Testing System to Support the Production of DECT Modules

Nuno Pereira Helena Sarmento
nuno.pereira@inesc.pt helena.sarmento@inesc.pt
INESC IST/INESC
Rua Alves Redol, 9
1000-029 Lisbon
Portugal

Abstract

This paper describes a system to test DECT modules, in a production environment. The modules can be used to build wireless voice and data communications. They provide radio frequency and base band processing. The DECT modules will be produced at different manufacturers.

A testing system based on a PC was developed. It diagnoses faults and verifies the functionality of the board, and programs the necessary information.

A generic approach was used. Pre-defined tests exists, which are stored on a database, and the schematics of a basic tester card is provided. Manufacturers can easily increase the number of test points they want to access on the board, as well as, the number of tests to be done.

1. Introduction

In the home, the growing number of PCs, peripheral, intelligent devices and network possibilities face users with new opportunities. These opportunities require a common connection between the various devices and networks found in the home. However, in order to be effective, the connection must avoid home wiring. Therefore, an enormous interest of users for mobile and wireless communications exists for SOHO (Small Office Home Office) applications.

DECT (Digital Enhanced Cordless Telecommunications) [1], a standard from ETSI (European Tele-communications Standard Institute) for cordless communications, is well suited for SOHO applications. DECT is only a radio access technology permitting in-door wireless applications, with or without a wired backbone (LAN, PSTN, ISDN, etc). The backbone is not part of the DECT system.

This paper describes a system to test DECT modules in the production phase. The modules, supporting voice and data communications, include DECT radio frequency and base band processing. These modules can be used to build wireless communication systems, connecting them to remaining system (portable or fixed DECT parts) through an eighty-pin connector. Hardware and software of these modules were developed at INESC in the scope of a contract with an industrial company. DECT modules will be produced at different manufacturers. Currently, they began to be produced in two different manufacturers, one in Europe and another in Asia.

The testing system, also developed at INESC, is based on a PC. It includes an ISA card (ISA adapter) to receive information from the DECT module. This information is received from the tester card where the DECT module is connected, using the eighty-pin connector. The tester card also acts like a probe card accessing test points on the DECT module. Electronic equipment can be connected to the test points through the tester card and to the PC through GPIB interfaces.

The test system defines a complete tool, which permits:

- The verification of the boards, looking for circuit malfunctions or short-circuits due to assembly problems.
- The verification of the RF module and the complete functionality of the DECT module.
- The programming of necessary information (RFPI – Radio Fixed Part Identifier and for calibration of crystal oscillator).

The paper is organised as follows. The principal characteristics of the DECT standard are introduced in section 2. Section 3 introduces the developed DECT modules. Description of the testing system is done in Section 4. Finally, conclusions are presented in Section 5.

2. DECT

Although DECT does not address high-speed data communications, it is a good technology for data communications in SOHO applications. Using symmetric connections 288kbps can be attained and with asymmetric connections even 552kbps are possible. Therefore they are adequate for ISDN and ISDN, or ADSL. Even when ADSL will attain higher bit rates in residential applications, new modulation schemes will keep DECT on the market.

Frequency band	1880-1900MHz
Number of carriers	10
Carrier spacing	1728MHz
Access technique	TDMA, TDD, FDMA
Traffic duplex channels	12
Data rate per channel	32kbps
Range	30m or 300m
Modulation	GFSK (BT = 0.5)
Sensitivity	-86dBm at 0.01BER
Average RF power/ slot	10mW
Peak RF power	250mW

Table 1 - DECT basic characteristics

DECT supports voice and data communications, and addresses a large range of applications, such as telephones WLL (Wireless Local Loop), PBX (Private Branch Exchange), etc. In the first years of its existence, DECT was mainly used in residential cordless voice applications. Now DECT began to be successfully used in data communications. Moreover, DECT has also been accepted as one of the five air interfaces of IMT 2000.

In summary, DECT is an evolutionary and low cost mass-market technology for wireless voice/data communications. Also, DECT is only a radio access technology permitting data transmission, both in local area networks and public networks. Adopting DECT for local area networks, in spite of its current speed limitations, means to offer today, an additional feature to SOHO applications. In a more long-term scenario, with the foreseen improvements, DECT will continue to be competitive.

2.1 DECT characteristics

Table 1 presents some characteristics of the DECT standard.

DECT relies on a decentralised channel allocation procedure, called Dynamic Channel Selection (DCS). Instead of having fixed channels, the portable terminal is continuously scanning the available channels, trying to use the best one. The channel to be used is not defined by the base station. The DECT portable terminal chooses the channel among the 120 existing channels, taking the least interfered channel from its channel list. The list is periodically updated. The set-up of new channel takes in account the local interference situation. Set-up is achieved for new connections or for handovers. DECT has the ability to handover time slots, in a seamless way, to improve communication quality.

