Multilevel Test Method for Testing Microcontroller based ECG System

Neelesh Jain
Research Scholar
Department of Computer Science and Application
Dr Hari Singh Gour Vishwavidyalaya Sagar

Ashish Verma
Assistant Professor
Department of Physics
Dr Hari Singh Gour Vishwavidyalaya Sagar

Shalini Jain
Research Scholar
Department of Physics
Dr Hari Singh Gour Vishwavidyalaya Sagar

ABSTRACT

Embedded systems are very complex and integrate heterogenous components on a single chip. Testing methodologies differ in hardware and software domains. Hardware testing concerns with the functional verification whereas the software testing is concerned with the series of processes of dynamically executing a program with the given inputs to make sure that code does that what it was designed for. A multilevel testing method is concerned with both the hardware and software domain. In comparison to conventional approach it involves all levels of testing. This paper explores the multilevel test method for testing microcontroller based ECG System.

Keywords

Multilevel test, ECG system, microcontroller 89C51

1. INTRODUCTION

Heart disease is diagnosed using Electrocardiogram signal. An electrocardiogram (ECG) is a recording of the electrical activity on the body surface generated by the heart. This paper presents the testing of the microcontroller based portable ECG system. Here we propose multilevel testing approach which involves both hardware and software domain. This approach has several advantages such as:

- It provide evaluation of other system configurations,
- It provide a consistent set of test scenarios,
- it provide real system performance,
- it provide the ability to test system components individually,
- it provide debugging at each level,
- it provide reliable component for reuse.

2. ECG PRINCIPLE

ECG measurement is recorded by skin electrodes placed at designated locations on the body. The ECG signal is characterized by six peaks and valleys labeled with successive letters of the alphabet P, Q, R, S, T, and U.

Normal ECG waveform is consists of these points P, Q, R.S & T as shown in figure (1). The P wave is associated with the activation of the atria, the QRS complex with the activation of the ventricles and the T wave with repolarization of the ventricles. Electrocardiogram Intervals are also shown in this figure (1). The P-R interval is the time from the beginning of the P wave to the start of the QRS complex. The QRS interval is the time from the beginning to the end of the QRS complex. The QT interval is the time from the beginning of the QRS complex to the end of the T wave. The RR interval is the time from the peak of one R wave to that of the following R wave.

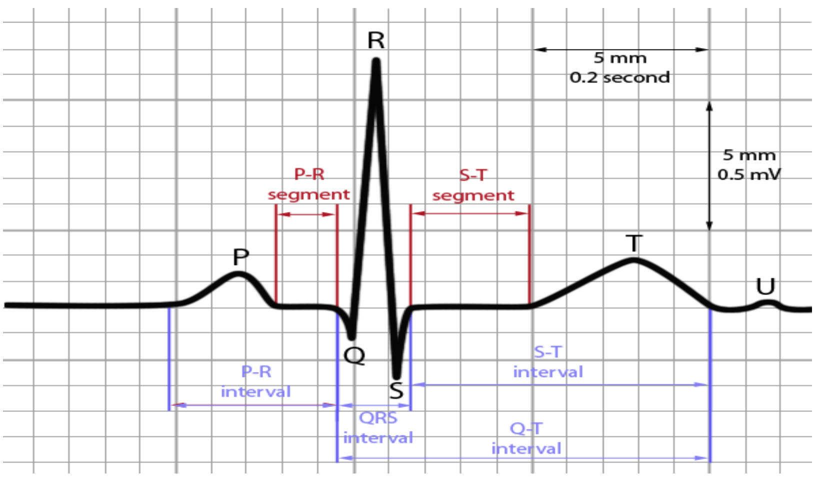

FIGURE 1: Normal ECG waveform

The Electrocardiograph (ECG) signal is an electrical signal generated by the heart's beating, which can be used as a diagnostic tool for examining some of the function of the heart. It has a principal measurement range of 0.5 to 4 mV and signal frequency range of 0.01 to 250 Hz.

In this system there are three leads use for measurement of ECG. These cable colors are based on European monitoring cable connection. The yellow is for left leg, red is for right arm and black is for right leg. In the present work a bipolar technique is used in this circuit. In bipolar leads have one positive and one negative pole. For measuring the ECG a non invasive pad that connected to the electrodes is used. Human skin is poor electric conductor so a low resistance jelly will be applied between the skin and pad to improve conductivity.

