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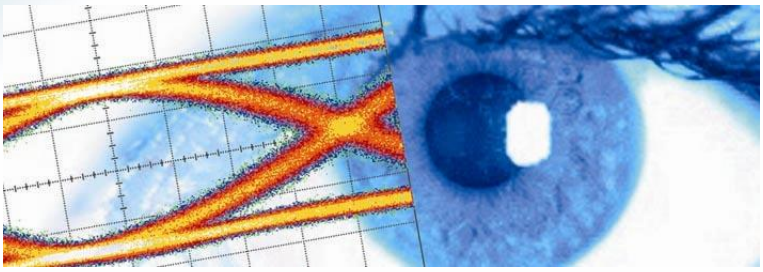
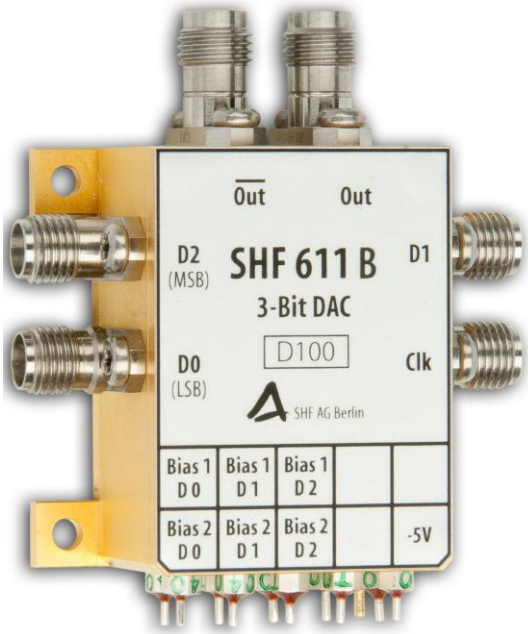


Application Note

AN-611 A / B

3-Bit DAC



SHF Communication Technologies AG
the bandwidth company

Description

The SHF 611 A or B is a 3-Bit Digital to Analog Converter module. Up to 3 input data streams with a bit rate of up to 32 Gbps are latched, summed and buffered internally to form an 8-level signal at the complementary outputs. For the latching, the module needs a clock signal synchronously to the 3 input data streams.

The DAC can generate either binary, 4-level or 8-level signals by applying 1, 2 or 3 data streams to the data inputs D0, D1 and D2. The output signal is constructed by summing up the (software adjustable) contributions of the input signals D0, D1 and D2, where D0 is the LSB and D2 is the MSB.

For a given desired output voltage, the control software reads the individual calibration table of the DAC and sets the contribution of D0, D1 and D2 according to the chosen combination of input streams at D0, D1 and D2. In the GUI, the sum of the contributions of D0, D1 and D2 is displayed.

The Bias box contains the voltage regulator and a USB-interface and provides the bias voltages for the DAC-module. For installation of the driver and control software, please refer to the programming manual.

Example setup

Figure 1 shows a typical setup for the SHF 611 A / B 3-Bit DAC. Each data input of the SHF 611 A / B is driven by a data output of the SHF 12103/12104 Pattern Generator. Usually the channels of the BPG provide de-correlated signals. If synchronous patterns are chosen, a delay of several bit-lengths should be introduced.

A bit-synchronous clock signal is required at the clock input to drive the data input latches.

Please note that excessive drive levels will generate a noticeable clock signal feed through on the DAC output.

