I J C T A, 10(9), 2017, pp. 163-169 ISSN: 0974-5572

Automatic Test Equipment for Phased Array Radar

K. Jyothi*, T. Vijetha* and T. Pardhu, R. Karthik****

ABSTRACT

The ATE is the main element in the Maintenance Shelter. It enables the testing of various LRUs on ATE and trouble shooting and fault isolation down to Shop Replaceable Unit (SRU) levels for the LRU's. It also includes the hardware description of the Standard Test Equipment (STE), which is automatically operated by the ATE computer. A detailed failure analysis indicating the various failures, which are detected during the time of conducting the tests on UUT, is also included. Typical test reports generated at the time conducting these tests on LRUs (TRC, GC, SGC and BFC) and the SRU (TRM) is also included.

Keywords: Automatic Test Equipment (ATE), Standard Test Equipment (STE), Shop Replaceable Unit (SRU).

1. INTRODUCTION

The ATE is the main element in the Maintenance shelter. It enables troubleshooting and fault isolation down to Shop Replaceable Unit (SRU) levels for the following Radar units: TRC, GC, SGC, and BFC and TRM.

The ATE is comprised of the following main elements:

1. ATE Computer
2. Standard Test Equipment (STE)

The ATE tests includes stimulus, measurements, control switching and display capabilities for functional and performance tests of the Unit under Test (UUT) [1]. The ATE is operator-controlled via terminal and keyboard. Self-tests are performed in order to check the ATE own operational status.

All ATE integral test equipment is based on COTS standard commercial test equipment, and is controlled by the ATE computer via General Purpose Interface Bus (GPIB) or Local Area Network (LAN). The ATE test results are provided in either hard-copy report format or magnetic media files.

The ATE is physically comprised of three 19" ventilated racks bolted together and installed on rubber-rimmed wheels, to provide one rigid unit. Figure 1 shows the general view of an ATE. A table is installed to the right-hand side of the racks. The ATE installation is physically divided into two functional groups:

Interface Group: - It enables signal and control paths between the standard test equipment (STE) and the UUT. It comprises RF switching drawers, module drawer, test cables and adapters.

Support Group: - It provides cooling and power supply to the UUT. This group comprises Liquid-to-Air cooling unit, electrical power distribution system, and DC power source unit.

The STE is permanently installed on front of rack, and can be removed by opening the respective bolts. The UUT interface drawer is slide-mounted and can be extended without interrupting the test procedure

* Dept. of Electronics and Communication Engineering MLR Institute of Technology Hyderabad, India, *Email: jyothi.tan@gmail.com*

** Dept. of Electronics and Communication Engineering MLR Institute of Technology Hyderabad, India, *Email: karthik.r@mlrinstitutions.ac.in*

Figure 1: ATE General View

process. Fixed signals and control paths are provided between the STE, the ATE computer, and the UUT interface. Cables ending on interface drawers rear panel permit side extension, if necessary. Each rack has a rear door permitting easy access to the inside.

AC power is fed to the equipment through power manager UPS. Figure 1 shows the general view of an ATE

2. ATE GENERAL BLOCK DIAGRAM

The ATE is computer controlled Intermediate Level (I-Level) test equipment comprising dedicated equipment and standard instruments. The dedicated equipment is controlled by means of the computer I/O card. The standard instruments are controlled via an IEEE-488 communication channel (General Purpose Interface Bus - GPIB). The control is accomplished by means of the computer GPIB communication card. Figure 2 shows the ATE Block Diagram.

The ATE enables to test and troubleshoot up to Shop Replaceable Unit (SRU) level the following RF components:

- Transmitter/Receiver Module (TRM).
- Transmitter/Receiver Controller (TRC).
- Group Controller (GC).
- Super Group Controller (SGC).
- Beam Forming Controller (BFC).

The ATE is comprised of the following functional systems:

- Computer system
- Simulation and measurement system
- RF signals switching system