3. WORKING OF THE CIRCUIT

First of all three surface electrodes are used for the measurement of ECG. We basically use clamb electrodes for the measurement of ECG. They are applied to the surface of the body with electrode jelly to remove the noise and have good connect impedance. These electrodes are connecting to right arm, left leg and right leg. Electrodes are used to pick up electrical signal reached to the voltage follower. Voltage follower is used for much higher input impedance and increase the current rating of the input, then after signal conditioning circuit is used to remove all the noise and interferences, which causes the signal distortion and to amplify it to the desired level. It consist three stages:-

a) Pre amplifier

b) Filter

c) Main amplifier

In Pre amplifier section we use an instrumentation amplifier for low noise, high input impedance, low power consumption and high CMRR. In the filter section low pass filter of first order is used for filtering of first order is used for filtering the signal for the final amplification of this signal main operational amplifier is used so that this signal can be observed on a computer or any other device with desired level of amplification necessary to analyze the wave form. This analog signal is converting to the digital signal via ADC0804. So this digital is reached to the input of programmed microcontroller 89C51. Microcontroller is interfaced with RS232 for transferring the data on PC. So a USB port is also connected by RS232.

The QT interval is calculated using the Bazzet formula as follows:

$$QTc=QT/ (RR)^{1/2}$$

Where QT is the interval between the onset of the Q wave and offset of the T wave and RR is the interval between the two consecutive R waves.

4. MULTILEVEL TESTING APPROACH

The complex embedded system leads to long development and testing cycles. Testing is important because as soon as fault is revealed, the correction becomes cheaper and cheaper. It is seen that more testing levels exist for testing embedded system than for the testing standard software.

Multi-level test cases supports functional test. It acts as a tool to reuse across test levels and test level integration. Test level integration means bringing the test levels closer to each other. Such test cases consist of two parts - first a test level-independent test core that is reused across test levels and second test level-specific test adapters. This structure of multi-level test cases supports the partition of commonality and variability across test levels.

Multi-level test methodology is proposed in the work. The block diagram of the microcontroller based ECG system is shown in the figure (2). The microcontroller unit, LED, Personal computer, EEPROM, are different electronic control units involved in measurement, calculation, storage and output of the signal. The microcontroller is the master component which decides all the communication.

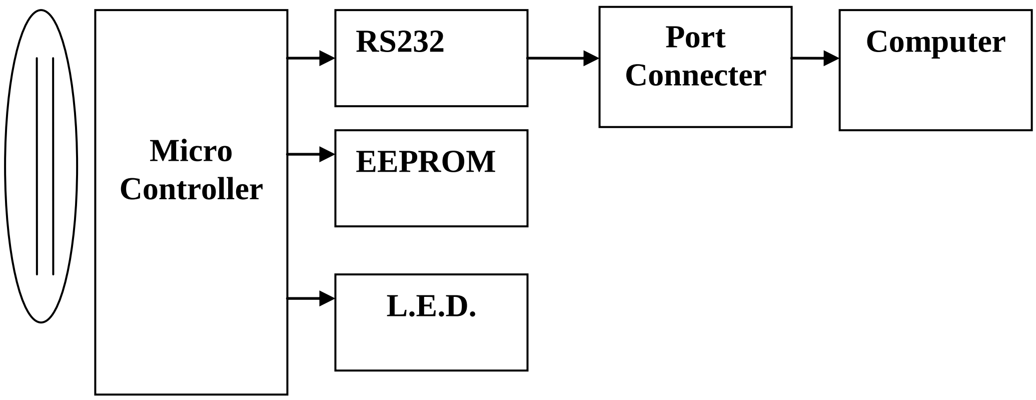

Figure 2 : Block diagram of ECG system

5. TEST LEVELS

There are four different test levels of testing: software component testing, software integration testing, software/hardware integration testing, and system integration testing as shown in Figure (3). In terms of functionality, the software component testing is the most detailed test level, while system integration testing is most abstract level testing. These test level involves the large integration from software components to the complete system consist of all electronic control units. The V model of the software testing treats each test level independently.

In ECG system microcontroller accept the ADC signal from the sensor and do the required calculation for calculating the pulse rate. There are two steps involved; first to accept the signal the instrument should be given some power to switch on, and second after accepting the signal the embedded software has to calculate and display it.

In the whole process of testing, two levels are involved they are component testing and software integration testing, i.e. every test level is based on the components integrated so far. So the faults resulted at every test level are directly related to the integration step performed by that test level. If the signals at software/hardware integration test level are not received while signal were received on software integration test level, it means there might be problem with the hardware or its interface to the software.

The test interface i.e. the information channels that are used for invoking and observing test objects are different for each test level due to different test objects at different levels, as a result only test cases that abstract from the test interface will really be reusable.

