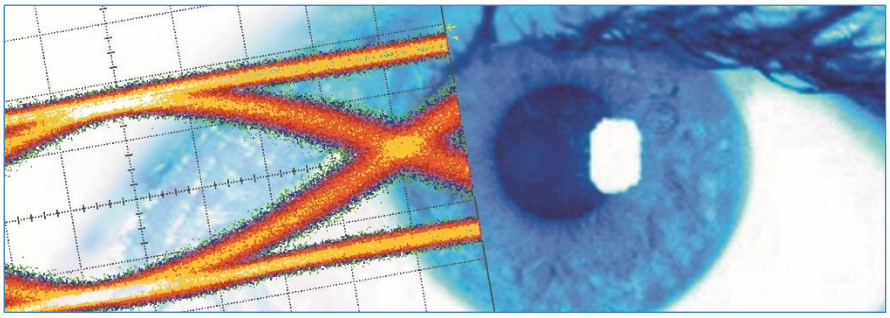
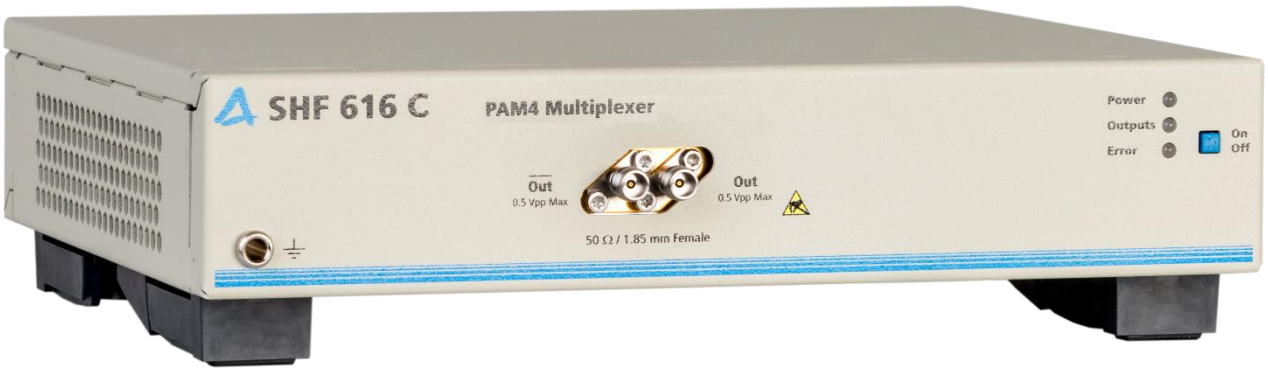


Data Sheet

SHF 616 C



128 GBaud
PAM4 Multiplexer

Description

The SHF 616 C is a PAM4 Multiplexer operating at PAM4 baud rates up to 128 GBaud (256 Gbps) for use in broadband test setups and telecom transmission systems.

The SHF 616 C is driven by four single ended serial NRZ data streams. Each two of these signals are multiplexed to two binary data streams of double the speed. These two high speed signals are internally combined to one differential PAM4 signal. With a programmable SHF BPG (e.g. the SHF 12105 A) you have full control of the patterns into the PAM4-MUX. The SHF Control Center (SCC) software package unifies the BPG to PAM4-MUX combination to virtually one 128 GBaud PAM4-Bit Pattern Generator. A typical setup is shown in the figure 1 below.

A single ended clock signal with a frequency equivalent to the input data rate is required to drive the SHF 616 C. For data regeneration purposes all input data signals are re-sampled to mitigate any signal impairments resulting e.g. from long cables. Therefore, it is possible to place the PAM4-MUX very close to the DUT. Clock input port is AC-coupled. Data input and output ports are DC-coupled.

Features

- Broadband operation up to 128 GBaud
- Differential data output, 0.8 V differential output swing (0.4 V in single-ended operation)
- Single ended clock and data inputs
- Latched (re-timed and re-shaped) input ports
- Output amplitude, output bandwidth & input threshold level control (remote by software)

