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SiTime Oscillator Rise and Fall Time Selection for SiT8103, SiT8003, and SiT9003

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1 Programmable Rise and Fall Times

The rise and fall times of the clock signal are important parameters for digital systems. In general, clock logic circuits benefit from fast clock rise and fall times, since these minimize the impact of power supply jitter. On the other hand, a slower slew rate on clock edge transitions may reduce electromagnetic interference (EMI) emissions from the printed circuit board.

The rise and fall times of an oscillator output driving a capacitive load depend on 1) the maximum drive strength of the oscillator output stage, and 2) the output load capacitance. The rise and fall times of SiTime oscillators with single-ended CMOS output are typically specified in the datasheet for a load capacitance of 15 pF. However, SiTime oscillators are designed to offer a wide range of drive strength options. This allows designers to optimize the rise/fall times for their specific applications.

To select the right part suitable for a specific application, the designer needs to know:

- The system requirement for the rise and fall times
- The total load capacitance
- The clock distribution traces and terminations.

Please refer to SiTime application note AN10002 [1] for more information on termination schemes for single-ended LVCMOS output.

This application note reports the rise/fall times for different selections of drive strength options, load conditions, and power supply voltages for the SiT8003, SiT8103, and SiT9003 devices.

2 Driving Large Loads Up To 60 pF

The SiTime datasheet for each standard oscillator product specifies the rise and fall times for one or more load capacitances. More data covering the full range of selection of rise and fall times of the SiTime SiT8003, SiT8103, and SiT9003 devices driving capacitive loads up to 60 pF are listed in Tables 1 through 4 in Appendix A for the following conditions:

- Power supply voltages of 3.3V, 2.8V, 2.5V, and 1.8V
- Full operating temperature range of -40˚C to 85˚C
- Four available drive strength options.

Based on the rise and fall time data given in Tables 1 through 4, we can derive the maximum frequency at which the oscillator can operate with guaranteed full swing of the output voltage as follows:

$$\text{Max Frequency} \sim \frac{1}{2 \times (T_{rise} + T_{fall})} \qquad (1)$$

The maximum frequencies for different drive strength and load options are summarized in Tables 5 through 8 for different supply voltages.

The following steps describe how to use these tables:

1. Select the table for the target power supply voltage.
2. Look at the rows highlighted in green. These rows correspond to the drive strength of standard devices. Order standard parts if the rise/fall times for the target capacitive load are sufficient for the application.
3. If rise/fall times other than the ones provided by standard devices are required, look at the boxes that provide the acceptable rise/fall times desired for the application. Refer to Tables 5 through 8 to find out the maximum frequency supported for the corresponding box in Tables 1 through 4. For example, if you selected drive strength option 4 in VDD=2.5V (Table 3) for 45 pF load, the maximum frequency to guarantee full output swing is 75 MHz, as specified in Table 7 in the row for option 4 and under the column for 45 pF.
4. If the rise/fall times and maximum frequency are acceptable, contact SiTime to order devices with the selected drive strength option.

3 Reducing Rise/Fall Time for EMI Reduction

In some applications, EMI may be reduced by choosing slower clock rise and fall times. The slower rise/fall edges reduce the higher clock harmonics in a digital clock signal, minimizing EMI radiation at these harmonics.

Figure 1 shows the harmonic power reduction as the rise/fall times are reduced. The rise/fall times are expressed as a ratio of the clock period. For the ratio of 0.05, the signal is very close to a square wave. For the ratio of 0.45, the rise/fall times are very close to half the clock cycle, leading to a near-triangular waveform. These results, for example, show that the 11th clock harmonic can be reduced by 35 dB if the rise/fall edge is increased from 5% of the period to 45% of the period.

