Spread Spectrum Frequency Timing Generator

Features

- **Generates a spread spectrum timing signal (SYSCLK) and a non-spread signal (USBCLK)**
- **Requires a 14.318-MHz crystal for operation**
- **Supports MIPS microprocessor clock frequencies**
- **Reduces peak EMI by as much as 12 dB**
- **Integrated loop filter components**
- **Cycle-to-cycle jitter = 250 ps (max)**
- **Operates with a 3.3 or 5.0V power supply**
- **Spread output is selectable from 10 to 133 MHz**
- **TEST mode supports modulation off (High-Z) and special test input reference frequency**
- **Guaranteed 45/55 duty cycle**
- **Packaged in a 16-pin, 300-mil-wide SOIC (Small Outline Integrated Circuit)**

Overview

The W155 incorporates the latest advances in PLL-based spread spectrum frequency synthesizer technology. By frequency modulating the SYSCLK output with a low-frequency carrier, peak EMI can be greatly reduced in a system. Use of this technique allows systems to pass increasingly difficult EMI testing without resorting to costly shielding or redesign.

In a system that uses the W155, not only is EMI reduced in the various clock lines, but also in all signals which are synchronized to SYSCLK. Therefore, the benefits of using this technique increase with the number of address and data lines in the system.

The W155 is specifically targeted toward MIPS microprocessor based systems where EMI is of particular concern. Each device uses a single 14.318-MHz crystal to generate a selectable spread spectrum output and an unmodulated 48-MHz USB Output.

The spreading function can be disabled by taking the SSON# pin high. Spread percentage can be selected with the SS% input (see *Table 2* below).

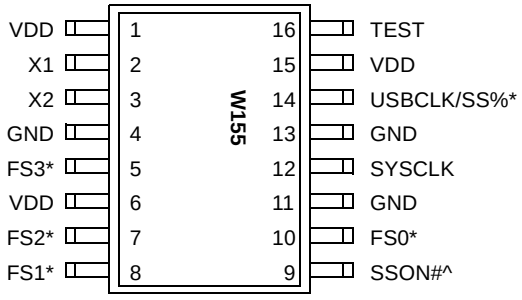
Table 1. Frequency Selection (14.318-MHz Reference)

FS3	FS2	FS1	FS0	SYSCLK (Output Freq.)
0	0	0	0	133.3 MHz
0	0	0	1	120 MHz
0	0	1	0	100 MHz
0	0	1	1	74.77 MHz
0	1	0	0	70 MHz
0	1	0	1	66.6 MHz
0	1	1	0	60 MHz
0	1	1	1	50 MHz
1	0	0	0	40 MHz
1	0	0	1	33.33 MHz
1	0	1	0	30 MHz
1	0	1	1	25 MHz
1	1	0	0	20 MHz
1	1	0	1	16.67 MHz
1	1	1	0	12 MHz
1	1	1	1	10 MHz

Table 2. Spread Percentage Selection

SS%	Spread Percentage
0	–1.25%
1	–3.75%

Pin Configuration[1]



Note:
1. Internal pull-up resistor present on inputs marked with '*' and pull-down resistor present on input marked with '^'.

Pin Definitions

Pin Name	Pin No.	Pin Type	Pin Description
USBCLK/ SS%	14	I/O	***USB Clock Output/Modulation Width Selection Input:*** When an input; if spread spectrum feature is enabled, this pin is used to select the amount of frequency variation on the SYSCLK output (see *Table 2*). Wider variations result in greater peak EMI reduction. When an output: supplies a non-spread 48-MHz signal for USB support.
SYSCLK	12	O	***System Clock Output:*** Frequency is selected per *Table 1*. Spread spectrum feature is controlled by pins 9 & 14.
FS0:3	10, 8, 7, 5	I	***Frequency Select Pins:*** These pins set the frequency of the signal provided at the SYSCLK output.
SSON#	9	I	***Spread Spectrum Control (active LOW):*** Pulling this input signal HIGH turns the internal modulating waveform off. This pin has an internal pull-down resistor.
X1	2	I	***Crystal Connection or External Reference Frequency Input:*** This pin has dual functions. It can be used as either an external crystal connection, or as an external reference frequency input.
X2	3	I	***Crystal Connection:*** If using an external reference, this pin must be left unconnected.
TEST	16	I	***Test Mode:*** For normal operation, tie this pin to ground.
VDD	1, 6, 15	P	***Power Connection:*** Connected to either 3.3V or 5.0V power supply. All VDD pins must be the same voltage level.
GND	4, 11, 13	G	***Ground Connection:*** Connect to the common system ground plane.