Test reuse across test levels reduces the test suites size at different test levels. Similar or even identical test cases across test levels could be reused and thus only implemented and maintained once. For test design and implementation multi-level test cases are more efficient.

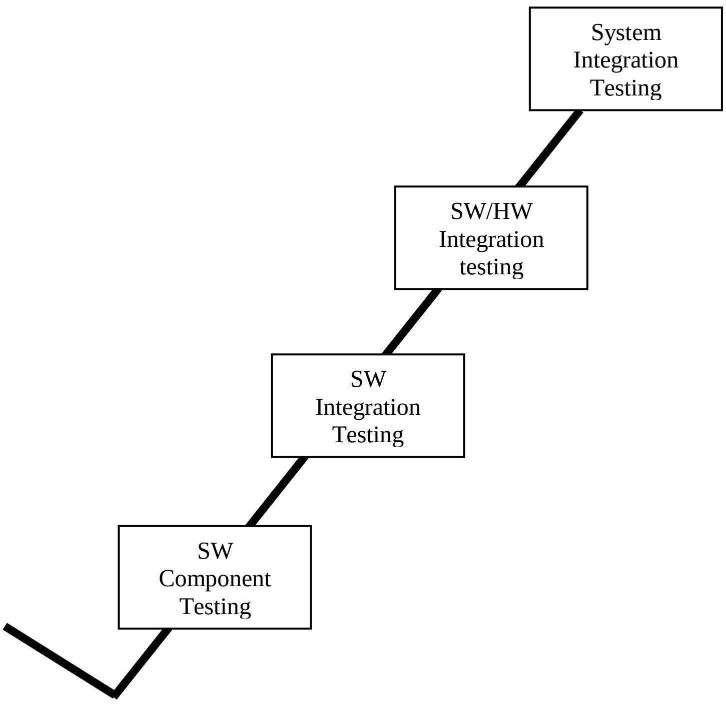

Figure 3 : Right Branch of the V Model for embedded system

6. MULTI-LEVEL TEST CASES

In Multi-level test cases test level integration is used. Reusing the test case implementation across up to four different test levels instead of implementing separate test cases for each test level reduces great efforts. The structure of multi-level test cases is shown in Figure (4). Here two different modules within two test cases are used for testing. First is a reusable test core (TC) and the second is the Test adapter specially designed for test level.

The test behaviour in the TC is test level independent. It is abstract and can be reused across test levels. It contains interface for interacting with the system under test. The test adapter (TA) varies across test levels and is thus test level specific. This TA is used as an interface between the TC and the test object. Ii is further divided into three parts; the input test adapter (ITA), the output test adapter (OTA) and the parameter test adapter (PTA).

Both ITA and OTA adapt the TC interface to the test object interface. They thus map the abstract test behaviour to the test object. In ECG system the sensor will require mapping with RS232 and microcontroller at software/hardware integration test level. The PTA is used to map test parameters that apply on test objects. Multi-level test cases can also be used for reusing test cases from lower test levels at more abstract levels.