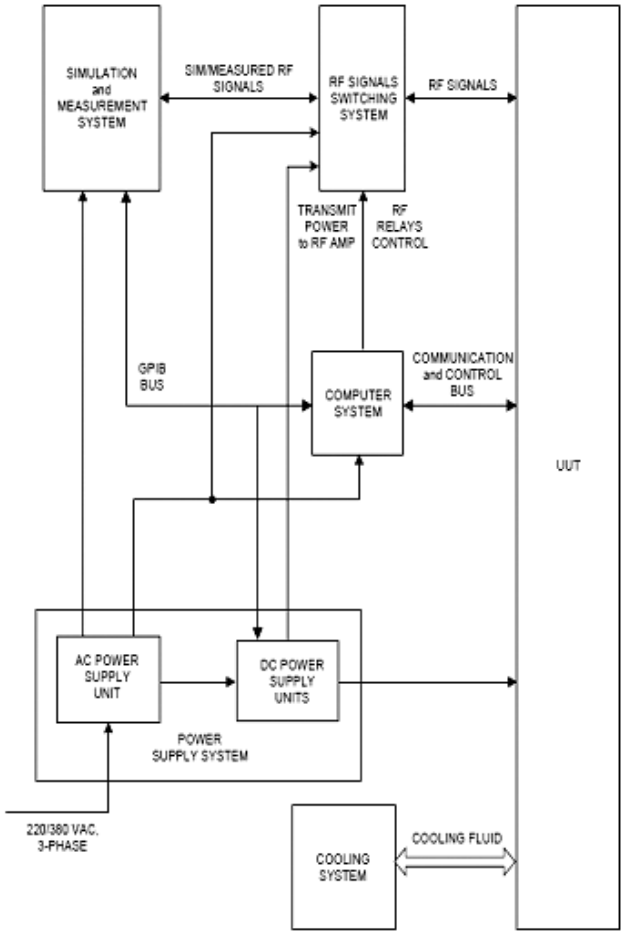

Figure 2: ATE Block diagram

- Communication and control system
- Power Supply system
- Cooling system.

2.1. Computer System

The computer system comprises an IBM compatible computer and peripherals, through which the command and control of the UUTs are carried out. The paths are closed, by RF switches that route the simulated signal from the ATE to the UUT and the measured signals from the UUT to the ATE. The computer system enables the performance of the following tasks:

- Controlling the standard instruments, the RF signals drawers and the UUT.
- Interface between the operator and the monitor, keyboard and mouse.
- Running the test programs and receiving of reports upon completion of tests.

2.2. Simulation and Measurement System

The simulation and measurement system is based on standard instruments and dedicated panels that interface between the instruments and the RF Signals Switching System.

The standard instruments are controlled by the ATE computer via an IEEE-488 communication channel (General Purpose Interface Bus - GPIB), and usually do not require operator intervention during test. The system enables to perform various tests that enable to define UUTs serviceability

2.3. RF Signals Switching System

The RF switching system routes simulated signals to the UUTs and measured signals from the UUTs to the appropriate measuring instrument [2]. The routing is carried out by means of computer controlled RF switches (within the RF switching drawers) using the computer Multi I/O card.

2.4. Communication and Control System

The GPIB communication channel is used for communication between the computer and the GPIB controlled instruments. The instruments function according to the following options:

a. "Listen" – in this state, the computer sends commands on the communication channel.

b. "Talk" – in this state, the computer receives status data.

It is possible to connect up to 15 different instruments to the GPIB channel, where each instrument has a unique address. During test, the computer addresses the required instrument, and determines the tasks to be performed during the test. Upon completion of test, the instrument transfers to the computer the measured data.

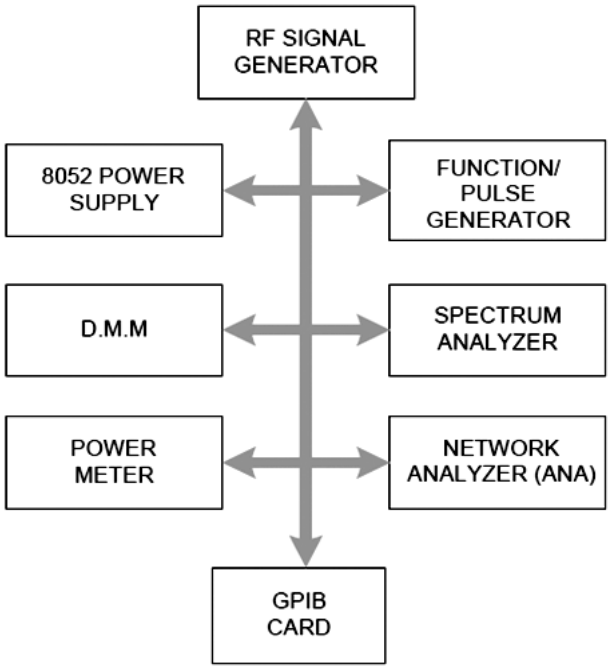

Figure 3: GPIB Communication channel

3. ATE FUNCTIONS AND INTERFACE

The ATE supplies the required operation voltages, control signals and RF signals to the UUTs and performs the following functions:

- Supply of operation voltages, communication and excitation to the UUT.
- Supply of the cooling required by the UUT.
- Performing serviceability checks to the UUT.
- Analysing test results.

The ATE comprises all the power supplies and RF signal source required for operating the UUTs. During test, the ATE supplies the input signals and control signals to the UUT. The ATE tests the UUT response via the measuring instruments installed on the ATE racks.

All RF signals from/to the UUTs pass through the dedicated drawers that route the RF signals from the UUT to the standard instruments and vice versa. The interface between the ATE and the UUTs is implemented through a set of cables that are adapted for each unit separately.

4. ATE TESTS

An Acceptance Test Procedure (ATP) available for each unit tests all the functions pertaining to the UUT. The overall test of the unit is divided by appropriate test programs to sub-tests each pertaining exclusively to the UUT. The user has the ability to run the sub-tests separately, to select part of the tests or select all the tests, i.e. to run a full ATP. The ATE software enables easy operation of the ATE, using a set of screens. Operator intervention is accomplished using a mouse and a keyboard.