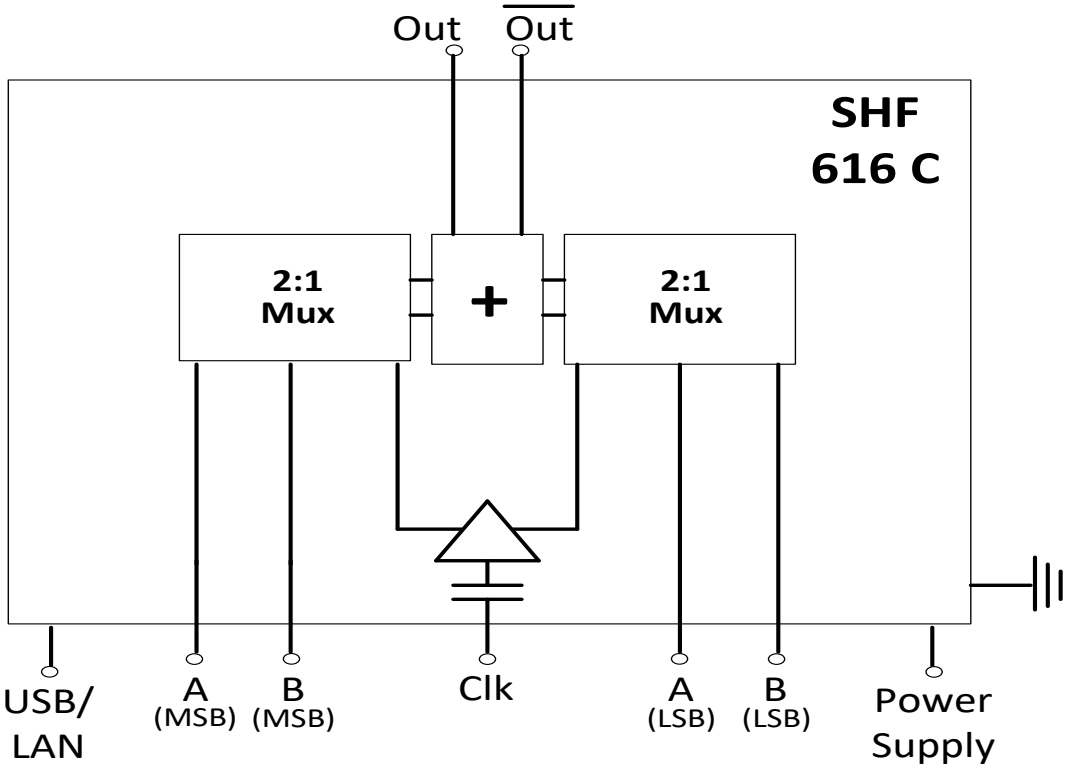
Applications

- 100G, 200G and 400G system evaluation & development
- Broadband test and measurement equipment
- PAM4 and Advanced Modulation Experiments

Available Option

- WF: 1.0 mm female connectors at the data output ports instead of 1.85 mm connectors

Block Diagram



Ease of Use

Housed in a small benchtop case, this remote head can be easily embedded in the customer's test environment close to the DUT.

Fig. 1: Typical setup with SHF clock source, SHF BPG and the PAM4-MUX

The easy to use software package, SHF Control Center (SCC) is the most convenient way to control the MUX. The software reads the individual calibration tables of the multiplexers and sets the contribution of the bias voltages accordingly. The rise and fall time (trim) and the symmetry of the output signal can be adjusted and is displayed in the graphical user interface (GUI). The duty cycle (clock bias) of the multiplexer stages as well as the input threshold level for the DC-coupled data inputs can be set. This enables the user to generate a perfect signal just by a few intuitive clicks.

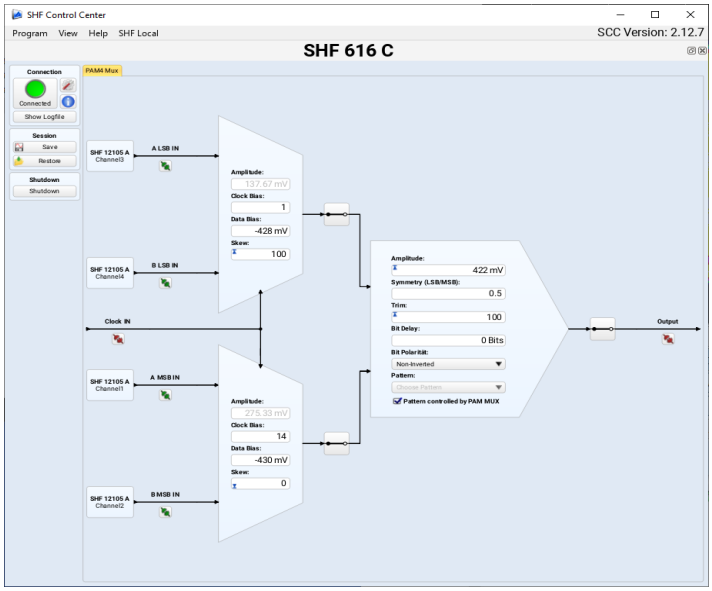


Fig. 3: SHF Control Center – GUI for the SHF 616 C

Specifications

Absolute Maximum Ratings

Parameter	Unit	Symbol	Min	Typ	Max	Comment
Data Input Voltage	mV	$V_{data\ in}$			900	Peak-to-Peak
Clock Input Voltage	mV	$V_{clk\ in}$			900	Peak-to-Peak
External DC Voltage on RF Clock Input Port	V	V_{DCin}	-10		+10	AC coupled ports
External DC Voltage on RF Data Input Ports	V	V_{DCin}	-0.6		+0.1	DC coupled inputs
DC Supply Voltage	V	V_{cc}			13	

Input Parameters

Parameter	Unit	Symbol	Min	Typ	Max	Comment
Min. Input Data Rate	Gbps	$R_{in,min}$			1.5	
Max. Input Data Rate	Gbps	$R_{in,max}$	64[1]			
Data Input Voltage	mV	$V_{data\ in}$	300		800	Eye amplitude
External DC Voltage on RF Data Input Ports	V	V_{DCin}	-0.5		0	DC coupled inputs
Min. Clock Input Frequency	GHz	$f_{in,min}$			1.5	
Max. Clock Input Frequency	GHz	$f_{in,max}$	64			
Clock Input Voltage	mV	$V_{clk\ in}$	300		800	Peak-to-Peak
External DC Voltage on RF Clock Input Port	V	V_{DCin}	-9		+9	AC coupled input

[1] The upper baud rate limit is defined by the absence of errors (BER < 10^{-12}) of a NRZ output generated with the MSB + LSB bit synchronized. The PAM4-MUX operates beyond this limit as shown in the typical eye diagrams on page 9

Output Parameters

Parameter	Unit	Symbol	Min	Typ	Max	Comment
Min. Output Data Rate	GBaud	$R_{out,min}$			3	
Max. Output Data Rate	GBaud	$R_{out,max}$	128[2]			
Output Voltage[3]	mV	V_{out}	430 350	470 420		≤ 100 GBaud > 100 GBaud Eye amplitude; Single ended; DC coupled; Full scale; Adjustable up to -6 dB
Rise / Fall Time	ps	t_r / t_f		5	6	20%...80%; Full scale; deconvolved[4]
Equivalent Output Bandwidth	GHz	BW	37	44		Derived from Rise Time using formula[5]; -3 dB bandwidth
Differential Output Skew	ps	t_{skew}		1	2	

Power Requirements

Parameter	Unit	Symbol	Min	Typ	Max	Comment
Supply Voltage	V	V_{cc}	+11.5	+12	+12.5	2.1 mm DC Power Jack
Supply Current	A	I_{cc}		950	1050	
Power Dissipation	W	P_d		11.4	12.6	@ V_C = +12 V

Mechanical Characteristics

Parameter	Unit	Symbol	Min	Typ	Max	Comment
Dimensions	mm					See Outline Drawing on pages 12-13
Weight	g			1700		

Conditions

Parameter	Unit	Symbol	Min	Typ	Max	Comment
Operating Temperature	°C	$T_{ambient}$	15		35	

[2] The upper baud rate limit is defined by the absence of errors (BER < 10^{-12}) of a NRZ output generated with the MSB + LSB bit synchronized. The PAM4-MUX operates beyond this limit as shown in the typical eye diagrams below.

