

ON Semiconductor P1P8160A: Spread Spectrum Clock Solution to Address Peak EMI in AMD Graphics Platforms with GDDR Memory



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APPLICATION NOTE

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Abstract

Graphics Processing Units (GPU) running with Graphics Double Data Rate memories, Version 3 and 5 (GDDR3/GDDR5), could potentially cause peak Electro-Magnetic interference (EMI) failure at compliance certification. This article is intended to address and solve this peak EMI failure using ON Semiconductor's new Spread Spectrum Clock Generator (SSCG) device*P1P8160A, specifically designed for use with AMD Northern Islands/ Evergreen series GPUs.

Introduction

GDDR3 and GDDR5 memories are commonly used in high performance graphics cards and run at very high frequencies. If memory capacity goes up to 1 GB GDDR3 and GDDR5, it requires eight memory modules with eight pairs of differential memory clocks from the GPU to the GDDR3 and GDDR5 memory modules. These clocks are a major source of EMI problems. The EMI certification tests come very late in the product cycle and can cause unexpected delays if the system fails EMI compliance.

Active Spread Spectrum (SS) technology modulates the frequency to suppress peak EMI and also ensures signal integrity is not degraded in the GDDR clock signal by preserving the rise/fall times. All signals derived from this SS clock will be modulated and peak EMI levels are suppressed. SSCG technology is an optimal solution to solve this peak EMI problem. P1P8160A is the ideal SSCG timing solution for AMD's Northern Islands and Evergreen series graphic cards with GDDR3 and GDDR5 memory support. The P1P8160A provides two clocks: a 27 MHz reference clock to GPU core, and a 100 MHz SS clock to the GDDR memory.

Using P1P8160A for AMD Graphic Chips Platforms

P1P8160A uses a 27 MHz fundamental crystal or an external reference clock to generate a 27 MHz (no SS) and a 100 MHz (SS) clock output. As shown in Figure 1, the 100 MHz SS clock will supply the reference clock to the internal GDDR controller.

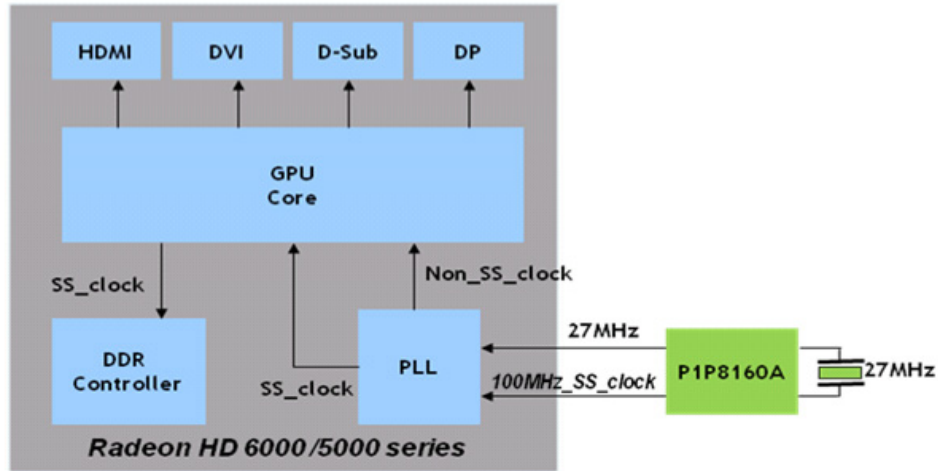


Figure 1. P1P8160A for AMD Graphic Chips Application

P1P8160A: Key Functional Characteristics

P1P8160A provides eight different user selectable SS deviation options to control the extent of frequency modulation by setting Pin 3 (SS1%) and Pin 7 (SS2%) to one of three levels (High, Medium, or Low). This flexibility

allows to user to customize the modulation depth such that P1P8160A provides the maximum EMI benefit without violating system timing specifications. The deviation settings of the P1P8160A are shown in Table 1.