5. ATE TEST RESULTS

For each test, the computer checks if the results are within the range of the requirements set. During and at the end of each test the UUT serviceability status and test conclusions are displayed – Pass/Fail. Upon completion of test, the computer accumulates all results and produces a printed report, according to operator request.

6. ATE HARDWARE

The ATE is comprised of dedicated equipment and standard instruments. The electrical connection between the ATE and the UUTs is performed at the front of the ATE by means of flexible cables utilized for communication, power supply and RF signals.

During test, the Units Under Test (UUTs) are laid on a dedicated UUTs testing trolley, except the TRM which is installed on a dedicated drawer (module drawer) and the amplifier driver which is installed on the PA Jig. The UUTs are cooled by a dedicated cooling system comprised of cooling unit (positioned outside the lab), a flexible piping array and a remote control box (for operating the cooling unit). In addition, the ATE comprises calibration aids, required for RF path calibration tests.

The following paragraphs provide a brief description of the ATE components.

6.1. Cooling System

The cooling system enables to keep the UUTs within the required temperature, during their testing by the ATE.

The system is comprised of the following components:

1. Cooling unit (positioned outside the lab) – a closed unit with air vents located at the bottom rear for entry of air and up with a deflecting panel for exit of air, in order to enable free air flow through the heat exchangers. The airflow cools the heat exchangers and lowers the temperature of the cooling fluid.
2. Remote control box – enables to operate the cooling unit from remote areas. The box comprises controls and indicators whose function is identical to those located on the cooling unit.

Flexible piping array and cables (not shown):

i) Warm fluid hose (red) – a 40 m long hose, with two quick-disconnect couplings one to the cooling unit and one to the ATE.

ii) Cold fluid hose (blue) – a 40 m long hose, with two quick-disconnect couplings one to the cooling unit and one to the ATE.

iii) Power cable – a 15 m long cable, connecting the cooling unit to a 230 VAC/50 Hz external power source.

iv) Data cable – a 35 m long cable, connecting the cooling unit to the cooling unit remote control box.

S. No	*Component*	*Main Functions*
1	10KHz - 2.7GHz Signal Generator	Simulates RF signals for the UUT.
2	Network Analyzer	Measures RF signals, amplification and phase, during receiving tests.
3	Multimeter	Measures the voltage levels of the internal power supply in the RF Switching Drawer 1.
4	S-Parameter test set	Checks the RF signals from the TRM in receiving test.
5	Spectrum Analyzer	Displays the RF signals received during test.
6	Power Meter	Measures during the transmitting test, the power level of thefollowing signals: • The simulated signal supplied by the ATE to the UUT. • The received signal from the UUT.
7	Pulse Generator	Simulates control signal – transmit/receive.
8	UPS Battery Drawer	Enables appropriate shutdown of the ATE computer in case ofpower failure.

Table 1
ATE Technical Specifications and Operating Conditions

Parameter	*Specification*
Main Power	220 VAC, 3-phase, 50 Hz
Operating Temperature	23±3°C
Operating Altitude	From sea level up to 1,000 m
Relative Humidity	Up to 80%
Dimensions (cm, including table)	H 170 × W 380 × D 225
Weight (without operator table)	500 kg (estimate)

7. ATE SOFTWARE

The ATE software application runs under Windows XP. The application performs the following main functions [3]:

- Initialization of the ATE components.
- Checking of the GPIB/LAN communication and RF switching drawer power supply
- Voltages at start up.
- Performing UUT tests.
- Performing ATE calibration tests.
- Producing test result reports.

The application is comprised of the following functional blocks:

- Man Machine Interface (MMI)
- Operation System
- Utilities.

7.1. ATE Technical Specifications

The following Tables 2 & 3 provides the technical specifications and operation conditions for the ATE and the cooling unit.

Table 2
Cooling Unit Technical Specifications and Operating Conditions

Parameter	*Specification*
Power supply	220/380 VAC, 3-phase, 50 Hz
Control power	24 VAC, 1-phase, 50 Hz
Current consumption	Up to 20 amp. (with all components operating)
Environmental temperature	–10°C to +35°C
Relative humidity	Up to 85%
Heat dissipation	5 kW
Width	84 cm
Length	93 cm (including 40 cm rear door)
Height	159 cm
Weight	App. 300 Kg
Cooling fluid quantity	App. 60 liter (including fluid tank and piping)
Cooling fluid type	AL-HOM-40I (40% Ethylene Glycol, 60% water) Inhibited

8. CONCLUSION

The test system described in this paper was designed for testing active solid-state microwave modules and circuit subassemblies used in the Active Phased Array Radar. Many of the test system concepts developed and used on this program are being applied to other similar programs, and will be useful as well in future test systems.

ACKNOWLEDGMENT

The authors would like to thank Electronics and Radar Development Establishment, Bangalore for their guidance and support.

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