Functional Description

I/O Pin Operation

Pin 14 is a dual purpose I/O pin.

Upon power-up each I/O pin acts as a logic input, allowing the determination of assigned device functions. A short time after power-up, the logic state of each pin is latched and each pin then becomes a clock output. This feature reduces device pin count by combining clock outputs with input select pins.

An external 10-kΩ “strapping” resistor is connected between each I/O pin and ground or V_{DD}. Connection to ground sets a “0” bit, connection to V_{DD} sets a “1” bit. See *Figure 1*.

Upon W155 power-up, the first 2 ms of operation is used for input logic selection. During this period, each clock output buffer is three-stated, allowing the output strapping resistor on each I/O pin to pull the pin and its associated capacitive clock load to either a logic HIGH or LOW state. At the end of the 2-ms period, the established logic 0 or 1 condition of each I/O pin is then latched. Next the output buffer is enabled converting all I/O pins into operating clock outputs. The 2-ms timer starts when V_{DD} reaches 2.0V. The input bits can only be reset by turning V_{DD} off and then back on again.

It should be noted that the strapping resistors have no significant effect on clock output signal integrity. The drive impedance of the clock outputs is <40Ω (nominal) which is minimally affected by the 10-kΩ strap to ground or V_{DD}. As with the series termination resistor, the output strapping resistor should be placed as close to the I/O pin as possible in order to keep the interconnecting trace short. The trace from the resistor to ground or V_{DD} should be kept less than two inches in length to prevent system noise coupling during input logic sampling.

When each clock output is enabled following the 2-ms input period, target (normal) output frequency is delivered assuming that V_{DD} has stabilized. If V_{DD} has not yet reached full value, output frequency initially may be below target but will increase to target once V_{DD} voltage has stabilized. In either case, a short output clock cycle may be produced from the CPU clock outputs when the outputs are enabled.

Output Buffer Configuration

Clock Outputs

All clock outputs are designed to drive serial terminated clock lines. The device outputs are CMOS-type which provide rail-to-rail output swing.

Crystal Oscillator

The device requires one input reference clock to synthesize all output frequencies. The reference clock can be either an externally generated clock signal or the clock generated by the internal crystal oscillator. When using an external clock signal, pin X1 is used as the clock input and pin X2 is left open. The input threshold voltage of pin X1 is (V_{DD})/2.

The internal crystal oscillator is used in conjunction with a quartz crystal connected to device pins X1 and X2. This forms a parallel resonant crystal oscillator circuit. The device incorporates the necessary feedback resistor and crystal load capacitors. Including typical stray circuit capacitance, the total load presented to the crystal is approximately 20 pF. For optimum frequency accuracy without the addition of external capacitors, a parallel-resonant mode crystal specifying a load of 20 pF should be used. This will typically yield reference frequency accuracies within ±100 ppm. To achieve similar accuracies with a crystal calling for a greater load, external capacitors must be added such that the total load (internal, external, and parasitic capacitors) equals that called for by the crystal.

