Configurable AMBA On-Chip Real-Time Signal Tracer

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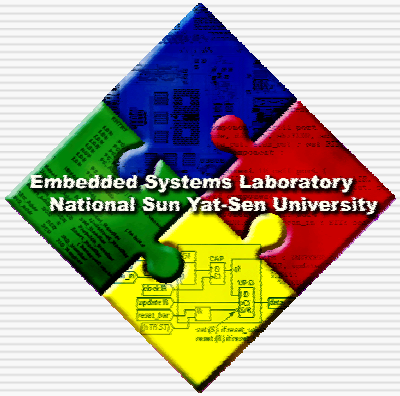
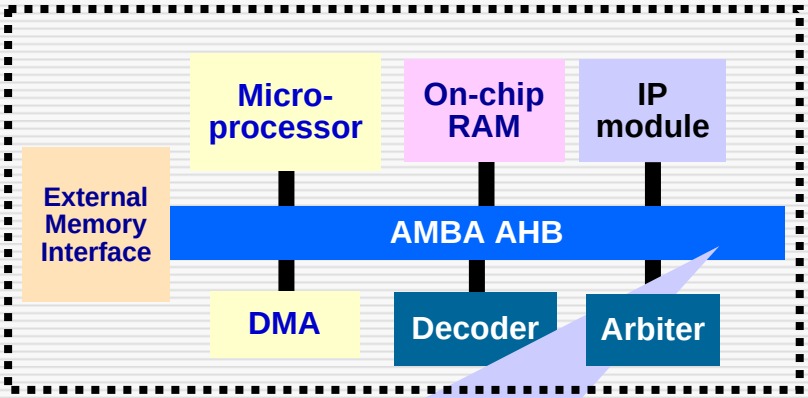
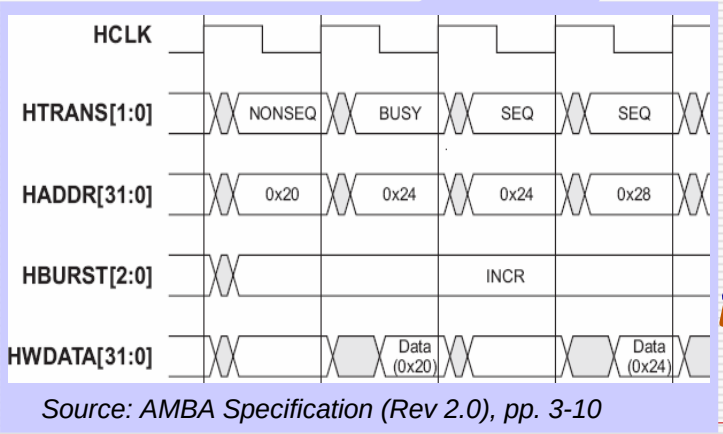


Motivation

- **Solution: On-chip Bus Trace Analyzer**
  - Levels of abstraction (signal, timing)
  - Trace reduction (encoding, lossless data compression)

