Step Response of HYPERLABS Ultra-Broadband Baluns

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OVERVIEW

The HL940X series is an industry leading balun product used in several serial data applications. On many occasions our customers inquire about the low frequency response (or long-term step response) of the different balun varieties. This application note will address these serial data questions and show the low frequency limitations by investigating the balun step responses.

PRBS DATA PATTERNS VERSUS STEP RESPONSE

The industry standard is to implement a Pseudo Random Binary Sequence, or PRBS, to exhibit the same statistical behavior of a real-world data sequence. Typical data patterns produced using this deterministic methodology have different lengths designated as a PRBS7, PRBS15, or PRBS31 along with others. This determines the PRBS pattern length by the following equation:

$$PRBSXX = 2^{XX}-1 \quad (1)$$

Given the deterministic nature of the PRBS pattern creation, the longest string of “1”s or “0”s is given by the “XX” number. Hence, a PRBS 31 pattern could have a string of 31 identical symbols. This, when coupled with the data rate, will define the length that the step response top line needs to remain flat. See the table below for some examples of this calculation:

Table 1: Data Rate versus Step Response Relationship Examples

Data (Gb/s)	Clock (GHz)	Clock Period (ns)	PRBSXX (XX)	Pattern Length (ns)
2.5	2.5	0.40	7	2.80
6.25	6.25	0.16	31	4.96
12.5	12.5	0.08	31	2.48

The final row of this table, for example, shows that a series of 31 “1”s or “0”s at 12.5 Gb/s would have a step responses span of 2.48 ns. This directly correlates to the required low-end cutoff frequency response of the HL940X balun selected.

STEP RESPONSE OF HL940X BALUNS

To exhibit the step response of the baluns, we first measure our baseline step from a Tektronix PPG3201 being measured by a LeCroy SDA 100G sampling mainframe along with a SE-50, 50GHz sampling head. *Figure 1* shows the response of the 15.625 MHz square wave output of the system.

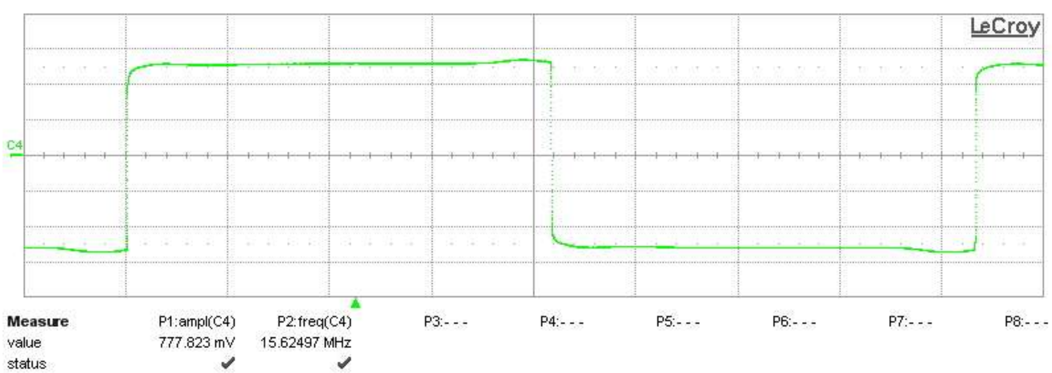


Figure 1: Baseline Step Response (7.7ns/div)

For this application note, the HL9401 will be compared to the HL9402 which have a low frequency cutoff of 100MHz, and 500kHz, respectively. After we investigate the step responses of these two baluns, we will investigate the effect that these responses have on different PRBS patterns.