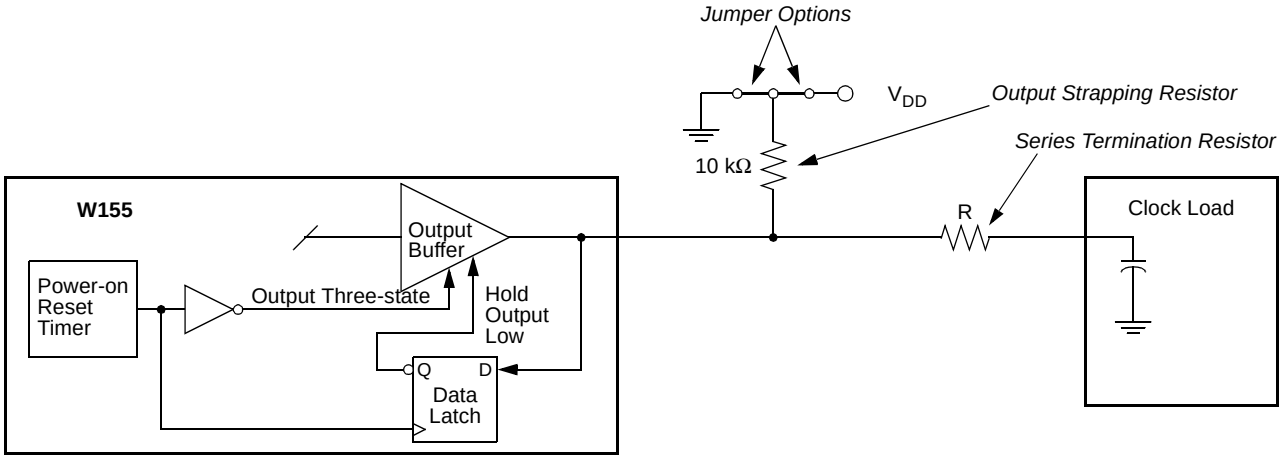


Figure 1. Input Logic Selection Through Jumper Option

Spread Spectrum Frequency Timing Generator

The device generates a clock that is frequency modulated in order to increase the bandwidth that it occupies. By increasing the bandwidth of the fundamental and its harmonics, the amplitudes of the radiated electromagnetic emissions are reduced. This effect is depicted in *Figure 2*.

As shown in *Figure 2*, a harmonic of a modulated clock has a much lower amplitude than that of an unmodulated signal. The reduction in amplitude is dependent on the harmonic number and the frequency deviation or spread. The equation for the reduction is

$dB = 6.5 + 9*\log_{10}(P) + 9*\log_{10}(F)$

Where *P* is the percentage of deviation and *F* is the frequency in MHz where the reduction is measured.

The output clock is modulated with a waveform depicted in *Figure 3*. This waveform, as discussed in "Spread Spectrum Clock Generation for the Reduction of Radiated Emissions" by Bush, Fessler, and Hardin produces the maximum reduction in the amplitude of radiated electromagnetic emissions. The deviation selected for this chip is specified in *Table 2*. *Figure 3* details the Cypress spreading pattern. Cypress does offer options with more spread and greater EMI reduction. Contact your local sales representative for details on these devices.

Spread Spectrum clocking is activated or deactivated by selecting the appropriate values for pin 9.

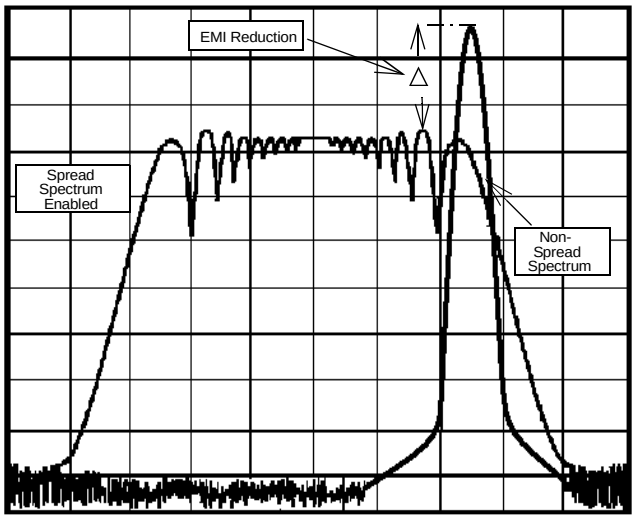


Figure 2. Clock Harmonic with and without SSCG Modulation Frequency Domain Representation

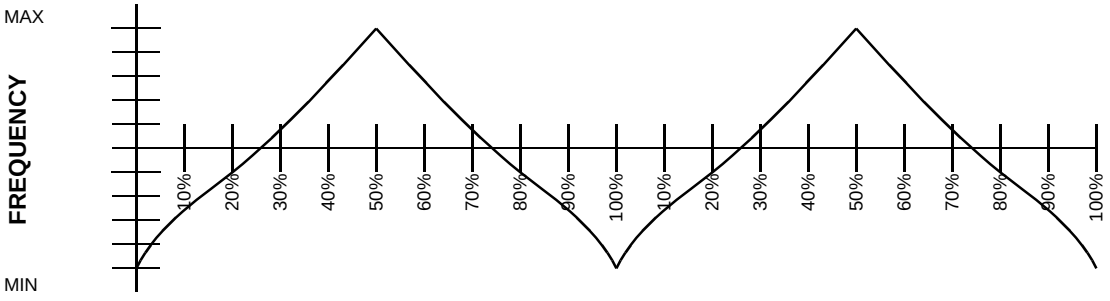


Figure 3. Typical Modulation Profile

Absolute Maximum Ratings[2]

