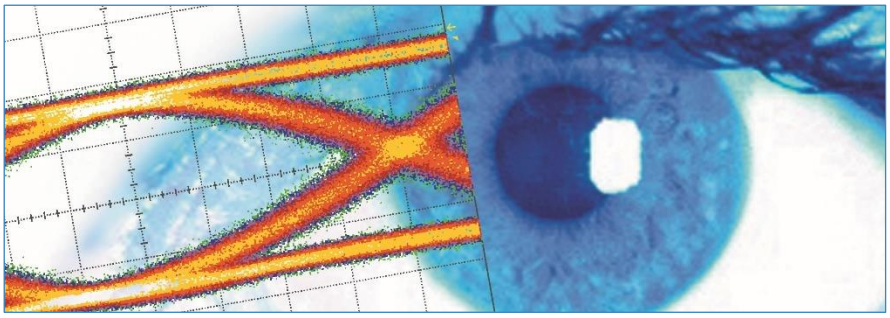


# Data Sheet

# SHF C911 A


## 32 / 67 GBaud 4-Bit DAC

## Description

The SHF C911 A is a 4-Bit Digital-to-Analog Converter (DAC) operating at symbol rates either up to 32 or 67 GBaud for use in broadband test setups and telecom transmission systems. Four single ended serial data streams of up to 32 or 67 Gbps are accepted by the DAC and converted into one differential 16-level data signal of up to 32 or 67 GBaud. By using two input ports only it is possible to generate 4-level output signals. A single ended clock signal with the same frequency as the data rate drives the SHF C911 A. Thus the baud rate of the resulting PAM signal is as fast as the sample rate of the system.

For data regeneration purposes all input data signals are re-sampled to mitigate any signal impairments resulting e.g. from long cables. Therefore, it becomes possible to place the DAC very close to the DUT. Clock input port and data output ports are AC-coupled. Data input ports are DC-coupled.

## Features

- Broadband operation up to 32 or 67 GBaud
- Output baud rate = sample rate
- Differential data output, 570 mV single ended output swing
- Single ended clock and data inputs
- Latched input ports
- Output level control
- Controlled by intuitive graphical user interface SHF Control Center (SCC) via USB

## Applications

- 100G, 200G and 400G system evaluation & development
- OC-768 / STM-256 applications
- Telecom transmission
- Fibre Channel®
- Broadband test and measurement equipment

## Configurations

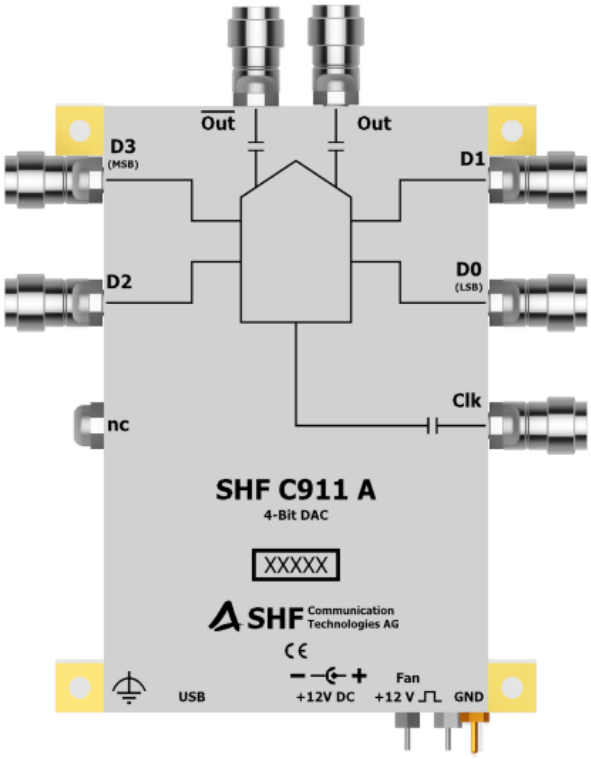
- 32: Operation up to 32 GBaud
- 67: Operation up to 67 GBaud

® Fibre Channel is a registered trademark of the Fibre Channel Industry Association

## Accessories

- +12 V Power Supply Desktop Adapter
- Mini-USB cable
- Functional earth cable → Connection to test setup ground has to be set up first before any other connection to prevent instrument damage!

## Block Diagram



## Ease of Use

The SHF C911 A DAC module including the power supply and the cooling measures can easily be embedded in the customer's test environment. It is to be connected to a computer by USB. At delivery the DAC module is mounted and connected to an active heat sink. The heat sink fans are regulated and powered by the DAC module. The DAC may also be used without the delivered heat-sink in case other adequate cooling measures are provided.

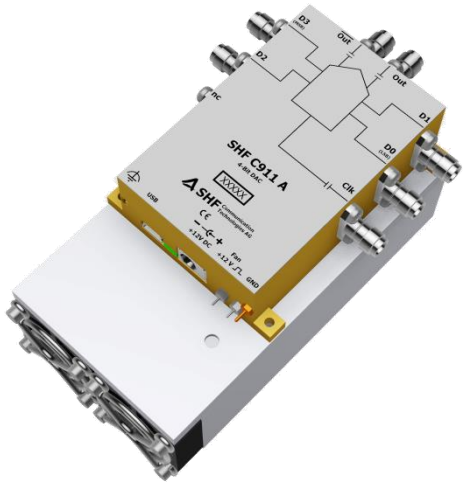



**Fig. 2: SHF C911 A**

The DAC is controlled by the easy to use SHF Control Center (SCC) software package. The software reads the individual calibration tables of the DAC and sets the contribution of the bias voltages accordingly. The amplitude of the individual eye openings as well as the input threshold level for the DC-coupled data inputs can be set and is displayed in the graphical user interface (GUI). This enables the user to generate a perfect signal with a few intuitive clicks.

This SCC software interface does further support the user in case the SHF C911 A DAC is connected to another SHF instrument. For example, if the DAC is connected to a SHF 12105 A Bit Pattern Generator (BPG) the software unifies the two discrete instruments to one single multi-level source. The user can program the signal desired at the DACs output; the SCC automatically translates the desired output multi-level pattern to the four individual binary patterns which are stored in the BPGs user pattern memory and sent to the DACs inputs.

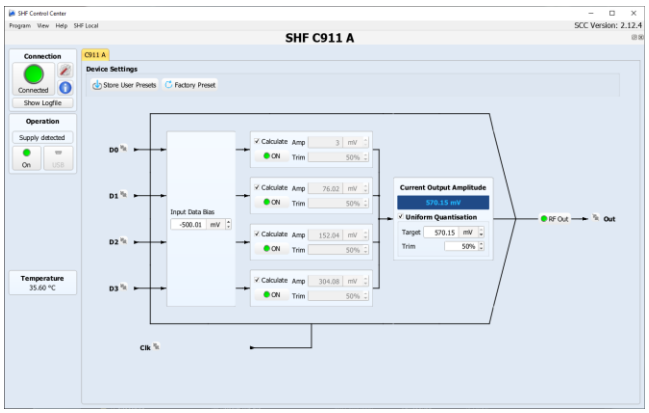



**Fig. 3: SHF Control Center – GUI for the SHF C911 A**

# Specifications

### Absolute Maximum Ratings

| Parameter | Unit | Symbol | Min | Typ | Max | Comment |
|---|---|---|---|---|---|---|
| Data Input Voltage | mV | $V_{data\ in}$ | | | 950 | Peak-to-Peak |
| Clock Input Voltage | mV | $V_{clk\ in}$ | | | 950 | Peak-to-Peak |
| External DC Voltage on RF Clock Input Port & Data Output Ports | 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 | $V_{cc}$ | | | 14 | |

### Input Parameters

| Parameter | Unit | Symbol | Min | Typ | Max | Comment |
|---|---|---|---|---|---|---|
| Min. Input Data Rate | Gbps | $R_{in,min}$ | | | 5 | |
| Max. Input Data Rate | Gbps | $R_{in,max}$ | 67[1]<br>32[1] | | | Configuration 67<br>Configuration 32 |
| Data Input Voltage | mV | $V_{data\ in}$ | 200 | | 850 | Eye amplitude |
| External DC Voltage on RF Data Input Ports | V | $V_{DCin}$ | -0.5 | | 0 | DC coupled inputs |
| Min. Clock Input Frequency | GHz | $f_{in,min}$ | | | 5 | |
| Max. Clock Input Frequency | GHz | $f_{in,max}$ | 67<br>32 | | | Configuration 67<br>Configuration 32 |
| Clock Input Voltage | mV | $V_{clk\ in}$ | 200 | | 900 | 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. The DAC operates beyond this limit as shown in the typical eye diagrams below.

## Output Parameters

| Parameter | Unit | Symbol | Min | Typ | Max | Comment |
|---|---|---|---|---|---|---|
| Min. Output Data Rate | GBaud | $R_{out,min}$ | | | 5 | |
| Max. Output Data Rate | GBaud | $R_{out,max}$ | 67[2]<br>32[2] | | | Configuration 67<br>Configuration 32 |
| Output Voltage | mV | $V_{out}$ | 520 | | | Eye amplitude;<br>Single ended;<br>AC coupled;<br>Full scale;<br>Adjustable up to -6 dB |
| Rise / Fall Time | ps | $t_r$ / $t_f$ | | | 6.8<br>8.2 | Configuration 67<br>Configuration 32<br>20%...80%;<br>Full scale;<br>deconvolved[3] |
| Equivalent Output Bandwidth | GHz | BW | 32<br>27 | | | Configuration 67<br>Configuration 32<br>Derived from Rise Time using formula[4];<br>-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 | +12.0 | +12.5 | |
| Supply Current | A | $I_{cc}$ | | 0.86<br>0.96 | | Without heat sink<br>With heat sink |
| Power Dissipation | W | $P_d$ | | 10.3<br>11.5 | | Without heat sink<br>With heat sink<br>@ $V_{CC}$ = +12 V |

[2] The upper baud rate limit is defined by the absence of errors (BER < $10^{-12}$) of a NRZ output.