Table 1. P1P8160A: FREQUENCY DEVIATION SELECTION

SS2% (Pin 3)	SS1% (Pin 7)	Deviation at 100 MHz (%) (Pin 5)
L	L	SSOFF
L	M	-0.5
L	H	-2.5
M	L	-0.25
M	M	-0.75
M	H	-1
H	L	-1.5
H	M	-2
H	H	-3

P1P8160A: AC Electrical Characteristics

The P1P8160A AC Electrical Characteristics for the 27 MHz and 100 MHz output clocks are shown in Table 2. These clocks meet AMD's GPU clock specifications.

Table 2. P1P8160A OUTPUT CLOCKS AC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Min	Typ	Max	Unit
f_{OUT}	ModOUT Clock frequency (SS1% & SS2% = 0) (Tolerance: ± 30 ppm)		100		MHz
	RefOUT Clock frequency (Tolerance: ± 30 ppm)		27		
t_{LH}, t_{HL}	RefOUT Rise and Fall time, $C_L = 15$ pF (Measured between 20% to 80%)		1.25	2	ns
t_{LH}, t_{HL}	ModOUT Rise and Fall time, $C_L = 15$ pF (Measured between 20% to 80%)		1.25	1.75	
T_{DCOUT}	Output Clock Duty Cycle	45	50	55	%

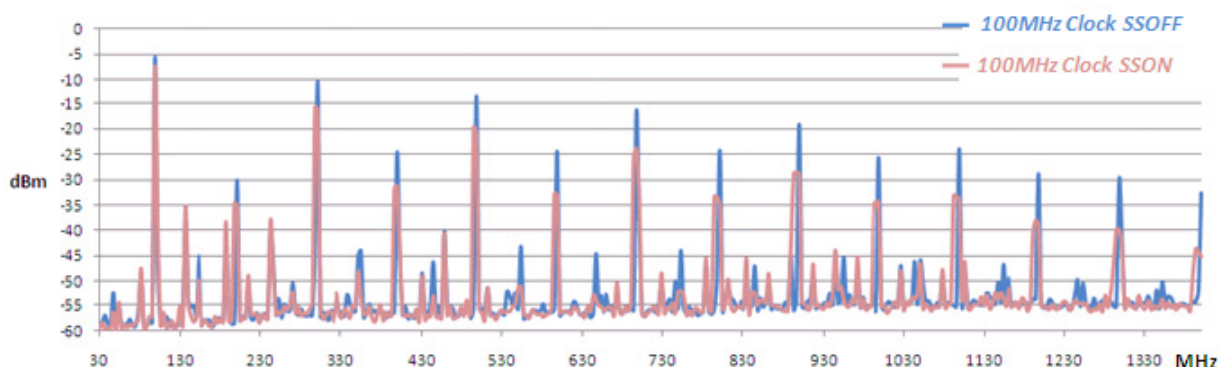
Table 2. P1P8160A OUTPUT CLOCKS AC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Min	Typ	Max	Unit
T _{JC}	Cycle–Cycle Jitter (For ModOUT, RefOUT)		125	200	ps
T _{JL}	Long Term Jitter (10k cycles), 27 MHz, RefOUT		150	300	
	Long Term Jitter (10k cycles), 100 MHz ModOUT (SSOFF)		350	600	
MF	Modulation Frequency	31	32	33	kHz

100 MHz Clock Output EMI Comparison

The plots in Figure 2 display the results of EMI bench testing using the P1P8160A. This test is performed on a characterization board and the EMI is measured on the 100 MHz output clock using a spectrum analyzer. The results show the difference in peak EMI levels, with and

without SS. As seen in Table 3, the EMI reduction in the 30 MHz– 1.3 GHz frequency range is 2 – 10 dB better with –0.5% down spreading, when compared to SS turned off. Device settings are: V_{DD} = 3.3 V, Deviation = –0.5% and Modulation rate = 32 kHz. Application testing was done using Anritsu MS2711D Spectrum Analyzer.