[3] During start up / shut down of the SHF 616 C and turning on / off the RF outputs, voltage spikes up to +0.7 V can occur at the data output ports

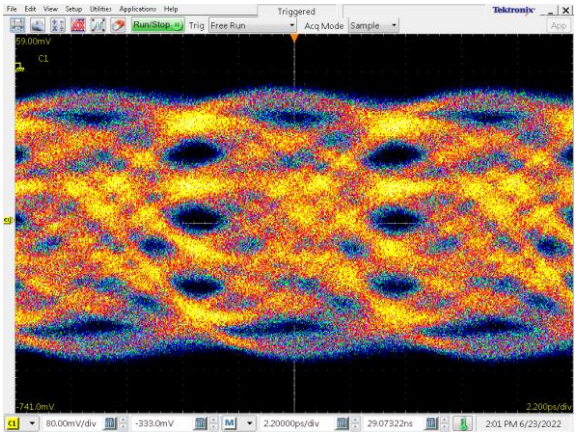
[4] Calculation based on typical rise / fall times from oscilloscope data sheet and with a NRZ output generated by bit synchronization of the MSB + LSB
$t_{r\,deconvolved} = \sqrt{(t_{r\,measured})^2 - (t_{r\,oscilloscope})^2} = \sqrt{(t_{r\,meas.})^2 - (3.68\,ps)^2}$

[5] Calculation based on formula: $BW = \frac{0{,}22}{Tr}$

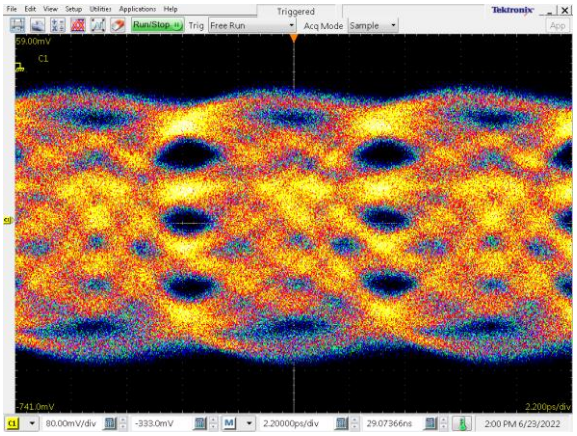
Typical Output Eye Diagrams

PAM4 Output Signal Measurement

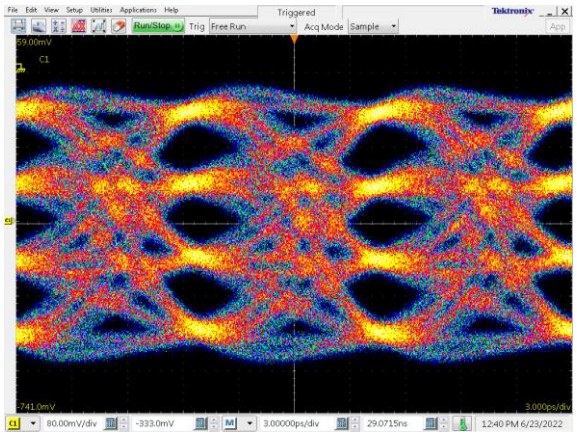
The measurements below had been performed using a SHF 12105 A Bit Pattern Generator (PRBS 2^{31}-1) and a Tektronix® DSA 8300 Digital Serial Analyzer (DSA) with Phase Reference Module (82A04B-60G) and 70 GHz Sampling Module (80E11). The outputs of the PAM4 MUX module had been connected directly to the DSA input.



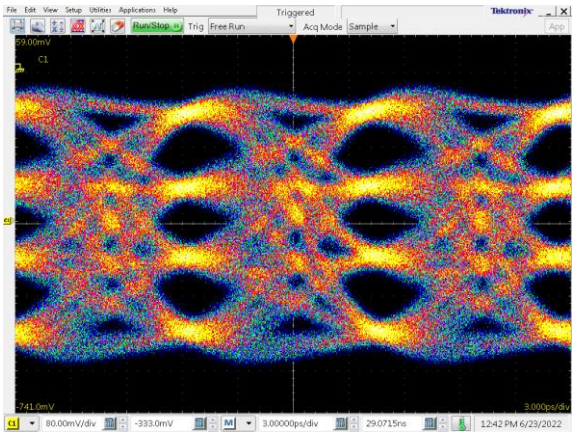
Out @ 128 GBaud (Trim=100)



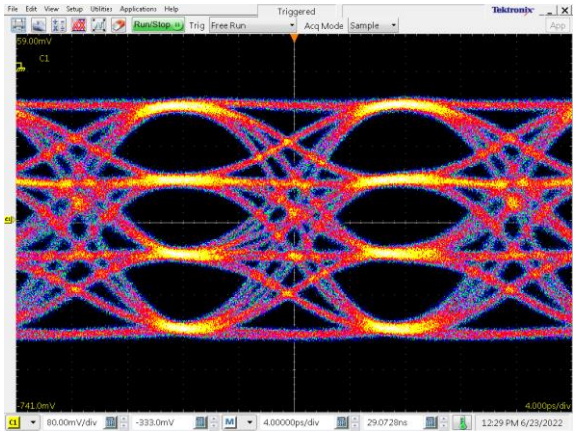
Out! @ 128 GBaud (Trim=100)



