

### SHF Communication Technologies AG

Wilhelm-von-Siemens-Str. 23D • 12277 Berlin • Germany Phone +49 30 772051-0 • Fax +49 30 7531078 E-Mail: sales@shf.de • Web: http://www.shf.de



# Datasheet SHF 614 A 60 GBaud 6-Bit DAC



SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 1/14





The SHF 614 A is a 6-Bit Digital-to-Analog Converter (DAC) operating at symbol rates up to 60 GBaud for use in broadband test setups and telecom transmission systems. Up to six single ended serial data streams are accepted by the DAC and converted into one differential 64-level data signal. By using less than six input ports it is possible to generate 2-level NRZ as well as 4, 8, 16 or 32-level output signals.

With a programmable SHF BPG (e.g. SHF 12104 A) you have full control of the patterns into the DAC. Therefore our BPG/DAC combination can be seen as a full blown remote head non-interleaved 60 GBaud Arbitrary Waveform Generator (AWG).

A single ended clock signal with the same frequency as the data rate is required to drive the SHF 614 A. 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 60 GBaud
- Output baud rate = sample rate
- Differential data output, 2.8 V differential output swing (1.4 V in single-ended operation)
- Single ended clock and data inputs
- Latched input ports
- Output amplitude & input threshold level control (remote by software)

# **Applications**

- 100, 200, 400 Gbps and 1 Tbps system evaluation & development
- Broadband test and measurement equipment
- PAM-N, OFDM, Advanced Modulation Experiments

# Options

• Option Case: DAC module, power supplies, cooling measures and 1.85 mm panel adaptors are housed in a small benchtop case.

# **Block Diagram**



SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 2/14





In addition to the DAC itself, the power supplies, USB cable and heat sink are complementary parts of each delivery. It is recommended to use the DAC only with the delivered power supply module. The heat sink can be removed by the customer. In this case it is required to provide other cooling measures to ensure that the maximum case temperature specified on page 6 will not be exceeded.



SHF 614 A

With Option Case the SHF 614 A DAC module, the power supplies, cooling measures and the Mini-SMP to 1.85 mm panel adaptors are housed in a small benchtop case that can be easily embedded in the customer's test environment.



SHF 614 A – incl. Opt. Case<sup>1</sup>

<sup>1</sup>The cables are not part of the delivery and must be ordered separately

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 3/14





The easy to use software package, SHF 600 Series Control is the most convenient way to control the DAC. 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 can be set and is displayed in the graphical user interface (GUI) as well as the input threshold level for the DC-coupled data inputs. This enables the user to generate a perfect signal just by a few intuitive clicks. The control software for other operating systems is available on request.



Fig. 2: "SHF 600 Series Control" - GUI

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 4/14



# Absolute Maximum Ratings

Parameter	Unit	Symbol	Min.	Тур.	Max.	Comment
Input Parameters						
Data Input Voltage	mV	V <sub>data in</sub>			900	Peak-to-Peak
Clock Input Voltage	mV	V <sub>clk in</sub>			900	Peak-to-Peak
External DC Voltage on RF Clock Input Port	V	V <sub>DCin</sub>	-10		+10	AC coupled input
External DC Voltage on RF Data Input Ports	V	V <sub>DCin</sub>	-0.5		0	DC coupled inputs
External DC Voltage on RF Output Ports	V	V <sub>DCout</sub>	-10		+10	AC coupled outputs
DC Supply Voltage	V	V <sub>cc</sub>			13.0	

# **Specifications**

Parameter	Unit	Symbol	Min.	Тур.	Max.	Comment	
Input Parameters							
Min. Input Data Rate	Gbps	R <sub>in,min</sub>			1		
Max. Input Data Rate	Gbps	R <sub>in,max</sub>	60				
Data Input Voltage	mV	V <sub>data in</sub>	300		800	Eye Amplitude; 500 mV recommended	
External DC Voltage on RF Data Input Ports	V	V <sub>DCin</sub>	-0.5		0	DC coupled inputs	
Min. Clock Input Frequency	GHz	f <sub>in,min</sub>			1		
Max. Clock Input Frequency	GHz	f <sub>in,max</sub>	60				
Clock Input Voltage	mV	$V_{\text{clk in}}$	300		800	Peak-to-Peak; 500 mV recommended	
External DC Voltage on RF Clock Input Port	V	V <sub>DCin</sub>	-10		+10	AC coupled input	

