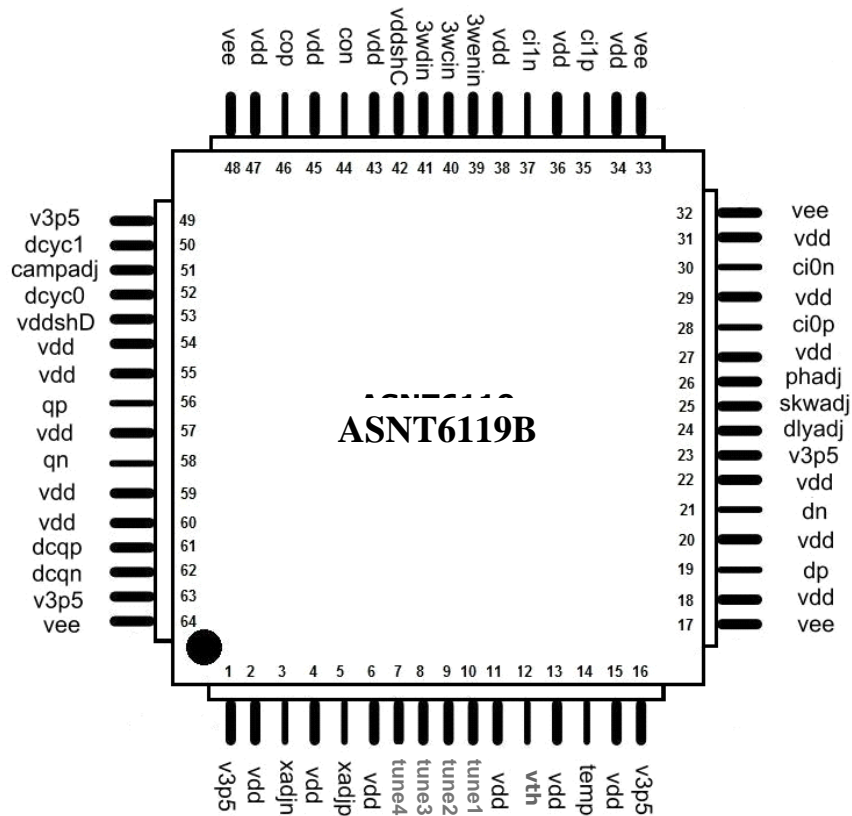




## ASNT6119B-KMF 33.5Gbps Advanced Driver/Amplifier

- High-speed limiting amplifier with selectable built-in pre-emphasis
- Four pre-emphasis taps with externally controlled weight and inversion
- Adjustable data output amplitude and eye quality
- Single-ended output data eye cross point adjustment
- Optional main clock frequency multiplier by 2
- Main clock duty cycle indicators located before and after the multiplier
- Opposite and parallel adjustment of the main clock and data delays
- Additional clock input
- Fully differential CML input and output data, and clock interfaces
- Selectable main or additional clock at the output with adjustable amplitude
- Standard CMOS 3-wire interface for digital controls
- On-chip linear temperature sensor
- Two power supplies: negative -4.3V and floating positive +3.5V
- Average power consumption: 4.0W
- Custom CQFP 64-pin package





