Datasheet

SHF 613 A

60 GBAud 3-Bit DAC
Description

The SHF 613 A is a 3-Bit Digital-to-Analog Converter (DAC) operating at symbol rates up to 60 GBaud for use in broadband test setups and telecom transmission systems. Three single ended serial data streams of up to 60 Gbps are accepted by the DAC and converted into one differential 8-level data signal of up to 60 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 613 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.

All RF input and output ports are AC-coupled.

Features

- Broadband operation up to 60 GBaud
- Output baud rate = sample rate
- Differential data output, 600 mV single ended output swing
- Single ended clock and data inputs
- Latched input ports
- Output level control
- Bias Box

Applications

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

Block Diagram

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Bias Box

At delivery, the Bias Box SHF 88120 B is mounted on a common base plate, together with the SHF 613 A 3-Bit DAC (Fig.1). All bias voltages are provided by this Bias Box which is controlled by a PC via a USB interface. The easy to use software package is a complementary part of each delivery. For system applications it is possible to remove the Bias Box. In that case the operating voltages have to be supplied by the customer’s circuitry.

It is recommended to use the Bias Box only with the delivered power supply. Using other power supplies can damage the Bias Box.

![Fig. 1: “SHF 613 A + Bias Box”-Assembly](image)

SHF 600 Series Control - Software

At delivery, the software package for a MS Windows installation including a 1.5m USB cable will be provided. Control software for other operating systems is available on request.

![Fig. 2: “SHF 600 Series Control” – GUI](image)

Heat Sink

The provided heat sink can be disassembled by the customer. In this case it is required to provide other cooling measures to ensure that the maximum case temperature specified on page 4 will not be exceeded.
## Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Input Voltage</td>
<td>mV</td>
<td>V_{data in}</td>
<td>300</td>
<td>500</td>
<td>800</td>
<td>Clock input amplitude = 500mV</td>
</tr>
<tr>
<td>Clock Input Frequency</td>
<td>GHz</td>
<td>f_{in}</td>
<td>1</td>
<td></td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Clock Input Voltage</td>
<td>mV</td>
<td>V_{clk in}</td>
<td>300</td>
<td>500</td>
<td>800</td>
<td>Data input amplitude = 500mV</td>
</tr>
<tr>
<td><strong>Output Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Output Data Rate</td>
<td>GBAud</td>
<td>R_{out,min}</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Output Data Rate</td>
<td>GBAud</td>
<td>R_{out,max}</td>
<td></td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Amplitude</td>
<td>mV</td>
<td>V_{out}</td>
<td>590</td>
<td>730</td>
<td>850</td>
<td>Single ended, full scale, adjustable up to -6dB, see table on page 5</td>
</tr>
<tr>
<td>Rise-/Fall Time</td>
<td>ps</td>
<td>t_{r/f}</td>
<td>6.1</td>
<td>7.1</td>
<td></td>
<td>20%...80%, deconvolved(^1)</td>
</tr>
<tr>
<td>Equivalent Output Bandwidth</td>
<td>GHz</td>
<td>BW</td>
<td>31</td>
<td>36</td>
<td></td>
<td>Derived from Rise Time using formula(^2), -3 dB bandwidth</td>
</tr>
<tr>
<td><strong>Power Requirements (incl. Bias Box)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>V</td>
<td>V_{ee}</td>
<td>+11.5</td>
<td>+12</td>
<td>+12.5</td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>mA</td>
<td>I_{ee}</td>
<td>520</td>
<td>540</td>
<td></td>
<td>@ V_{ee} = +12V</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>W</td>
<td>P_{d}</td>
<td>6.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power Requirements (DAC-Module only)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>V</td>
<td>V_{ee}</td>
<td>-5.2</td>
<td>-5</td>
<td>-4.8</td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>mA</td>
<td>I_{ee}</td>
<td>1000</td>
<td>1100</td>
<td></td>
<td>@ V_{ee} = -5V</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>W</td>
<td>P_{d}</td>
<td>5</td>
<td></td>
<td></td>
<td>@ V_{ee} = -5V</td>
</tr>
<tr>
<td><strong>Bias Voltages</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bias Adjust 1 for D0, D1 &amp; D2</td>
<td>V</td>
<td>V_{Bias1}</td>
<td>-3.3</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Bias Adjust 2 for D0, D1 &amp; D2</td>
<td>V</td>
<td>V_{Bias2}</td>
<td>-3.3</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case Temperature(^3)</td>
<td>°C</td>
<td>T_{case}</td>
<td>10</td>
<td>45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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1. Calculation based on typical rise/fall times from oscilloscope data sheet: \(t_{r,deconvolved} = \sqrt{(t_{r,measured})^2 - (t_{r,oscilloscope})^2}\)
2. Calculation based on formula: \(BW = \frac{\frac{0.32}{Tr}}{Tr}\)
3. Rise time of the output data signal can be slightly decreased by applying additional cooling measures like heat sinks or cooling fans.

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Typical 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.

<table>
<thead>
<tr>
<th>Input D2 (MSB)</th>
<th>Input D1</th>
<th>Input D0 (LSB)</th>
<th>Minimum Output Amplitude [mV]</th>
<th>Maximum Output Amplitude [mV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>On</td>
<td>80</td>
<td>130</td>
</tr>
<tr>
<td>-</td>
<td>On</td>
<td>-</td>
<td>160</td>
<td>240</td>
</tr>
<tr>
<td>On</td>
<td>-</td>
<td>-</td>
<td>350</td>
<td>480</td>
</tr>
</tbody>
</table>

The typical output amplitude of a multilevel signal can be calculated by accumulating the typical 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 | 590 | 850 |
Typical Output Eye Diagrams

The measurements below had been performed using a SHF 12104 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 6 dB attenuator.

4-Level Output Signal Measurement

Out @ 60 GBaud

Out! @ 60 GBaud

Out @ 56 GBaud

Out! @ 56 GBaud

Out @ 43 GBaud

Out! @ 43 GBaud
Out @ 32 GBaud

Out! @ 32 GBaud

Out @ 28 GBaud

Out! @ 28 GBaud
8-Level Output Signal Measurement

Out @ 60 GBaud

Out! @ 60 GBaud

Out @ 56 GBaud

Out! @ 56 GBaud

Out @ 43 GBaud

Out! @ 43 GBaud
Typical Output Eye Diagrams

The measurements below had been performed using a SHF 12104 A Bit Pattern Generator (PRBS $2^{31}-1$) and an Agilent Digital Communication Analyzer (DCA) with Precision Timebase Module (86107A) and 70 GHz Sampling Module (86118A). The outputs of the DAC module had been connected directly to the DCA input with a 6 dB attenuator.

4-Level Output Signal Measurement

- Out @ 60 GBaud
- Out! @ 60 GBaud
- Out @ 56 GBaud
- Out! @ 56 GBaud
- Out @ 43 GBaud
- Out! @ 43 GBaud
Out @ 32 GBaud

Out! @ 32 GBaud

Out @ 28 GBaud

Out! @ 28 GBaud
8-Level Output Signal Measurement

Out @ 60 GBAud

Out! @ 60 GBAud

Out @ 56 GBAud

Out! @ 56 GBAud

Out @ 43 GBAud

Out! @ 43 GBAud
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Outline Drawing – “Module + Bias Box”- Assembly

All dimensions in mm
Outline Drawing – “Module + Bias Box”- Assembly with Heat Sink