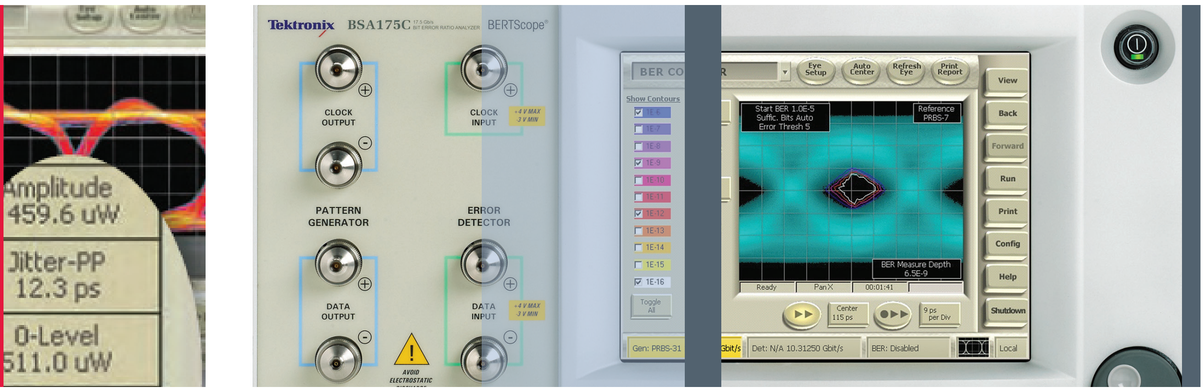

D.C. Blocks, a Trap for the Unwary When Using Long Patterns

Application Note

Introduction

It is common in high speed digital applications to use a d.c. block in test setups. For example, it can be useful to isolate a component – such as an optical receiver that requires a bias voltage on the signal path – from either damaging or being damaged by other instruments in the signal path. In addition to attributes such as low insertion loss and good return loss, a key specification of a d.c. block is its frequency response. It is obvious to focus on ensuring that the upper frequency of the range is adequate to pass the desired data signal; while it is less obvious to worry about the low end frequency specification, we will see that it can be equally important.

Pattern	Length (bits)	Lowest Frequency Component for a 10 Gb/s signal
PRBS-7	127	78.7 MHz
PRBS-9	511	19.5 MHz
PRBS-1	12,047	4.9 MHz
PRBS-1	532,767	305 kHz
PRBS-2	38,388,607	1.2 kHz
PRBS-3	12,147,483,647	5 Hz
CJTPAT	2,640	3.8 MHz

Table 1. Lowest frequency components for some common test patterns.

Background

A simple rule of thumb is that the lowest frequency contained in an NRZ spectrum will be around (data rate [in Gb/s]) /(test pattern length). For example, for a 10 Gb/s signal, a PRBS-7 containing 127 bits will have its lowest frequency component around 80 MHz. This and other examples are shown in the table. The frequency we've calculated also corresponds with the line spacing in the spectrum. See Table 1.

As will be obvious by now, a d.c. block that does not have a low enough frequency cutoff at the bottom end might attenuate frequency components of a signal involving a longer pattern, affecting measurement results.

Figure 1 is a reminder of the characteristics of an NRZ data spectrum. Figure 2 shows two example pattern lengths, as well as two d.c. blocks (described in the next section), along with their low end cutoff frequencies.

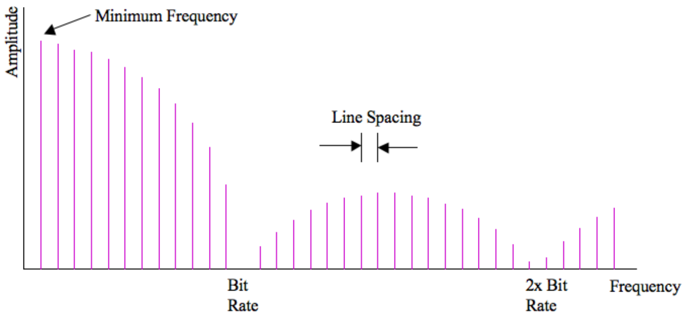

Figure 1. Reminder of an NRZ spectrum, with nulls at multiples of the bit rate, and sin(x)/x envelope. The minimum frequency and line spacing are both given by the formula in the text, with examples in Table 1.