[3] Calculation based on typical rise / fall times from oscilloscope data sheet and with a NRZ output generated by bit synchronization of the MSB + LSB

$t_{r\ deconvolved} = \sqrt{(t_{r\ measured})^2 - (t_{r\ oscilloscope})^2} = \sqrt{(t_{r\ meas.})^2 - (3.68\ ps)^2}$

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

### Integrated Fan Control[5]

| Parameter | Unit | Symbol | Min | Typ | Max | Comment |
|---|---|---|---|---|---|---|
| Output Voltage Fan | V | $V_{Fan+12V}$ | | +12 | | 30 Hz – PWM-Signal |
| Output Current Fan | A | $I_{Fan+12V}$ | | 0.13 | | |
| Input Tacho Fan | V | $V_{Fan\ Tacho}$ | | 3.3 | | |

### Mechanical Characteristics

| Parameter | Unit | Symbol | Min | Typ | Max | Comment |
|---|---|---|---|---|---|---|
| Clock In | Ω | | | 50 | | Configuration 67:<br>1.85 mm (V) female<br><br>Configuration 32:<br>2.92 mm (K) female |
| Data In | Ω | | | 50 | | Configuration 67:<br>1.85 mm (V) female<br><br>Configuration 32:<br>2.92 mm (K) female |
| Data Out | Ω | | | 50 | | Configuration 67:<br>1.85 mm (V) female<br><br>Configuration 32:<br>2.92 mm (K) female |
| Dimensions | mm | | | | | See Outline Drawing on pages 20 - 23 |
| Weight | g | | | 190<br>480 | | Without heat sink<br>With heat sink |

### Conditions

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

[5] It is necessary to operate the module with the supplied heat sink and fan or an adequate cooling measure

## Output Amplitudes

Below mentioned values assume no attenuation to be set in the control software. The output amplitude of the DAC can be reduced by 0 to -6 dB by making the appropriate setting in the control software.

| Output Amplitude | | | | | |
|---|---|---|---|---|---|
| **Input D3 (MSB)** | **Input D2** | **Input D1** | **Input D0 (LSB)** | **Minimum Output Amplitude [mV]** | **Maximum Output Amplitude [mV]** |
| - | - | - | On | **30** | **45** |
| - | - | On | - | **70** | **90** |
| - | On | - | - | **140** | **180** |
| On | - | - | - | **280** | **360** |

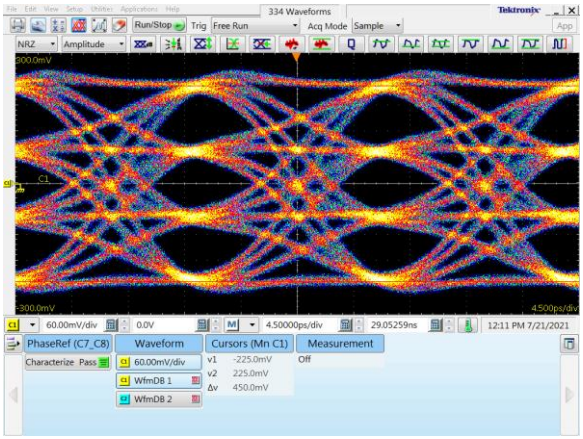
The output amplitude of a multilevel signal can be calculated by accumulating the output amplitudes of all applied input ports of the DAC as shown in the table above. Thus the full scale output swing (all inputs active) accumulates as follows:

| | | | | | |
|---|---|---|---|---|---|
| On | On | On | On | **520** | **675** |

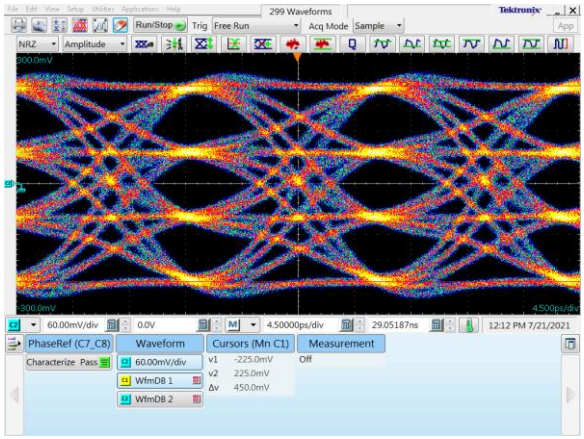
# Typical Output Waveforms – Configuration 67

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 DAC module had been connected directly to the DSA input with a 10 dB attenuator. In all measurements the most significant bits have been used, i.e. 4-Level = D3,D2, 8-Level = D3,D2,D1 and 16-Level = D3,D2,D1,D0.