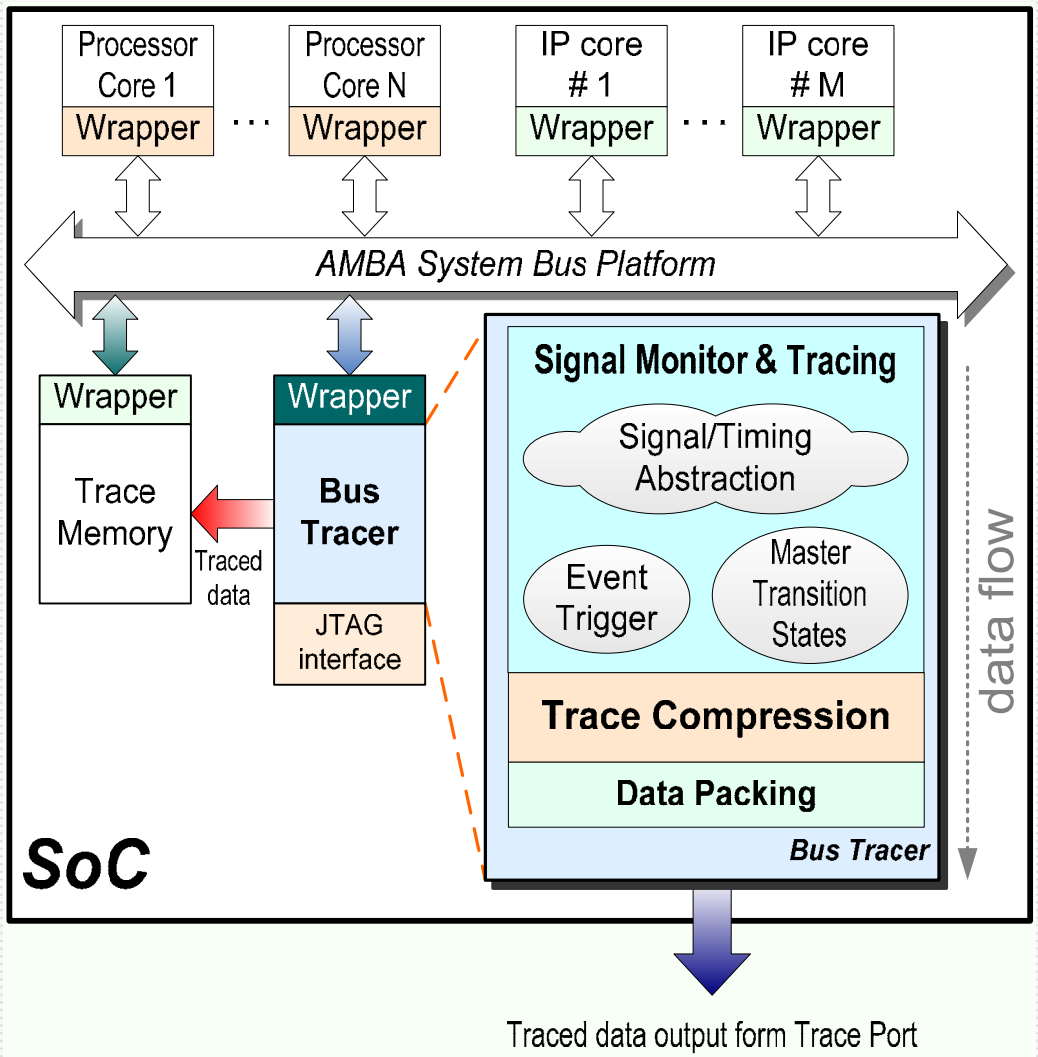




Source: AMBA Specification (Rev 2.0), pp. 3-10

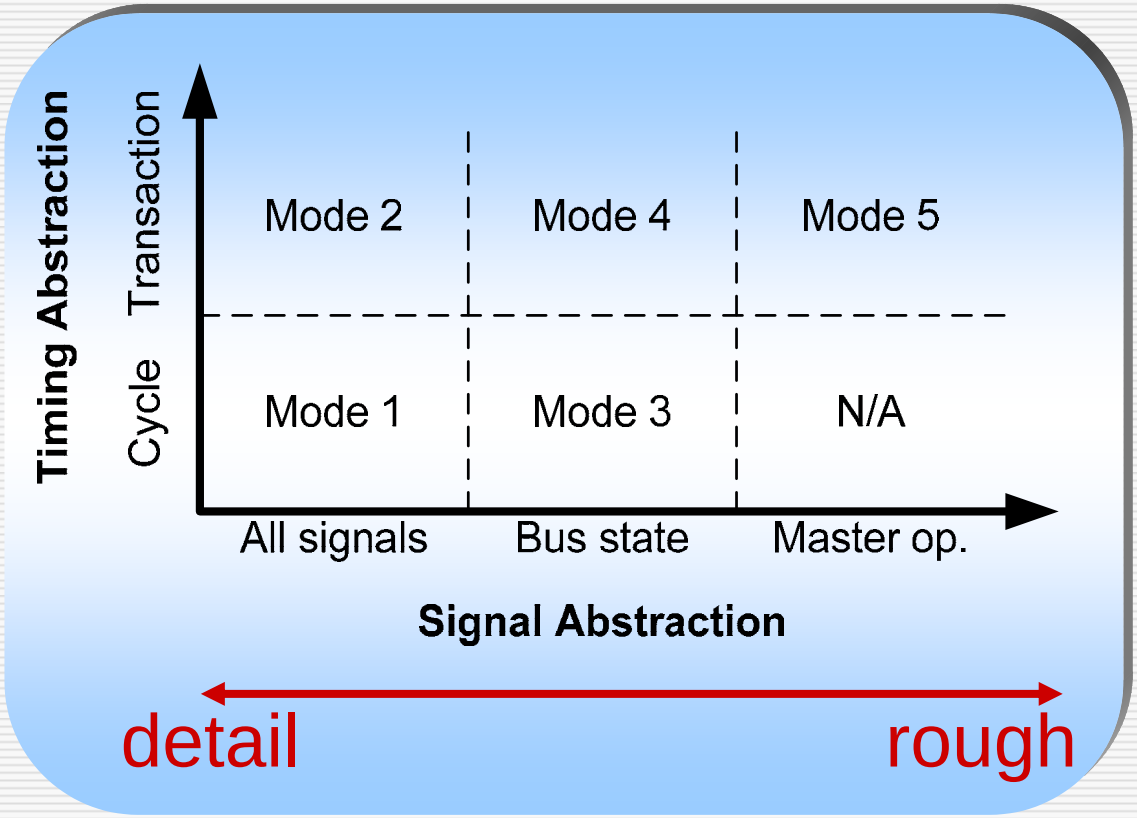
- **Signals tracing can help designers to debug the system HW/SW**
  - Bus wrapper design
  - Bus utilization, arbitration, *etc*.
  - Hardware/software interface
- **For real-time tracing, we should reduce the trace size as much as possible.**

AMBA Signal Tracer Block Diagram



- **JTAG Interface**
  - user can setup the tracer through JTAG port
- **Signal Monitor & Tracing (Signal/Timing Abstraction)**
  - to determine when and which signals should be monitored
- **Trace Compression**
  - to compress the trace size generated from timing/signals abstraction module
- **Data Packing**
  - packs the trace data generated from the data compression module and buffer the output data
- **Trace Output**
  - transfers the trace data to host (PC)
  - Stored in on-chip memory

