Implementation of a Very Low Cost Portable SpaceWire Monitor and Debugger

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The Need for a Very Low Cost SpaceWire Debugger

- An objection raised to the use of SpaceWire is that it is not as widespread as other interfaces proposed for space. MIL-STD 1553, RS-422, IEEE-1394 variants, Ethernet, I2C, and USB have been posed as alternatives.

- Many factors go into interface selection, including data transfer capacity, prior spaceflight heritage, power consumption, and development complexity. Often price and availability of test equipment are cited as a salient variables to be weighed.

- Historically, the costs of interface test equipment are generally dwarfed by other space program cost elements, such as flight hardware procurement and staffing.

- This is changing as the prevalence of high school and university student satellite projects joins ranks with small aerospace companies who may be developing only one component or a small experiment. These entities may be severely cost-constrained and may depend on uncompensated student labor and donated launch opportunities.

Rough Test Interface Costs

Approximate cost ranges of ground test equipment for various interfaces - prices $USD				
Interface	**Hardware needed**	**Software needed**	**2008 ~cost range**	**Suppliers**
MIL-STD-1553	Interface card	Incl. with hardware	$500-$2,000	SBS, Paravant, others
RS-422	USB or RS232 to 422 conv	Free d/l: Terminal software	$100-$300	Black Box, B&B, others
I2C	USB-I2C converter	Incl. with hardware	$250-$750	MCC, Total Phase, others
USB	(included with PC)	Free d/l: USBET, USBTester	$0	usb.org, Jungo, others
IEEE-1394	(included with many PCs)	Free d/l: libdc1394, VHPD1394	$0-$1500	sourceforge.net, Thesycon
Ethernet	(Included with PC)	Free d/l: tcpdump, Wireshark	$0	tcpdump.org, wireshark.org
SpaceWire	Interface card or converter	Incl. with hardware	$3,500-$12,000+	Star-Dundee, 4Links, others
	DESWBO and LA	Incl. with USB logic analyzer	$900+LA*	Dynamic Engineering

*appropriate USB logic analyzers (LA) range from $149 to $1500+

- Cost of time to become familiar with hardware and software tools, which is considerable in some case, is not included.
- **The level of capability provided by the options in the table is highly variable**

The idea: combine an inexpensive USB logic analyzer with an inexpensive SpaceWire breakout box for SpaceWire monitoring and debugging.

USB Logic Analyzers

- Logic analyzers have gone from being cumbersome, complex, expensive pieces of equipment that cost tens of thousands of dollars to small, easy-to-use devices available at near commodity pricing. This has been enabled in large part by two advances:
  - the ubiquity of the personal computer
  - the comparatively recent rise of the USB interface

- By 2008, several billion USB interface devices had entered the market, and USB had become the dominant interface in the personal computer realm.

- Over a dozen different types of USB logic analyzers were available for less than $1,000 US, offering amenities such as integrated oscilloscopes, pattern generators, as many as 34 channels per device, and up to oscillator frequencies of 1 GHz.

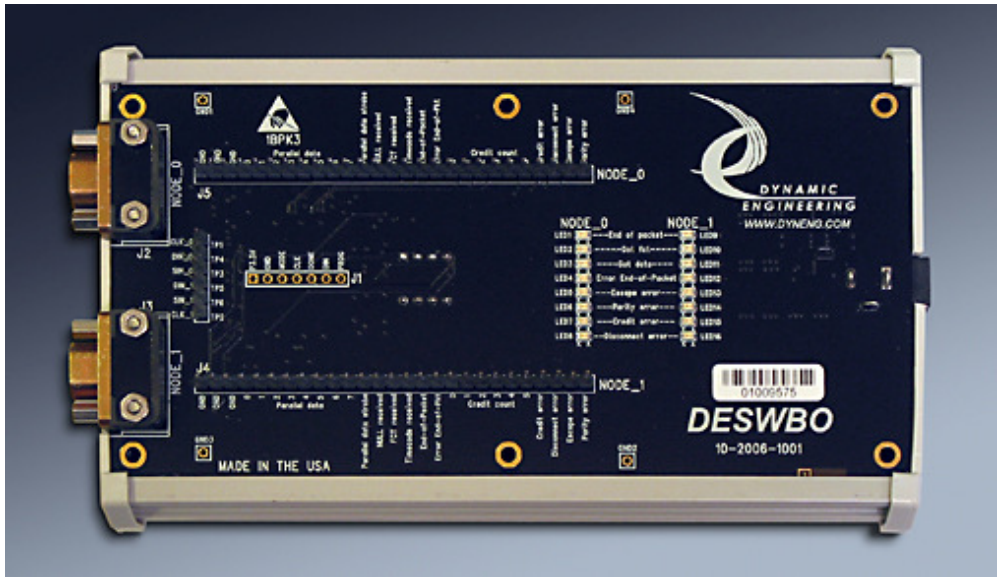
DigiView DV1-100

- 18 Channels @ 100 MHz (10ns)
- USB interface and power source for portability
- Real time Hardware Compression.
- Eliminates Resolution vs. Depth tradeoffs.
- Compression Ratio up to 256,000:1 depending on activity.
- Trigger on rising, falling or transition of any channel.
- Multi-channel High, low and don't care trigger qualifier.
- Pre-trigger and post-trigger data capture.