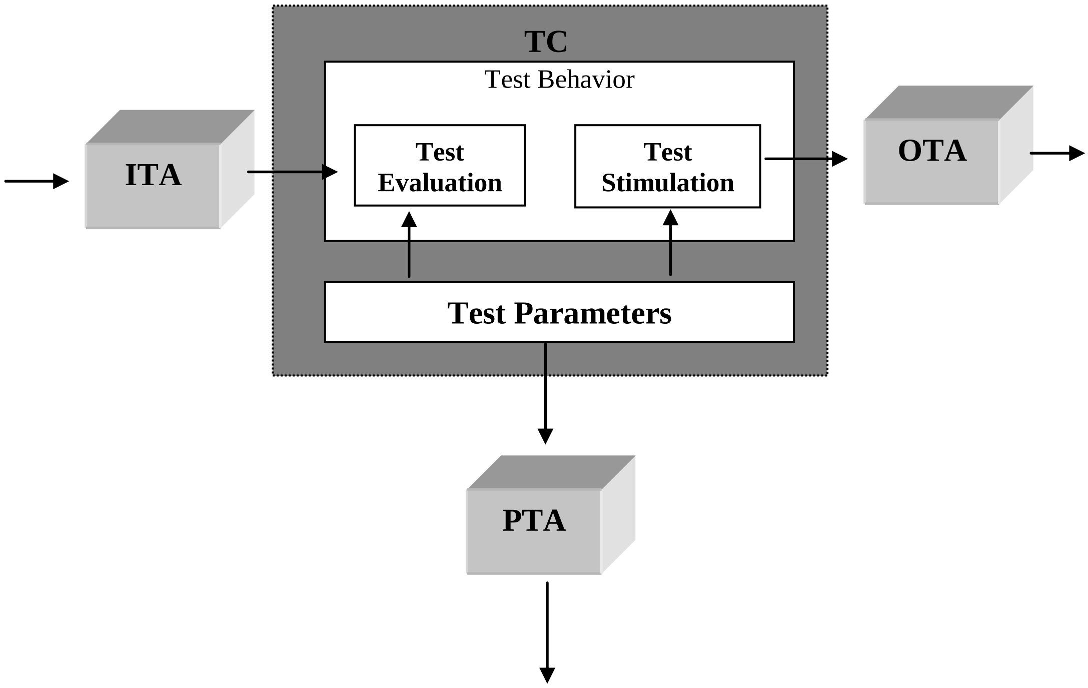

Figure 4: Structure of Multi-level Test Cases

7. TEST MODULES

The test modules for the ECG system is designed which focuses on the Control Unit, which interact with the sensors. Our approach is to decompose the system into sensor, data cable, ADC converter, microcontroller, LED and the computer. The ADC is the interface between the interaction between the sensor and microcontroller which calculates the results using formula and further they are display or saved on the LED or the computer.

8. CONCLUSION

The multi-level test cases separate the test behaviour into a abstract part within the TCC and an input or output adapter to a concrete test level having different test object with different interfaces. This approach is efficient in testing large embedded system at different levels.

9. REFERENCE

[1] Neelesh Jain et all, *"Testing embedded system in Microcontroller based ECG recording system"*, at International Conference WECON 2011 held at Chitkara University Chandigarh.

[2] Stephan Schulz et all, *"Multilevel Testing for Design Verification of Embedded Systems"*, IEEE Design & Test of Computers, 2002.

[3] Abel Marrero Perez et all, *"Multi-level Test Models for Embedded Systems"*, a research paper from www.crcnetbase.com

[4] Manuel Nunez et all, "*A Formal methodology to test complex embedded system: Application to interactive Driving System", a research paper from http://antares.sip.ucm.es/manolo/ papers/iess05a.pdf*

[5] Bird, R. and Wadler, P.(1988), *"Introduction to Functional Programming"*, Prentice Hall.

[6] Description from http//www.opel.com

[7] Eckard Bringmann and Andreas Kramer, *"Model based Testing of Automative System"*, In 1st International Conference on Software Testing, Verification and Validation (ICST 2008), Lillehammer, Norway, 2008.

[8] Blood pressure , web site http://www.blood pressure.com

[9] Prof. K. Padmanbhan, *"Microcontroller based heart rate meter"*, Electronics for You, pp 58, may 2008.

[10] Deshmukh, "Microcontroller an introduction", Pearson pub. 2005.

[11] Douglas Dana, "pulse measurement", web site: http://www.healthwise.com.

10. AUTHORS PROFILE

Neelesh Kumar Jain is an Electrical Engineering Graduate with MCA, M. Phil in Computer Science and Application. He is doing his Ph. D in *Some New Testing Methodologies for testing Embedded System*. He has more than ten years of teaching experience. He had worked as Lecturer in Indira Gandhi Govt. Engineering College Sagar MP, SR Women Govt. Polytechnic College Sagar, and other institutes of repute. Presently he is working as an Assistant Professor in Dr. Hari Singh Gour Vishwavidyalaya Sagar a Central University. His research interests include Embedded Systems, Cyber Crime, Entrepreneurship Development and others related to socio-economic development. He is the life member International Association of Computer Science and Information Technology (IACSIT), Computer Science Teachers Association (CSTA) and International association for engineering and Management Education. He is also a reviewer of various CSTA organized conferences. He has published four research papers in National and International Journals and 15 research papers published/presented in National and International Conferences and Seminars.

Dr Ashish Verma is received the M. Sc degree in Physics with specialization in Electronics and Solid State Physic in 1984 and Ph. D degree in Physics in 1991 from Dr Hari Singh Gour Vishwavidyalaya Sagar. He is currently working as a Assistant Professor in Department of Physics in Dr Hari Singh Gour Vishwavidyalaya Sagar. He has published / presented about 70 research papers in National and International Conferences, Seminars and IEEE Proceedings and two books. He is the member of ISTE, and fellow Member of Science. He is the editor and reviewer for different journals and conferences. His area of Interest is embedded system and VLSI Design.