# Bit Rate Multiplication of High Speed Pulses

## White Paper

PN 200-0300-00
Revision 1.2
January 2009

## Overview

Bit rate multiplication enables researchers to increase the pulse frequency of their existing pulsed laser sources. Calmar's Bit Rate Multiplier can increase pulse repetition rates by 2, 4, 8, and 16 times. When used in combination with a 40 GHz laser source, the repetition rate will be up to 640 GHz.

Calmar's Bit Rate Multiplier splits the input pulse into two identical images, and sends them to a Mach-Zehnder interferometer. One leg of the interferometer has variable pulse delay and amplitude equalization, while the other leg has fixed bit pattern delay. Bit pattern delay ensures that the output is a pseudo-random bit sequence (PRBS) when the input signal is PRBS. After re-combination, the repetition rate is twice the input rate. By cascaded up to four stages, the bit rate can be multiplied 16 fold. Figure 1 is a schematic of the Bit Rate Multiplier.

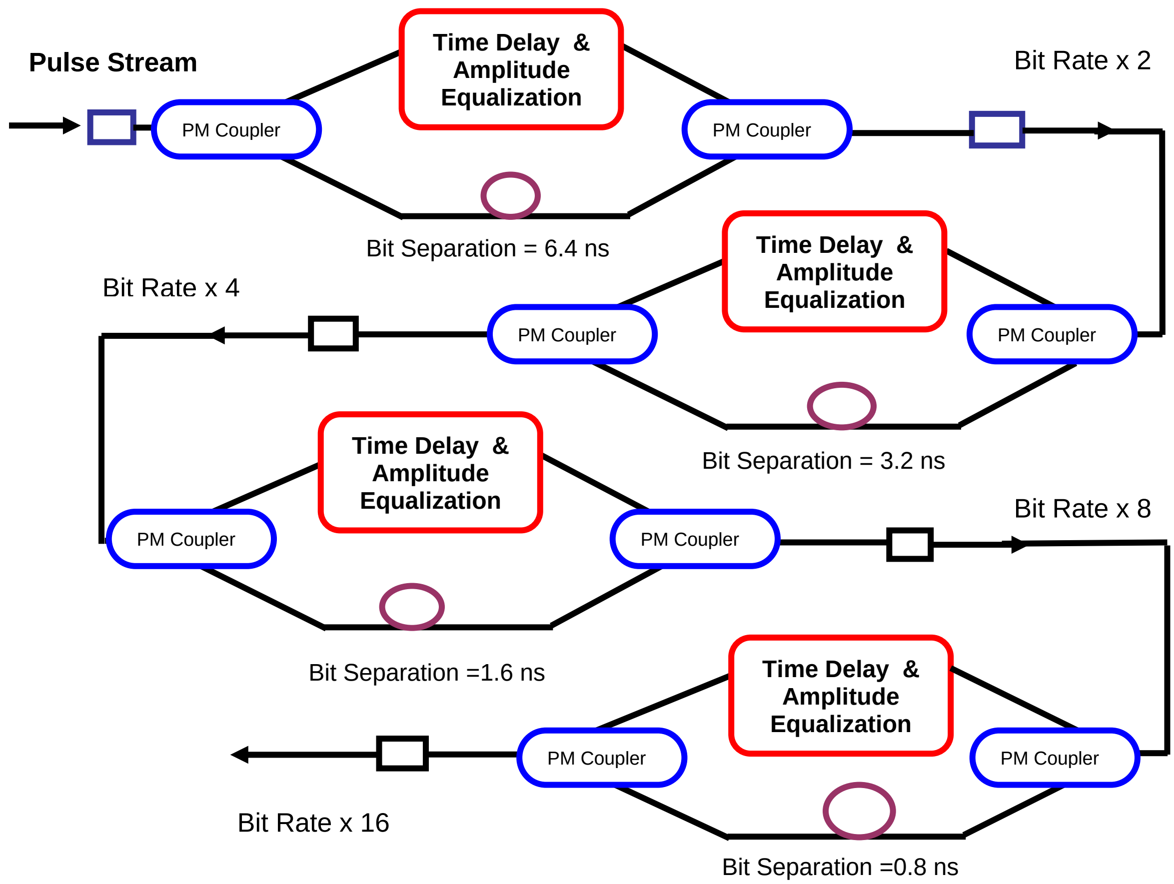



**Figure 1 – Schematic of Bit Rate Multiplier**

The bit-pattern delays shown in Figure 1 are for a $2^7 - 1$ bit pattern length.

## Features


- Bit rate multiplication x2, x4, x8 and x16 input bit rate
- Wavelength range 1530 – 1560 nm
- Polarization extinction ratio > 20 dB
- Output format $2^7$-1 PRBS
- Sequential polarization switching
- Amplitude equalization
- Tunable delay
- Temperature stability 10 ppm/°C
- Easy configuration and operation
- Long term stability

## Applications

Engineers working at the leading edge of telecom research are often restricted by a lack of test and measurement equipment capable of probing at ultra high speeds. While solutions exist at speeds lower than 10 Gb/s, there is a shortage of test equipment that can adequately support research at 10 Gb/s, 40 Gb/s and higher.