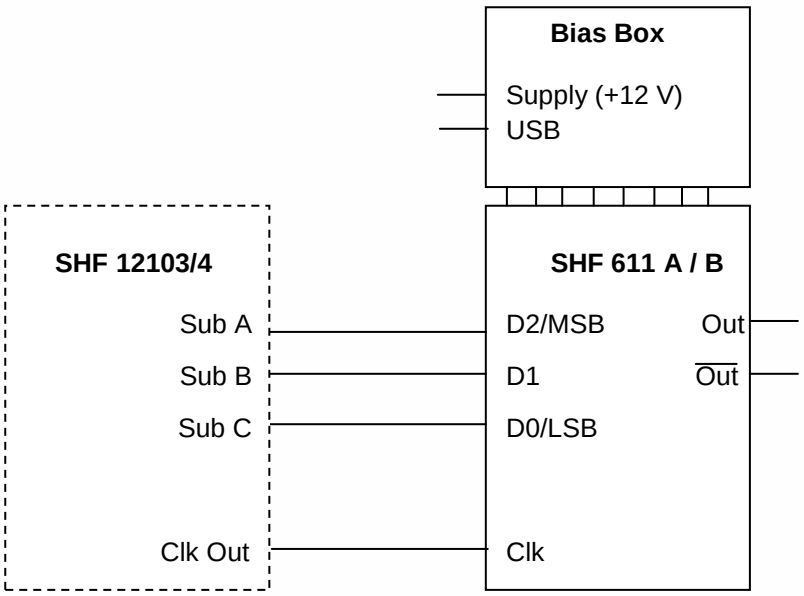


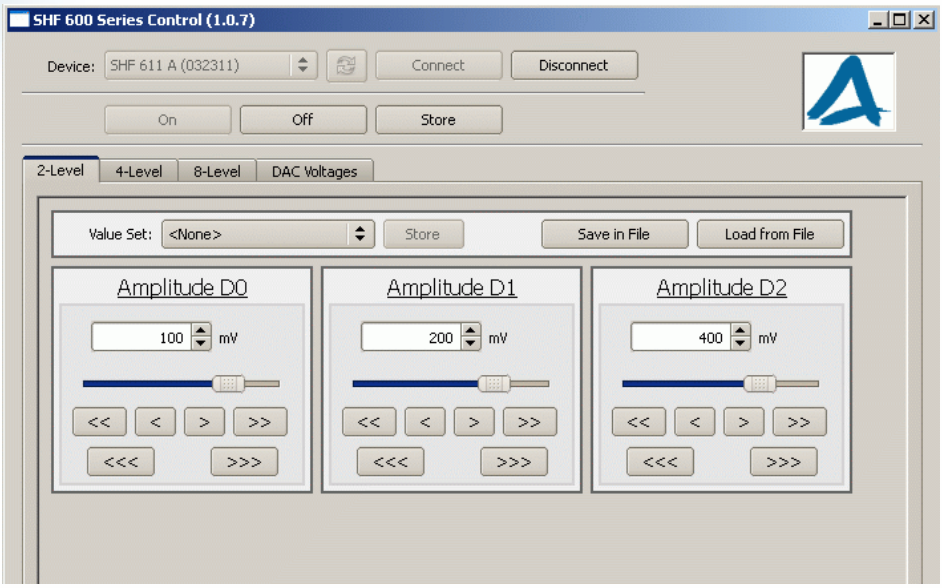
Figure 1: Setup of the SHF 611 A / B

The timing of the data inputs should be adjusted for each of the inputs individually prior to applying 2 or 3 data inputs at once.

The proper timing is easily adjusted with the skew control of the pattern generator. For each channel the respective skew is used to find out at which positions the eye diagram begins to collapse. Then the skew is set to exactly the middle between the ‘collapsing’-skew settings.

1-Bit DAC application

In the 1-Bit DAC application, a data signal is applied to either D0, D1 or D2. The output amplitude is set in the 2-Level tab of the control program:

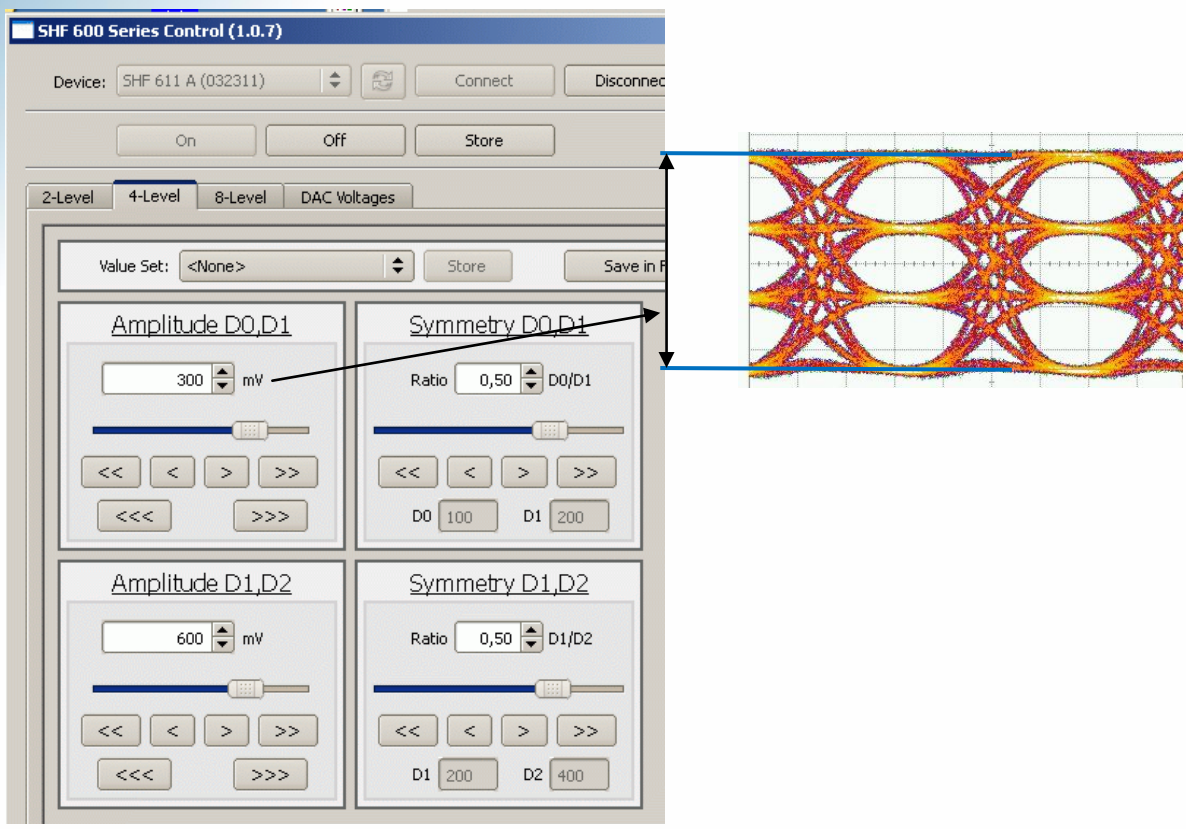


Dependent on where the signal is applied, the output voltage is set in the D0, D1 or D2 field. If the voltage setting of an 'unconnected' input is changed (applies only to the SHF 611 A-version), only the output offset voltage changes.

This tab is useful as well in the case where a multi level signal needs to be constructed by adding up the D0, D1 and D2 contributions.

2-Bit DAC application

In the 2-Bit DAC application, 2 data signals are applied to either D0 & D1 or to D1 & D2. The output amplitude is set in the 4-Level tab of the control program:



Dependent on where the signals are applied, the output voltage is set in the D0 & D1 or in the D1 & D2 fields.

- The **sliders 'Amplitude D0, D1'** and **'Symmetry D0, D1'** control the output conditions if the data signals are applied to D0 and D1.
- The sliders **'Amplitude D1, D2'** and **'Symmetry D1, D2'** control the output conditions if the data signals are applied to D1 and D2.

There is no calibrated control for the input signal combination D0 and D2. For that combination, the user should set the contributions in the 2-Level –tab.

The displayed amplitude refers to the voltage difference between the topline of the upper eye and the baseline of the lower eye. If the settings in the other tabs are changed, the settings for the 4-Level signal are no longer valid. The symmetry will come back immediately, once the settings in the 4-Level tab are changed.