**Figure 2. 100 MHz EMI Spectrum Analyzer performance****Table 3. EMI PERFORMANCE TABLE**

Freq	EMI P1P8160A SSOFF (dBm)	EMI P1P8160A SSON = –0.5% (dBm)	EMI Reduction (dB)
100 MHz	–5.16	–7.46	2.3
300 MHz	–10.58	–15.73	5.15
500 MHz	–13.01	–19.51	6.5
700 MHz	–16.17	–23.33	7.16
900 MHz	–18.33	–26.58	8.25
1100 MHz	–23.48	–32.55	9.07
1300 MHz	–30.71	–41.63	10.92

Validation in Barts (HD6870) System

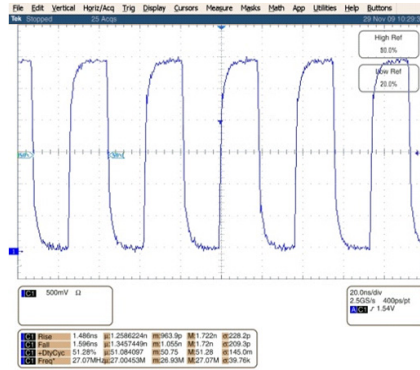
This case study is based on an AMD Radeon HD6870 (DDR5 GPU) with a P1P8160A. The 27 MHz output clock AC electrical characteristics are shown in Table 4 and the output waveforms are shown in Figures 3a, 3b and 3c.

The P1P8160A meets the AMD GPU clock specifications. Measurements were performed using a Tektronix TDS6604B Digital Oscilloscope, P7260 Active Probes and TDSJITV3 Jitter Analysis Software.

Table 4. APPLICATION TEST FOR P1P8160A: 27 MHZ OUTPUT CLOCK

	Rise Time	Fall Time	Duty Cycle		Cycle–Cycle Jitter		Long Term Jitter
P1P8160A	1.25 ns	1.34 ns	48% (min)	51% (max)	–183 ps (min)	139 ps (max)	200 ps

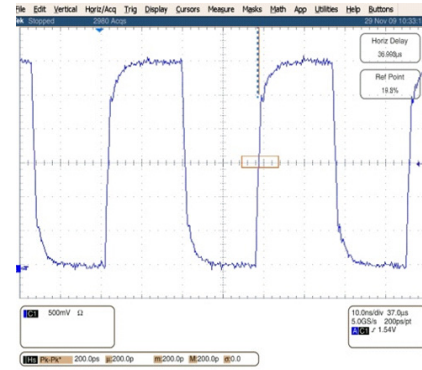
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a. Rise/Fall Time, Duty Cycle



b. Cycle-Cycle Jitter



c. Long Term Jitter

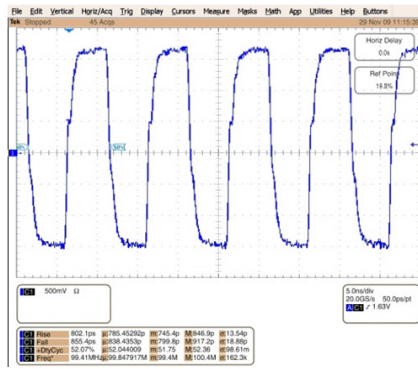
Figure 3.

Table 5 and Figures 4a, 4b and 4c show the 100 MHz output clock Rise/ Fall time, Duty Cycle, Cycle-Cycle jitter and Long term jitter measured values and waveforms. Long

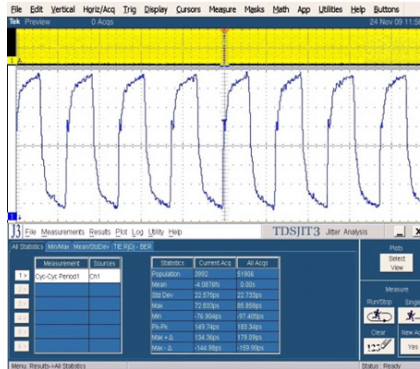
term jitter is with SS turned OFF and the other parameters are measured with SS ON (-0.5% down spreading). The P1P8160A meets the AMD GPU clock specifications.