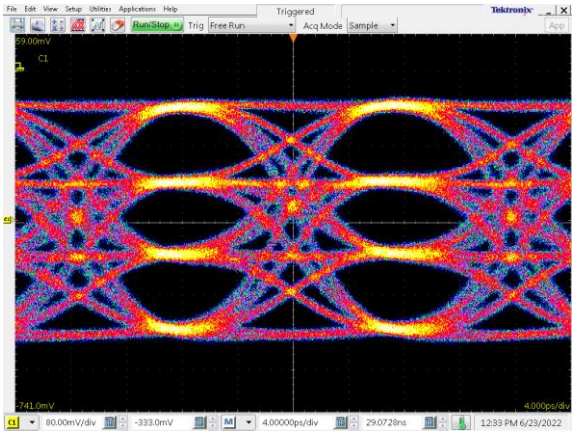
Out @ 100 GBaud (Trim=100)



Out! @ 100 GBaud (Trim=100)



Out @ 64 GBaud (Trim=25)



Out! @ 64 GBaud (Trim=25)

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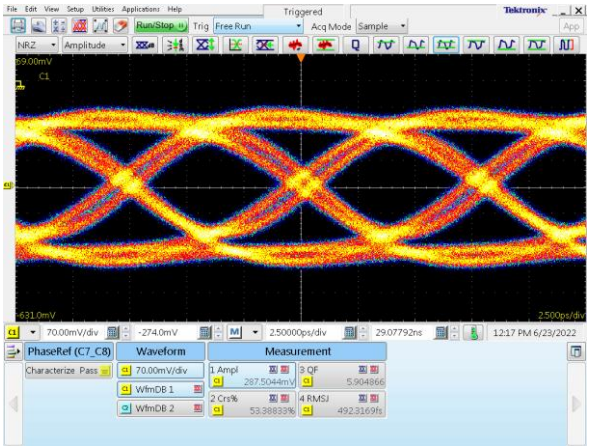
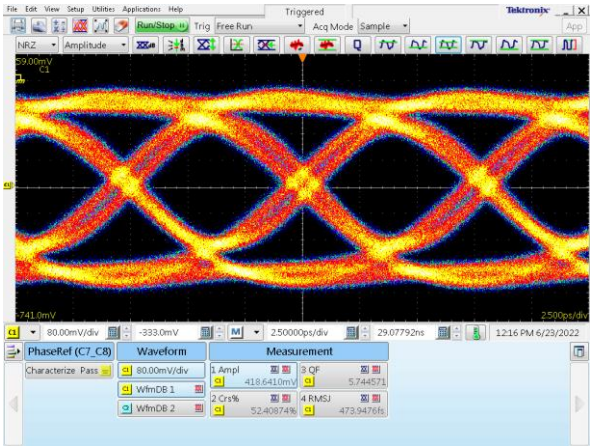
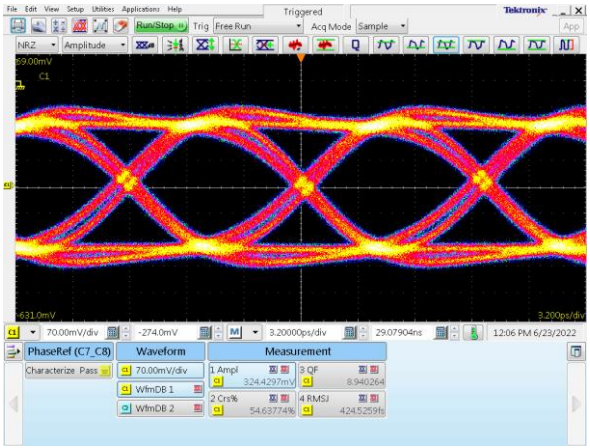
NRZ Output Signal Measurement



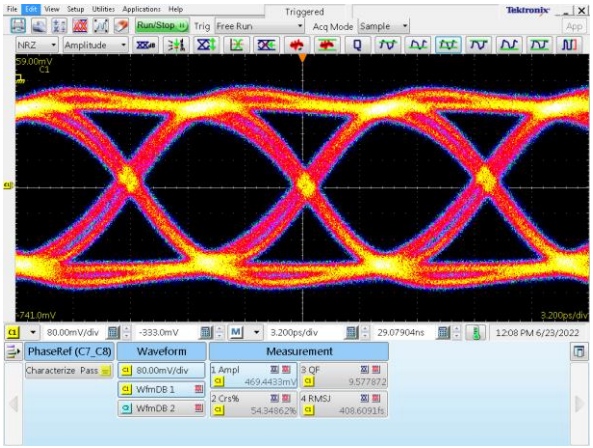
MSB @ 128 Gbps (Trim=100)



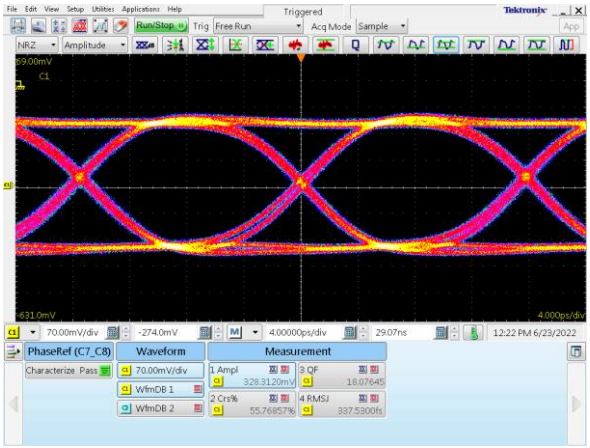
MSB+LSB (bit aligned) @ 128 Gbps (Trim=100)