Abstraction of Bus Signal/Timing



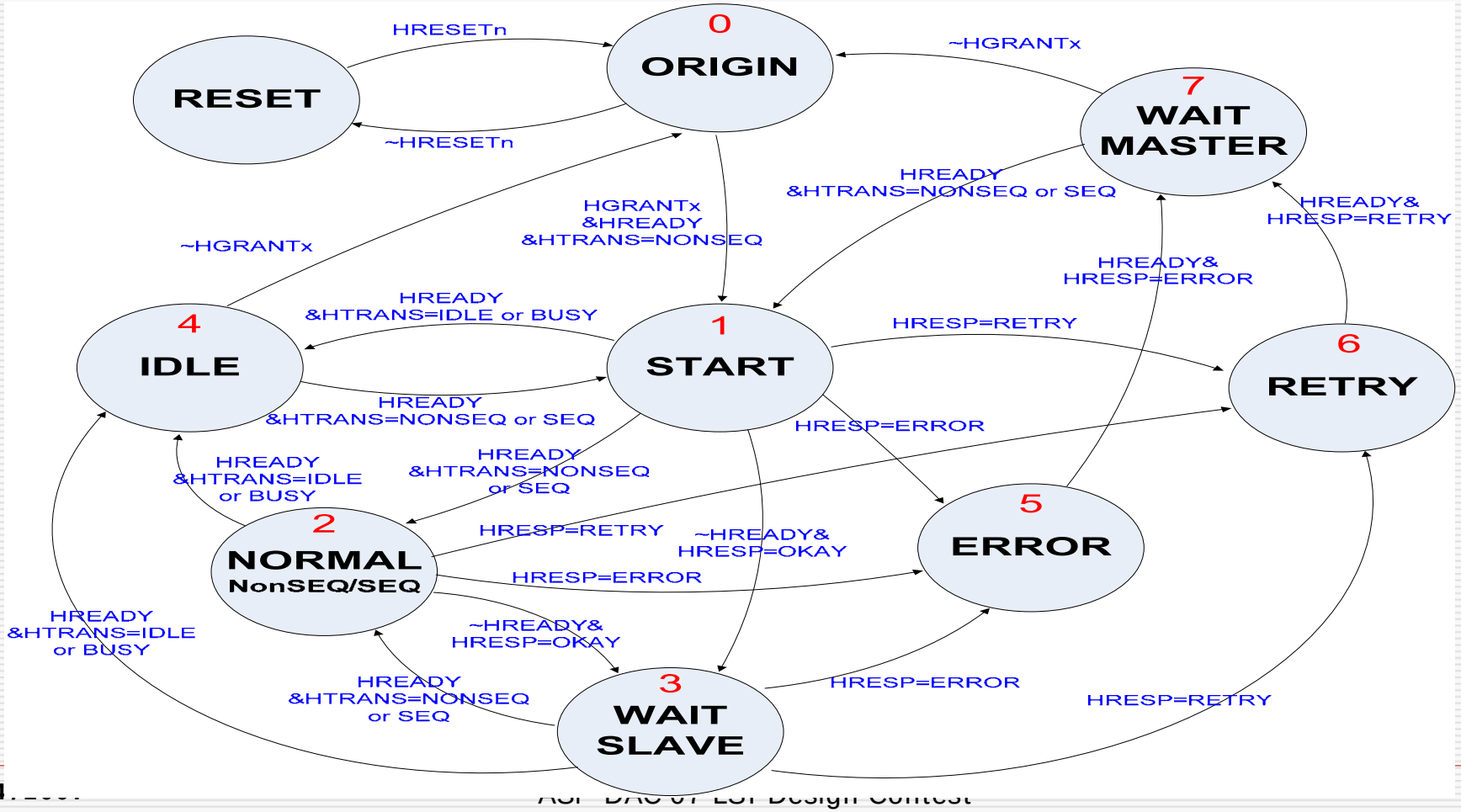
Trade-off

- Trace size vs. trace depth
- Detail vs. rough trace information

- **Abstraction (multi-resolution):**
  - the granularity of signal and timing observation