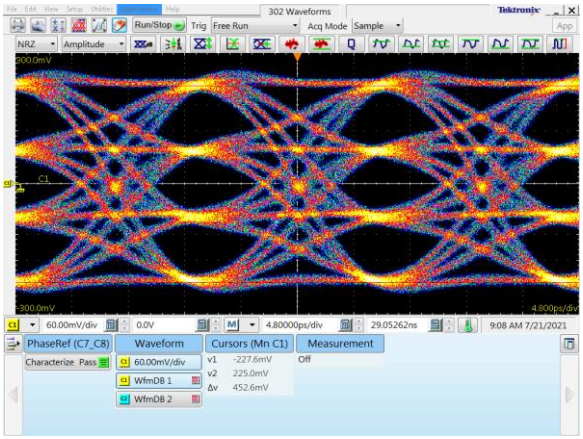
**4-Level Output Signal Measurement**



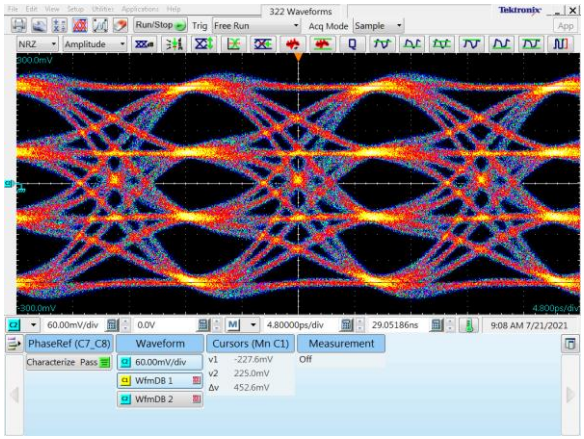
Out @ 67 GBaud



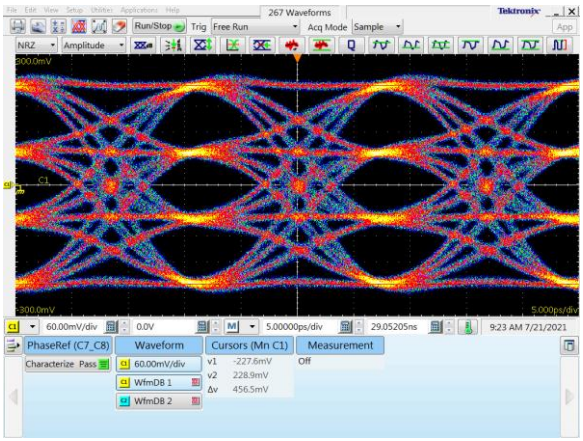
Out! @ 67 GBaud



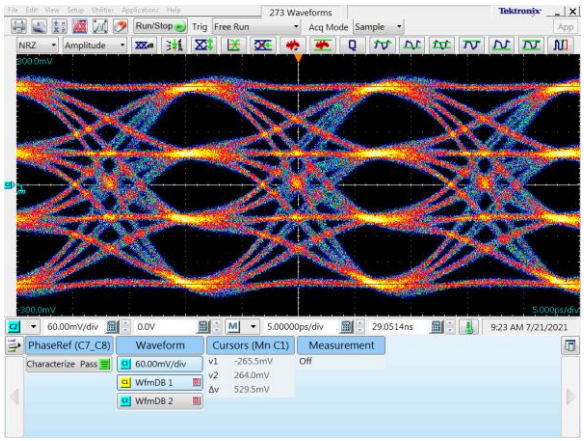
Out @ 64 GBaud



Out! @ 64 GBaud

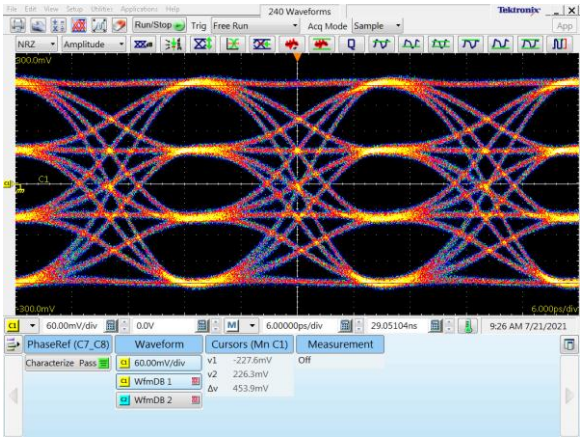


Out @ 60 GBaud

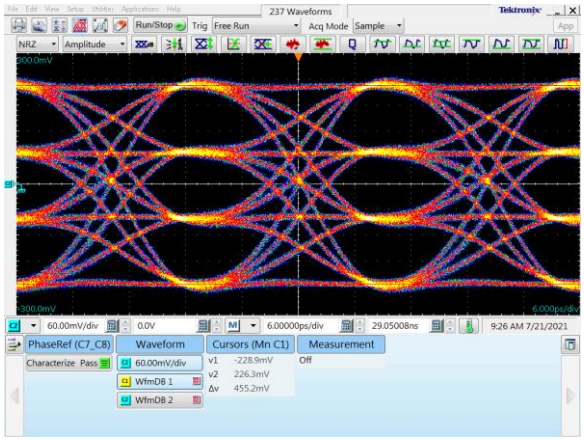


Out! @ 60 GBaud

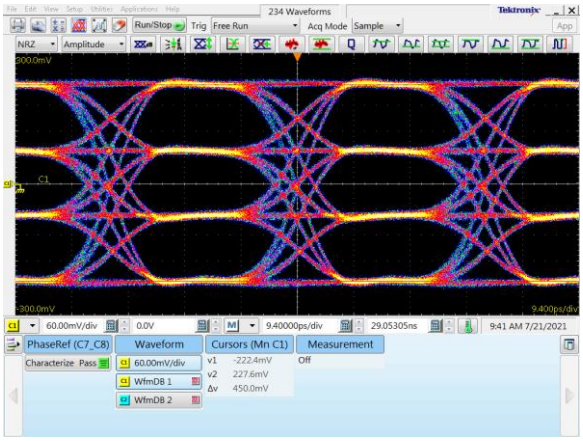
## 4-Level Output Signal Measurement



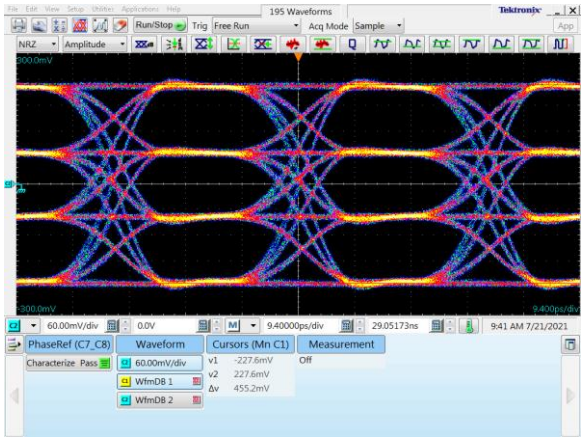
Out @ 50 GBaud



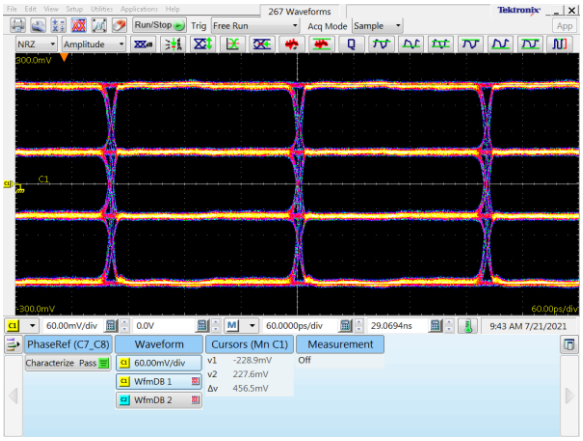
Out! @ 50 GBaud



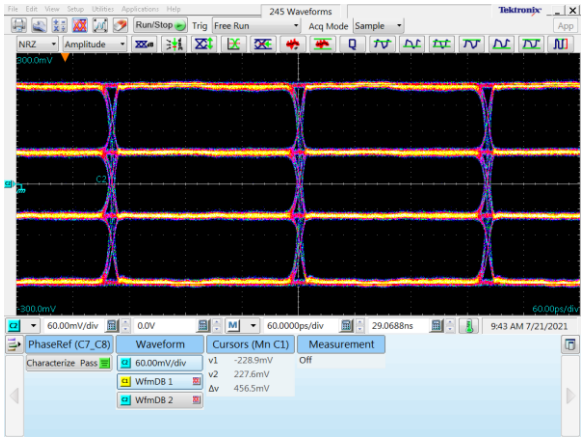
Out @ 32 GBaud



Out! @ 32 GBaud

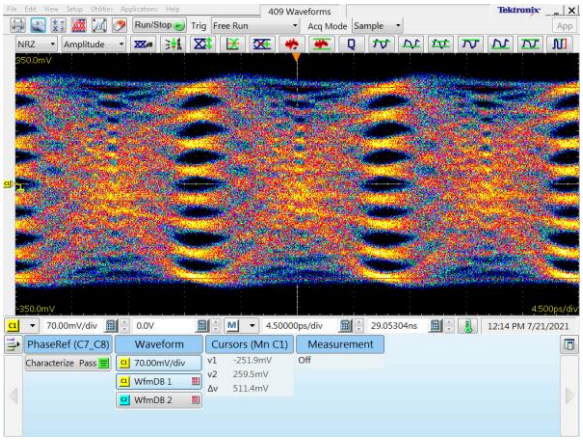


Out @ 5 GBaud

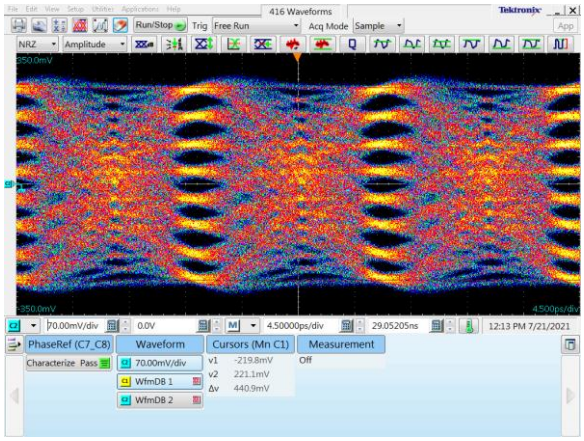


Out! @ 5 GBaud

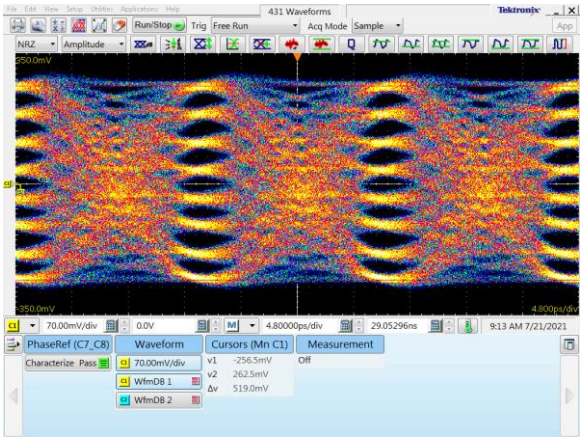
## 8-Level Output Signal Measurement



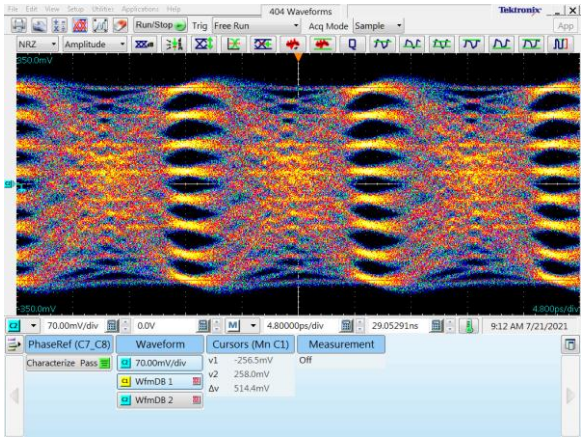

Out @ 67 GBaud



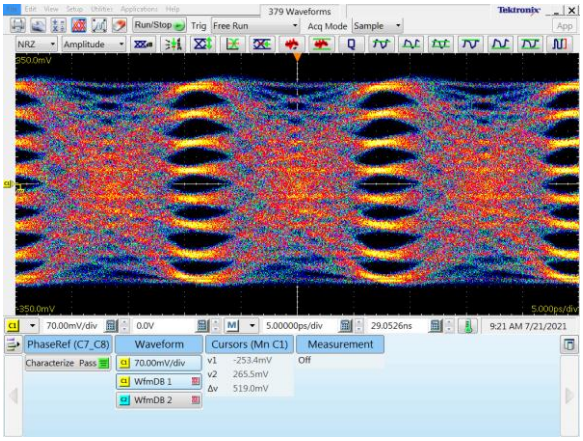

Out! @ 67 GBaud



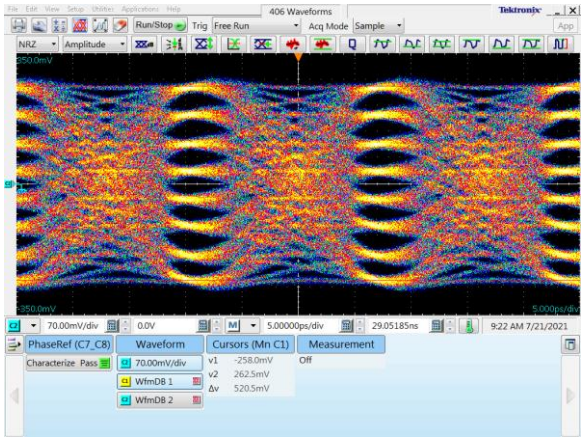

Out @ 64 GBaud




Out! @ 64 GBaud

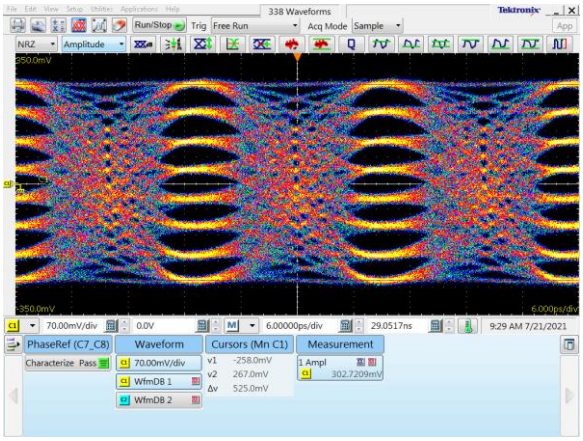



Out @ 60 GBaud

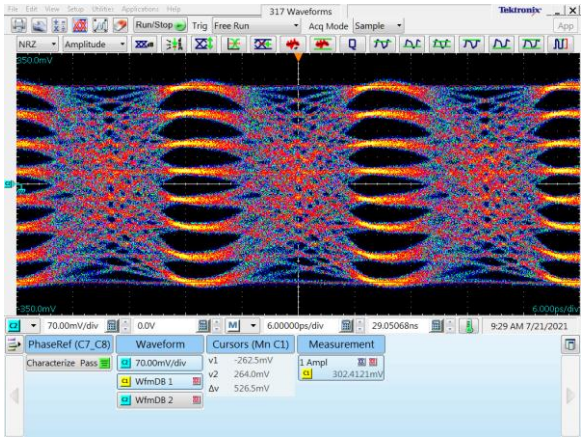