Table 5. APPLICATION TEST FOR P1P8160A: 100 MHz OUTPUT CLOCK

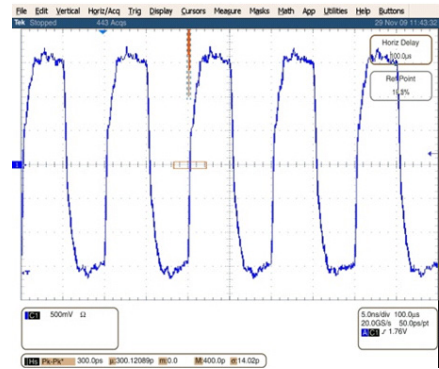
	Rise Time	Fall Time	Duty Cycle		Cycle-Cycle Jitter		Long Term Jitter (SSOFF)
P1P8160A	0.785 ns	0.838 ns	48% (min)	52% (max)	-97.4 ps (min)	85.8 ps (max)	300 ps



a. Rise/Fall Time, Duty Cycle



b. Cycle-Cycle Jitter



c. Long Term Jitter

Figure 4.

The EMI Spectrum Analyzer performance comparison with the original non-SS DDR5 clock and a DDR5 SS Clock is shown in Figure 5. The results show that the EMI peak is

lowered by 9.5 dB when -0.5% (down spreading) SS is used at 1.225 GHz. Testing was performed using Anritsu MS2711D Spectrum Analyzer.

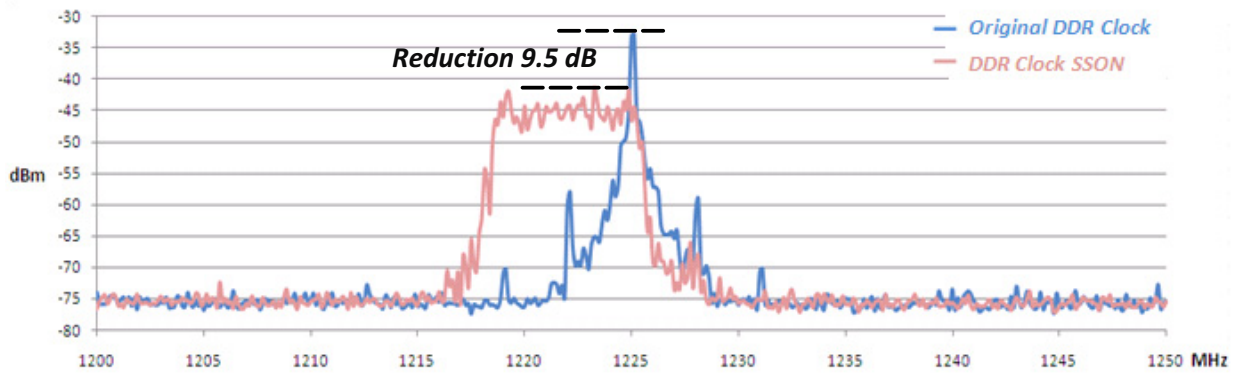


Figure 5. DDR Clock EMI Performance

Summary

Based on this case study, the Peak EMI benefits that can be expected with -0.5% (down spreading) SS when using the P1P8160A are:

1. 2 -3 dB, In 30–200 MHz frequency range
2. 5-9 dB, In 200–900 MHz frequency range
3. 9-10dB, In 1100–1300 GHz frequency range

The P1P8160A was designed to meet AMD clock specifications and this case study highlights the benefits of using the P1P8160A in AMD GPUs.

The key jitter specs are as follows:

1. On the 27 MHz output clock, the measured Cycle – Cycle Jitter values are -183 ps(min) to 139 ps(max) and long term jitter is 200 ps.

2. On the 100MHz output clock, the measured Cycle – Cycle Jitter values are -97.4 ps(min) to 85.8 ps (max) and long term jitter is 300 ps.

The peak EMI comparison on the GDDR5clock shows that the EMI is reduced by 9.5 dB at 1.225 GHz when -0.5% down spread is used. The P1P8160A device is an efficient and cost effective way to reduce the EMI peaks in systems that use GDDR3 and GDDR5 memories.

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