## DESCRIPTION

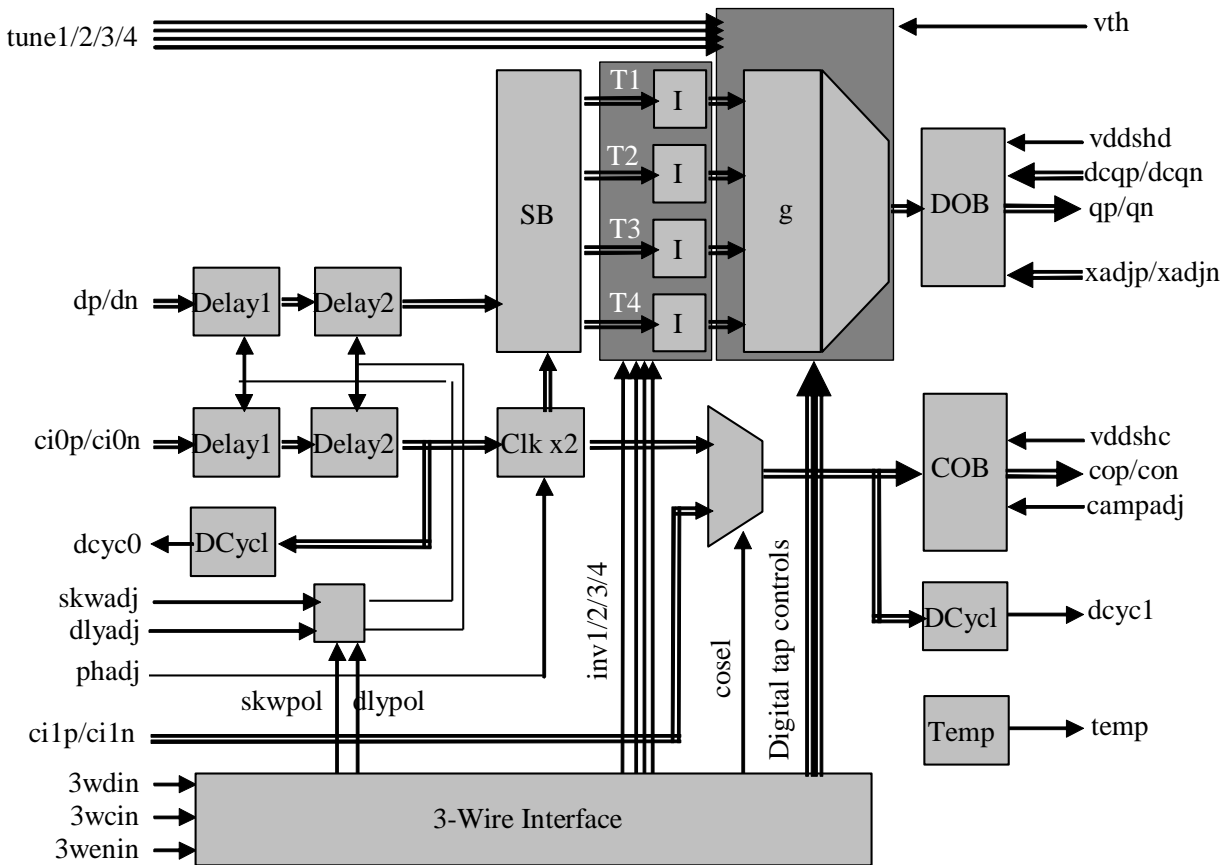


Fig. 1. Functional Block Diagram

The ASNT6119B-KMF SiGe IC shown in Fig. 1 is an advanced programmable driver-amplifier (ADA) with built-in 4-tap pre-emphasis. The ADA generates a combination of four delayed copies of its input differential data signal  $dp/dn$  with certain user-controlled weights and polarities. The copies are created in a 4-bit shift register activated by the ADA's internal high-speed clock signal (see **Sampling Block and Taps**). This clock signal is a copy of the main input clock  $ci0p/ci0n$  with either matching or doubled (multiplied-by-2) frequency. In the multiply-by-2 clock mode, the duty cycles of the input and internal clock signals are monitored, and the output duty cycle can be adjusted through the external control port  $phadj$  (see **Clock Multiplier**). For the part's correct operation, the input data rate in  $Gbps$  should be equal to the internal clock frequency in  $GHz$ .

Input clock and data signals can be delayed in the same or opposite directions to ensure their correct phase relation at the inputs of the shift register and at the chip outputs (see **Input Delay Section**). The ADA can accept one additional clock signal  $ci1p/ci1n$  and deliver it to the output port  $cop/con$  instead of the main clock  $ci0p/ci0n$ , thus operating as a clock buffer (see **Additional Input Clock and Clock Output Buffer**).

The part's I/Os support CML logic interface with on-chip  $50\Omega$  termination to ground. External  $50\Omega$  termination is also required. DC-coupling for data and clock output ports is

strongly recommended. The input ports can use DC or AC coupling. Differential input clock and data are strongly recommended. Amplitude and peaking in the clock and data output signals can be externally adjusted. Both single-ended data output signals also have controlled DC common-mode levels and eye crossing points (see **Data Output Buffer**).

All operational modes of the chip are controlled through a 3-wire serial interface. For more details see **3-Wire Interface Control Block**.

The chip operates from one negative power supply (positive pin connected to external Ground, negative pin  $v_{ee} = -4.3V$ ) and one floating positive power supply (negative pin connected to  $v_{ee}$  and positive pin  $v_{3p5} = 3.5V$ ). It is recommended to keep the relative deviation of  $v_{3p5}$  from Ground within less than  $\pm 0.1V$ .

### ***Input Delay Section***

As shown in Fig. 1, the ADA accepts differential input data  $dp/dn$  and clock  $ci0p/ci0n$  signals and inserts them both into identical variable delay blocks **Delay1** and **Delay2** that can be adjusted in parallel or opposite modes depending on the polarity of internal digital signals  $skwpol$  and  $dlypol$  (“0”=parallel, “1”=opposite) provided by the 3-Wire Interface block. The **Delay1** blocks are controlled by the analog voltage  $skwadj$ . The **Delay2** blocks are controlled by the analog voltage  $dlyadj$ .

It should be noted that the delay settings may affect the multiplied-by-2 clock’s duty cycle and should be tuned for each specific case.

### ***Clock Multiplier***

The clock doubler **Clkx2** uses a “delay and XOR” mechanism to create output clock pulses from each edge of the input clock  $ci0p/ci0n$ . The multiplier is intended for operation with input clock signals within a certain frequency range specified in **ELECTRICAL CHARACTERISTICS**. Analog control voltage  $phadj$  performs a dual function of multiplier activation and linear phase control. Voltages within the linear control range activate the multiplication function and are used for tuning the block’s internal delay in order to achieve 50% duty cycle of the multiplied clock. Voltages below the switch-off threshold disable the multiplication function and allow for direct passing of the input clock to the multiplier’s output.

Two duty cycle control blocks **DCycl** are used for monitoring the clock pulse shapes before and after the multiplier. The first block is positioned before the multiplier and delivers single-ended analog voltage  $dcyc0$  that indicates the input clock’s duty cycle deviation from 50%. The second block is positioned after the multiplier and delivers a similar signal  $dcyc1$  for the output clock. Both generated output voltages can be used in combination with  $phadj$  input within external control loops for getting an optimal shape of the multiplied clock.

It should be noted that the duty cycle of the multiplied clock may depend on the delay settings (see Input Delay Section).

## ***Additional Input Clock and Clock Output Buffer***

The ADA can also accept an additional input clock signal  $ci1p/ci1n$  and deliver it to the clock output. This allows the IC to operate solely as a clock amplifier where the output clock signal's amplitude supplied by output buffer COB can be adjusted using the analog signal  $campadj$ . The amplitude changes from its minimum value ( $campadj = \text{switch-off threshold}$ ) to its maximum value ( $campadj = \text{maximum}$ ). COB can also be completely disabled by applying  $campadj$  voltage below the switch-off threshold.

Either  $ci0$  or  $ci1$  clock signals can be processed by the output buffer COB. Selection of the input clock is accomplished through the digital control signal  $clock\ select$  ("0" -  $ci0$ , "1" -  $ci1$ ) delivered by the 3-wire interface block.

The quality of the output signal's shape can be optimized using the external control  $vddshc$ . This voltage controls peaking on the falling edge of the output signal. More positive voltages correspond to higher peaking.