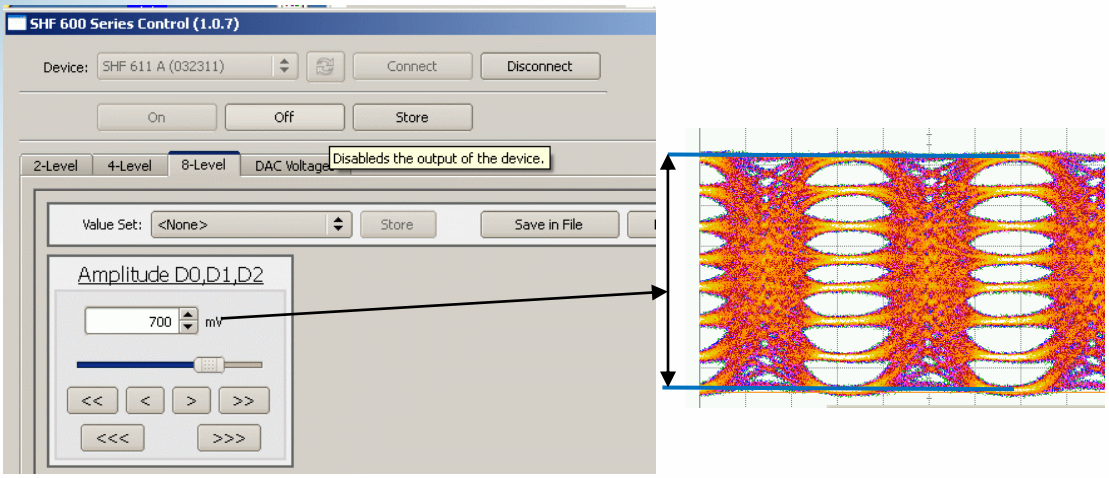
This 4-Level tab has additional 'symmetry'-controls: A 'symmetry' value of 0.5 generates a signal with identical spacing between the 4 individual levels.

The ratio of 0.5 refers to the ratio of the individual contributions of D0 & D1 or D1 & D2 respectively:

- If the 'symmetry' is set to < 0.5, the outer eyes will be compressed.
- If the 'symmetry' is set to > 0.5, the inner eye will be compressed.

3-Bit DAC application

In the 3-Bit DAC application, 3 data signals are applied to D0, D1 and D2. The output amplitude is set in the 8-Level tab of the control program:



The output voltage is set in the Amplitude D0, D1, D2 field. The displayed amplitude refers to the voltage difference between the topline of the upper eye and the baseline of the lower eye.

If the settings in the other tabs are changed, the settings for the 8-Level signal are no longer valid.

The symmetry of equal spacing between the levels will come back immediately, once the settings in the 8-Level tab are changed.

Interfacing the DAC with amplifiers

If the DAC is used to generate 4- or 8-level signals, the following amplifier should work in its linear range ($P_{out} < P_{1dB}$).

Amplifier	P_{1dB} [dBm]	U_{out} [V] @P_{1dB}	Gain [dB] / lin	U_{in} [mV] @P_{1dB}	Att [dB] / $U_{DAC\ out}$ [mV]
SHF 100AP	16	4	19 / 9x	450	3 / 630
SHF 100BP	21	6	17 / 7x	800	- / 800
SHF 803	19	5.5	17 / 7x	750	- / 700
SHF 804EA	13	3	20 / 10x	300	6 / 600
SHF 806	21	6	26 / 20x	300	6 / 600
SHF 807	18	5	22 / 12.5x	400	3 / 560; 6 / 800
SHF 810	19	5.5	29 / 28x	200	10 / 630
SHF 827	16	4	11 / 3.5x	1100	- / max Setting

Example:

- The amplifier SHF 807 can deliver up to 5 V_{pp} multilevel signals without noticeable nonlinear distortions.
- The amplifier has a gain of 22 dB (factor of 12.5).
- To achieve an output swing of 5 V_{pp}, an input swing of 5 V_{pp}/12.5 = 400 mV_{pp} is required.
- The DAC works best with an output amplitude setting of > 600 mV_{pp}.

Therefore, the usage of a 6 dB attenuator is recommended, thus setting the DAC output amplitude to 800 mV_{pp}. If only a 3 dB attenuator is available, the output voltage of the DAC should be set to 560 mV_{pp} without too much signal quality deterioration.

Compensating compression behavior of amplifiers

If an amplifier is driven into compression by a 4-level signal, the outer eyes are getting compressed with respect to the inner eye.

The amplitude ratio between inner eye and outer eye can be adjusted with the ‘Symmetry’ slider, thus generating a ‘pre-distorted’ input signal for the amplifier.

The result will be a signal having identical spacing between the 4 individual levels although the amplifier already operating in compression.

That ‘pre-distortion’ can be used as long as the amplifier compresses the positive swing and the negative swing of the signal by the same percentage.

An 8-level signal cannot be pre-distorted with the DAC settings.