Out! @ 60 GBaud

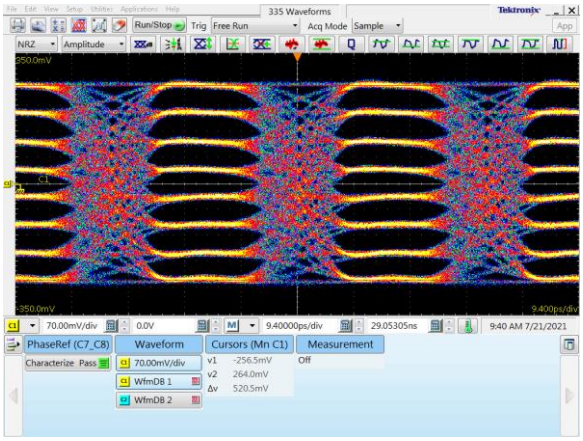
## 8-Level Output Signal Measurement



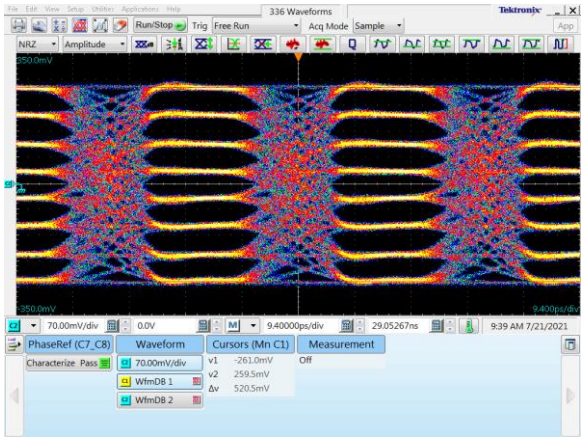
Out @ 50 GBaud



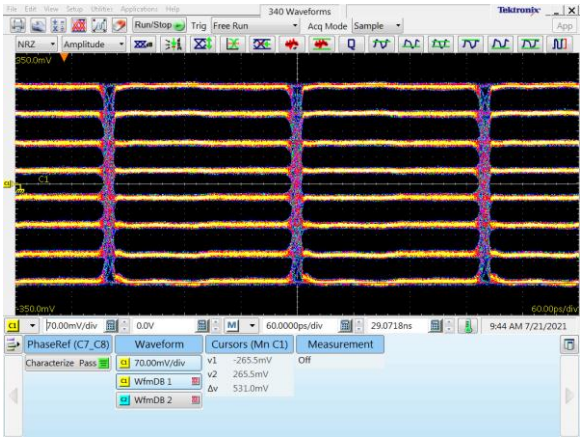
Out! @ 50 GBaud



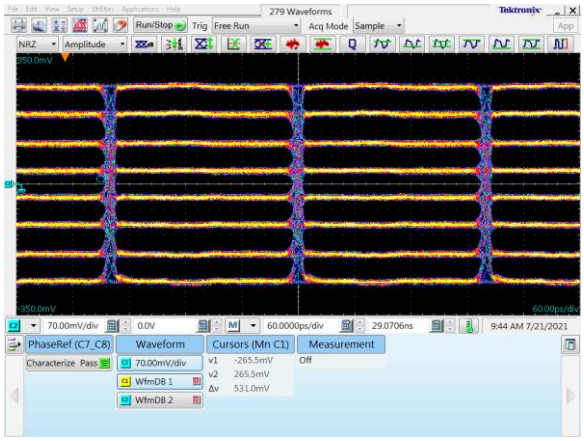
Out @ 32 GBaud



Out! @ 32 GBaud

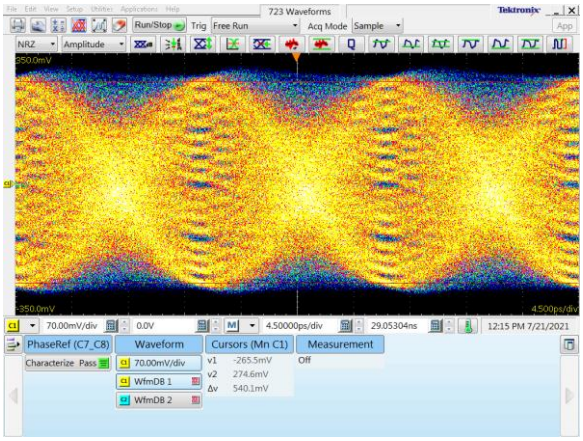


Out @ 5 GBaud

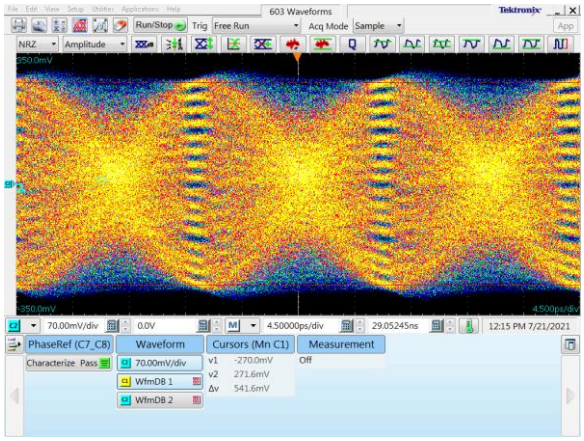


Out! @ 5 GBaud

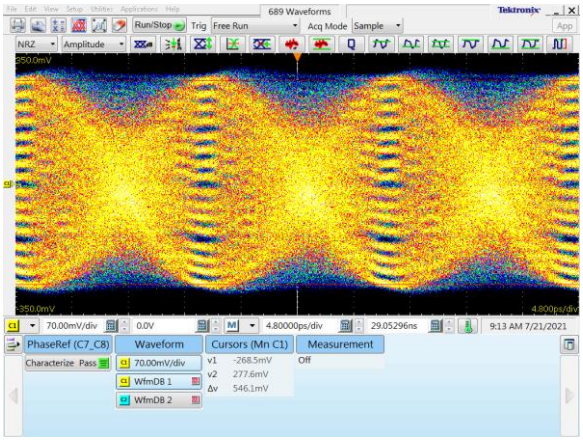
## 16-Level Output Signal Measurement



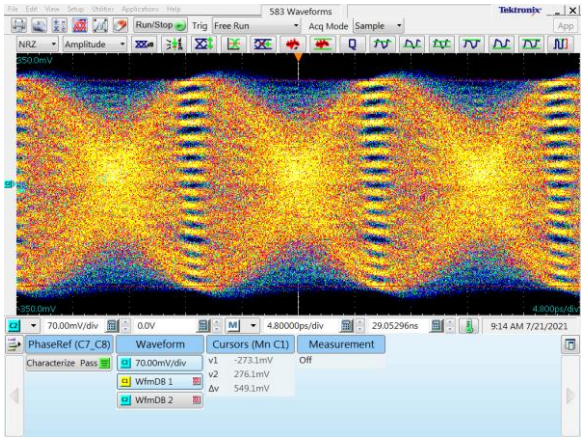

Out @ 67 GBaud



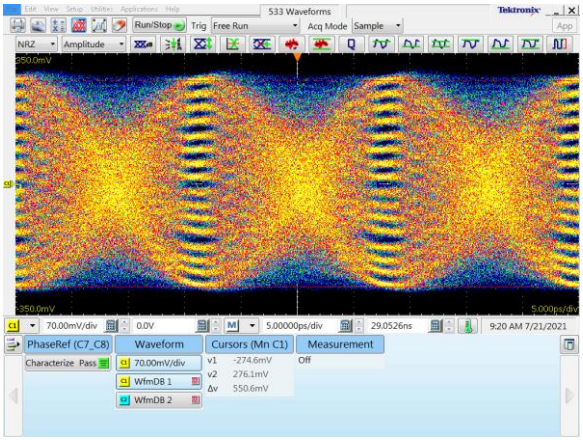

Out! @ 67 GBaud



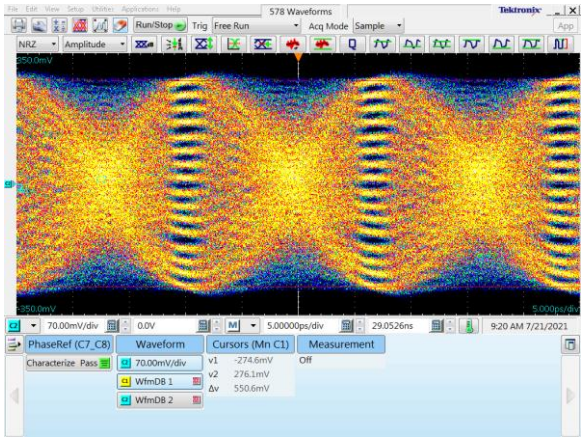

Out @ 64 GBaud




Out! @ 64 GBaud

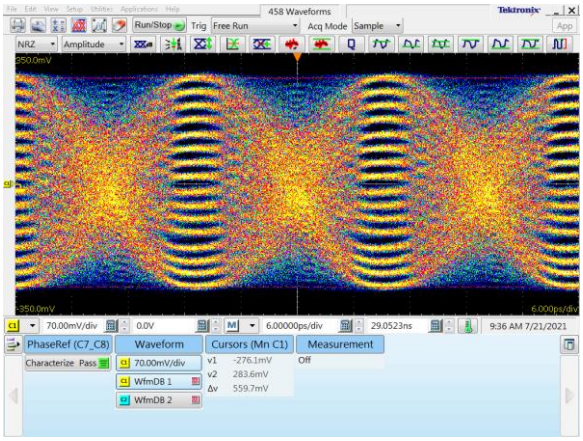



Out @ 60 GBaud

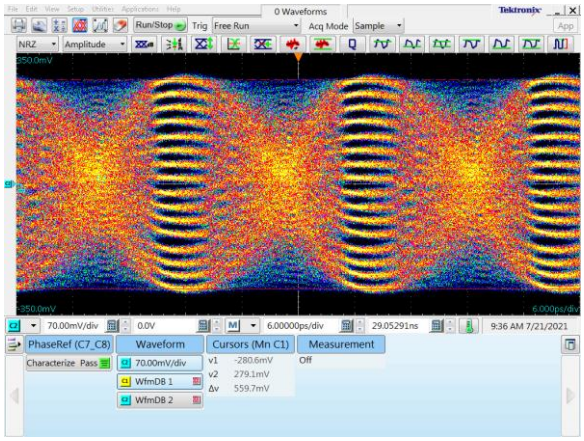



Out! @ 60 GBaud

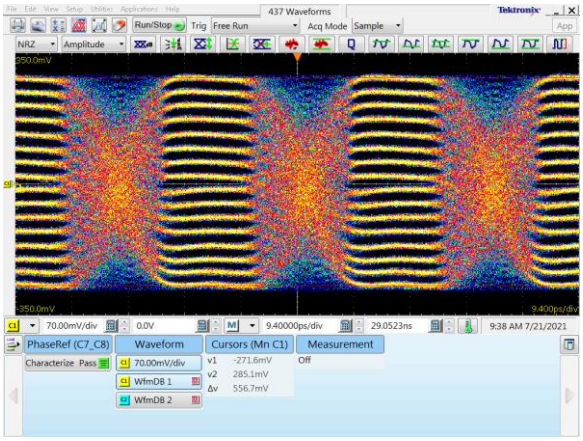
## 16-Level Output Signal Measurement



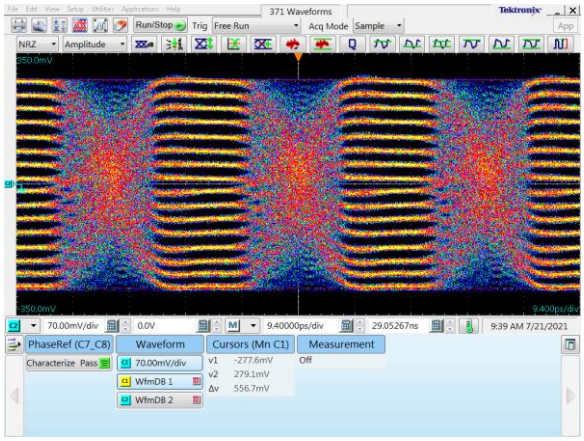
Out @ 50 GBaud



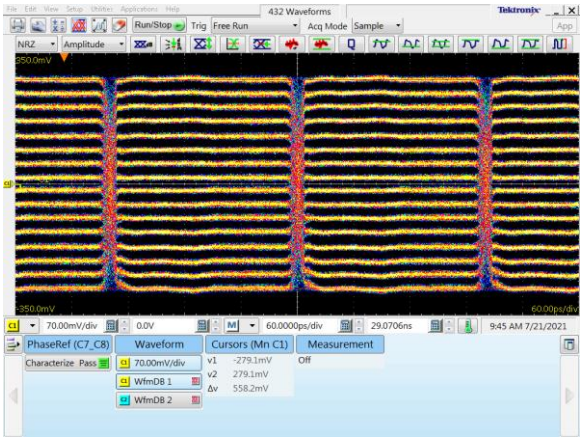
Out! @ 50 GBaud



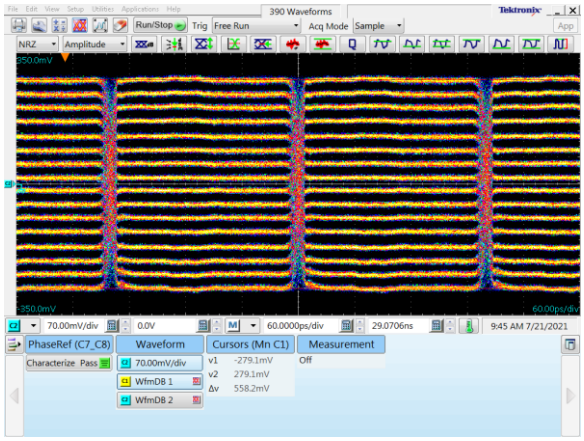
Out @ 32 GBaud



Out! @ 32 GBaud

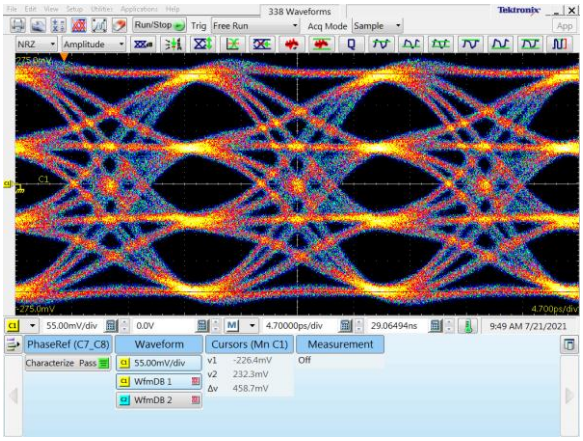


Out @ 5 GBaud