## ***Sampling Block and Taps***

Sampling block SB is essentially a 4-bit shift register that generates 4 delayed data streams T1-T4 needed for the ADA's 4-tap pre-emphasis capability. As stated above, the analog control voltage  $dlyadj$  is used to adjust the phase relationship between clock and data to ensure optimum sampling in SB. The four samples of the data stream with certain weights and polarities are delivered to the output buffer via four identical channels.

The polarity of the data streams can be independently inverted by circuit blocks I under control of four signals  $inv1/inv2/inv3/inv4$  ("0"=direct, "1"=inverted) provided by the 3-wire interface.

This version of the ADA has 4 Taps (1, 2, 3, and 4) designed as 11 parallel buffers with a common load that are combined into a single output driver. Each buffer has its maximum amplitude equal to  $1/8^{\text{th}}$  of the optimal total output amplitude  $A_{out}$ . The first 7 buffers can be assigned to one of 2 Taps or switched off completely using digital signals provided by the 3-wire interface as shown in Table 1. For detailed interface mapping, see the 3-Wire Interface Control Block section below.

*Table 1. Buffer's Assignment to Taps*

<b>Buffers</b>	1	2	3	4	5	6	7	8	9	10	11
<b>Taps</b>	1/2	1/2	3/2	3/2	3/2	4/2	4/2	1	2	3	4
<b>Amplitude</b>	Constant, 0 or $1/8^{\text{th}}$ of $A_{out}$							From 0 to $A_{analog} = A_{out}/8$			
<b>Control</b>	Digital							Analog			

The last 4 buffers are assigned to one Tap each and are linearly controlled by four external voltages  $tune1/tune2/tune3/tune4$  from minimum (0) to maximum ( $A_{analog}$ ) amplitude that is approximately equal to  $1/8^{\text{th}}$  of  $A_{out}$ . The actual value of the amplitude  $A_{analog}$  available for the analog controls can be adjusted through the external control voltage  $vth$ . The calibration procedure is described in the Application Notes.

It should be noted that the output amplitude may exceed the optimal value by up to  $3/8^{\text{th}}$  of  $A_{\text{out}}$ , if more than one analog buffer is activated. It is recommended to avoid such situations by the appropriate assignment of Tap weights.

For example, if all seven digital buffers are activated, the total value of the analog amplitude should not exceed  $1/8^{\text{th}}$  of  $A_{\text{out}}$ . This means that one analog buffer can be fully switched on while the controls of the three remaining analog buffers should stay at minimum. If two analog buffers are required, then one of them can be assigned a weight of  $A_1 \leq 1/8^{\text{th}}$  of  $A_{\text{out}}$  and the other one can have a weight of  $A_2 \leq 1/8^{\text{th}} \cdot A_1$ .

The recommended algorithm of the weight assignment is described in the ASNT6119B Application Notes.

### ***Data Output Buffer***

Data output buffer DOB includes several features to tune the output data signal generated by the ADA.

The quality of the output signal shape can be optimized using the control voltage  $v\text{ddshd}$  similar to what is described in the Additional Input Clock and Clock Output Buffer section above.

Optimized output eyes with a  $625\text{mV}$  amplitude delivered from one Tap at data rates of  $28\text{Gb/s}$  and  $32\text{Gb/s}$  are shown in Fig. 2 and Fig. 3 respectively. Fig. 4 to Fig. 6 show this part's capabilities for driving a PAM4 signal.

Differential analog control voltage  $x\text{adjp}/x\text{adjn}$  can be utilized to adjust the crossing points of single-ended output eyes. At the default state of  $x\text{adjp} = x\text{adjn} = 0\text{V}$ , the crossing points in both direct and inverted eyes should be centered. The crossing points are moving up in the direct eye and down in the inverted eye if  $x\text{adjp} = -x\text{adjn} > 0$ , or in the opposite directions if  $x\text{adjp} = -x\text{adjn} < 0$ .

