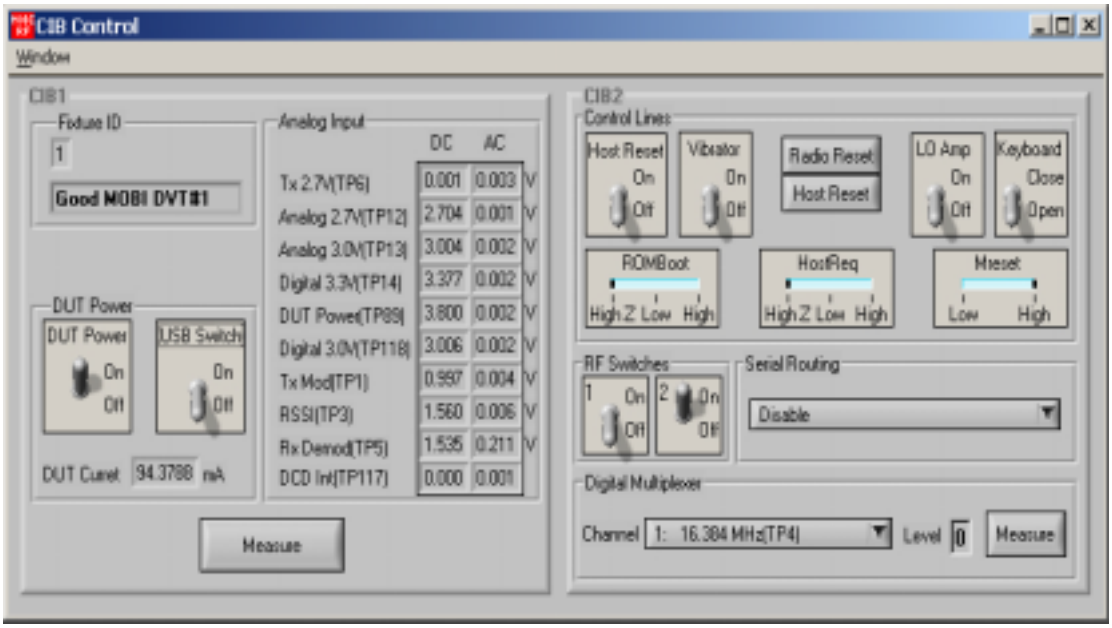
Tuning Functions

This section lets you manually set all the internal DACs used to tune the reference ADC. This section also allows you to set the gain and offset for the modulation of the transmitter and for the demodulation circuitry of the receiver.

Status Functions

This section displays the current values (when update button is depressed) of the internal monitoring circuitry.

CIB Control Panel



This panel provides a control over the CIB1 and CIB2. It allows the user to measure voltages at all the connected test points as well as to manage USB connection, the DUT Power, control signals, the serial port routing, and the digital multiplexers.

CIB1 (Analog interface)

DUT Power

This section allows you to operate the relays on the interface board, to apply main power from the power supply, and to enable or disable (through relays) the USB interface.

Analog Input

Various voltages are monitored for different power supplies. The transmit modulation voltage is available here, as well as the RSSI and the receiver demodulation signal.

CIB2 (Digital interface)

Control Lines

These are a variety of signals that are sent to the DUT (through level shifters) to perform a variety of functions.

RF Switches

The switches would normally be operated from the relay icons on the main panel, but they can also be operated here.