Information and image downloaded from http://www.tech-tools.com/dv_dv1.htm

Dynamic Engineering DESWBO

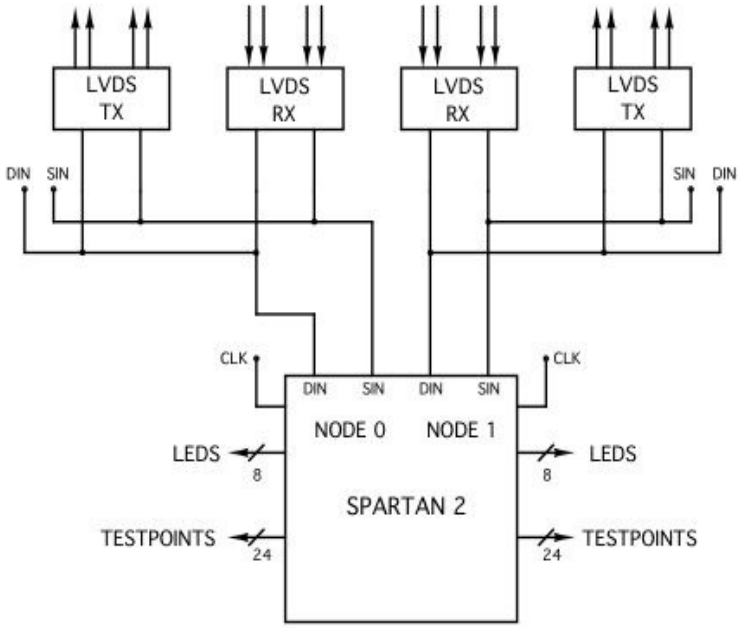
- The DESWBO monitors a single SpaceWire link and is packaged as a printed circuit board mounted on a compact enclosure with many mounting rail options.
- The board has two 9-pin MDM connectors
- Signals indicate what types of characters are passing between nodes, as well as the contents of data and timecode characters.



- A running count of flow control credits for each node is calculated by the DESWBO by monitoring FCTs and N-character occurrences.
- The low voltage differential signalling (LVDS) signals from each node are buffered and monitored by a field programmable gate array (FPGA).
- The DESWBO has been tested comprehensively with a hardware that has the ability to insert errors under software control.
- The end-of-packet, got-data and got-FCT signals from each node are connected to pulse capture and duration extension circuits to drive three green LEDs.
- The error-end-of-packet, parity error, escape error, credit error and disconnect error signals for each node drive five red LEDs.