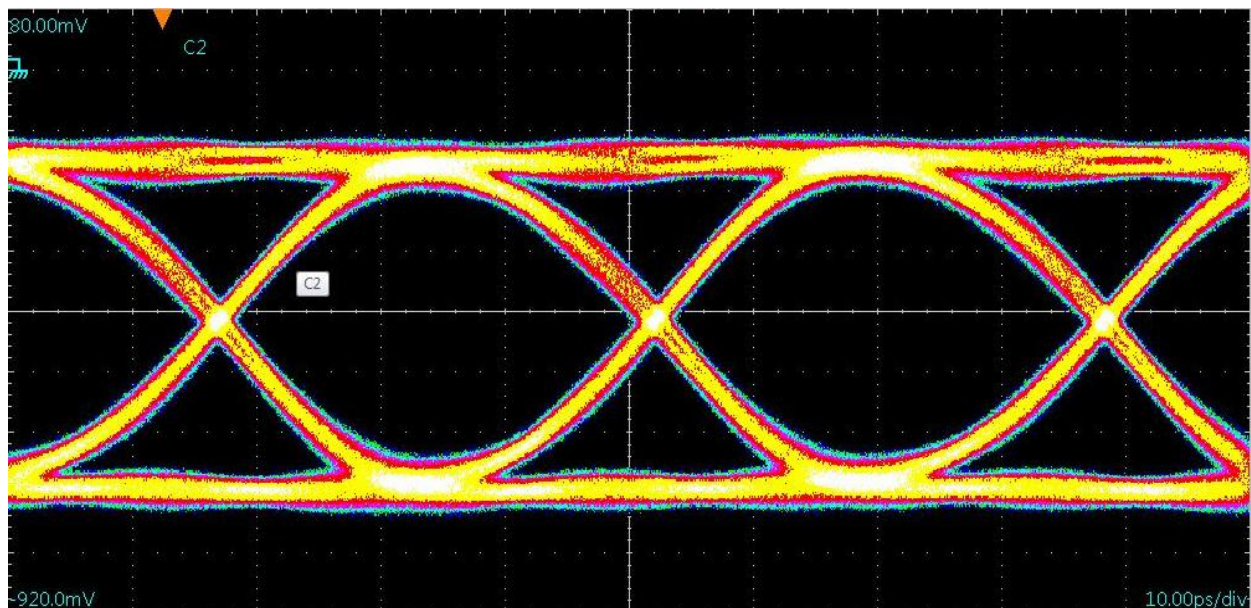




Fig. 2. 1-Tap Output Eye at 28Gb/s Data Rate

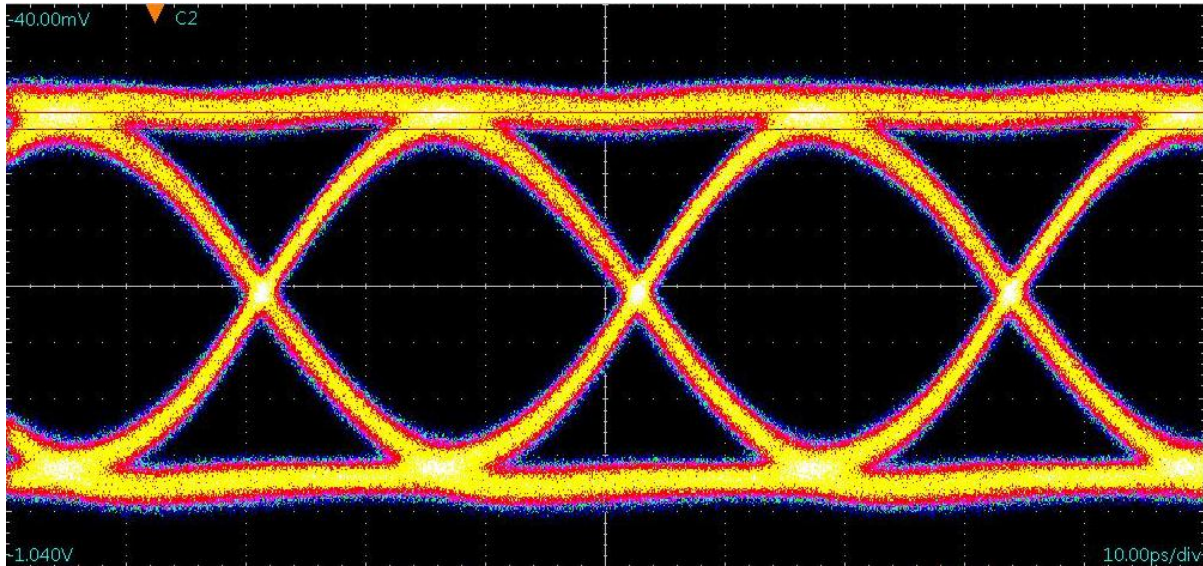


Fig. 3. 1-Tap Output Eye at 32Gb/s Data Rate

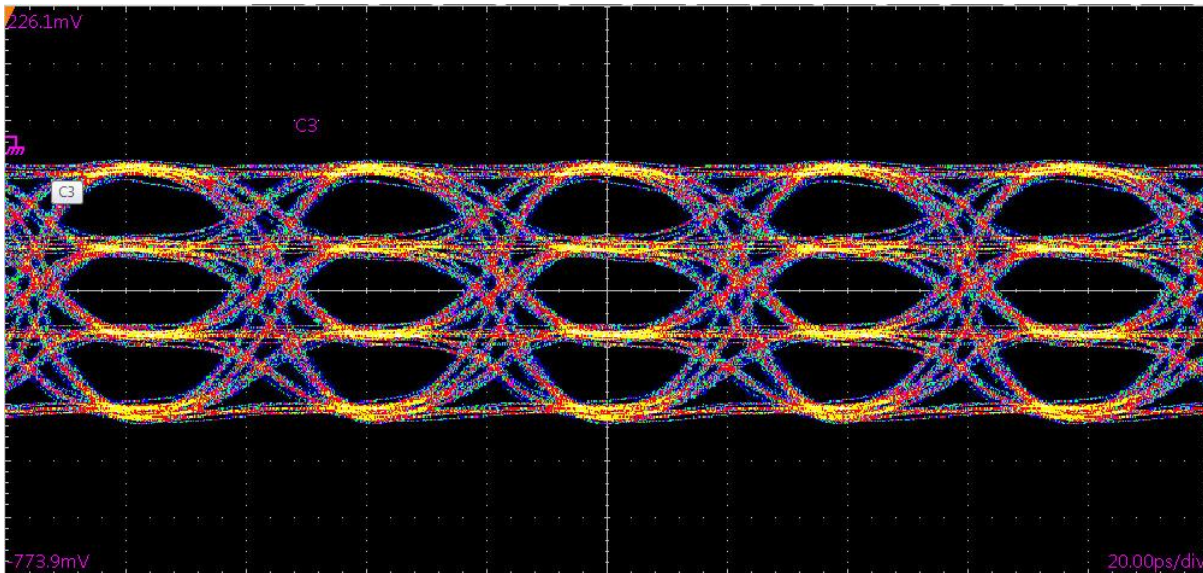


Fig. 4. PAM4 Output Eye Diagram at 25.8Gb/s Data Rate

Finally, 1.0KOhm resistors are attached to both data outputs qp and qn to provide DC shifting of the output signals. Access to the resistors is available through control pins dcqp/dcqn.

### Temperature Sensor

A linear temperature sensor is included on chip. Its behavior is illustrated in Fig. 7 below. The demonstrated voltage has been generated on the internal 11KOhm resistor connected to vdd.