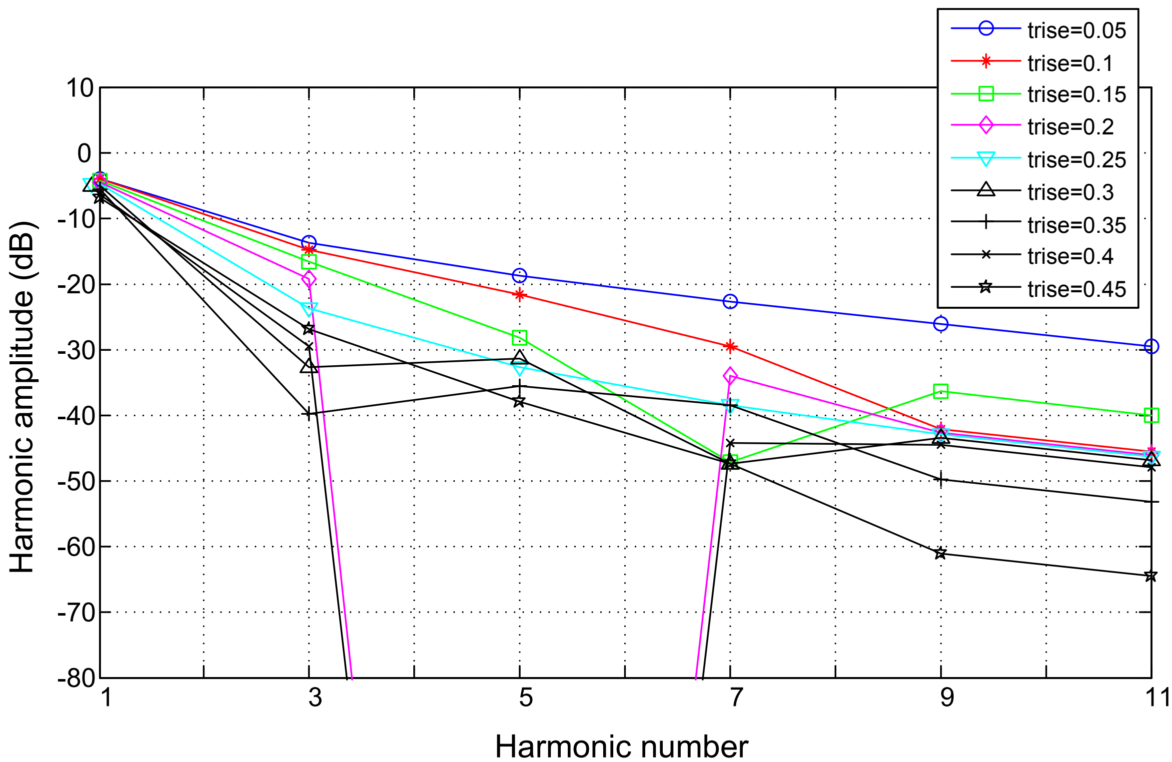

Figure 1: Harmonic EMI reduction as a function of slower rise/fall time

For SiTime oscillators, it may be possible to get a slower rise and fall time by operating at a lower power supply voltage, with a reduced output voltage swing. Additional load capacitance will also slow down the clock edges, at the expense of increasing supply current consumption. The best way to slow down the edges is to select lower drive strength options. Such options increase rise/fall times without needing to drive larger capacitive loads and resulting higher supply current. This can be achieved by selecting the right option in Tables 1 through 4.

SiTime also offers oscillators with a spread spectrum clocking (SSC) feature [2], which can effectively reduce EMI radiation not only on the clock traces but also throughout the network that is clocked from the SSC clock.

4 References

[1] SiTime Corporation, “Termination Recommendations for SiTime Single-Ended Oscillators,” AN100002, Rev.1.1.