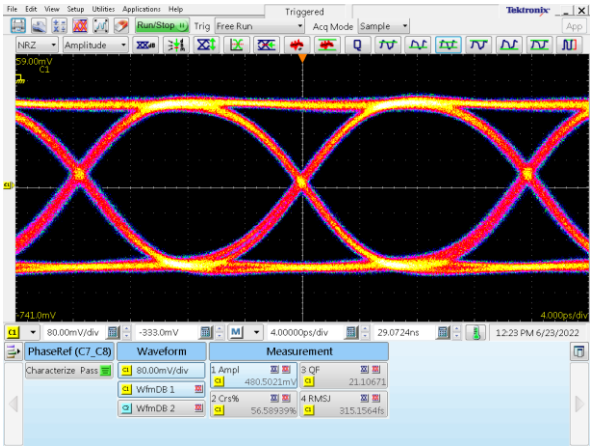
MSB @ 100 Gbps (Trim=100)



MSB+LSB (bit aligned) @ 100 Gbps (Trim=100)

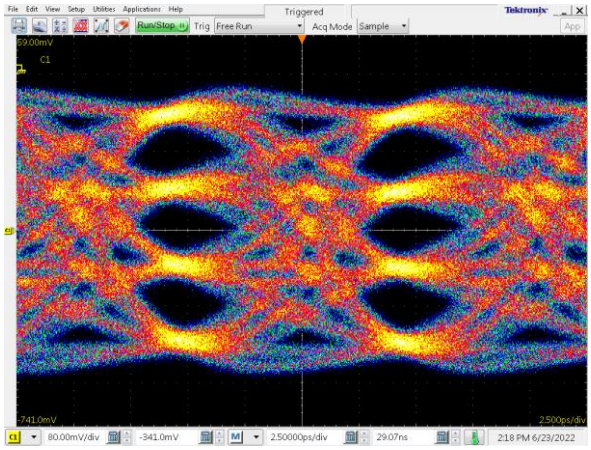


MSB @ 64 Gbps (Trim=25)

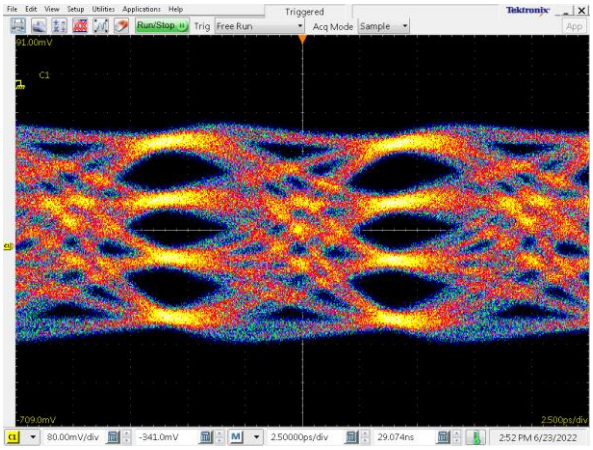


MSB+LSB (bit aligned) @ 64 Gbps (Trim=25)