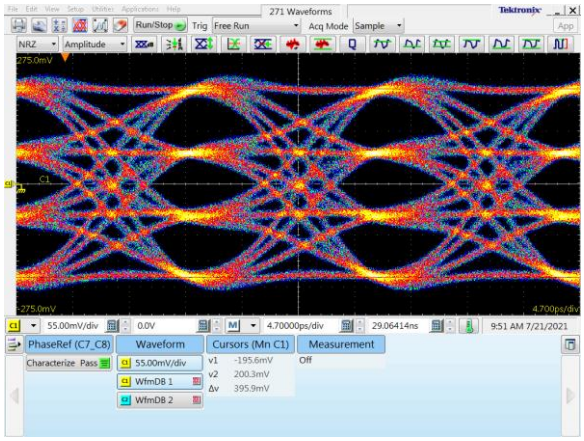


Out! @ 5 GBaud

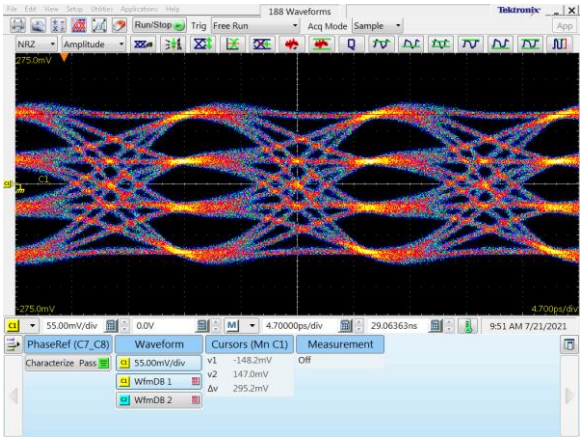
## Output Amplitude Adjustment



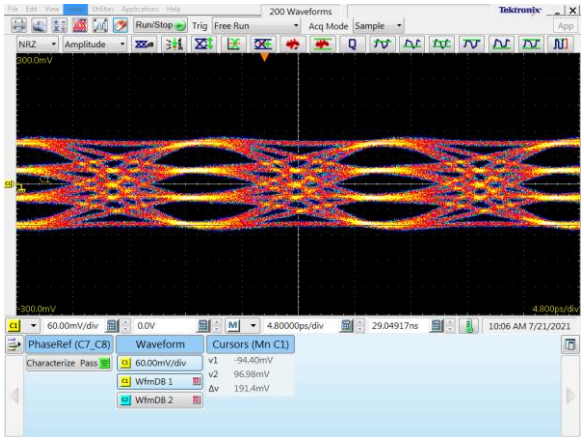
64 GBaud @ 460 mV



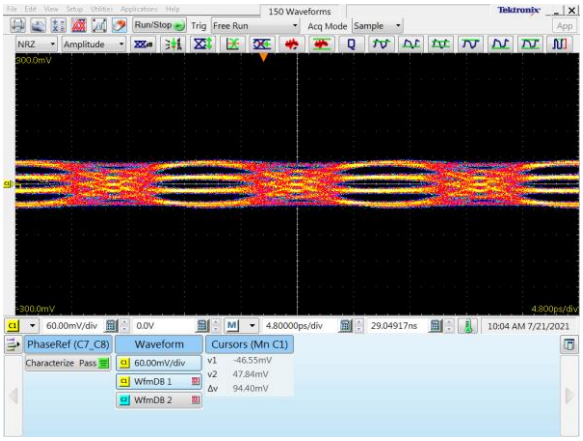
64 GBaud @ 400 mV



64 GBaud @ 300 mV

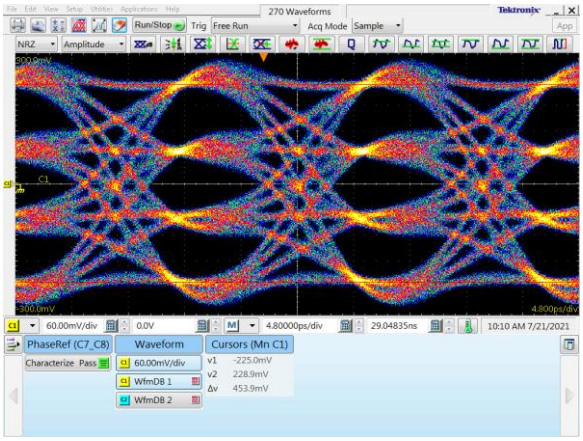


64 GBaud @ 200 mV

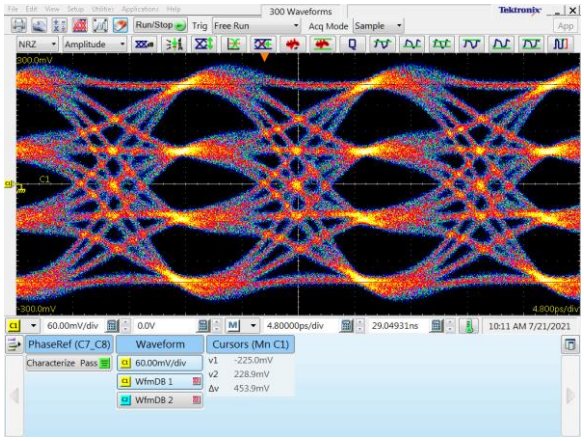


64 GBaud @ 100 mV

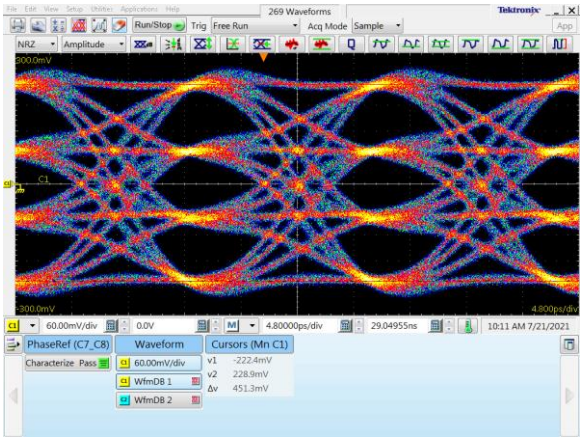
## Output Signal Speed (Trim) - Adjustment



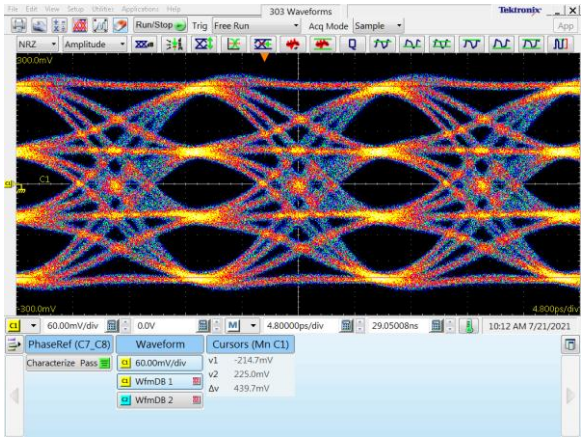
64 GBaud @ TRIM = 100 %



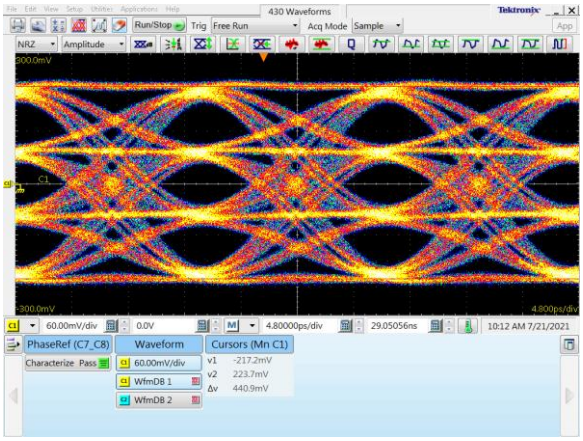
64 GBaud @ TRIM = 80 %



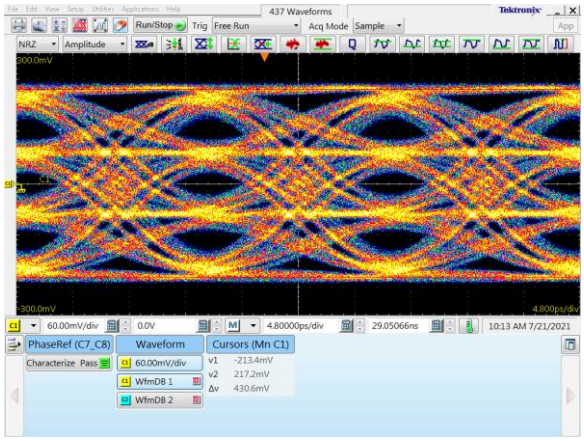
64 GBaud @ TRIM = 60 %



64 GBaud @ TRIM = 40 %



64 GBaud @ TRIM = 20 %

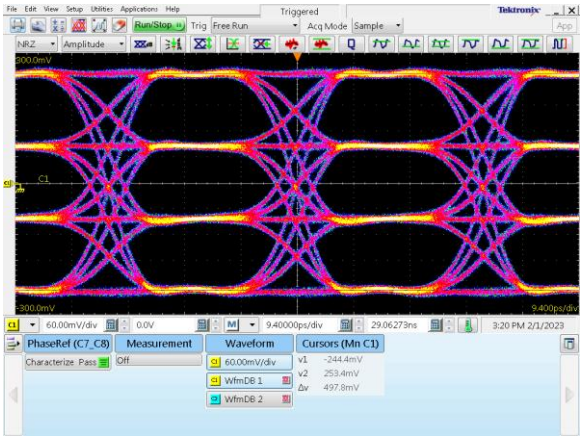


64 GBaud @ TRIM = 0 %

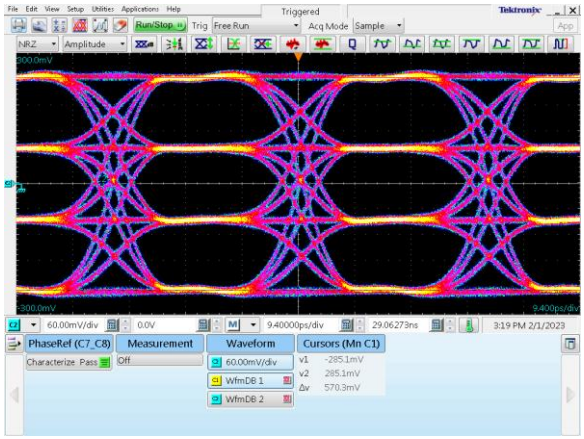
## Typical Output Waveforms – Configuration 32

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 DAC module had been connected directly to the DSA input with a 10 dB attenuator. In all measurements the most significant bits have been used, i.e. 4-Level = D3,D2, 8-Level = D3,D2,D1 and 16-Level = D3,D2,D1,D0.