Bit rate multipliers, when used in combination with a pulsed laser source, such as Calmar's 10GHz Picosecond Fiber laser, provide engineers with repetition rates up to 160 GHz; when used with Calmar's 40 GHz Picosecond Fiber Laser, provide repetition rates up to 640 GHz.

The availability of very high pulse rates facilitates a wide variety of applications, including high-speed sampling, dynamic time response analysis of opto-electronic components, and optical code division multiple access (O-CDMA).

## Technical Specifications

The following table provides specifications for Calmar's Bit Rate Multiplier.

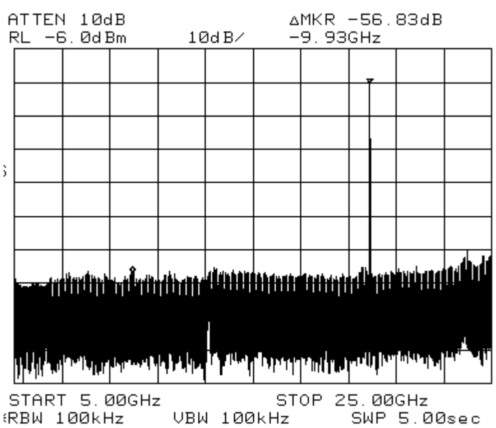
These specifications are subject to change without notice.

| **Model Number** | **BRM-T-2** | **BRM-T-4** | **BRM-T-8** | **BRM-T-16** |
|---|---|---|---|---|
| Multiplication Factor | 2 | 4 | 8 | 16 |
| Wavelength (nm) | 1530 - 1560 | 1530 - 1560 | 1530 - 1560 | 1530 - 1560 |
| Polarization Extinction Ratio (dB) | > 20 | > 20 | > 20 | > 20 |
| Input Data Format | $2^7$-1 to $2^{31}$-1 PRBS | $2^7$-1 to $2^{31}$-1 PRBS | $2^7$-1 to $2^{31}$-1 PRBS | $2^7$-1 to $2^{31}$-1 PRBS |
| Output Data Format | $2^7$-1 PRBS | $2^7$-1 PRBS | $2^7$-1 PRBS | $2^7$-1 PRBS |
| Tunable Delay (ps) | 70 | 70 | 70 | 70 |
| Temp Stability (ppm/°C) | 10 | 10 | 10 | 10 |
| Insertion Loss (dB) | 5 | 10 | 15 | 20 |
| Dimensions (cm) | 48(w) x 42(d) x 9(h) | 48(w) x 42(d) x 9(h) | 48(w) x 42(d) x 9(h) | 48(w) x 42(d) x 9(h) |

**Table 1 – Specifications for Bit Rate Multiplier**

## Performance

The following test results give an indication of the performance of Calmar's Bit Rate Multiplier. Figure 2 shows the microwave spectrum for a 20 GHz output signal that was achieved by multiplying a 10 GHz input signal by a factor of two. The 10 GHz signal has been suppressed by over 55 dB. Figure 3 shows the microwave spectrum for a 40 GHz output that was achieved by multiplying a 10 GHz input signal by a factor of four. The 10 GHz, 20 GHz, and 30 GHz components have been suppressed by over 35 dB.