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 – November 13, 2015 Page 5/14





Parameter	Unit	Symbol	Min.	Тур.	Max.	Comment	
Output Parameters							
Min. Output Data Rate	GBaud	R <sub>out,min</sub>			1		
Max. Output Data Rate	GBaud	R <sub>out,max</sub>	60				
Output Voltage	mV	V <sub>out</sub>	1200	1386		Eye Amplitude; Single ended; Full scale; Adjustable up to -6 dB → see page 7	
Rise / Fall Time	ps	t <sub>r</sub> / t <sub>f</sub>		8.2	10	20%80%; deconvolved <sup>2</sup>	
Equivalent Output Bandwidth	GHz	BW	22	27		Derived from Rise Time using formula <sup>3</sup> ; -3 dB bandwidth	
Differential Output Skew	ps	t <sub>skew</sub>		±1	±2		
Power Requirements (witho	ut Option	Case)					
Supply Voltage	V	Vc	+11.5	+12	+12.5	2.1 mm DC Power Jack	
Supply Current	mA	Ι <sub>c</sub>		1150			
Power Dissipation	W	Pd		13.8		@ V <sub>C</sub> = +12V	
Power Requirements (with 0	Power Requirements (with Option Case)						
Supply Voltage	V	Vc	+11.5	+12	+12.5	2.1 mm DC Power Jack	
Supply Current	mA	l <sub>c</sub>		1350	1450		
Power Dissipation	W	Pd		16.2	17.4	@ V <sub>C</sub> = +12V	
Conditions							
Module Temperature <sup>4</sup>	°C	T <sub>case</sub>	10		45	without Option Case	

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 – November 13, 2015 Page 6/14



<sup>&</sup>lt;sup>2</sup> Calculation based on typical rise / fall times from oscilloscope data sheet:  $t_{r \, deconvolved} = \sqrt{(t_{r \, measured})^2 - (t_{r \, oscilloscope})^2} = \sqrt{(t_{r \, meas.})^2 - (3.68 \, ps)^2}$ 

<sup>&</sup>lt;sup>3</sup> Calculation based on formula:  $BW = \frac{0.22}{Tr}$ 

 $t_r$  /  $t_f$  of the output data signal can be slightly decreased by applying additional cooling measures like heat sinks or cooling fans.



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.

Input D5	Input D4	Input D3	Input D2	Input D1	Input D0	Typical Output Amplitude [mV]
-	-	-	-	-	On	22
-	-	-	-	On	-	44
-	-	-	On	-	-	88
-	-	On	-	-	-	176
-	On	-	-	-	-	352
On	-	-	-	-	-	704

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	On	On	On	1386
----	----	----	----	----	----	------

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 7/14





The measurements below had been performed using a SHF 12104 A Bit Pattern Generator (PRBS 2<sup>31</sup>-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.



### **4-Level Output Signal Measurement**

Tektronix \_\_\_ X

Out @ 64 GBaud

Out @ 60 GBaud

100 Waveforms #Acqs 100 of 100

Tektronix \_ X



Out @ 56 GBaud

Out @ 43 GBaud



SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 8/14





### 8-Level Output Signal Measurement



Out @ 60 GBaud





Out @ 43 GBaud

Out @ 32 GBaud



### Out @ 10 GBaud

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 9/14





### **16-Level Output Signal Measurement**





Out @ 20 GBaud

Out @ 10 GBaud



### **32-Level Output Signal Measurement**

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 10/14





### Arbitrary Waveform Generation (4-Bit Mode)





Triangle @ 60 GBaud

Stepped Eye @ 60 GBaud



### "SHF"- writing @ 60 GBaud

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 11/14





Power Supply

Control

3







SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 12/14







SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 13/14







Designation	Connector
Data Out	1.85mm (V) Female
Data Out	1.85mm (V) Female
Clock In	1.85mm (V) Female
D0	1.85mm (V) Female
D1	1.85mm (V) Female
D2	1.85mm (V) Female
D3	1.85mm (V) Female
D4	1.85mm (V) Female
D5	1.85mm (V) Female
	Designation Data Out Data Out Clock In D0 D1 D2 D3 D4 D4 D5

Pos.	Designation
а	GND
b	Power Supply
С	USB
d	GND

SHF reserves the right to change specifications and design without notice - SHF 614 A - V002 - November 13, 2015 Page 14/14

