The Digital Pattern Generator - An essential instrument for digital system development

In the world of signal generators used for testing and debugging embedded systems, we can find 3 categories of instruments, according to the characteristics of the generated signals and the purpose of generating them. 'Embedded system' should be understood in its broad sense, that is an electronic system with 'out of the PC' computing resources such as microprocessor or microcontroller, ASIC, FPGA, SoC (System-on-Chip), DSP, including analog, digital or mixed-analog/digital systems. Refer to the table below for an overview.

Instrument type	Signal characteristics	Usage
Digital Pattern Generator	Digital. Sequences of '1's and '0's complying to a digital voltage standard such as LVCMOS, LVTTL, LVDS, ...	Mainly functional validation. The generated signal is generated to convey digital information as inputs to a digital system. Usually features at least 16 channels and more.
Pulse/Pattern Generator	Digital, suite of square pulses. Ability to tune the electrical characteristics of the signal, such as rise/fall time, signal drive strength, jitter, ...	Test and qualification of input buffers electrically. Sometimes used for functional validation like a digital pattern generator. Usually features 1 or 2 channels only.
Waveform Generator	Analog. Generation of standard waves like sine, sawtooth, square waves or arbitrary complex signals with the ability to define the amplitude of the output.	Stimulate the analog inputs of a system. Used for electrical validation of such inputs and functional validation of a complex system featuring analog inputs.

Table 1: Signal generators typology

In this paper, we'll specifically evoke the 'Digital Pattern Generator' as an essential piece equipment for all engineers involved in embedded system design.

Digital pattern generator improves semiconductor and digital system testing during design.

During design, the digital pattern generator is an essential stimulus source for almost every type of digital device: digital and mixed-signal ASIC, FPGA, microprocessors and microcontrollers. The digital pattern generator is useful for functional testing, debug of new designs and failure analysis of existing designs.

The digital pattern generator can be used early in the design cycle to substitute for system components that are not yet available. For example, a digital pattern generator might be programmed to send interrupts and data to a newly developed bus circuit when the processor that would normally provide the signals doesn't yet exist.

It allows exploring new test cases – and create infrequently encountered test conditions to help verify that a code works and is robust enough – and this, before the complete hardware is even available.

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A digital pattern generator can also be used to put a circuit into a desired state and then let it operate at full speed or step the circuit through a series of states. Generating the right specific initialization sequences and configuring control register will help in exploring many modes of operations of a circuit. Because nowadays circuits use digital interfaces that may run at more than a few 10th of megahertz, the old way to do it with microcontrollers coupled with a GPIO is not sufficient any more.

By substituting for missing pieces and offering maximal flexibility when generating digital logic signals, digital pattern generators will speed up new product's time-to-market. The digital pattern generator is an effective solution just about anywhere that complex digital bit streams are needed to stimulate a device under test (DUT)