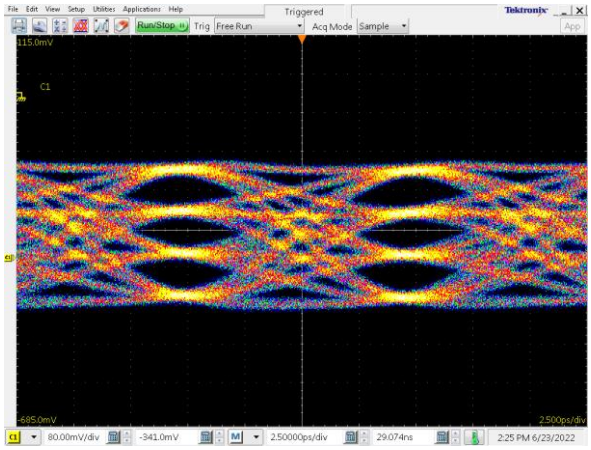
Output Amplitude Adjustment



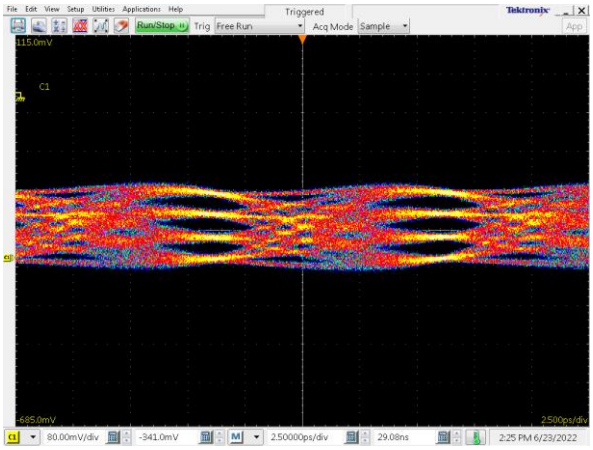
100 GBaud @ 450 mV



100 GBaud @ 350 mV



100 GBaud @ 250 mV

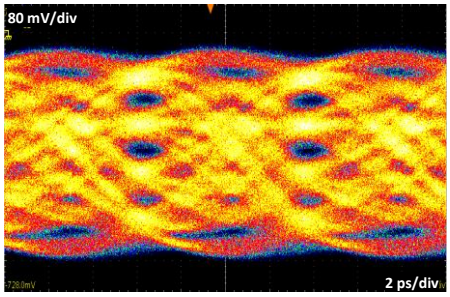


100 GBaud @ 150 mV

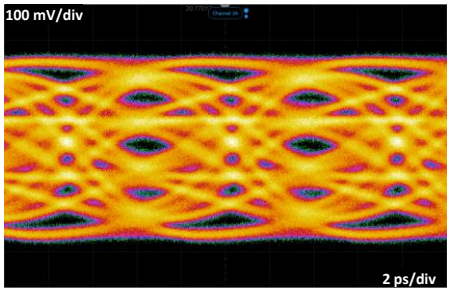
PAM4 signal oscilloscope comparison

The measurements below had been performed using a SHF 12105 A Bit Pattern Generator (PRBS 2^{20}-1), a Tektronix DSA 8300 Digital Serial Analyzer (DSA) with Phase Reference Module (82A04B-60G) and 70 GHz Sampling Module (80E11) and a Keysight DCA N1000A with Precision Timebase and 122 GHz Sampling Module (N1046A). The outputs of the module had been connected directly to the DSA/DCA input. Measurements with the Keysight DCA will not be part of the inspection report delivered with each particular device.

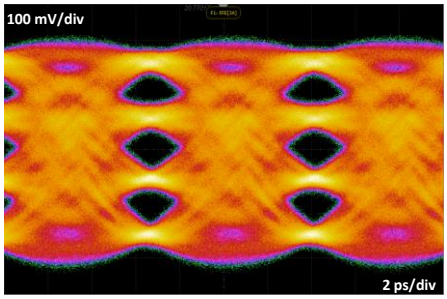
Tektronix DSA / BW = 70 GHz **Keysight DCA / BW = 122 GHz**



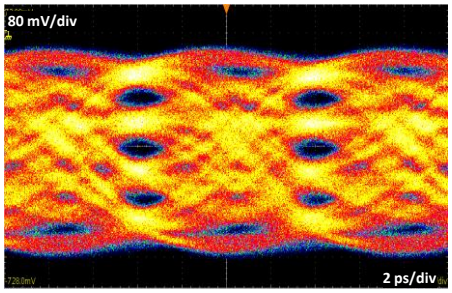
134 GBaud PAM4 measurement



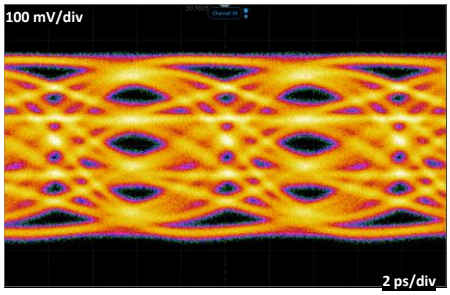
134 GBaud PAM4 measurement



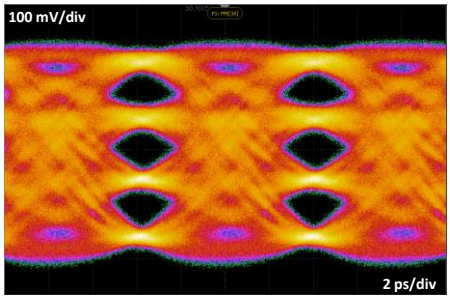
134 GBaud PAM4 measurement
+ Linear FFE (7-Tap with 2 pre cursors)



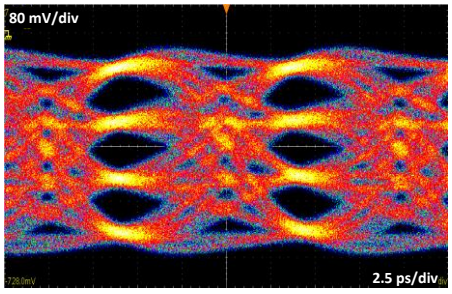
128 GBaud PAM4 measurement



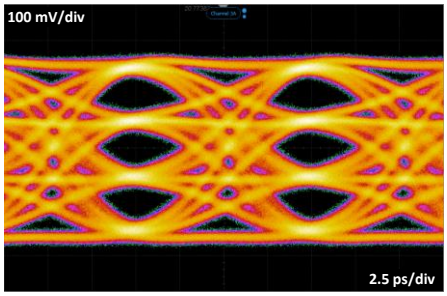
128 GBaud PAM4 measurement



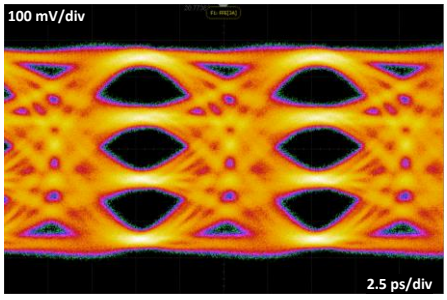
128 GBaud PAM4 measurement
+ Linear FFE (7-Tap with 2 pre cursors)