Within the 10ms TDMA frame (Figure 1) there are 24 slots. The 24 slots are divided into two groups of 12 slots. One group is employed in forward transmission and the other in reverse transmission. Channel data rate is 32kbps. ADPCM (ADaptative Pulse Code Modulation) for voice communication uses the 32kbps. For data transmission, a CRC is introduced and only 24kbps, per channel, are affordable. Therefore, multiple channels are needed to improve data rate. Using symmetric connections 12 channels (12×24 = 288kbps) is the limit. To attain higher data rates, asymmetric connections can be used. Using asymmetric connections, at least one slot is necessary to receive acknowledgements. In this situation, using 23 slots, 264kbps (23×24 = 532kbps) can be achieved.

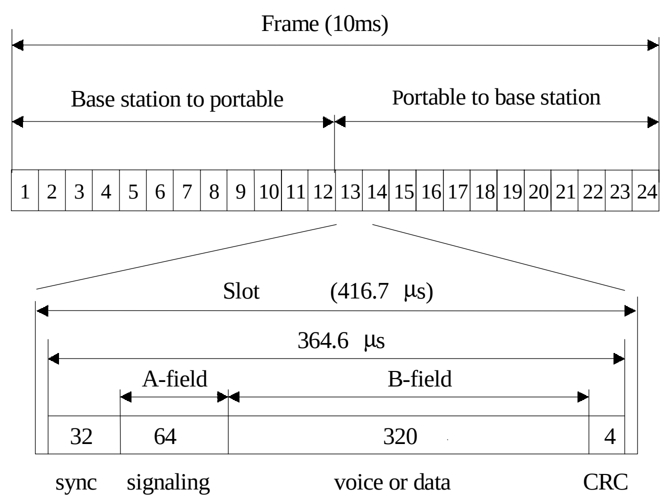

Figure 1 - DECT basic characteristics

The architecture of DECT protocol is closely related to the lower layers of the OSI reference model. DECT has a physical layer, a data link layer, and a network layer. The data link layer is composed of a MAC (Medium Access Control) layer and a DLC (Data Link Control) layer.

2.2 DECT architecture

DECT is a micro-cellular system, consisting of base stations (FP – Fixed Part) and portable terminals (PP) for data or voice (Figure 2). In each cell exists a base station, which can serve several portable terminals. DECT defines the radio interface between the base station and the portables. It can be used as a single cell cordless system for SOHO applications or as a multiple cells system for larger area coverage.

The base station can be connected to different networks, like a LAN or a public network. If no connections exist, the standalone base station only allows internal communications.

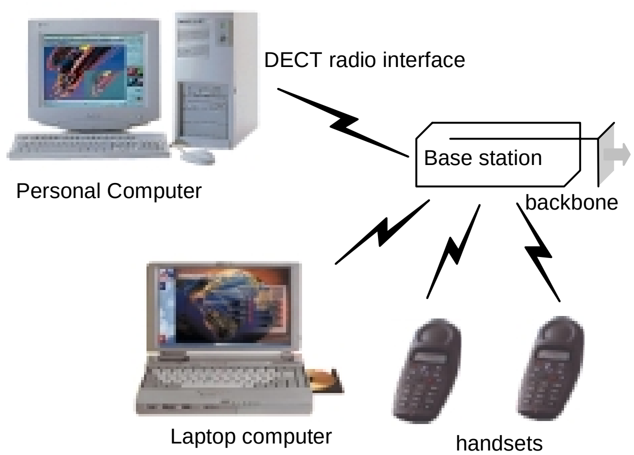

Figure 2 – DECT architecture in a SOHO application

For voice communication, an increasing amount of commercial DECT phones is now available at the market**.** To ensure portable and base station compatibility a standard protocol (GAP – Generic Access Profile) for voice exists. Recently, a protocol to ensure data compatibility was approved but for now existent systems do not yet support it.

3. DECT Modules

INESC developed hardware and software for DECT prototypes [2], during the last years. Recently, we were asked by an industrial company to develop generic DECT modules. These modules permit to build wireless communications systems, using the DECT air interface. DECT modules incorporate a commercial DECT RF (Radio Frequency) module, a dual port RAM, FLASH memory, SRAM, and a DECT base band processor optimised to handle audio, signal, and data processing specific to DECT (Figure 3).
DECT module currently uses a 128kByte SRAM and a 128kByte flash memory. The SRAM memory guaranties a safe firmware upgrade download procedure. During each DECT frame, it is necessary to transfer data between the external processor (from the system using the DECT module) and the DECT base band processor. The transfer is achieved using a 1kByte dual port RAM. Interrupts signal the existence of new data in DPR. When data is written on the dual port RAM, the corresponding control byte is updated and an interrupt to the processor connected to the other port is generated. When data is read by the receiver, it indicates to the sender the number of the message read, writing this information on the corresponding control byte.