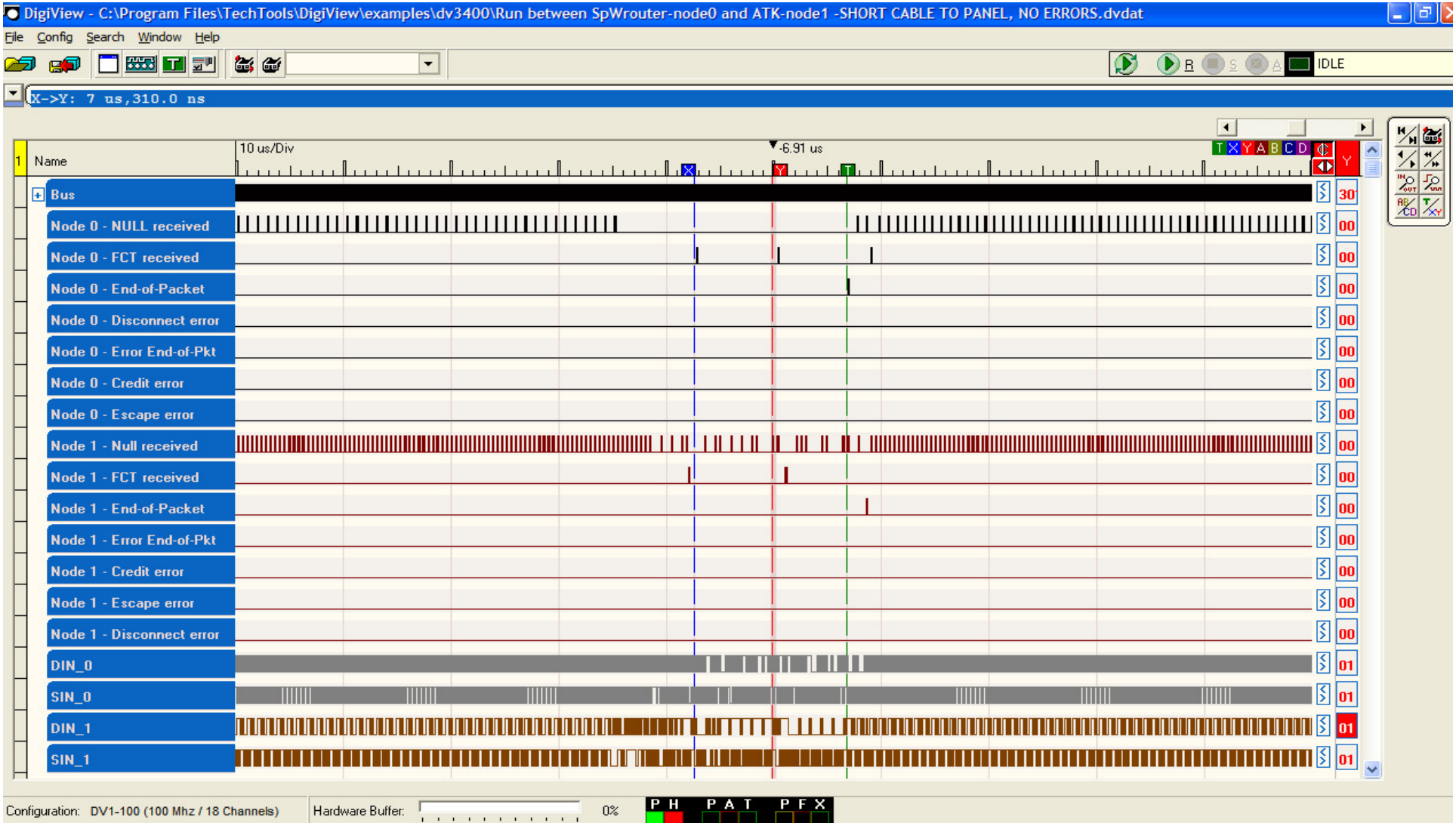
Dynamic Engineering DESWBO

- There are 24 test points for each node that are driven by the real-time signals from the SpaceWire character receivers
  - eight data bits
  - six credit count bits
  - Parallel data strobe
  - NULL received
  - FCT received
  - Timecode received
  - End-of-Packet
  - Error End-of-Packet
  - Credit error
  - Disconnect error
  - Escape error
  - Parity error