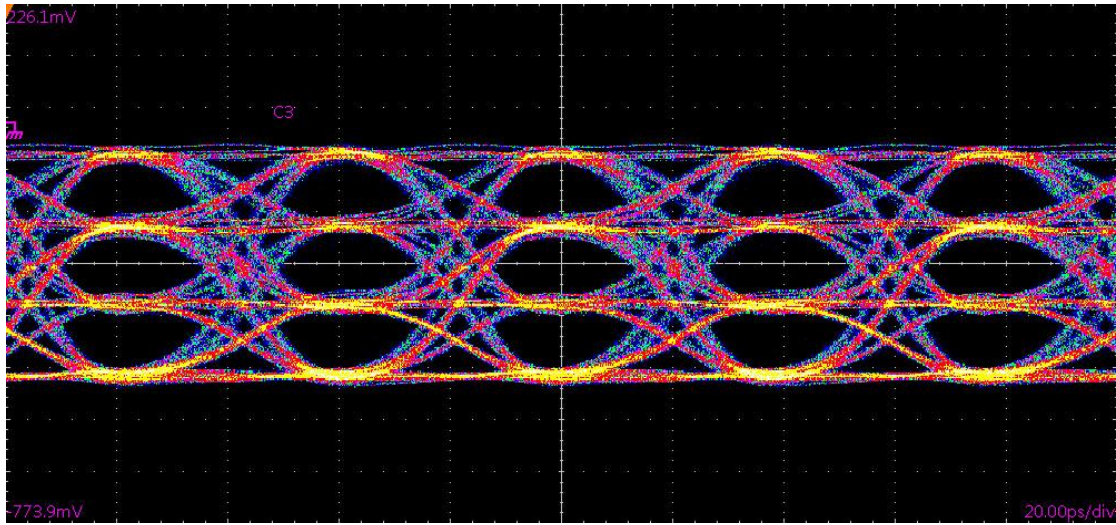


Fig. 5. PAM4 Output Eye Diagram at 28Gb/s Data Rate

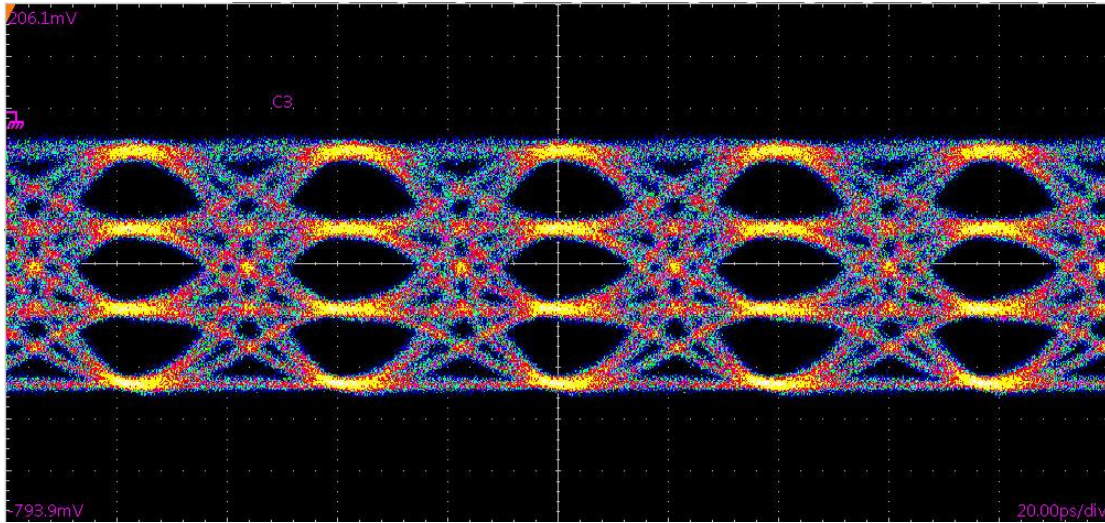


Fig. 6. PAM4 Output Eye Diagram at 28Gb/s Data Rate

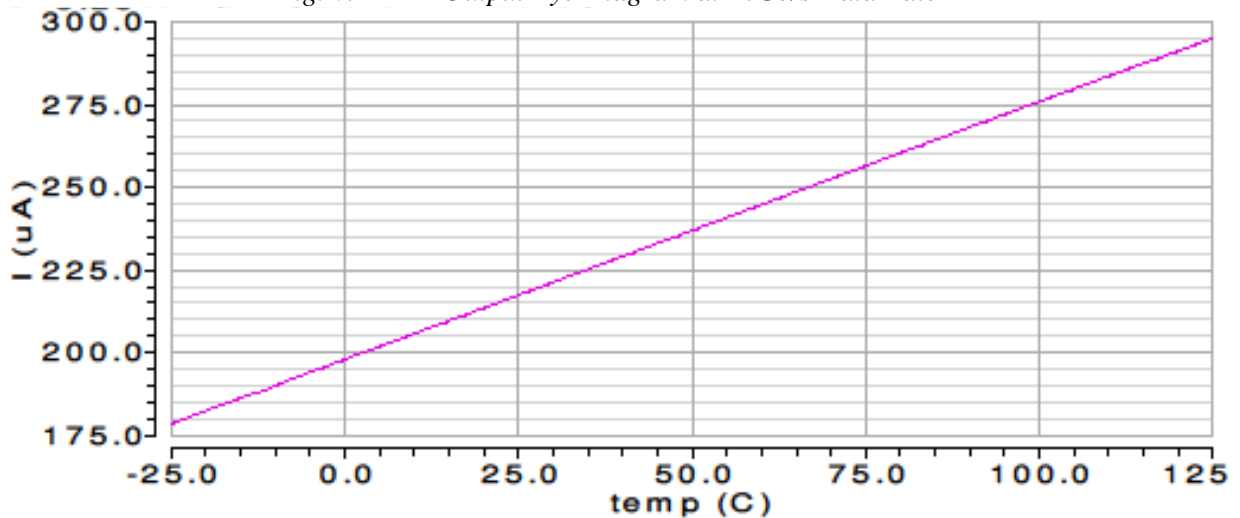




Fig. 7. Temperature Sensor's Characteristic

## 3-Wire Interface Control Block

To reduce the physical number of digital control inputs to the ADA, a 32-bit shift register with a 3-wire input interface has been included on chip. The digital control bits applied through **3w<sub>din</sub>** input are latched in and shifted down the register by negative edges of low-speed clock **3w<sub>cin</sub>** (Bit 0/MSB first). Write enable signal **3w<sub>enin</sub>** must be set to logic "1" during the data read-in phase and then set to logic "0" to retain the shifted in values after 32 clock periods of **3w<sub>cin</sub>**. Table 2 below maps the input 32-bit word to the internal digital control signals.

