Design, Test and Testability on VLSI Circuits

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Abstract— Historically the subject of testing has not been one which has fired the imagination of many electronic design engineers. It was a subject rarely considered in academic courses. However the vast increase in on-chip circuit complexity arising from the evolution of LSI and VLSI technologies has brought this subject into rightful prominence, making it an essential part of the overall design procedure for any complex circuit or system. The design and production of the majority of manufactured products usually involves a rigorous design activity followed by detailed testing and evaluation of prototypes before volume production is begun. The ability to test end products as comprehensively as possible within a given budget or time.

Keywords-- OEM, IC manufacturer, Digital circuit, Analogue circuit, Mixed circuit, DFT, PCB circuit etc;

I. INTRODUCTION

The range of testing involves both the IC manufacturer and the Original Equipment Manufacturer (OEM). Tests by the IC manufacturer (vendor) to ensure that all the fabrication steps have been correctly implemented during wafer manufacturer and possibly test by the OEM of incoming IC’s to confirm their functionality.

The final two phases of activity are clearly the province of the OEM, not involving the vendor unless problems arise with incoming production IC’s. Such testing will be unique to a specific product and its components. Although in its design the requirements of testing and possibly the design for test (DFT) features must be considered as follows:

1. Chip design activity including simulation
2. Wafer fabrication
3. Wafer probe and test
4. Prototype product tests
5. Test and approval of production chips before product assembly.

Digital Circuit Testing: Because of the difficulties or complexities encountered due to many different number of gates using, when formulating acceptable tests for integrated circuit as they become larger and more complex, it is now essential to consider testing at the design stage of a VLSI circuit or system. It may be appropriate to define three basic terms which arise in digital circuit testing which are as shown in the Figure 1.1. These terms are:

Input Test Vector- Its also termed as input vector or test vector. This is a combination of logic 0 and logic 1 signals applied in parallel to the accessible (primary) inputs of the circuit under test. For example – If eight primary inputs are present then one test vector may be (0 1 1 1 0 1 0 1)

Test Pattern- A test pattern is an input test vector plus the addition of the fault free output response of the circuit under test to the given test vector.

If suppose there are four possible accessible (primary) outputs ie; (0 0 0 1)

Now as per definition –

Test pattern = [Input Test Vector + Fault Free Output Response]

Test Pattern= [0 1 1 1 0 1 0 1 0 0 0 1]

Test Set – Test set is a sequence of test patterns, which ideally should determine whether the circuit under test is fault free or not.

Analogue Circuit Testing: Purely analogue networks are usually characterised by having relatively few circuits primitives such as operational amplifiers, Class A, B, C amplifiers etc. The numbers complexity is replaced by the increased complexity of each building block, and the need to test a range of parameters such as gain, bandwidth, signal to noise ratio, common mode rejection ratio (CMRR), offset voltage and other factors.

The actual testing of analogue ICs involves standard test instrumentation such as wave form generators, signal analysers programmable supply units, voltimeters, ammeters etc.
The general purpose test systems are frequently made as an assembly of rack-mounted instruments, under the control of a dedicated microcontroller or processor. Such an assembly is known as a Rack-And-Stack Test resource, as illustrated in Figure-1.2.

**Figure-1.2**

In this case of rack-and-stack test resource firstly we will test amplifier and feedback circuit working condition individually, then final output response we get. It means that on each rack we will test component or circuit individually for getting best final output responses.

**Mixed Analogue/Digital Circuit Testing:** The testing of analogue part and testing of the digital part of a combined analogue/digital circuit or system each require their own distinct forms of test. Hence it is usually necessary to have the interface between the two brought out to accessible test points so that the analogue tests and the digital tests may be performed separately.

The unsophisticated mixed circuits containing say, simple input A-to-D converter, and an output D-to-A converter. Now to combine both analogue and digital testing by using multiple discrete voltage levels or serial bit streams to drive the analogue circuits (A/D converter) or voltage-limited analogue signals for the digital circuits (D/A converter). A block diagram of a mixed analogue/digital test resource are as shown in the Figure-1.3—

**Figure-1.3**

**DFT for Mixed Circuits:** Design for test (DFT) is an essential part of the design phase of a complex circuit. DFT involves building into the circuit or system some additional feature or features which would not otherwise be required. There may be simple features such as follows:

1. The provision of additional input/output (I/O) pins on an IC or system, which will give direct access to some internal points in the circuit for signal monitoring.
2. Provision to break certain internal interconnections during the test procedure, for example feedback loops.
3. Provision to partition the complete circuit into smaller parts which may be individually tested.

The design for testability, sometimes called as design for test and almost always abbreviated to DFT. DFT normally use its best technique for testing ie; Partitioning or ad hoc testing.

**Ad hoc design method:** It is also termed as partitioning methods. One of the most obvious for easing the testing problems is to partition the overall circuit or system into functional blocks, then tested each blocks one by one. Its only demerit is that many more inputs and outputs to be provided on the circuit.

**Printed Circuit Board (PCB) Testing:** All OEM systems employ some form of printed-circuit board (PCB) for the assembly of ICs and other components. PCB complexity ranges from very simple one or two-sided board to extremely complex multilayer boards containing ten or more layers of interconnect which may be necessary for avionics or similar areas.

PCB testing falls into three categories, namely:

**Bare–board testing:** Which seeks to check the continuity of all tracks on the board before any component assembly is begun.

**In-circuit testing:** Which seeks to check the individual components, including ICs, which are assembled on the PCB. Which is shown in the Figure1.4.

**Functional testing:** Which seeks to check on the correct functionality of the completed PCB.
Software Testing: Software is an essential element in perhaps the majority of present-day systems, and can account for a greater design time and cost than the hardware costs. Examples of software problems in complex systems such as airport baggage handling, combined police, fire and ambulance control systems and other similar distributed systems are increasingly known, and have demonstrated that software design and test is critical to final system performance.

The software reliability, testing and failure is a more recent subject area. Indeed, until recently any system fault in service was assumed to be a hardware failure, the software programs being considered fault free. The merits and demerits of software testing are as follows—

**Merits:**
1. Extreme conditions of input parameter values, timing and memory utilisation.
2. Extreme conditions of ranges of input sequences utilisation.
3. Finding fault conditions on input data.

**Demerits:** The greatest problems are software sneak conditions, namely:
1. Sneak outputs, where the wrong output code is generated;
2. Sneak inhibits, where an input or output code is incorrectly inhibited;
3. Sneak timings, where an incorrect output code is generated due to some timing irregularity.

**Abbreviation:**
- OEM (Original Equipment Manufacturer)
- DFT (Design for Test)
- PCB (Printed Circuit Board)
- VLSI (Very Large Scale Integration)

**II. CONCLUSION**

The testing circuits of VLSI complexity and systems into which they may be assembled. The testing problem is not usually one of fundamental technical difficulty, but much more one of the time and/or the cost necessary to undertake a procedure which would guarantee 100% correct functionality.

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