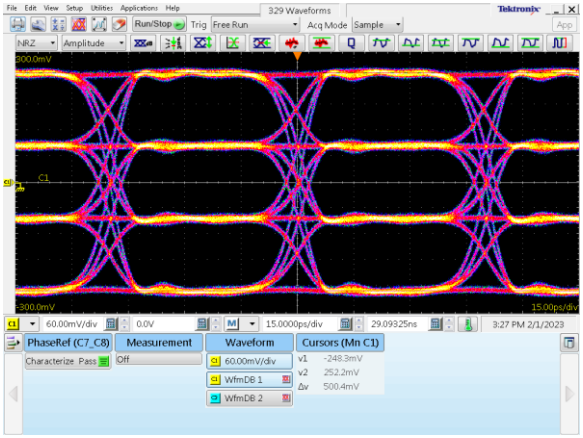
### 4-Level Output Signal Measurement



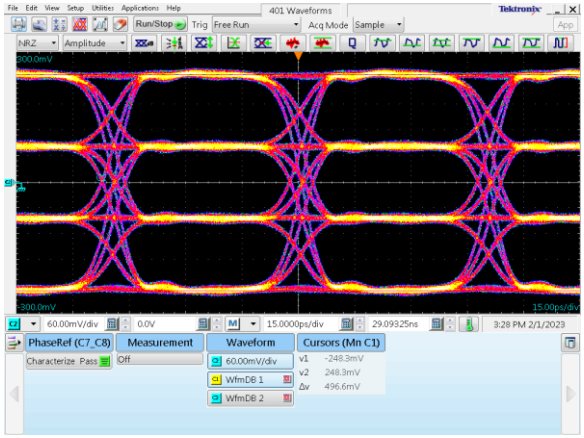
Out @ 32 GBaud



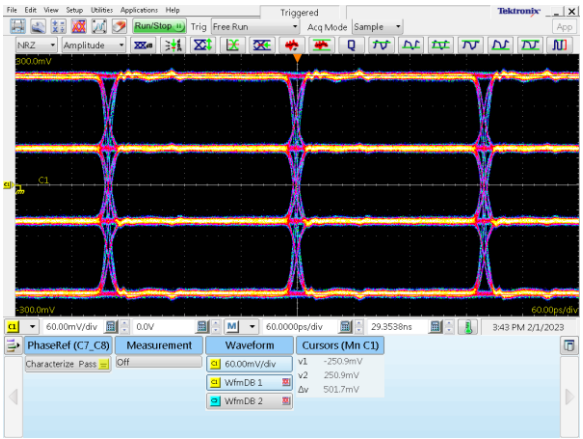
Out! @ 32 GBaud



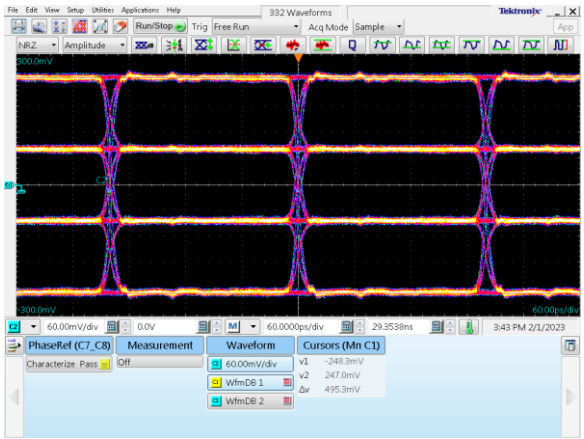
Out @ 20 GBaud



Out! @ 20 GBaud

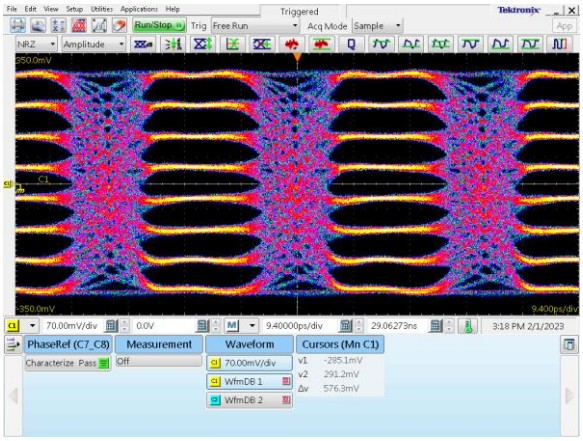


Out @ 5 GBaud

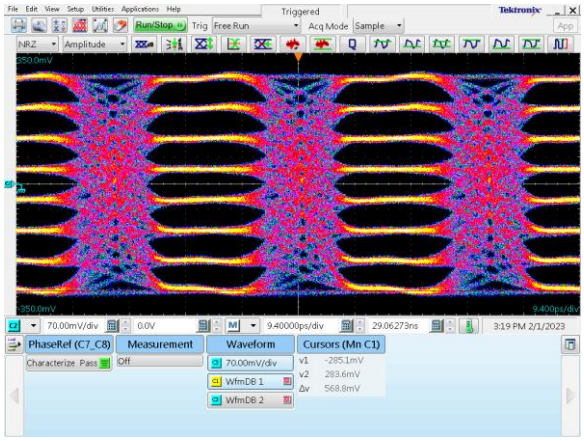


Out! @ 5 GBaud

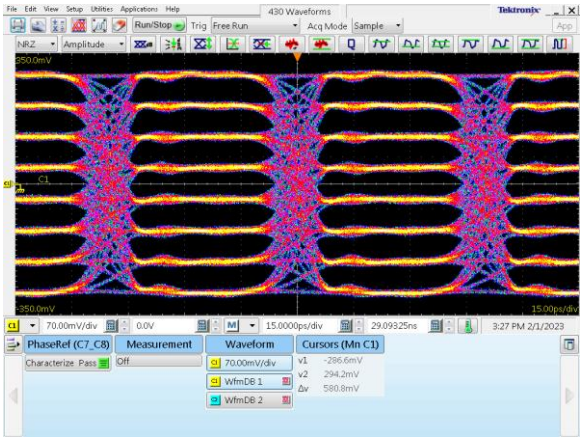
## 8-Level Output Signal Measurement



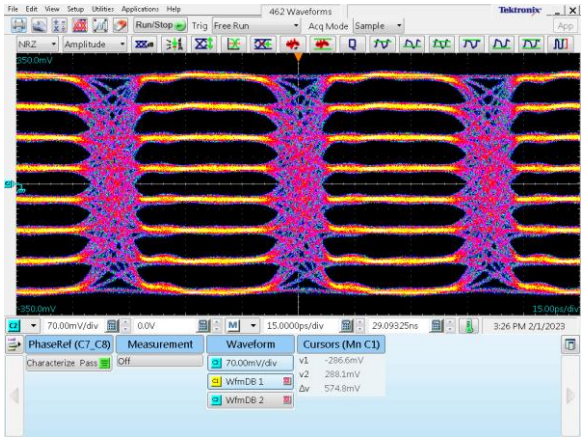
Out @ 32 GBaud



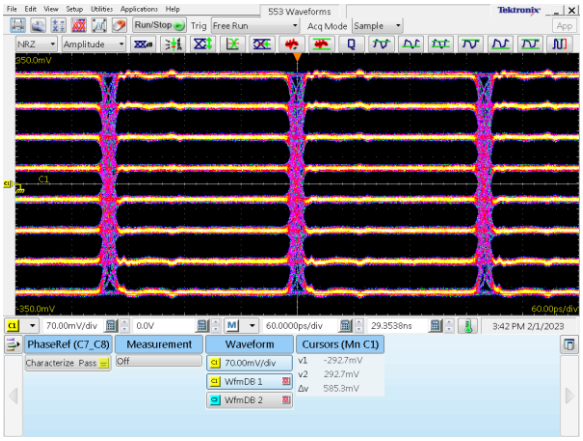
Out! @ 32 GBaud



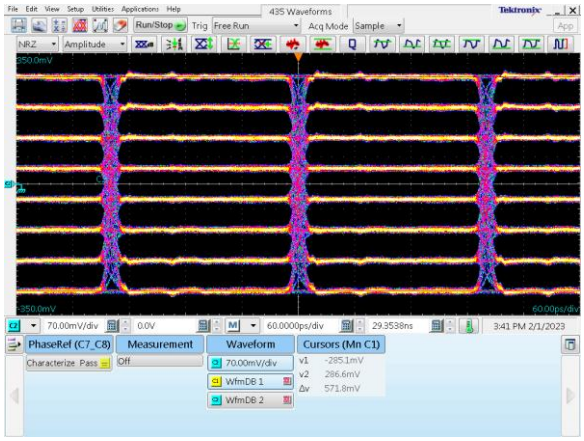
Out @ 20 GBaud



Out! @ 20 GBaud

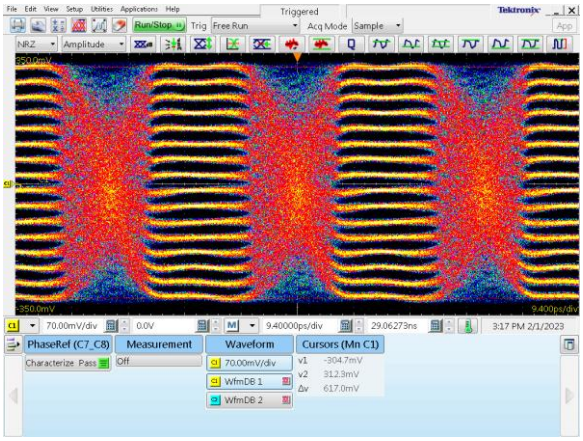


Out @ 5 GBaud

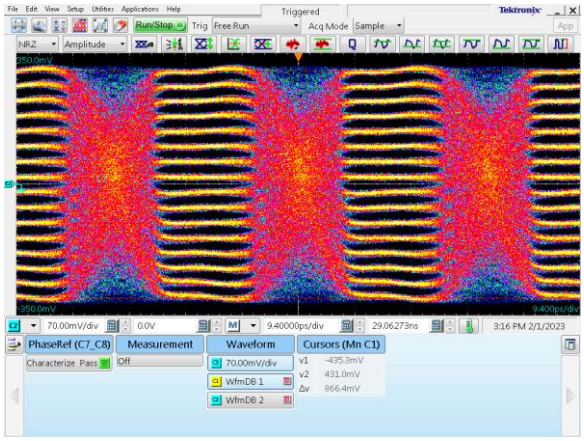