Serial Routing

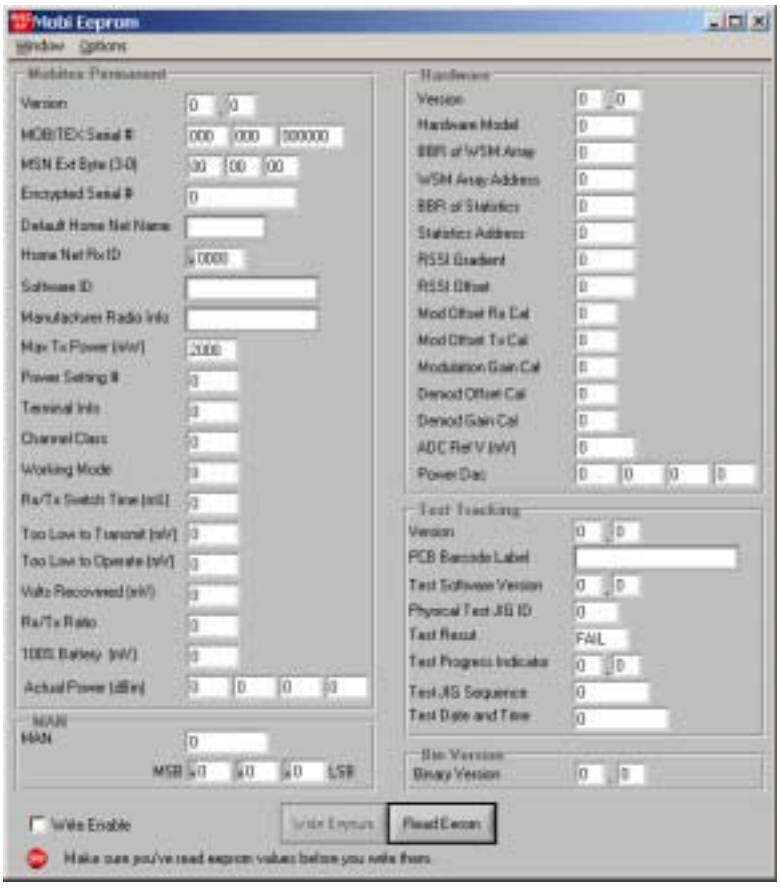
The system COM port can be configured to drive one of the onboard RS-232 interfaces, or configured to ‘sniff’ the traffic between the two onboard processors.

Digital Multiplexer

This routes one of four signals to the frequency counter for measurement, and one of 12 digital signals to edge detection circuitry.

Radio EEPROM Panel

This panel allows the user to easily read and write into the radio's EEPROM. Information that is vital to the proper operation of the radio is stored here.



Permanent Settings

These settings will be permanent throughout the life of the radio. These are read-only at all times and are used only to view the current settings.

Hardware Settings

These settings are a combination of firmware values and alignment values set during the alignment phase of the testing. These are required to be properly set in order for the unit to perform within proper levels.

Test Tracking

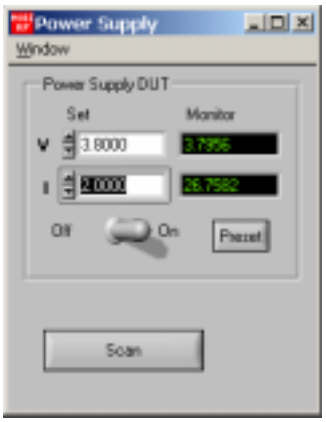
These settings are used during the life of the product to track test results and ensure that units do not pass through the manufacturing process without being properly aligned and meeting all test specifications.

Other Stuff

Controls exist to read the current state of the EEPROM as well as to enable writing with proper authentication.

Power Supply Panel

This panel provides a detailed representation of the DUT battery power supply that would normally only be operated through the main panel on/off switch. Although the system would use the user defined test parameters for voltage and current limit, this panel allows you to enter directly into the panel to test the product at different bias conditions.

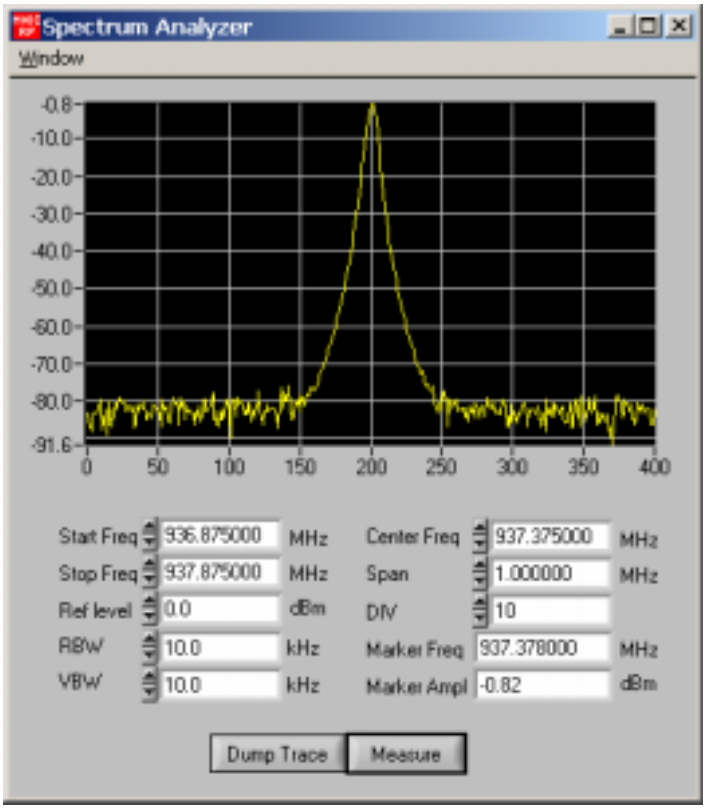


Spectrum Analyzer Panel

This panel provides a detailed representation of the spectrum analyzer. This allows users to control basic functions on the spectrum analyzer directly from the screen.