[2] SiTime Corporation, “SiTime Spread Spectrum Clock Oscillators”, AN10005, rev1.1

5 Appendix A: Rise/Fall Times for SiT8003, SiT8103, and SiT9003 Devices

Table 1: Rise/fall times, VDD=3.3V ±10%, T=-40˚C to 85˚C

Drive strength option		Unit	Load (pF)			
			15	30	45	60
1	Max.	ns	2.4	3.5	5.5	6.4
	Typ.	ns	1.7	2.8	4.3	5.4
2*	Max.	ns	2.0	2.5	3.9	4.8
	Typ.	ns	1.1	2.0	2.9	3.8
3	Max.	ns	1.2	2.0	3.0	3.7
	Typ.	ns	0.8	1.6	2.2	2.9
4	Max.	ns	0.9	1.7	2.5	3.0
	Typ.	ns	0.6	1.3	1.9	2.3

* Default option for standard devices

Table 2: Rise/fall times, VDD=2.8V ±10%, T=-40˚C to 85˚C

Drive strength option		Unit	Load (pF)			
			15	30	45	60
1	Max.	ns	2.5	4.1	6.0	7.3
	Typ.	ns	2.0	3.2	4.8	5.9
2	Max.	ns	2.2	3.0	4.5	5.4
	Typ.	ns	1.3	2.2	3.3	4.3
3*	Max.	ns	2.0	2.4	3.5	4.3
	Typ.	ns	1.0	1.7	2.5	3.2
4	Max.	ns	1.2	1.9	2.9	3.6
	Typ.	ns	0.7	1.5	2.0	2.6

* Default option for standard devices

Table 3: Rise/fall times, VDD=2.5V ±10%, T=-40˚C to 85˚C

Drive strength option		**Unit**	**Load (pF)**			
			15	**30**	**45**	**60**
1	Max.	ns	2.8	4.6	6.8	8.3

	Typ.	ns	2.1	3.6	5.2	6.4
2	Max.	ns	2.3	3.3	5.0	5.9
	Typ.	ns	1.4	2.5	3.7	4.7
3*	Max.	ns	2.0	2.6	3.4	4.8
	Typ.	ns	1.1	1.9	2.8	3.6
4	Max.	ns	1.3	2.2	3.3	4.0
	Typ.	ns	0.9	1.6	2.3	2.9

* Default option for standard devices

Table 4: Rise/fall times, VDD=1.8V ±10%, T=-40˚C to 85˚C

Drive strength option		Unit	Load (pF)			
			15	30	45	60
1	Max.	ns	4.2	6.8	9.4	12.1
	Typ.	ns	3.1	5.1	7.3	9.2
2	Max.	ns	3.2	4.9	6.9	8.7
	Typ.	ns	2.3	3.7	5.3	6.5
3	Max.	ns	2.7	3.9	5.5	6.7
	Typ.	ns	1.7	2.9	4.2	5.2
4*	Max.	ns	2.5	3.3	4.6	5.7
	Typ.	ns	1.4	2.4	3.4	4.3

* Default option for standard devices

Table 5: Maximum frequency for different load and drive strength options, VDD=3.3V

Drive strength option	Unit	Load (pF)			
		15	30	45	60
1	MHz	110	70	45	40
2*	MHz	110	100	65	55
3	MHz	110	110	85	70
4	MHz	110	110	105	85

* Default option for standard product

Table 6: Maximum frequency for different load and drive strength options, VDD=2.8V

Drive strength option	Unit	Load (pF)			
		15	30	45	60
1	MHz	100	60	40	35

2	MHz	110	85	55	45
3*	MHz	110	110	75	60
4	MHz	110	110	90	70

* Default option for standard product

Table 7: Maximum frequency for different load and drive strength options, VDD=2.5V

Drive strength option	**Unit**	**Load (pF)**			
		15	**30**	**45**	**60**
1	MHz	90	55	35	30
2	MHz	110	75	50	40
3*	MHz	110	95	65	50
4	MHz	110	110	75	65

* Default option for standard product

Table 8: Maximum frequency for different load and drive strength options, VDD=1.8V

Drive strength option	**Unit**	**Load (pF)**			
		15	**30**	**45**	**60**
1	MHz	60	35	25	20
2	MHz	85	50	35	30
3	MHz	105	65	45	40
4*	MHz	110	80	55	45

* Default option for standard product

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