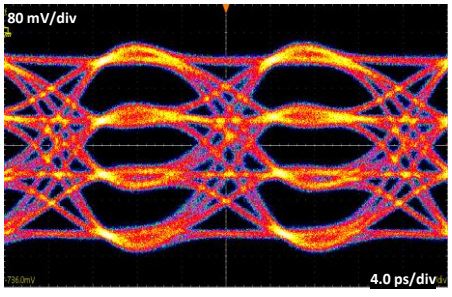
100 GBaud PAM4 measurement

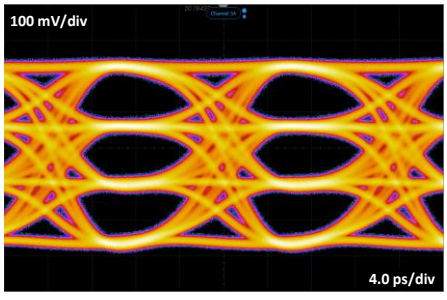


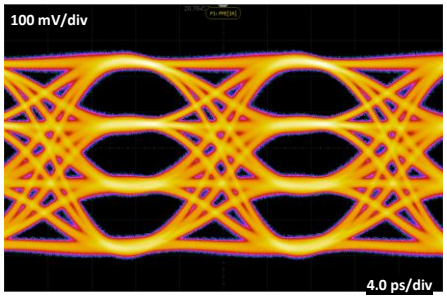
100 GBaud PAM4 measurement



100 GBaud PAM4 measurement
+ Linear FFE (7-Tap with 2 pre cursors)



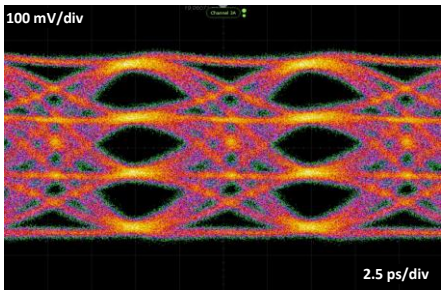




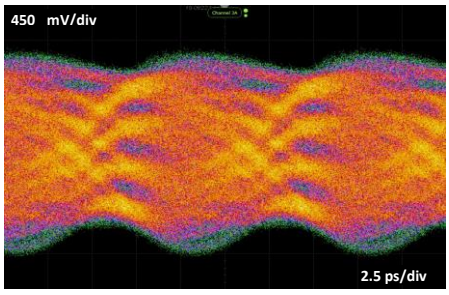
PAM4 signals with recommended output amplifier

The measurements below had been performed using a SHF 12105 A Bit Pattern Generator (PRBS 2^{13}-1), a Keysight DCA N1000A with Precision Timebase and 122 GHz Sampling Module (N1046A). The outputs of the PAM4 MUX module had been connected directly to the amplifier input. The output of the amplifier had been connected with a 20 dB attenuator (SHF ATT110 A) to the DCA input.

Output SHF 616 C -WF

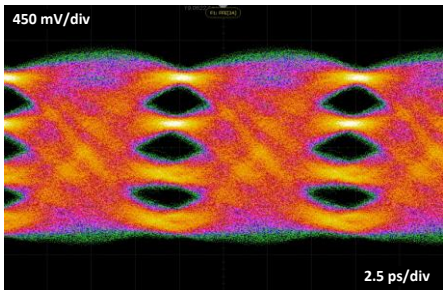


100 GBaud PAM4 measurement

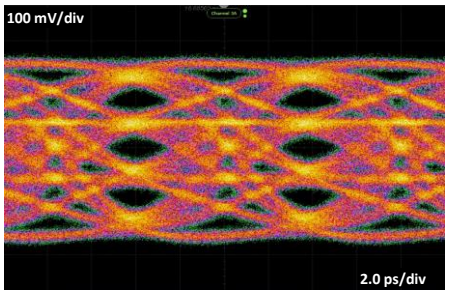


100 GBaud PAM4 measurement

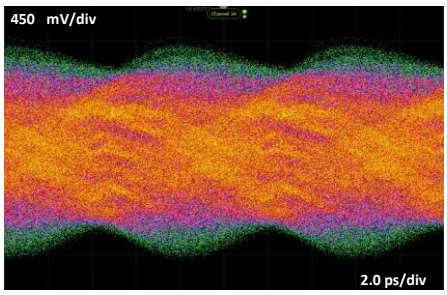
Output SHF M827 B –WMWM



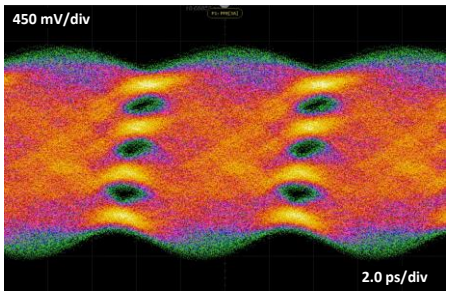
100 GBaud PAM4 measurement
+ Linear FFE (8-Tap with 2 pre cursors)



128 GBaud PAM4 measurement



128 GBaud PAM4 measurement

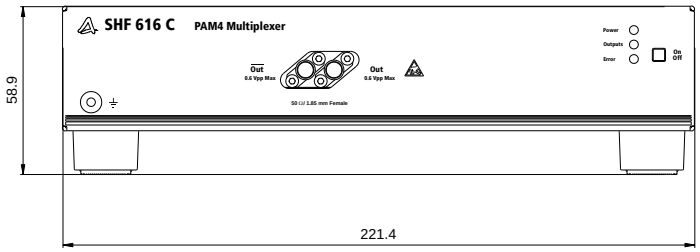


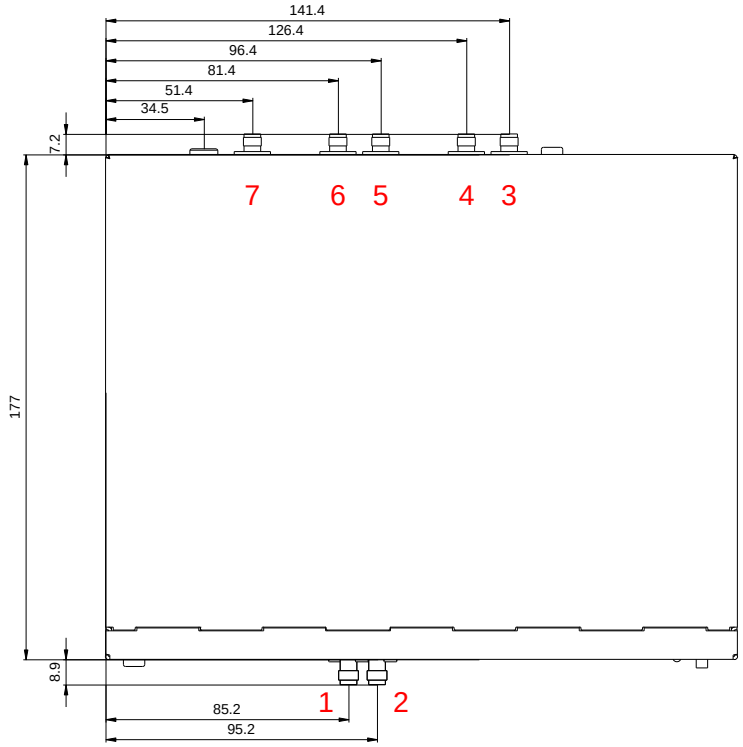
128 GBaud PAM4 measurement
+ Linear FFE (8-Tap with 2 pre cursors)