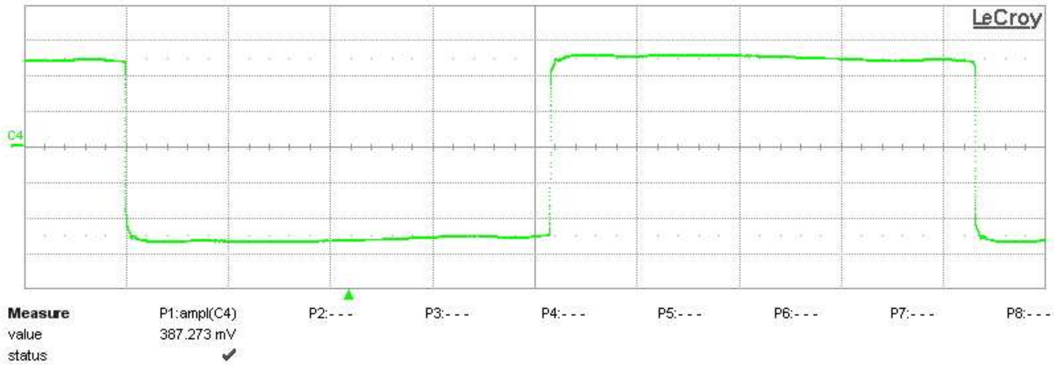


Figure 2: HL9402 Step Response (7.7ns/div)

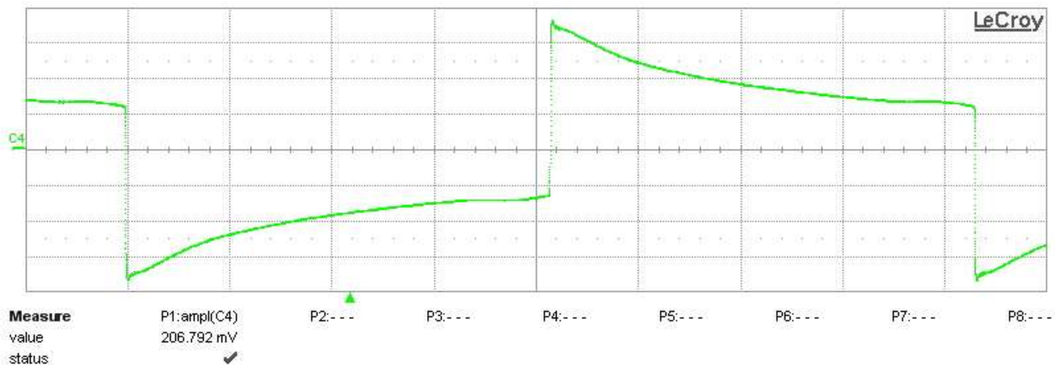
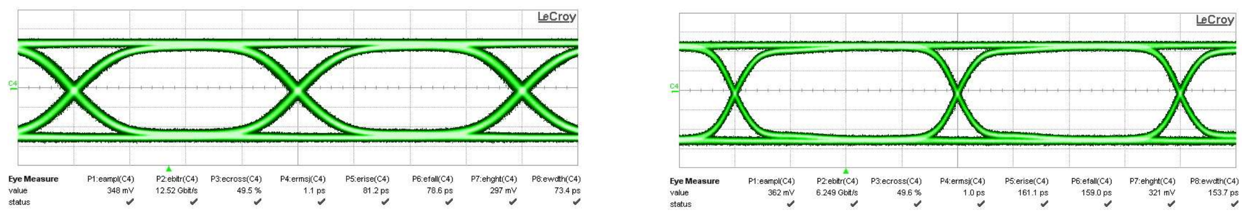


Figure 3: HL9401 Step Response (7.7ns/div)

Figure 2 and *Figure 3* show the resulting step responses through the two baluns under test. We can directly see the effect of the low frequency cutoff on the step responses, but the question that arises now is, "How does this affect the data patterns?"

DATA RESPONSE OF HL940X BALUNS

Since we want to investigate the effects on the step responses above on data patterns, we need to make a data pattern long enough to show this. Referring to *Table 1* we will use the 12.5 Gb/s and 6.25 Gb/s patterns to do our comparisons. The 6.25 Gb/s PRBS31 has a step response within the pattern sequence that correlates to a 4.96ns step.