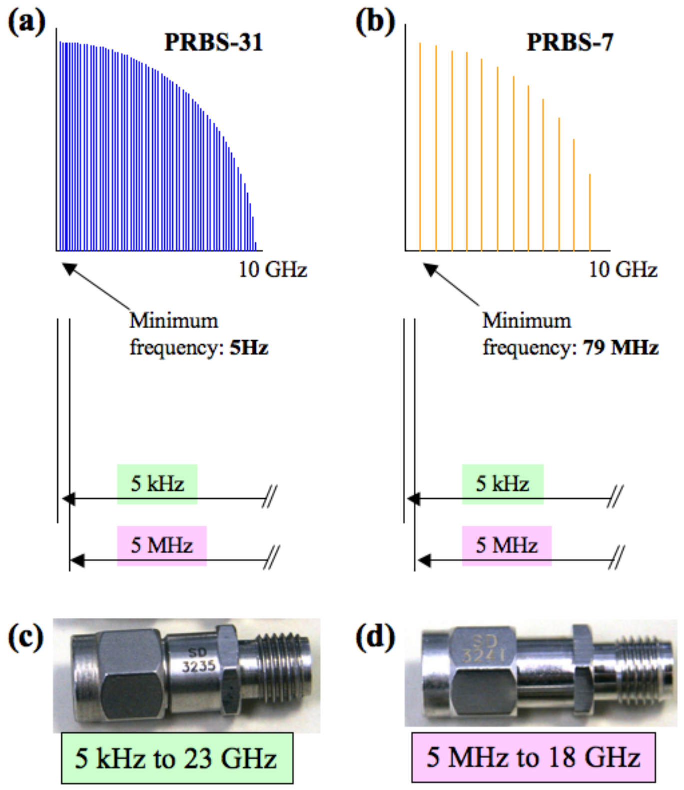

Figure 2. The minimum frequency in the longest common test pattern, PRBS-31 (a) is shown alongside one of the commonest short patterns, PRBS-7 (b). The minimum frequencies of two different models of d.c. blocks (c) and (d) are also shown.