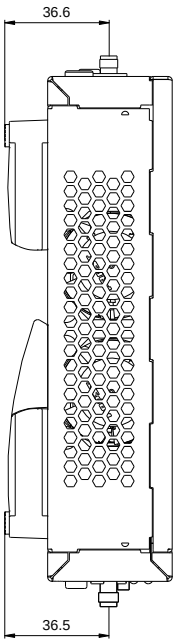
For more information about SHFs amplifiers, please refer to:

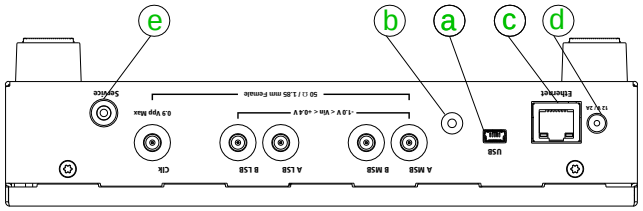
https://www.shf-communication.com/products/rf-broadband-amplifiers/

Mechanical Drawing – SHF 616 C







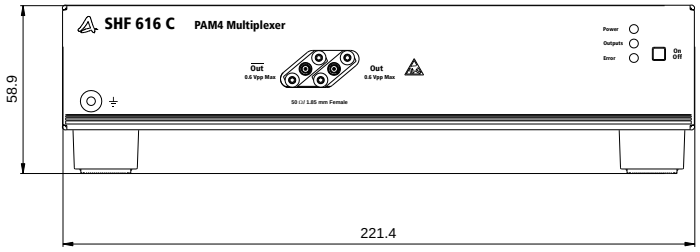


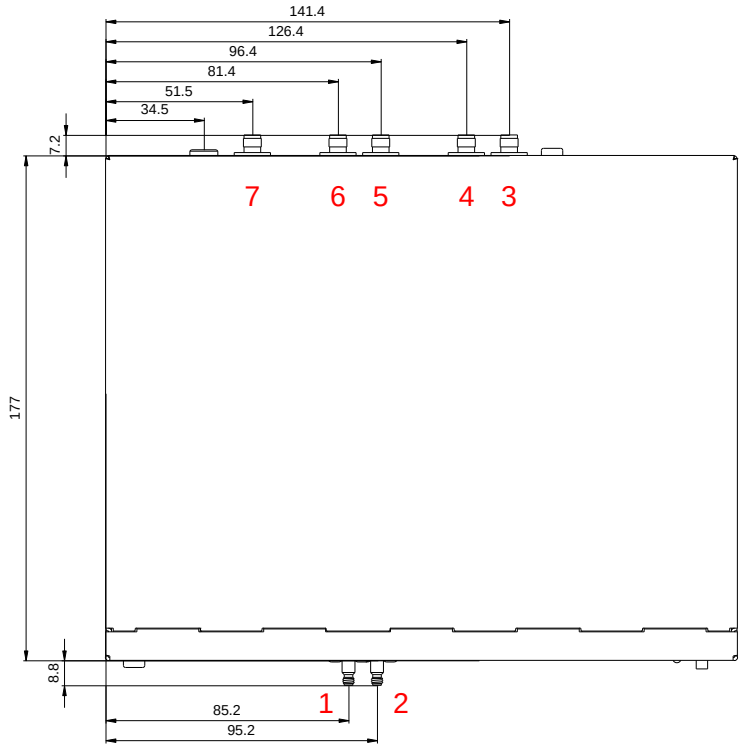
Pos.	Designation	Connector
1	Output	1.85mm (V) Female
2	Output	1.85mm (V) Female
3	A MSB	1.85mm (V) Female
4	B MSB	1.85mm (V) Female
5	A LSB	1.85mm (V) Female
6	B LSB	1.85mm (V) Female
7	Clock Input	1.85mm (V) Female

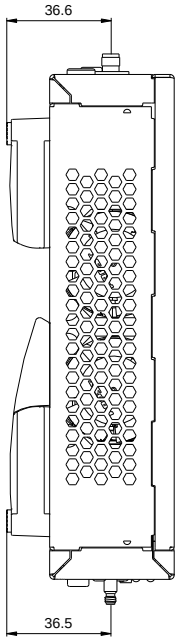
Pos.	Designation
a	USB
b	GND
c	Ethernet
d	Power Supply
e	Service

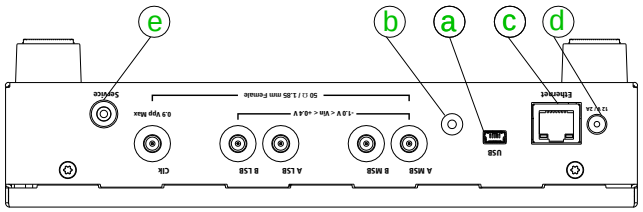
all dimensions in mm

Mechanical Drawing – SHF 616 C with Option WF









Pos.	Designation	Connector
1	Output	1.00mm Female
2	Output	1.00mm Female
3	A MSB	1.85mm (V) Female
4	B MSB	1.85mm (V) Female
5	A LSB	1.85mm (V) Female
6	B LSB	1.85mm (V) Female
7	Clock Input	1.85mm (V) Female

Pos.	Designation
a	USB
b	GND
c	Ethernet
d	Power Supply
e	Service

all dimensions in mm

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