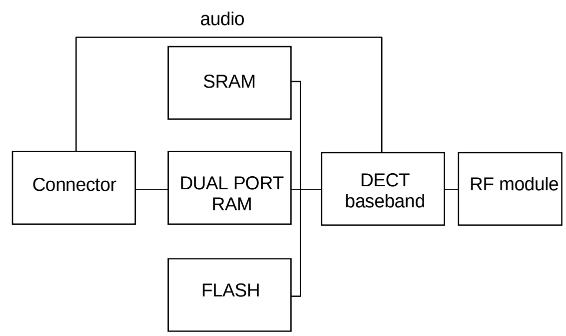

Figure 3 – DECT modules architecture

A connector has been defined to connect the DECT module to the external system. This connector carries the following type of signals: power, ground, data and control interrupts, audio signals, etc. A RS232 interface is also provided for development and debug.

4. Testing System

The testing system, developed at INESC, is based on a PC where test software runs. Two cards were specified. Manufacturers can use schematics of these cards to implement their own cards.
The developed hardware and software (Test Manager) define the testing system that verifies and to diagnosis faults on the board, verifies the functionality and programs the necessary information.

4.1 Hardware

The test system is based on a PC (Figure 4). The hardware of the testing system includes an ISA card (ISA adapter), which receives information from the DECT module. This information is received via the tester card where the DECT module is connected, using the eighty-pin connector. The connection between the ISA and tester cards is implemented by a special cable where data, address, RS232, read, write and control lines are available. The tester card can also access the test points available on the DECT module.

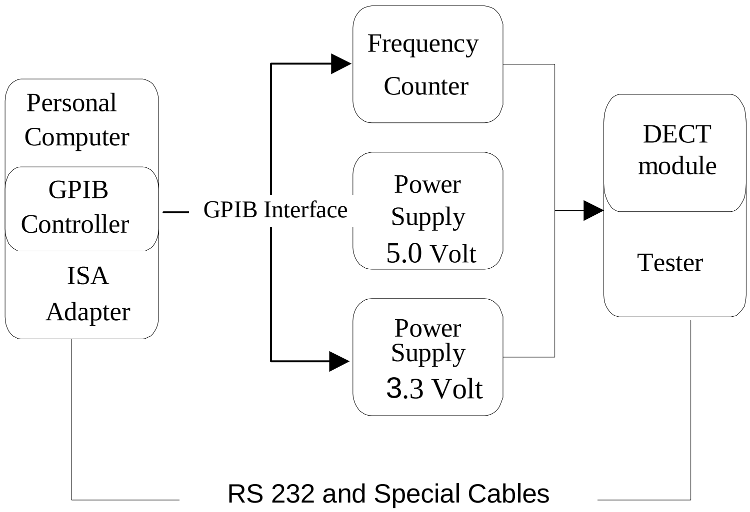

Figure 4 – Testing system architecture

The manufacturer shall develop their own ISA adapter and tester card based on supplied schematics. Basic schematics only include three access points. Connectors to link these points to electronic equipment are also defined on the basic schematics.

The electronic equipment connected to the DECT module, through the tester board, will interface with the test system through GPIB interfaces. Figure 4 presents the current implementation of the system (basic system) where two power supplies and a frequency counter are used. DECT modules need to be powered externally because they are used in a standalone mode, without the remaining system. The frequency counter is used to calibrate the clock frequency. The value measured by the frequency counter is compared with 10,368MHz. When a difference exists a digital value is sent to the DECT module, where an internal DAC of the micro-controller generates a voltage value for the varactor of the crystal oscillator.

The program running in the PC (Test Manager) controls the set-up and configuration of the frequency counter and the power supplies, using GPIB software. The software to control electronic equipment shall be developed by manufacturers as a dynamic library (DLL).

Although, a Test Manager was developed, manufacturers can create their own Test Managers. Test Managers communicate with the DECT modules, sending test messages over the RS232 interface. The messages sent by the Test Manager are defined in an Excel file with a pre-defined format.

The Test Manager runs as a Windows 95/98 or Windows NT application (Figure 5). Figure 5 (a) shows the main window where a new project is being selected. Figure 5 (b) shows the selection of test for a DECT module for a base station. It is written using Visual Basic.

The Test Manager application is distributed as a zip file and can be installed, executing the *set-up* file, after extracting the files. Test Manager is executed, selecting the START button in or Windows Desktop.

4.2 Test Manager

The Test Manager is the software to control the testing system. It provides a complete tool to verify if DECT modules are working properly, to detect faults and to program the information to be stored in the FLASH memory.