The plot is also shown in a smaller format on the main panel. This panel allows you to operate the spectrum analyzer functions in a separate window for more detailed analysis. You can change the frequencies, the span, and the reference level.

You can dump a trace from the display of the instrument and you have a full-featured marker on this panel for signal analysis.



Test Description

General Tests

- **Initialization Current Test**
  Measures the DUT power up current.
- **Power Supplies Test**
  Verifies the DC and AC voltages of the on-board and battery power supplies.
- **POST Tests**
  Performs Power On Self Tests (POST) that verify the integrity of the basic digital parts such as the RAM, CPU, GMSK chip, timer, and flash memory.
- **Oscillators Verification Test**
  This test verifies the frequency error of the 16.384 MHz and 32.768 kHz oscillators'.
- **CPU ADC Reference Alignment**
  Adjusts the CPU ADC reference to generate the proper voltage.
- **Vibrator Test**
  This test verifies the functionality of the on-board vibrator.

Transmitter Alignments

- **Reference and Modulation Alignment**
  This step performs reference and deviation alignment of the RF signal. It adjusts three internal DAC controls. It aligns the reference frequency to the center for RX and TX modes and aligns the modulation deviation to +/- 2 KHz.
- **Output Power 4 Level Alignment**
  This step adjusts internal DAC value for controlling output power and records DAC values for 33, 30, 27 and 24 dBm power levels.

Receiver Alignments

- **Demodulation Alignment**
  This step performs offset and amplitude alignment of the RX demodulated signal by changing two internal DAC controls. It tunes the DC voltage to 1.5V and the AC voltage to 600mV.
- **RSSI Alignment**
  This step performs alignment of the RSSI slope. Measures RSSI at –73dBm and –103dBm and calculates the offset and gradient of the RSSI vs. Input Power slope.