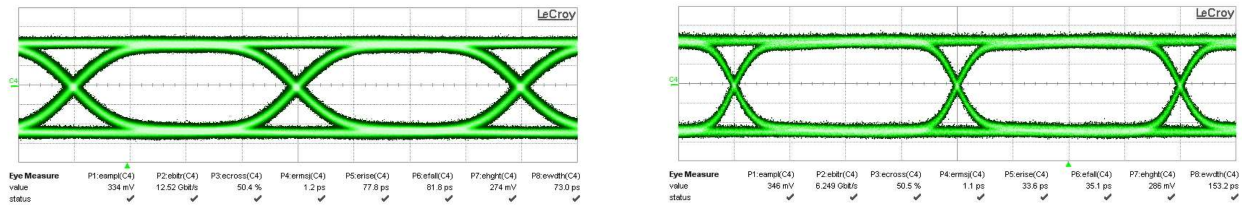


(a) (b)

Figure 4: Baseline Eye Responses to Test the Balun Throughput: (a) 12.5 Gb/s and (b) 6.25 Gb/s PRBS31.

The Plots in *Figure 4* were driven through a 6dB attenuator since the baluns have 6dB of typical loss. This addition of the attenuator on the input step will equate any sampler noise between our measurements so that we obtain a one-to-one comparison.

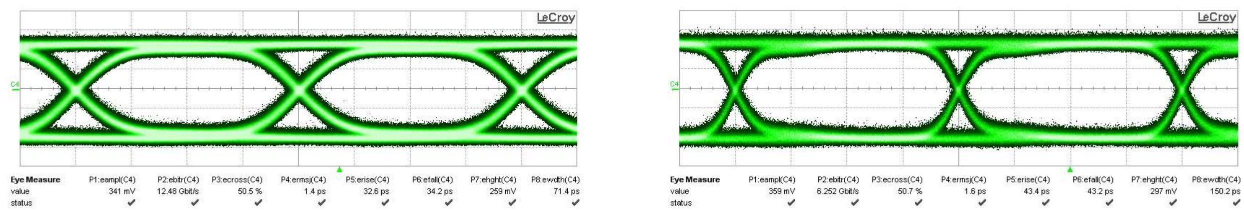
Figure 5 shows the two eye diagrams passed through a HL9402 balun. The measurements show the eye rms jitter remains roughly the same as the input eyes (1.1ps to 1.2ps and 1.0ps to 1.1ps), agreeing with the step response from *Figure 2* and the lack of sag shown in the step response. We see that the top and bottom lines are slightly blurrier than the input, but this is due to pulse distortion as it passes through the balun, not due to any type of step response sag.



(a) (b)

Figure 5: HL9402 Eye Responses to Test the Balun Throughput: (a) 12.5 Gb/s and (b) 6.25 Gb/s PRBS31.

Figure 6 shows the two eye diagrams passed through a HL9401 balun. The measurements show the eye rms jitter increases significantly from the input eyes (1.1ps to 1.4ps and 1.0ps to 1.6ps), showing the effects of the pulse response from *Figure 4* and the amount of sag shown in the step response. These eyes will also contain the pulse distortion from the balun along with the step response sag.



(a) (b)

Figure 6: HL9401 Eye Responses to Test the Balun Throughput: (a) 12.5 Gb/s and (b) 6.25 Gb/s PRBS31.

CONCLUSION

This application note describes the effects of the low frequency response of the different HL940X baluns and the effects of this response on different input signaling. We investigated the throughput of the balun with respect to step responses and eye diagrams.

Depending on the pattern length of the signaling and the data rate, some balun selections will be a better choice over others. If lower frequency cutoffs are needed as to not distort lower data rate patterns having long lengths of “1”s or “0”s, the versions with the lower cutoffs would be needed.

We are always available to assist in any applications. Feel free to contact us.

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