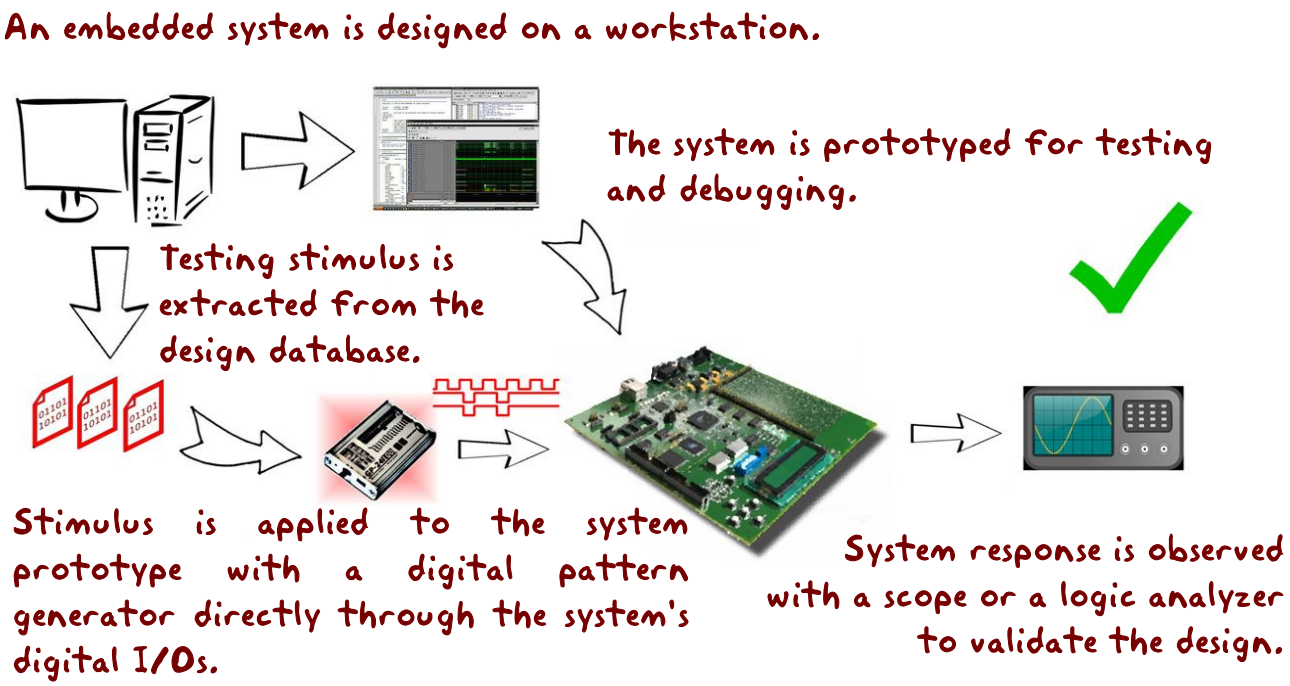

Figure 1: Principle of stimulus-and-response setup for a prototyped digital system

'Debug & verification' does not mean 'measurement only'.

Byte Paradigm conducted a survey in 2009 with over 300 respondents involved in embedded hardware and software design. This survey shows that:

- A majority of engineers (61%) agree with the statement that ***'Using a hardware prototype speeds up embedded system debug'.*** Only less than 10% of the total respondents (335 total) somewhat disagree or disagree with this statement (see table 2).
- Over 83% of the total number of respondents declare that stimulus generation is at least ***'as challenging as system response observation'.*** Figures are sensibly the same whether it concerns IP, FPGA, ASIC, SoC, or full embedded system testing (see figure 2, which presents an average view).

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	Agree	Somewhat agree	Rather disagree	Disagree	Don't know	Response Count
Using a hardware prototype speeds up embedded system debug	**61.2%** (205)	**29.3%** (98)	**2.7%** (9)	**1.8%** (6)	**5.1%** (17)	**335**

Table 2: 2009 survey results (excerpt 1)

A vast majority of development engineers like going to a 'real hardware' prototype to test and debug what they are designing. Basically, 'testing on prototype' always reduces to ***'stimulating and observing'***.

Interestingly, this survey also shows that engineers are usually well-equipped with oscilloscopes (69.5% of the respondents), logic analyzers (57.1% of the respondents) and JTAG probes (59.3% of the respondents).

On the other hand, only 20.6% of our respondents find a digital pattern generator in the lab to perform their testing and debugging work. This number rises to 32.8% as for waveform generators – for analog signal generation such as sine waves. When asked about this situation, preliminary results show that engineers will be more eager to use standard commercially-available signal sources for stimulus generation for future projects.
In retrospect, they also acknowledge that they would have saved valuable design time if they had used a digital pattern generator for functional testing and debugging of their last digital system.

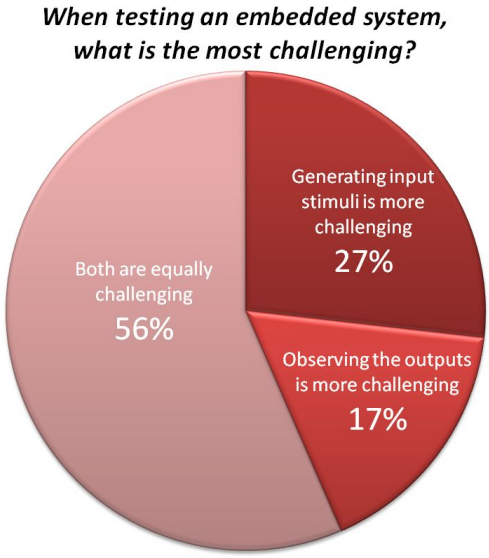

Figure 2: 2009 survey results (excerpt 2)

The reason why engineers are not systematically equipped with such a tool – whereas they always receive a PC and a oscilloscope – is not very clear. This question is being investigated by Byte Paradigm.

Every engineer should have a digital pattern generator.

At Byte Paradigm, we consider that digital pattern generators help overcome the many challenges of embedded system test, debug and validation.

We share the opinion of the engineers that going on prototype early in the design cycle speeds up system debug and hence, helps shorten the overall product design cycle. Testing a prototyped system basically requires 2 types of tasks: ***1) Generating the input stimulus to the system***, and ***2) Analyzing the system's response.***

To solve the 'stimulus-and-response' challenge the engineer will save valuable design time if he is correctly equipped. There is no doubt that scopes, logic analyzers and perhaps more specialized analyzers will help doing the 'analysis job'. They have an important companion for digital systems: the digital pattern generator.

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