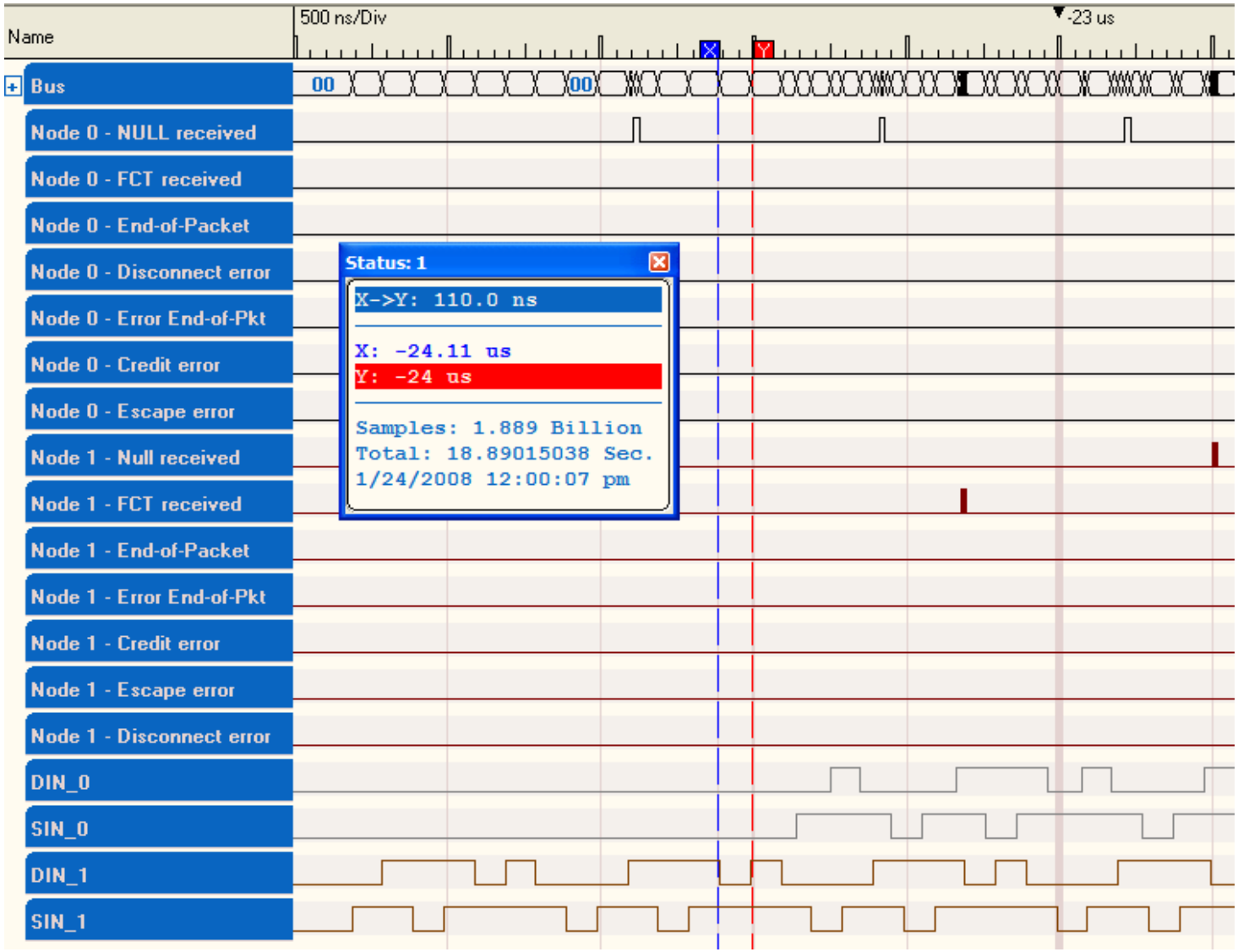


- DIN and SIN signals test points for each node from the LVDS receivers
- One test point for each node that is driven by the recovered clock
- Three ground test points per node to facilitate probe grounding.
- Powered by an included external 5-volt supply
- Cost: $900 US

Monitoring the Link

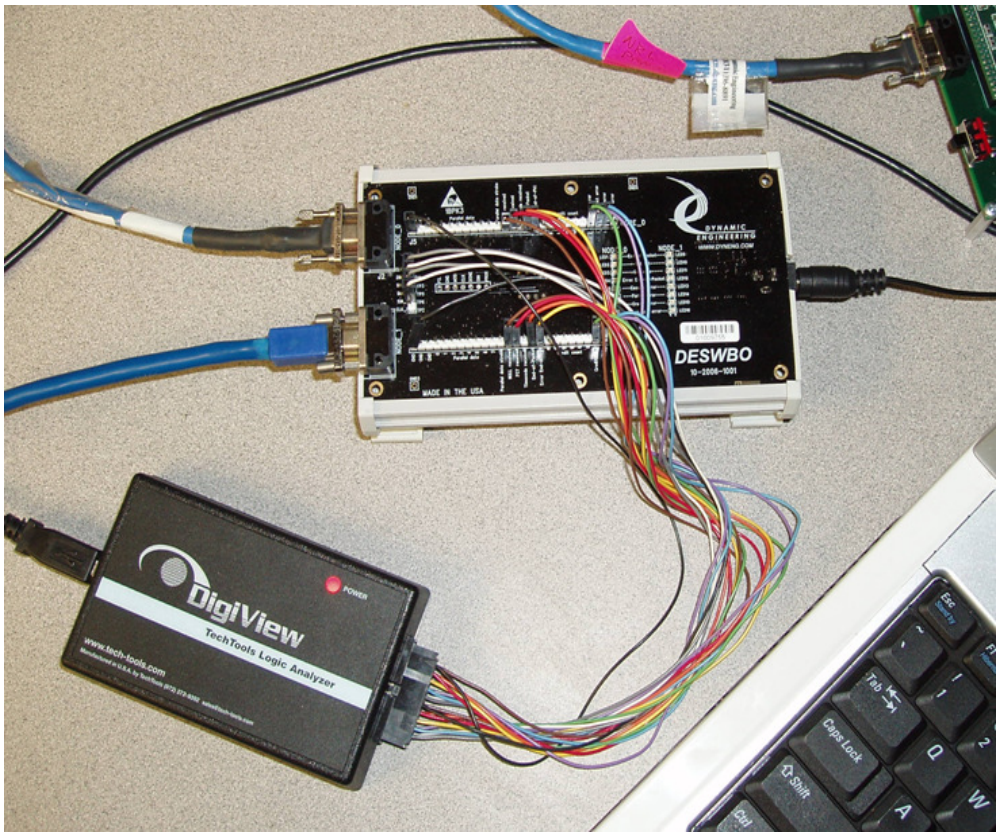


Inspecting Data & Strobe Signals



Use of the System

- This test resource has been used successfully to support TacSat-4, PnPSat, Herschel II, and other satellite projects.



Combining an inexpensive USB logic analyzer with an inexpensive SpaceWire breakout box provides a portable, capable, resource for SpaceWire monitoring and debugging.