Out! @ 5 GBaud

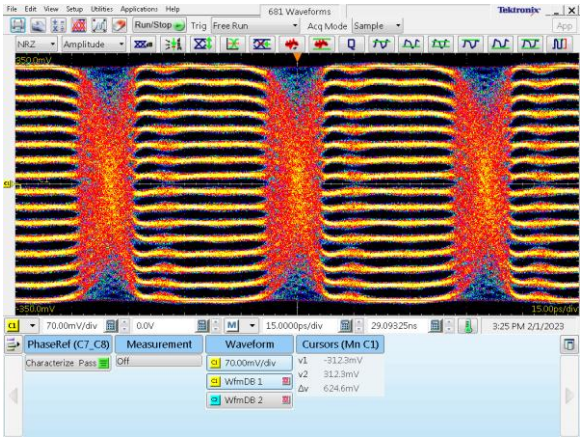
## 16-Level Output Signal Measurement



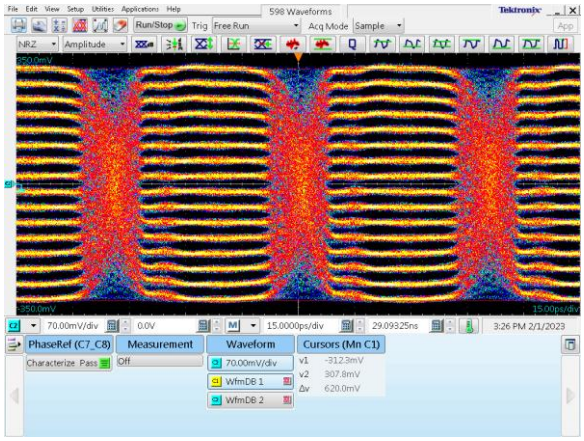
Out @ 32 GBaud



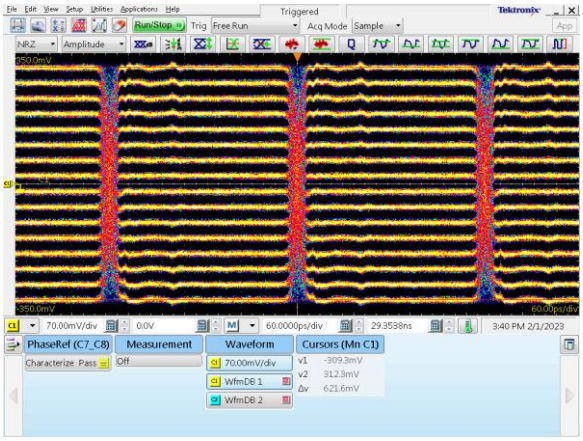
Out! @ 32 GBaud



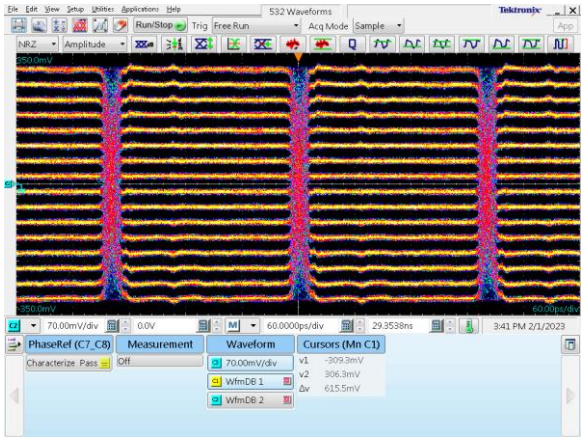
Out @ 20 GBaud



Out! @ 20 GBaud

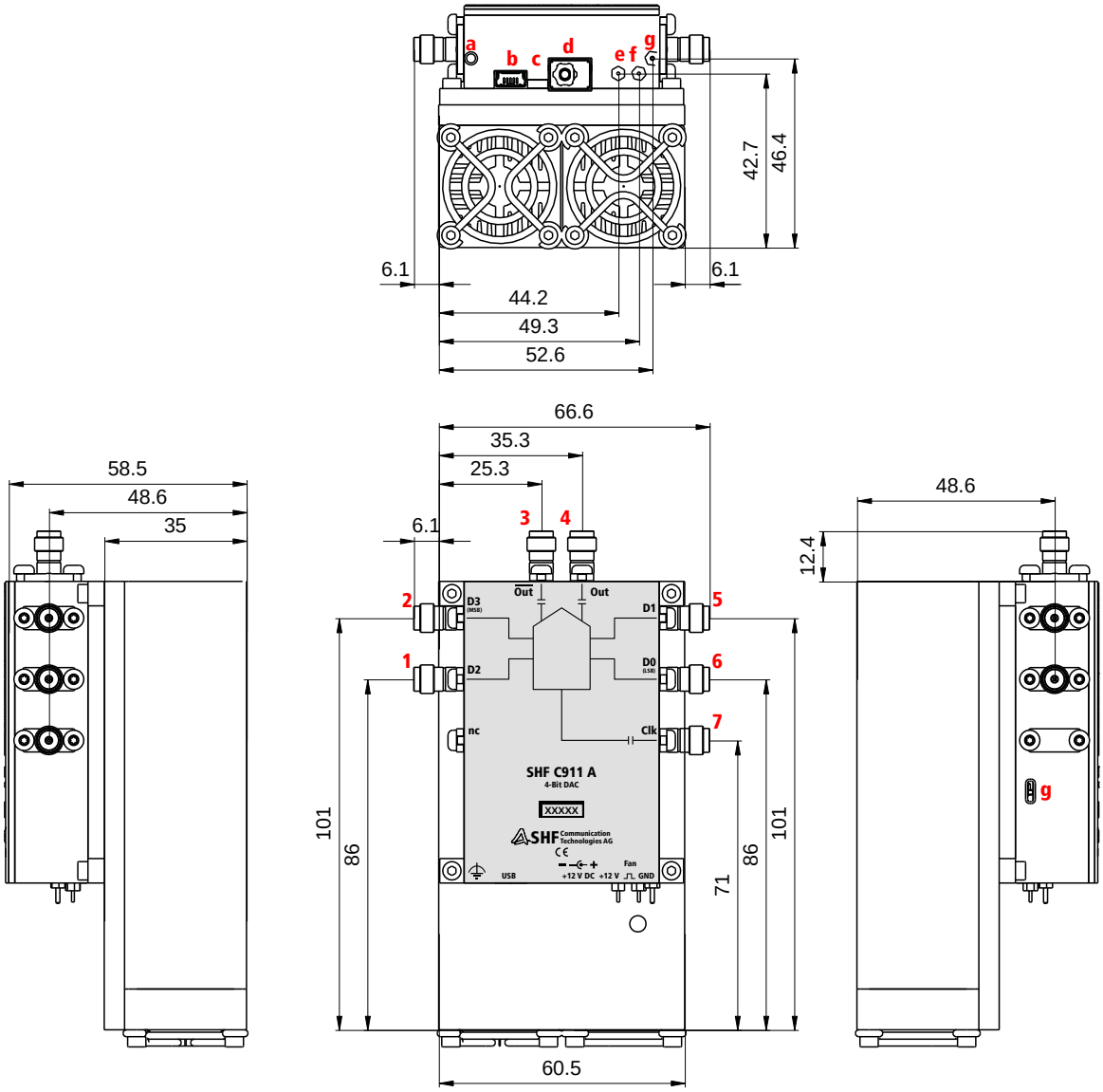


Out @ 5 GBaud



Out! @ 5 GBaud

# Mechanical Drawing - Configuration 67

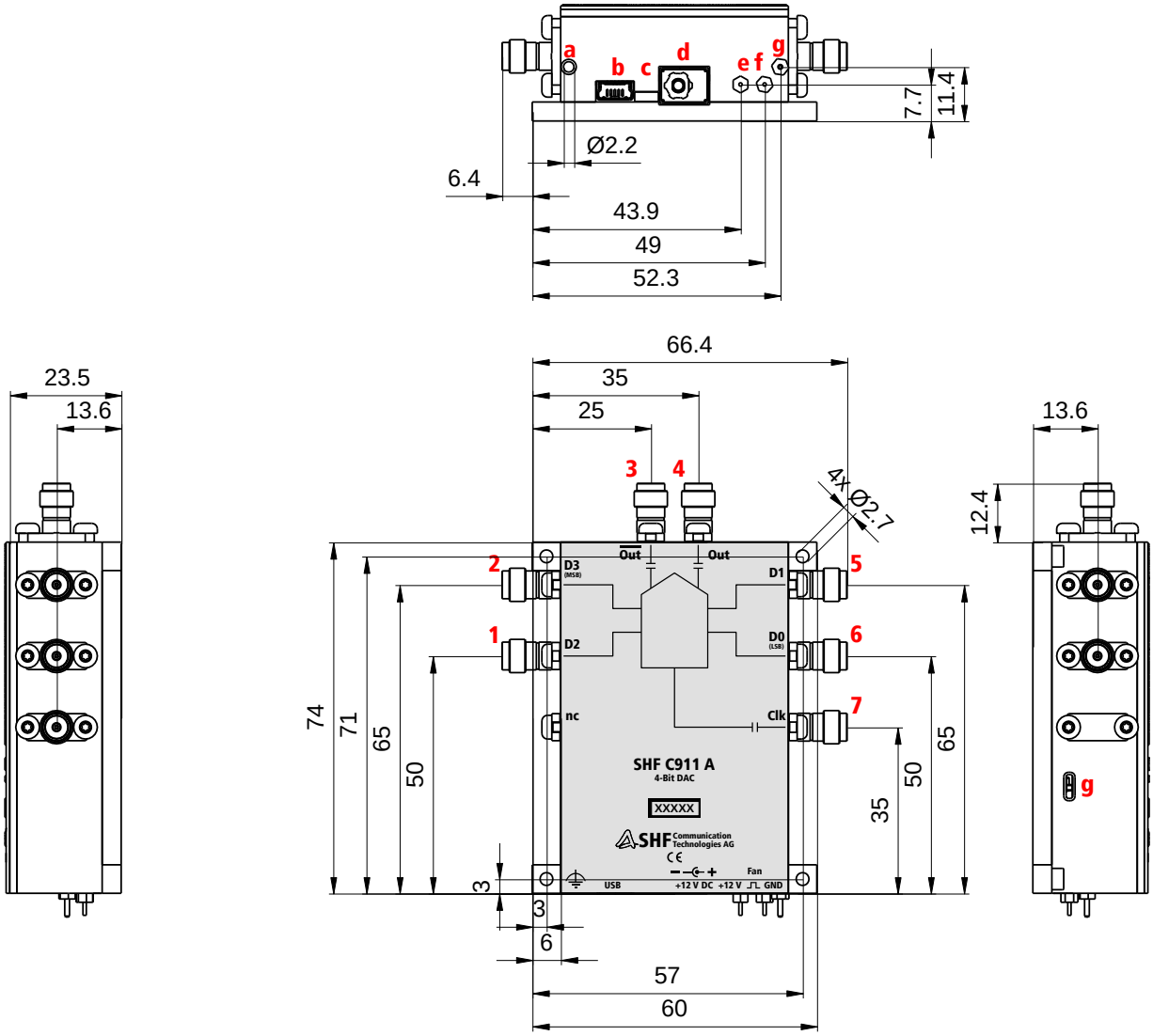



| Pos | Port | Connector |
|---|---|---|
| 1 | D2 | 1.85mm (V) female |
| 2 | D3 (MSB) | 1.85mm (V) female |
| 3 | $\overline{\text{Out}}$ | 1.85mm (V) female |
| 4 | Out | 1.85mm (V) female |
| 5 | D1 | 1.85mm (V) female |
| 6 | D0 (LSB) | 1.85mm (V) female |
| 7 | Clk | 1.85mm (V) female |