Abstraction of Bus Transfer State

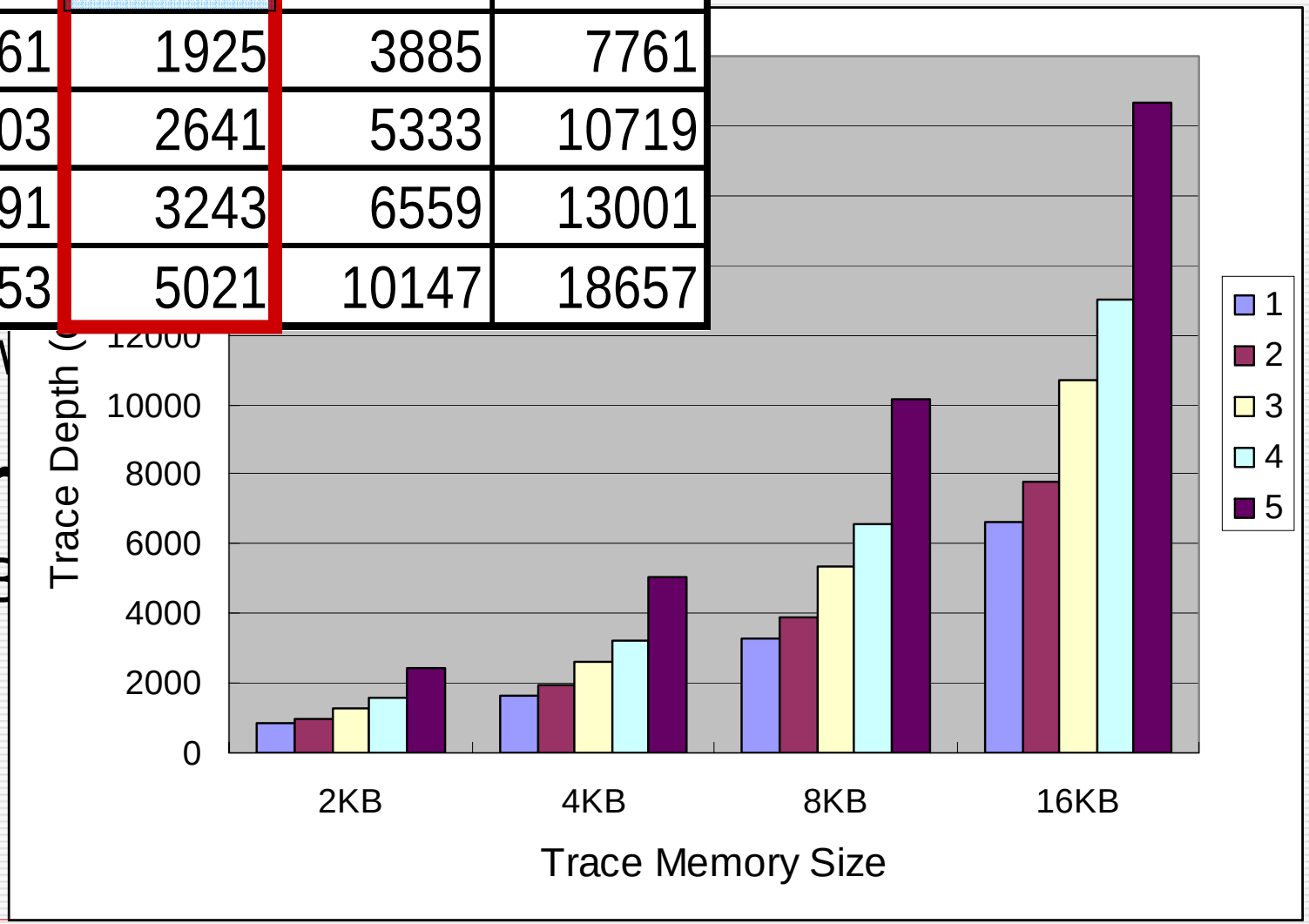
- Provide high level debugging scheme
- Reduce trace size



Trace Depth vs. Trace Memory Size

Mode	2KB	4KB	8KB	16KB
1	821	1641	3303	6619
2	961	1925	3885	7761
3	1303	2641	5333	10719
4	1591	3243	6559	13001
5	2453	5021	10147	18657