Table 2. 3-Wire Interface Bit Map

Bit #	Function	State at Bit="1"/"0"
0, MSB	Activation of additional 1/2 pre-buffer current in one of the Taps.	ON/OFF in Tap 4
1	Must be ON if the amplitude in the corresponding Tap is more than half of its maximum value (more than 1/16 <sup>th</sup> of the full output amplitude, or $A_{out}/16$ ).	ON/OFF in Tap 3
2		ON/OFF in Tap 2
3		ON/OFF in Tap 1
4		Activation of analog-controlled sections of the Taps including the corresponding output drivers and 1/2 pre-buffer currents.
5		ON/OFF in Tap 3
6		ON/OFF in Tap 2
7		ON/OFF in Tap 1
8		Buffer 7 activation ( $A_{out}/8$ for Tap 2 or Tap 4 as defined by Bit 16)
9	Buffer 6 activation ( $A_{out}/8$ for Tap 2 or Tap 4 as defined by Bit 17)	ON/OFF
10	Buffer 5 activation ( $A_{out}/8$ for Tap 2 or Tap 3 as defined by Bit 18)	ON/OFF
11	Buffer 4 activation ( $A_{out}/8$ for Tap 2 or Tap 3 as defined by Bit 19)	ON/OFF
12	Buffer 3 activation ( $A_{out}/8$ for Tap 2 or Tap 3 as defined by Bit 20)	ON/OFF
13	Buffer 2 activation ( $A_{out}/8$ for Tap 2 or Tap 1 as defined by Bit 21)	ON/OFF
14	Buffer 1 activation ( $A_{out}/8$ for Tap 2 or Tap 1 as defined by Bit 22)	ON/OFF
15	Not used	
16	Buffer 7 assignment to Tap 2 or Tap 4	Tap 2 / Tap 4
17	Buffer 6 assignment to Tap 2 or Tap 4	Tap 2 / Tap 4
18	Buffer 5 assignment to Tap 2 or Tap 3	Tap 2 / Tap 3
19	Buffer 4 assignment to Tap 2 or Tap 3	Tap 2 / Tap 3
20	Buffer 3 assignment to Tap 2 or Tap 3	Tap 2 / Tap 3
21	Buffer 2 assignment to Tap 2 or Tap 1	Tap 2 / Tap 1
22	Buffer 1 assignment to Tap 2 or Tap 1	Tap 2 / Tap 1
23	Not used	
24	Selection of the clock (C0 or C1) to be sent to the output	C1 / C0
25	Selection of the data and clock short delay (opposite or parallel)	Parallel/Opposite
26	Selection of the data and clock long delay (opposite or parallel)	Parallel/Opposite
27	Activation of the Tap 4 data inversion	ON/OFF
28	Activation of the Tap 3 data inversion	ON/OFF
29	Activation of the Tap 2 data inversion	ON/OFF
30	Activation of the Tap 1 data inversion	ON/OFF
31, LSB	Not used	





This chip includes a standard 3-wire interface with a 100KOhm terminations to vdd for all interface inputs.

## TERMINAL FUNCTIONS

TERMINAL			Description	
Name	No.	Type		
<b>High-Speed I/Os</b>				
dp	19	CML input with internal SE 50Ohm termination to VCC	Differential high-speed data input	
dn	21			
ci0p	28			
ci0n	30			
ci1p	35			
ci1n	37			
cop	46	CML output requires external SE 50Ohm termination to VCC	Differential high-speed clock output	
con	44			
qp	56			
qn	58			
<b>Low-Speed I/Os</b>				
3wenin	39	3.3V	Enable input signal for 3-wire interface	
3wcin	40	CMOS	Clock input signal for 3-wire interface	
3wdin	41	input	Data input signal for 3-wire interface	
<b>Analog Control Voltage Inputs</b>				
xadjp	5	Analog input with 100KOhm termination to vdd	Output data eye cross point adjustment, Differential	
xadjn	3			
tune4	7			
tune3	8			
tune2	9			
tune1	10			
vth	12			
dlyadj	24			
skwadj	25			
phadj	26			
campadj	51			
dcqp	61		Analog input	Direct data output common-mode DC shift, SE
dcqn	62			Inverted data output common-mode DC shift, SE
<b>Analog Control Indicators</b>				
temp	14	Analog output	Linear temperature-dependent voltage output with internal 11KOhm termination to vdd.	
dcyc1	50		Linear voltage indicating output clock duty cycle	
dcyc0	52		Linear voltage indicating main input clock duty cycle	



Supply And Termination Voltages		
Name	Description	Pin Number
vdd	External ground	2, 4, 6, 11, 13, 15, 18, 20, 22, 27, 29, 31, 34, 36, 38, 43, 45, 47, 54, 55, 57, 59, 60
vee	-4.3V negative power supply	17, 32, 33, 48, 64
v3p5	+3.5V positive power supply Negative pin to vee	1, 16, 23, 49, 63
vddshC	Output clock and data peaking adjustment	42
vddshD	Positive power supply. Negative pin to vee	53

## ABSOLUTE MAXIMUM RATINGS

Caution: Exceeding the absolute maximum ratings shown in Table 3 may cause damage to this product and/or lead to reduced reliability. Functional performance is specified over the recommended operating conditions for power supply and temperature only. AC and DC device characteristics at or beyond the absolute maximum ratings are not assumed or implied. All min and max voltage limits are referenced to ground (assumed vdd).