| Port | Connector |
|---|---|
| a | Functional earth (FE) |
| b | Mini-USB |
| c | Power-LED |
| d | Power |
| e | Fan+12V |
| f | Fan Tacho |
| g | GND |
| h | Service |

all dimensions in mm

# Mechanical Drawing (Module only) – Configuration 67

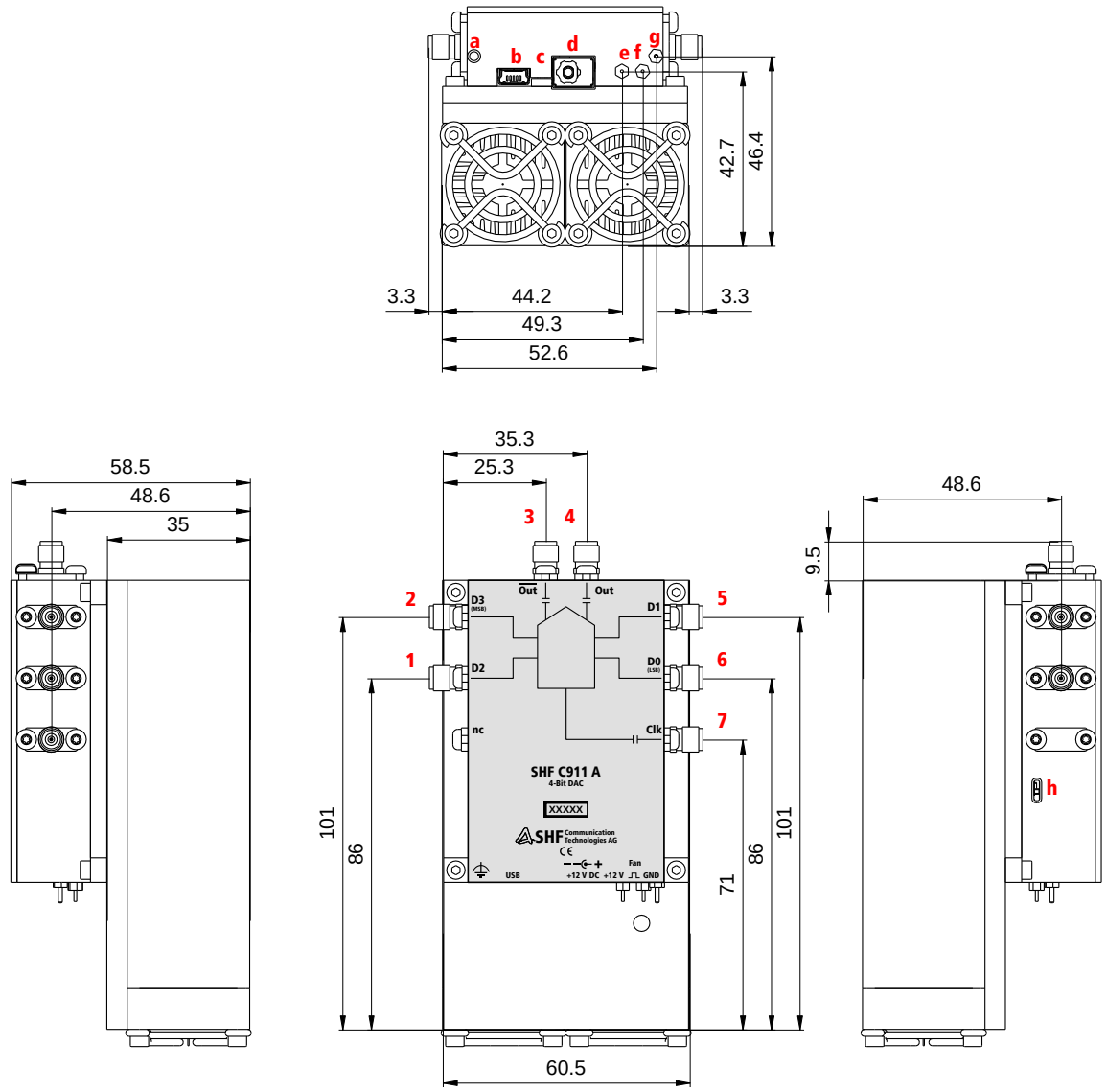



| Pos | Port | Connector |
|---|---|---|
| 1 | D2 | 1.85mm (V) female |
| 2 | D3 (MSB) | 1.85mm (V) female |
| 3 | $\overline{\text{Out}}$ | 1.85mm (V) female |
| 4 | Out | 1.85mm (V) female |
| 5 | D1 | 1.85mm (V) female |
| 6 | D0 (LSB) | 1.85mm (V) female |
| 7 | Clk | 1.85mm (V) female |

| Port | Connector |
|---|---|
| a | Functional earth (FE) |
| b | Mini-USB |
| c | Power-LED |
| d | Power |
| e | Fan+12V |
| f | Fan Tacho |
| g | GND |
| h | Service |

all dimensions in mm

# Mechanical Drawing – Configuration 32

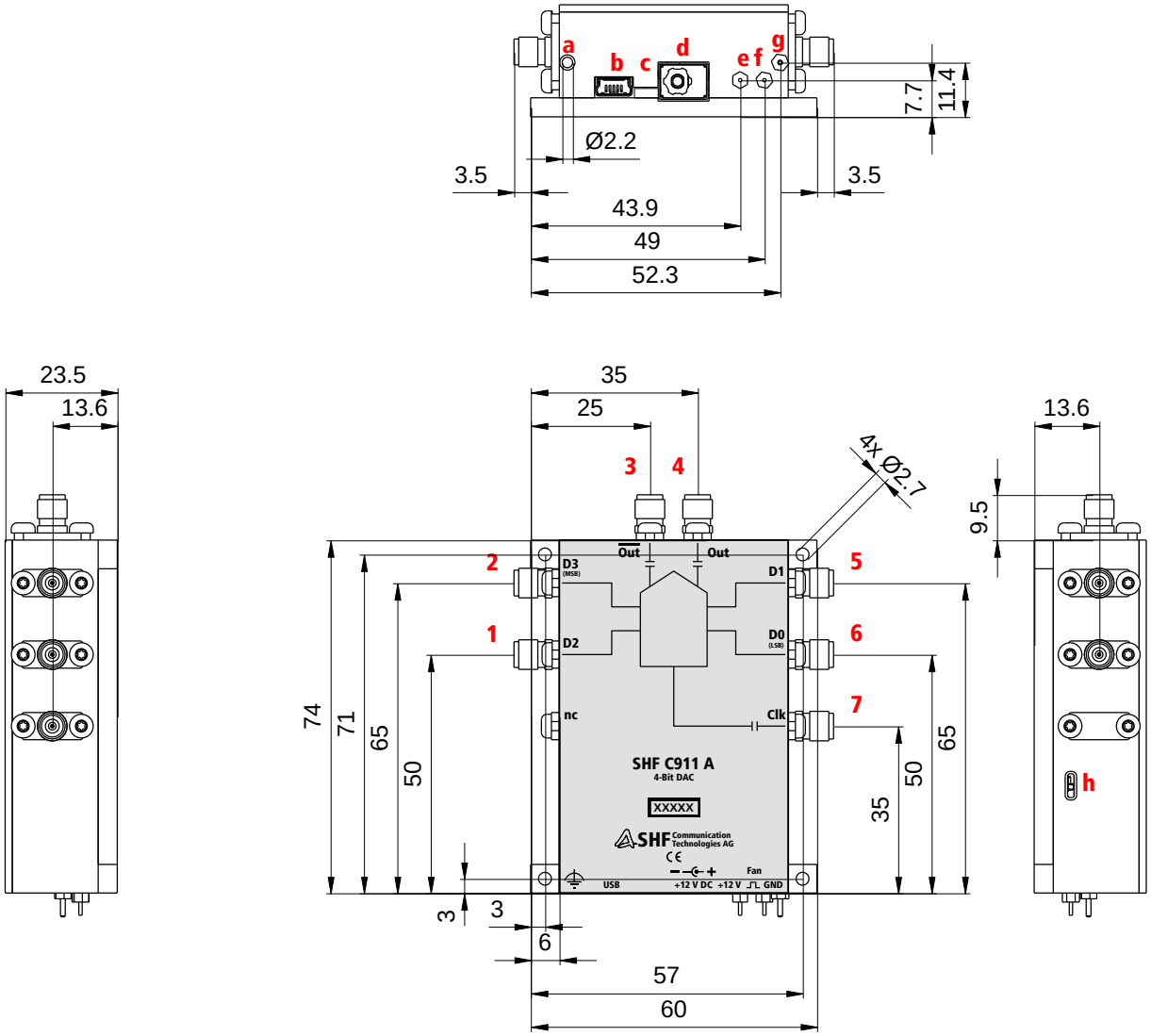



| Pos | Port | Connector |
|---|---|---|
| 1 | D2 | 2.92mm (K) female |
| 2 | D3 (MSB) | 2.92mm (K) female |
| 3 | $\overline{\text{Out}}$ | 2.92mm (K) female |
| 4 | Out | 2.92mm (K) female |
| 5 | D1 | 2.92mm (K) female |
| 6 | D0 (LSB) | 2.92mm (K) female |
| 7 | Clk | 2.92mm (K) female |

| Port | Connector |
|---|---|
| a | Functional earth (FE) |
| b | Mini-USB |
| c | Power-LED |
| d | Power |
| e | Fan+12V |
| f | Fan Tacho |
| g | GND |
| h | Service |

all dimensions in mm

# Mechanical Drawing (Module only) – Configuration 32




| Pos | Port | Connector |
|---|---|---|
| 1 | D2 | 2.92mm (K) female |
| 2 | D3 (MSB) | 2.92mm (K) female |
| 3 | $\overline{\text{Out}}$ | 2.92mm (K) female |
| 4 | Out | 2.92mm (K) female |
| 5 | D1 | 2.92mm (K) female |
| 6 | D0 (LSB) | 2.92mm (K) female |
| 7 | Clk | 2.92mm (K) female |

| Port | Connector |
|---|---|
| a | Functional earth (FE) |
| b | Mini-USB |
| c | Power-LED |
| d | Power |
| e | Fan+12V |
| f | Fan Tacho |
| g | GND |
| h | Service |

all dimensions in mm

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