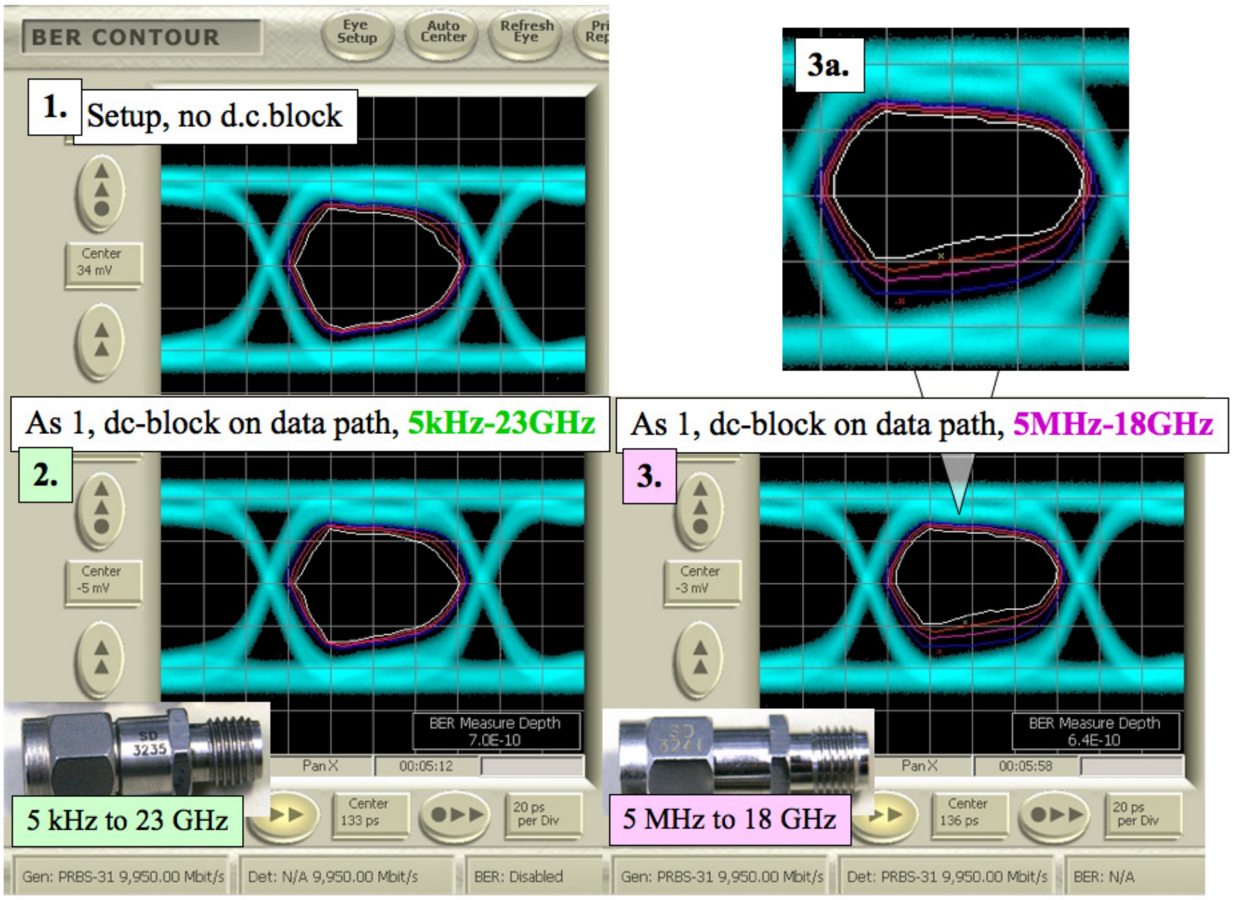

Figure 3. Passing 9.95 Gb/s data using a PRBS-31 pattern. (1) shows the signal after passing through the measurement setup but d.c. coupled; (2) has the better of the two d.c. blocks in place, (3) has a 5 MHz lower frequency cutoff and shows significant eye degradation.

A Simple Experiment

We ordered two different model d.c. blocks from the same manufacturer. The two models were:

(a) 5 kHz to 23 GHz

(b) 5 MHz to 18 GHz

The maximum frequencies are similar, but there are three orders of magnitude difference in the low end; 5 kHz compared with 5 MHz. As can be seen from Figure 2, for a short pattern such as PRBS-7, both models should be capable of passing the entire low end of the spectrum; for PRBS-31 both are likely to clip the low end, but by not passing appreciable energy below 5 MHz, the second model d.c. block is likely to be altering the signal in a noticeable way. The results of the experiment are shown in Figure 3, with significant closure in the BER Contour observable at low probabilities. A shallow eye diagram would show negligible difference, but a real receiver would be negatively impacted by the block with the higher bottom-end cutoff frequency.

Conclusion

PRBS-31 is a particularly exacting pattern in many ways. As demonstrated above, combining such a long pattern with a d.c. block requires care. Using one that removes appreciable low end energy can affect system performance and measurements. (This was learned through bitter practical experience — much time was wasted trying to track down the source of unexpected results before realizing it wasn't the device under test after all.)

Contact Tektronix:

ASEAN / Australasia	(65) 6356 3900
Austria*	00800 2255 4835
Balkans, Israel, South Africa and other ISE Countries	+41 52 675 3777
Belgium*	00800 2255 4835
Brazil	+55 (11) 3759 7600
Canada	1 (800) 833-9200
Central East Europe, Ukraine and the Baltics	+41 52 675 3777
Central Europe & Greece	+41 52 675 3777
Denmark	+45 80 88 1401
Finland	+41 52 675 3777
France*	00800 2255 4835
Germany*	00800 2255 4835
Hong Kong	400-820-5835
India	000-800-650-1835
Italy*	00800 2255 4835
Japan	81 (3) 6714-3010
Luxembourg	+41 52 675 3777
Mexico, Central/South America & Caribbean	52 (55) 56 04 50 90
Middle East, Asia and North Africa	+41 52 675 3777
The Netherlands*	00800 2255 4835
Norway	800 16098
People's Republic of China	400-820-5835
Poland	+41 52 675 3777
Portugal	80 08 12370
Republic of Korea	001-800-8255-2835
Russia & CIS	+7 (495) 7484900
South Africa	+27 11 206 8360
Spain*	00800 2255 4835
Sweden*	00800 2255 4835
Switzerland*	00800 2255 4835
Taiwan	886 (2) 2722-9622
United Kingdom & Ireland*	00800 2255 4835
USA	1 (800) 833-9200

*** If the European phone number above is not accessible, please call +41 52 675 3777**

Contact List Updated 25 May 2010

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