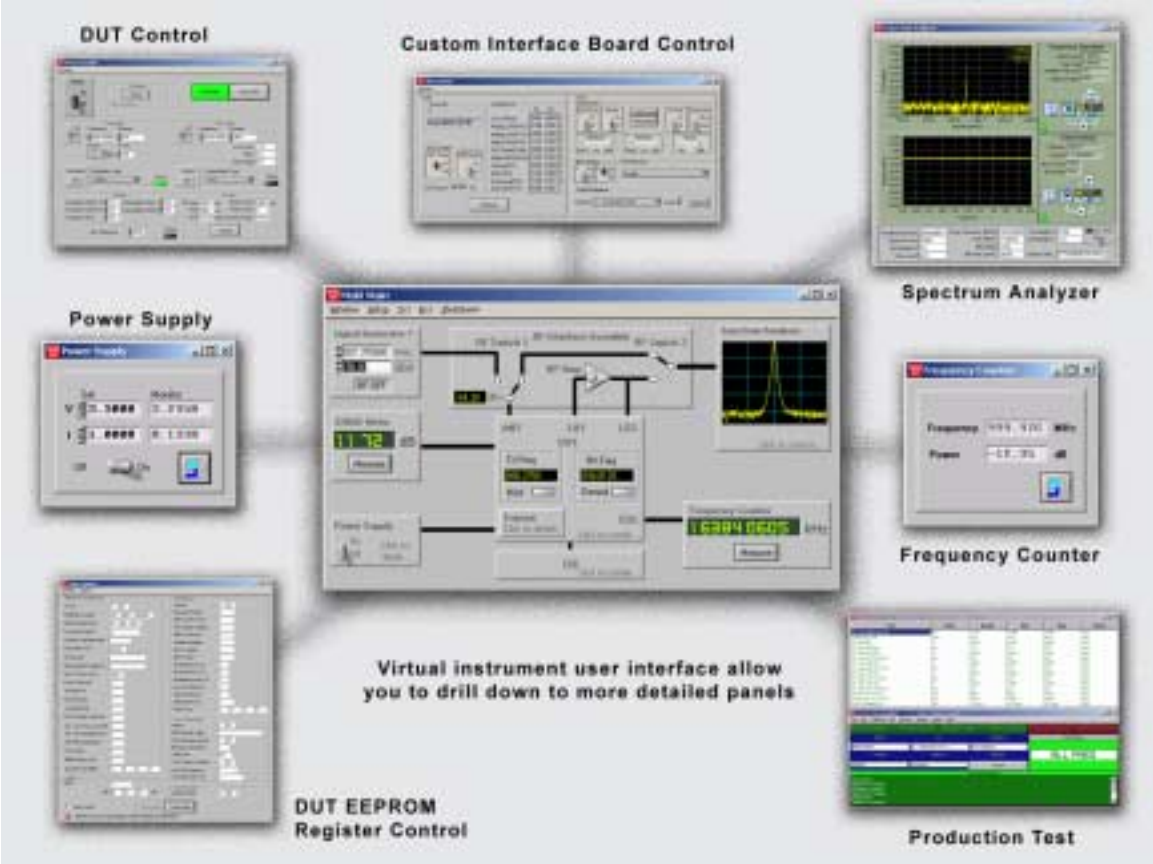
Transmitter Tests

- **Output Power Alignment Verification**
  This test verifies output power alignment by measuring power at 33, 30, 27 and 24 dBm power levels at two different frequencies.
- **4 Power Level Current Test**
  This test measures power supply current at 33, 30, 27 and 24 dBm power levels.
- **Power Ramp Test**
  This test performs power ramp at 33 and 24 dBm. Calculates ramp time, maximum power and one-second power stability.
- **Second Harmonic Test**
  This test measures the power at the second harmonic when the modem transmits at the maximum power.
- **Adjacent Channels Test**
  This test measures the power at adjacent channels when the modem transmits at the maximum power.
- **FCC Mask Test**
  This test verifies that the modulated signal passes FCC transmit mask.
- **Peak Deviation Test**
  This test verifies the proper deviation levels.
- **Channel Acquisition Time Test**
  This test verifies the transmitter VCO lock time.

Receiver Tests

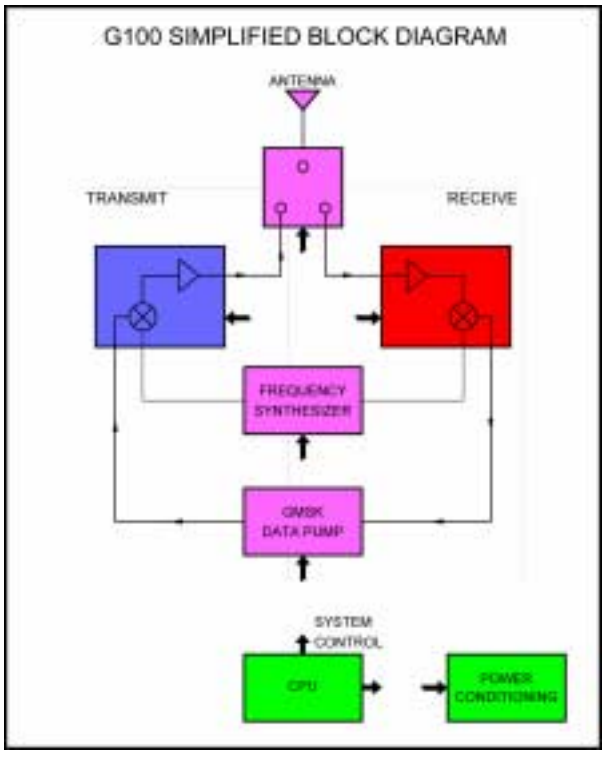
- **Demodulation Alignment Verification**
  This test verifies demodulation alignment at several different frequencies. DC voltage should be around 1.5V and the AC voltage should be around 600mV.
- **Channel Acquisition Time Test**
  This test verifies the receiver VCO lock time.
- **SINAD Threshold Test**
  This test constantly measures SINAD while the signal generator drops the input power until the SINAD 12dB point is reached.
- **SINAD Verification Test**
  This test verifies other SINAD operations.
- **BER Test**
  This test performs BER measurement at 0, -1, -2, -3 and -4 dB from the sensitivity level.
- **Image Rejection Test**
  This test verifies the proper image rejection.
- **Packet Detection Test**
  This test adjusts the input signal until the packet detection circuitry triggers. Then slowly adjusts the signal until packet detection circuitry releases and record values.
- **Adjacent Channel Selectivity Test**
  This test verifies adjacent channel selectivity.