- Tow
- **Envir**
  - 2KB



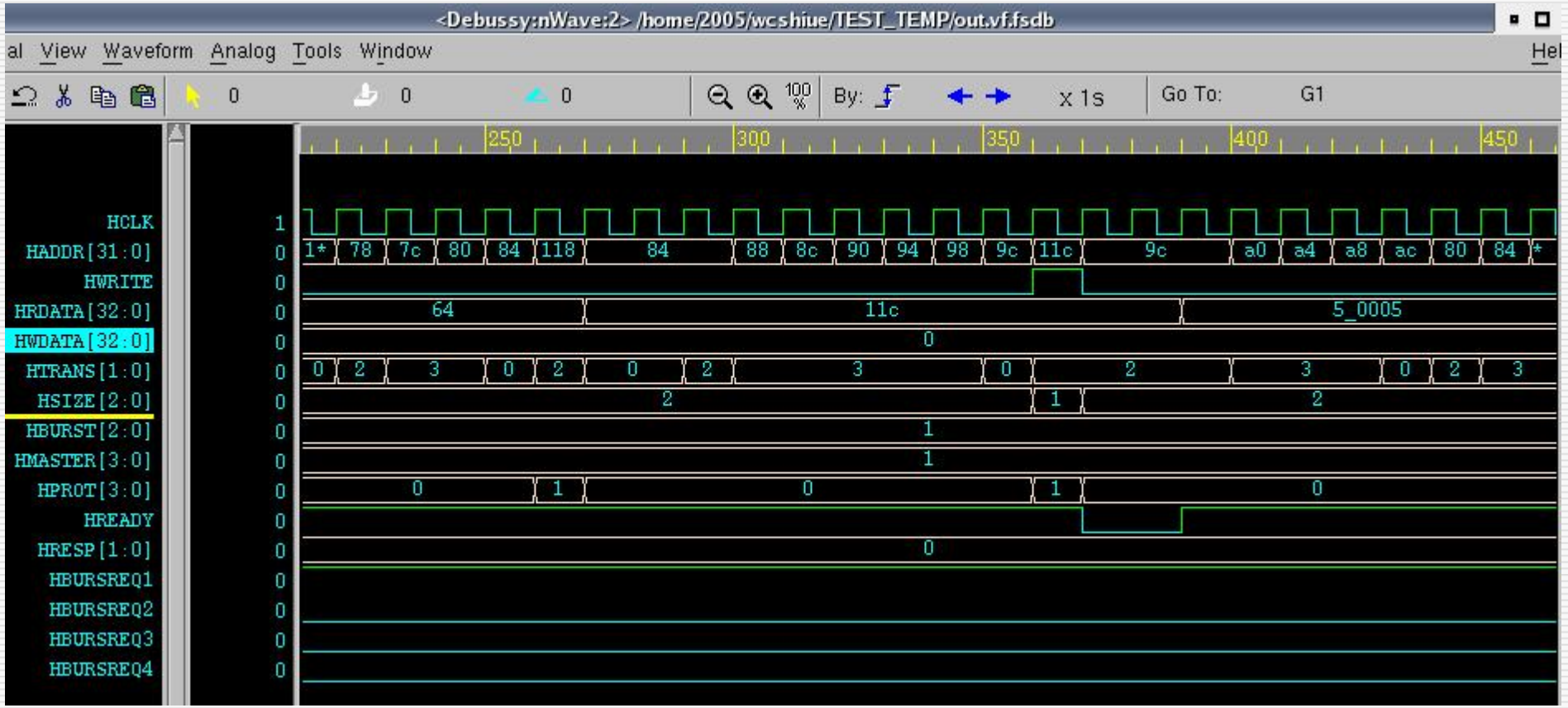
Trace Compression Ratio

- **Trace AMBA AHB 88 bits signal**
- **Run 10,000 cycles**

	Original trace size **(88bits/cycle)**	Compression Ratio After Signal/Timing Abstraction and Trace Reduction				
		@ mode 1	@ mode 2	@ mode 3	@ mode 4	@ mode 5
Perpetual Calendar	**880000**	**83.71%**	**83.79%**	**90.05%**	**94.67%**	**96.99%**
Fib. Sequence	**880000**	**78.51%**	**80.05%**	**87.91%**	**90.45%**	**94.73%**
G.C.D.	**880000**	**83.22%**	**83.45%**	**89.14%**	**92.76%**	**95.68%**
Towers of Hanoi	**880000**	**78.64%**	**80.61%**	**85.99%**	**88.58%**	**92.56%**
Knight Problem	**880000**	**83.96%**	**84.33%**	**96.39%**	**97.16%**	**98.32%**
Quick Sort	**880000**	**78.27%**	**79.99%**	**99.64%**	**99.71%**	**99.80%**
Geometric mean	**-**	**81.01%**	**82.02%**	**91.39%**	**93.81%**	**96.32%**