Table 3. Absolute Maximum Ratings

Parameter	Min	Max	Units
Negative Supply Voltage (vee)		-4.8	V
Positive Supply Voltage (v3p5)		3.8	V
Power Consumption		5.0	W
RF Input Voltage Swing (SE)		1.2	V
Case Temperature		+90	°C
Storage Temperature	-40	+100	°C
Operational Humidity	10	98	%
Storage Humidity	10	98	%



## ELECTRICAL CHARACTERISTICS

PARAMETER	MIN	TYP	MAX	UNIT	COMMENTS
<b>General Parameters</b>					
vee	-4.1	-4.3	-4.5	V	
vdd		0.0		V	External ground
v3p5	3.4	3.5	3.6	V	“-“ pin to vee
$I_{-4.3}$	120		220	mA	Depending on the settings of the clock multiplier and the clock and data amplitudes <sup>1)</sup>
$I_{v3p5}$	850		1020	mA	
Power	3.5	4.0	4.5	W	
Junction temperature	0	50	100	°C	
<b>Data input (dp/dn)</b>					
Rate	1.0		33.5	Gb/s	
SE Swing	50	200	500	mV	Peak-to-peak
CM Level	vdd-(SE swing)/2				
<b>Clock inputs (ci0p/ci0n, ci1p/ci1n)</b>					
Frequency (C0 input)	1.0		17	GHz	Fx1 mode, any skwadj and dlyadj
	4.0		16.75	GHz	Fx2 mode, skwadj and dlyadj need tuning
SE Swing	50	200	500	mV	Peak-to-peak
CM Level	vdd-(SE swing)/2				
<b>Data output (qp/qn)</b>					
Rate	1.0		33.5	Gbps	
SE Swing	0.0		1250	mV	Peak-to-peak
CM Level	vdd-0.1	vdd-0.75		V	Depends on the amplitude <sup>2)</sup>
Rise/Fall Times	12	13	14	ps	20%-80%
<b>Clock output (cop/con)</b>					
SE Swing, max	530		920	mV	Pk-pk, 1.0-17GHz
	160		400	mV	Pk-pk, 18-32GHz
CM Level	vdd-0.05	vdd-0.55		V	Depends on the amplitude <sup>3)</sup>
Rise/Fall Times	TBD			ps	20%-80%
<b>SE tuning ports (tune1/2/3/4, skwadj, dlyadj, phadj, campadj)</b>					
Linear control voltage	vdd-2		vdd	V	
Switch-off threshold	vdd-2			V	
<b>Cross point control (xadjp/xadjn)</b>					
Differential voltage range	vdd-8.0		vdd+8.0	V	±4V at each input
CM Level	vdd				
Current in/out of the pin	+4 / -4			mA	at +4V / -4V
<b>Threshold control (vth)</b>					
Voltage range	vdd-2		vdd	V	
<b>DC common mode voltage control (dcqp/dcqn)</b>					
Voltage range	vee		vdd	V	



PARAMETER	MIN	TYP	MAX	UNIT	COMMENTS
<b>Externally Controlled Operational Ranges</b>					
Clock-to-Data skew	-30		+30	ps	opposite skwadj control
Clock and Data delay	0		+30	ps	parallel skwadj control
Clock-to-Data skew	-45		+45	ps	opposite dlyadj control
Clock and Data delay	0		+45	ps	parallel dlyadj control
Output eye cross point	-25		+25	%	of the eye amplitude

PARAMETER	MIN	TYP	MAX	UNIT	COMMENTS
<b>Variable supply voltages (vddshc, vddshd)</b>					
Voltage range	2.8		4.3	V	“-“ pin to vee
$I_{vddshd}$		2.2		mA	All 4 taps active
$I_{vddshc}$		1.1		mA	
<b>Duty Cycle Indicator (dcyc0/dcyc1)</b>					
Voltage range	vdd-3.3		vdd-0.8	V	
<b>Temperature Sensor (temp)</b>					
Voltage range	vdd-3.3		vdd-2.3	V	
<b>3-Wire Inputs (3wdin, 3wcin, 3wenin)</b>					
High voltage level	vdd-0.2		vdd	V	
Low voltage level	vdd-3.3		vdd-3.1	V	
Clock speed		350	400	MHz	

## Power Supply Currents

*(Preliminary Data, for Reference Only)*

co amplitude	q amplitude	Clock multiplier	$I_{-4.3}, mA$	$I_{v3p5}, mA$
min	min	off (Fx1)	120	850
min	min	on (Fx2)	120	920
min	max	off (Fx1)	180	880
min	max	on (Fx2)	180	950
max	min	off (Fx1)	160	930
max	min	on (Fx2)	160	1000
max	max	off (Fx1)	220	950
max	max	on (Fx2)	220	1020



## ***Data Output Common Mode Voltage Levels (Preliminary Data, for Reference Only)***

Amplitude			V <sub>CM</sub> , V	Amplitude			V <sub>CM</sub> , V
Total, mV	Digital	Analog, mV		Total, mV	Digital	Analog, mV	
150	0	min	vdd-0.089	790	4A <sub>out</sub> /8	min	vdd-0.461
150	A <sub>out</sub> /8	max	vdd-0.182	790	5A <sub>out</sub> /8	max	vdd-0.554
310	A <sub>out</sub> /8	min	vdd-0.182	950	5A <sub>out</sub> /8	min	vdd-0.554
310	2A <sub>out</sub> /8	max	vdd-0.275	950	6A <sub>out</sub> /8	max	vdd-0.647
470	2A <sub>out</sub> /8	min	vdd-0.275	1100	6A <sub>out</sub> /8	min	vdd-0.647
470	3A <sub>out</sub> /8	max	vdd-0.368	1100	7A <sub>out</sub> /8	max	vdd-0.740
630	3A <sub>out</sub> /8	min	vdd-0.368	1250	7A <sub>out</sub> /8	min	vdd-0.740
630	4A <sub>out</sub> /8	max	vdd-0.461				