Manufacturers are responsible for the implementation of the interface between the Test Manager and the GPIB equipment. This interface is implemented as a dynamic library (DLL). A specification, including the complete list of functions signature, is defined in order to guarantee compatibility between GPIB equipment. These functions control the GPIB equipment and forward the information received from the equipment to the Test Manager.

Currently, for the demo system, only a frequency counter and two power supplies are used. In the Test Manager they are represented by two different forms (graphical windows). To introduce new equipment, new forms have to be included.

4.2.1 Test Manager tools

The Test Manager has two different levels of operation. One, the operator mode, provides a simple way to control the assembly process. The other, the debug mode, is used to help the technician in the diagnosis of problems in the damaged boards.

(a) Opening a new project (b) Testing a DECT module for base station

Figure 5 –Test Manager

Operator and Debug modes stop when an error is detected. However, another tool is also available to run the complete set of tests. In this situation, the Test Manager will not stop and will show the results of all the tests, even if more that one error occurs.

Operator Mode

In the operator mode, tests run automatically, including the calibration of the crystal and attribution of RFPI identifier. This mode identifies ten different error levels to simplify the repair procedure. Based on the level information, damaged boards are delivered to different technicians.

Debug Mode

The Debug Mode is used to help the Technician to correct the damaged boards. This mode shows the result of the running tests. The error codes will define the problem of the board and the technician only have to consult the Test Procedures Manual to find out the best way to resolve the tests that are not passing.

4.2.2 Test Manager procedures

There are two types of tests implemented by assembly and functionality procedures. The assembly procedures look for faults generated during the assembly of DECT modules PCBs. The functionality procedures check the RF module (carriers frequency, antenna diversity, power amplifier level, sensitivity and loop back tests) and transmission over A-field and B-field (Figure 1). Procedures to store the Radio Fixed Part Identifier and the value to calibrate crystal oscillator are include in functionality procedures group.

Assembly procedures

The boot program, loaded during initialisation, will perform the assembly procedures. This program only uses the internal memory of the DECT processor, therefore allowing the test of SRAM, FLASH and Dual Port RAM memories. Download of the boot program is done using the RS232 interface. After the assembly test software is downloaded, the DECT processor enters the loop mode, waiting for test messages.

Functionality procedures

In order to guarantee the correct download of Functionality procedures, these procedures shall only be downloaded after running with the successful execution of assembly procedures. Functionality procedures are downloaded to the SRAM memory.

4.2.3 Test Manager protocol

Assembly procedures and functionally procedures are invoked in the DECT module by test messages sent by the Test Manager to the DECT module, through the RS232 interface. The syntax of these messages is presented on Table 2. The number of bytes for each test message depends on the size of the parameters.

The Test Manager protocol is the list of messages stored on the Test Manager database, which is a Windows Resource file. A pre-defined set of messages exists, but new messages can be added. Therefore, manufacturers can create their own messages and corresponding assembly and functionally procedures.

4.2.4 Test Manager execution

Tests can be done after a successful reset of the DECT module, which downloads the assembly procedures. The tests to be executed are defined in an Excel file. There is no need to execute the complete list of tests stored on the test database. This will give total flexibility to the user to only run the tests he wants.

The Test Manager reads the Excel file when it starts up and converts the test format in the Excel to the message syntax.

Byte 1	Byte 2	Byte 3	Byte 4	Byte p	Byte p+1	Byte q
Categories and Info	Test Case Number	Parameter Value	N / A	N / A	N / A	N / A
		Size of Parameter 1	Parameter 1 Byte 1	Parameter 1 Byte n	Size of Parameter 2	Parameter 2 Value m

Table 2 – Test message format

4. Conclusions

We presented the implementation of a testing system to be used by different manufacturers during the production of a printed circuit board for voice and data communications, using the DECT air interface. The system is already configured to begin the production phase. The system will be, for now, used in two different locations. Test of memories, microprocessors, and RF were implementing.

A generic approach was used. Pre-defined tests exists, which are stored on a database, and the schematics of a basic tester card is provided. Manufacturers can easily increase the number of test points they want to access on the board, as well as, the number of tests to be done.

Up to now, INESC was mainly involved in the development of DECT prototypes. The development of the manufacturing test system permitted the understanding of the production environment needs and gave us a new perspective that will helpful in future developments.

References

[1] ETS 300 175: Radio Equipment and Systems (RES); Digital Enhanced Cordless Telecommunications (DECT) Common interface, Parts 1-5, ETSI, 1992

[2] António Muchaxo, Alexandre Sousa, Nuno Pereira and Helena Sarmento, “Wireless Data Communications Using DECT Air Interface”, ACM Computer Communication Review, April 1999