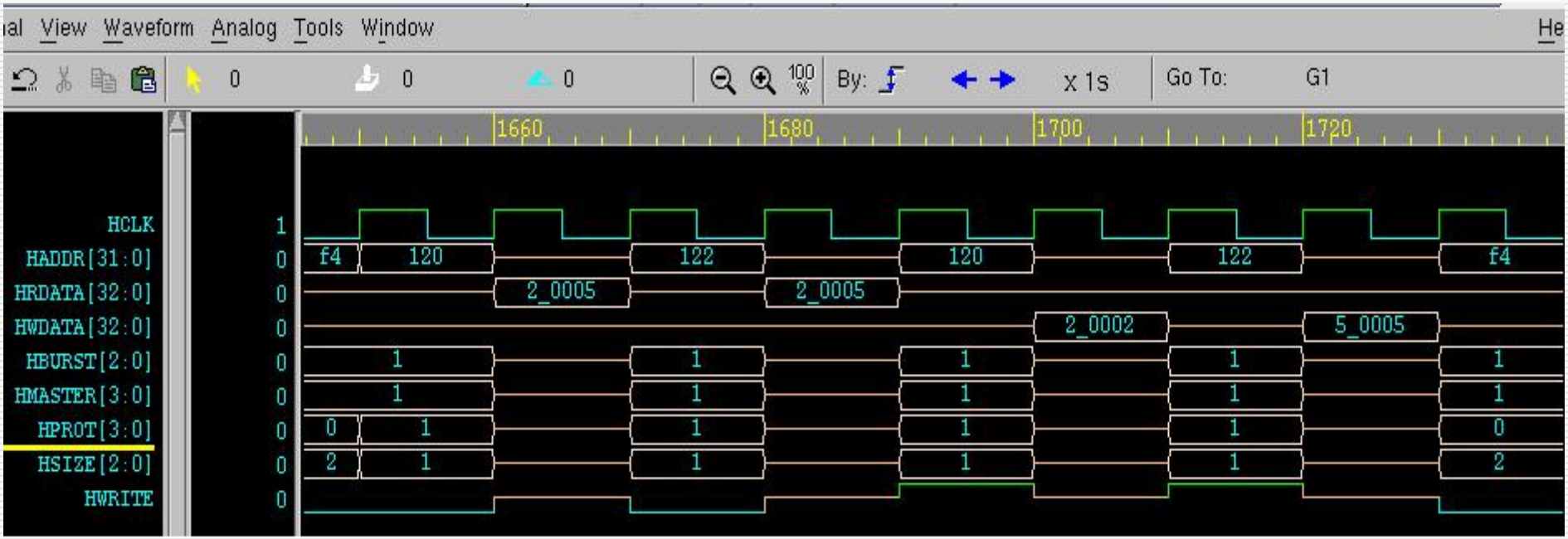
$$Compression\ ratio = \left(1 - \frac{\text{Trace Size @ each mode}}{88\ \text{bits} \times \text{trace cycles}}\right) \times 100\%$$

Decompression Signal Waveform



- **Trace mode 1**
  - Using Debussy tool to display the VCD format waveform

Decompression Signal Waveform



- **Trace mode 5**
  - Using Debussy tool to display the VCD format waveform

Conclusion

- **Supports AMBA AHB wrapper for easy integration**
- **Real time on-chip AMBA bus tracer**
  - Bus trace signals captured at different abstraction levels
  - Hardware-based lossless trace compression
    - For signal characteristics, provides different compression methods
- **Flexible design allowing trade-offs between**
  - Signal/timing granularity
  - Output pin counts
  - On-chip memory size