Virtual Test Station Inter-relationship (Software)

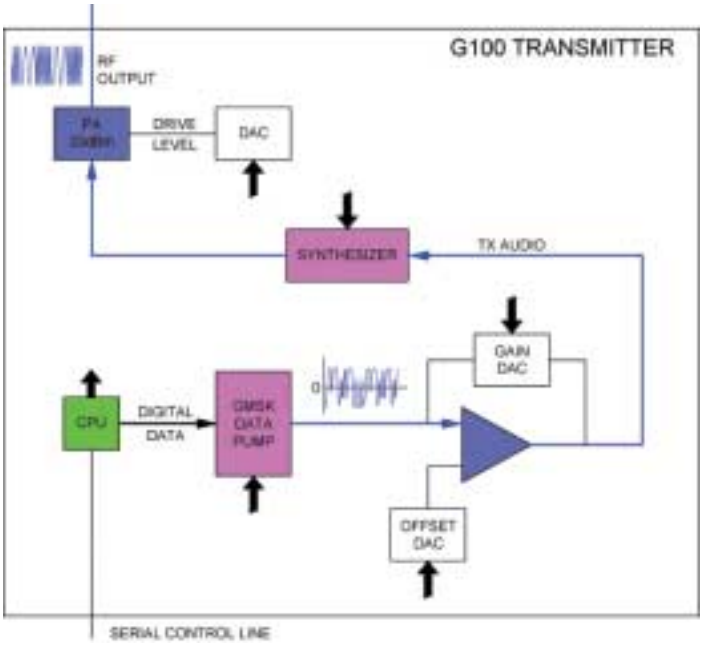


G100 Wireless Handheld Functional Description

The G100 consists of a receiver, a transmitter, and host processor functions. The receiver is used to translate the RF signal into useful information from the base station to the processor where it is converted to user messages. The transmitter up-converts and amplifies data packets generated by the GMSK data pump to the base station. We will discuss the receiver and transmitter separately. Both of these sections depend upon the host processor for communications and control to support their operations.

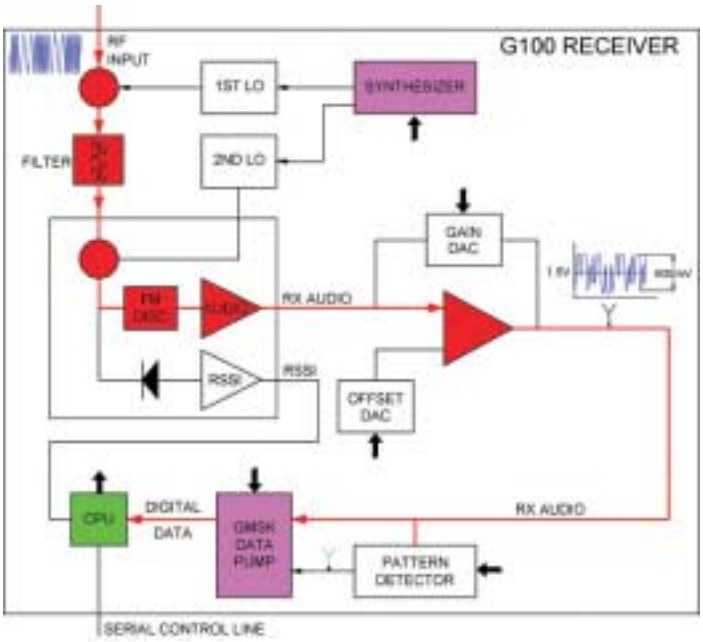


G100 Transmitter Functional Description



The G100 transmitter is used to transmit data to the base station when the user sends an email message or data. The host processor formats the information to send to the base station in small packets. These are passed to the encoder circuitry where it is turned into a GMSK voltage that represents +/- 2 kHz modulating voltage waveform. This is passed through DAC controlled conditioning buffers to provide the proper voltage levels to modulate the Voltage Controlled Oscillator (VCO) to +/- 2 kHz centered at the transmit frequency. The modulated IF signal is applied as a reference voltage to a VCO that is phase locked to the transmit frequency. The signal is applied to the Power Amplifier (PA) where it is driven by a DAC to the proper output power level. This is routed through an RX/TX switch to the antenna and off to the base station.

G100 Receiver Functional Description



The G100 receiver is used to receive data from the base station when email or data is sent to the user.
The receiver is tuned to its proper frequency listening at the appropriate time for any valid incoming traffic. A valid frequency detected at a sufficient power level to drive the Receive Signal Strength Indicator (RSSI) circuitry causes the processor to attempt to decode the signal. The signal is demodulated to a GMSK voltage and passed through the conditioning circuitry to trigger the pattern detection circuit. The processor will attempt to decode the packet of information and build it into an email message.

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