## ***Clock Output Common Mode Voltage Levels (Preliminary Data, for Reference Only)***

Amplitude, mV	100	200	300	400	500	600	700	750
V <sub>CM</sub> , V	vdd-0.07	vdd-0.14	vdd-0.21	vdd-0.28	vdd-0.35	vdd-0.42	vdd-0.49	vdd-0.54

## **PACKAGE INFORMATION**

The chip die is housed in a custom 64-pin CQFP package. The dimensioned drawings are shown in Fig. 8.

The package provides a center heat slug located on its back side to be used for heat dissipation. ADSANTEC recommends for this section to be soldered to the vdd plain, which is ground for a negative supply, or power for a positive supply.

The part's identification label is ASNT6119B-KMF. The first 9 characters of the name before the dash identify the bare die including general circuit family, fabrication technology, specific circuit type, and part version while the 3 characters after the dash represent the package's manufacturer, type, and pin out count.

This device complies with the Restriction of Hazardous Substances (RoHS) per 2011/65/EU for all ten substances.



## 64-PIN KMF Package

All Dimensions are in millimeters

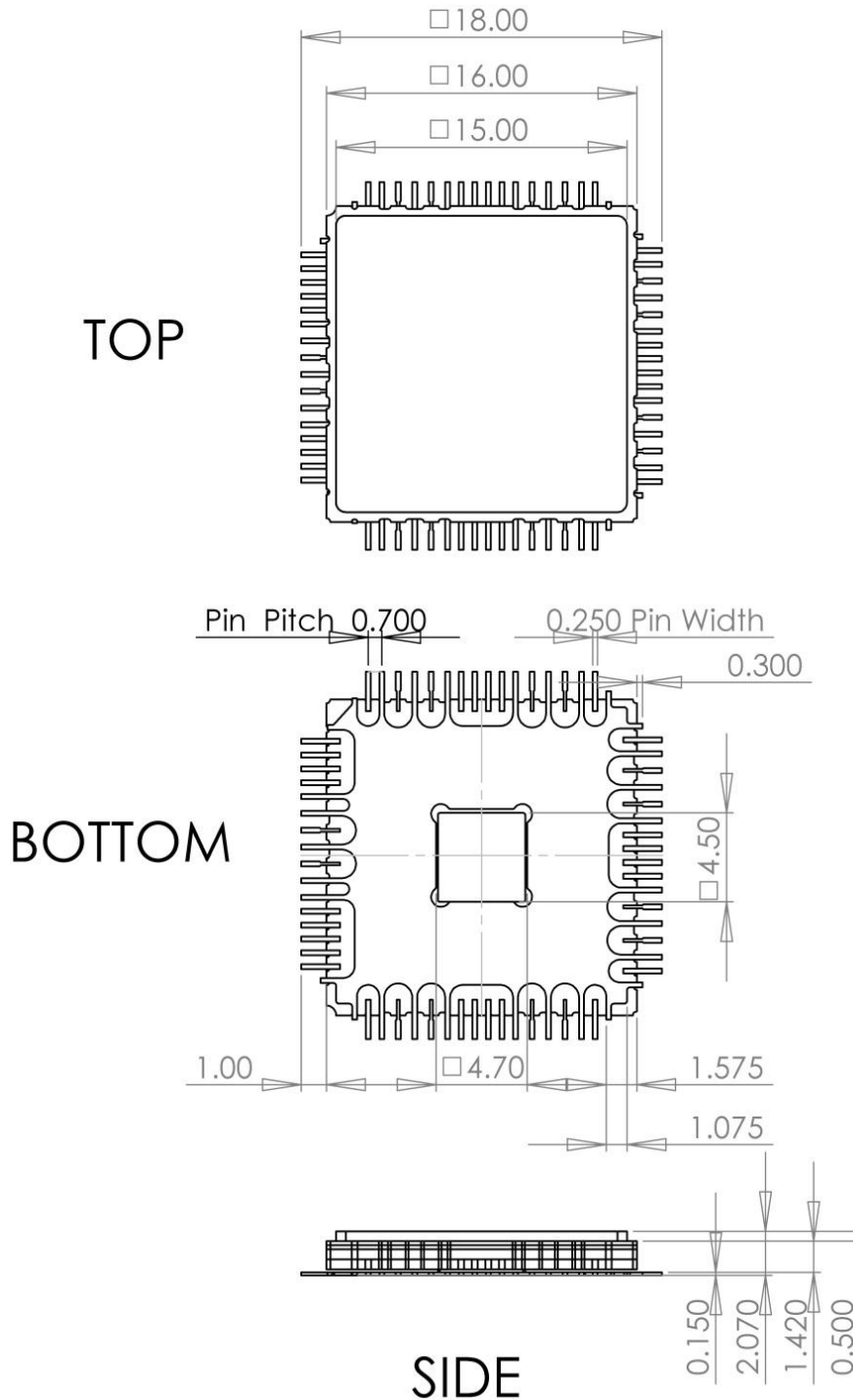


Fig. 8. CQFP 64-Pin Package Drawing (All Dimensions in mm)



**ADSANTEC**

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## REVISION HISTORY

Revision	Date	Changes
1.2.2	01-2020	Updated Package Information
1.1.2	07-2019	Updated Letterhead
1.1.1	09-2017	Corrected frequency of operation Updated electrical characteristics
1.0.1	09-2017	Initial release