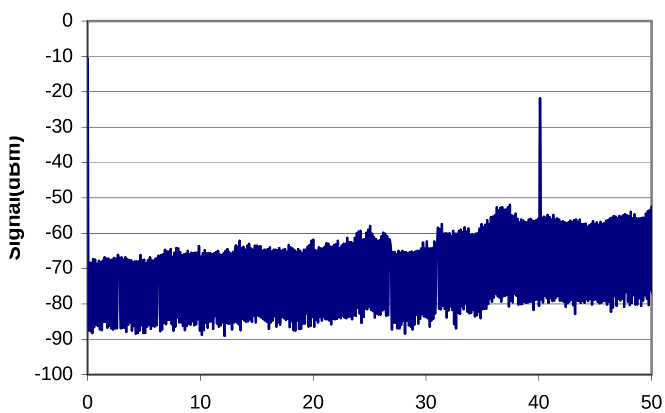
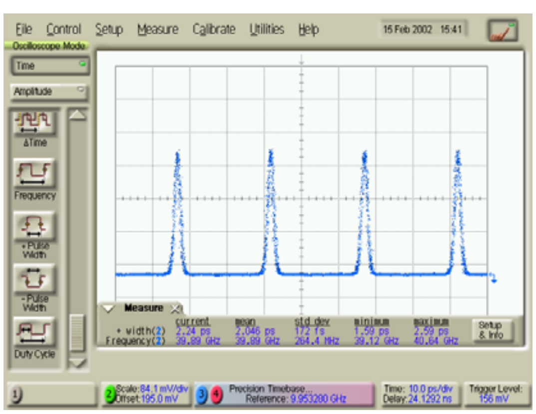




**Figure 2 – 20GHz output signal, after x 2 multiplication**

**Figure 3 – 40 GHz output signal, after x 4 multiplication**

Figures 4 shows an optical sampling scope trace for a 40 GHz signal that was derived from a 10 GHz input signal. Figure 5 shows a trace for a 160 GHz signal that was derived form a 10 GHz input signal. The sampling scope speed used to obtain these traces was over 800 GHz.



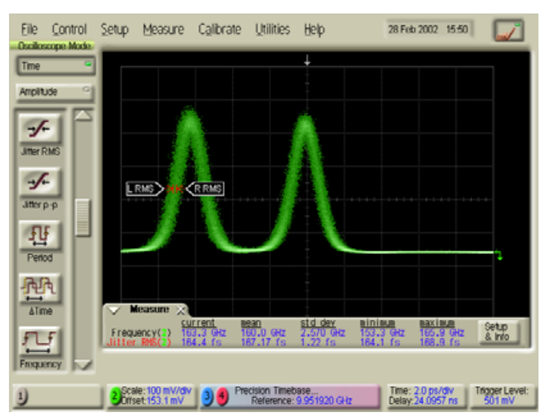


**Figure 4 – Sampling scope trace for 40 GHz output signal**

**Figure 5 – Sampling scope trace for 160 GHz output signal**

For more information on our Picosecond Fiber Laser series, Femtosecond Fiber Laser series, or any other Calmar products, please contact us.

**E-mail:**

sales@calmarlaser.com

**Telephone:**

(408) 733-7800, extension 110

**Fax:**

(408) 733-3800

**Mail:**

Calmar Laser
755 N. Pastoria Avenue
Sunnyvale
CA 94085