Stresses greater than those listed in this table may cause permanent damage to the device. These represent a stress rating only. Operation of the device at these or any other conditions above those specified in the operating sections of this specification is not implied. Maximum conditions for extended periods may affect reliability

Parameter	Description	Rating	Unit
V_{DD}, V_{IN}	Voltage on any pin with respect to GND	–0.5 to +7.0	V
T_{STG}	Storage Temperature	–65 to +150	°C
T_A	Operating Temperature	0 to +70	°C
T_B	Ambient Temperature under Bias	–55 to +125	°C

Note:
2. **Single Power Supply:** The voltage on any input or I/O pin cannot exceed the power pin during power-up.

DC Electrical Characteristics: $0°C < T_A < 70°C$, $V_{DD} = 3.30V \pm 10\%$

Parameter	Description	Test Condition	Min	Typ	Max	Unit
I_{DD}	Supply Current				35	mA
V_{IL}	Input Low Voltage				0.8	V
V_{IH}	Input High Voltage		2.0			V
V_{OL}	Output Low Voltage	I_{OL} = 2 mA			50	mV
V_{OH}	Output High Voltage	I_{OH} = –2 mA	3.10			V
I_{OL}	Output Low Current	V_{OL} = 1.5V	80	110	155	mA
I_{OH}	Output High Current	V_{OH} = 1.5V	80	120	175	mA
I_{IL}	Input Low Current				10	µA
I_{IH}	Input High Current				10	µA
C_I	Input Capacitance			5	10	pF
C_L	XTAL Load Capacitance			20		pF

Switching Characteristics

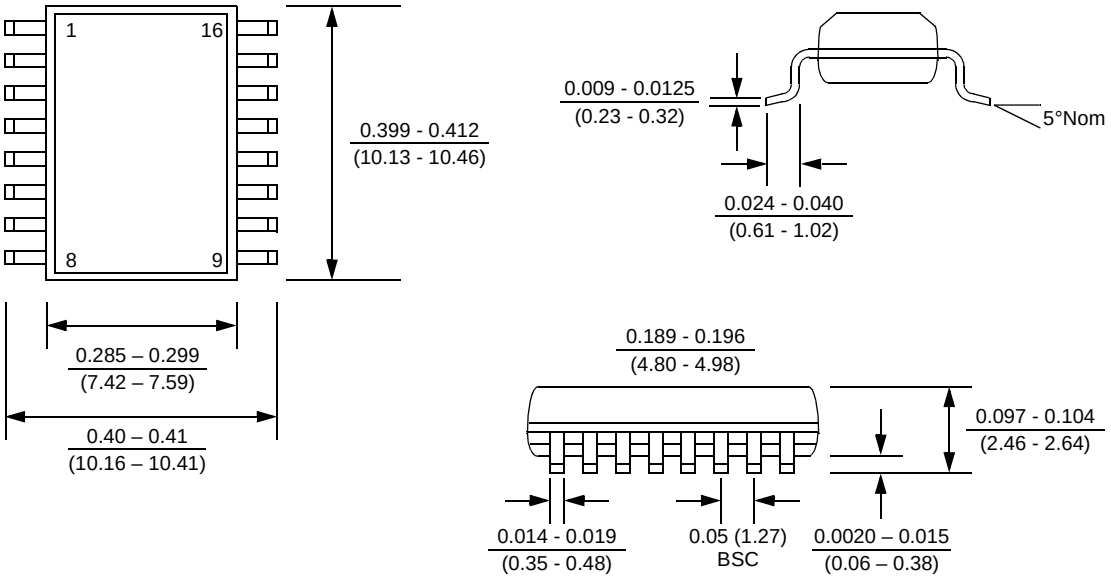
Parameter	Description	Test Conditions	Min	Typ	Max	Unit
t_{TLH}, t_{THL}	Output Rise and Fall Time measured at 10% of 90% of V_{DD}		0.8		4.0	ns
t_{TLH}, t_{THL}	Output Rise and Fall Time measured at 0.8V–2.0V		0.3		1.0	ns
t_{SYM}	Output Duty Cycle		45		55	%
t_{JCC}	Cycle-to-Cycle Jitter				250	ps
EMI	EMI Attenuation	11th Harmonic, 25 MHz	10			dB

Ordering Information

Ordering Code	Package Name	Package Type
W155	G	16-pin Plastic SOIC (300-mil, wide body)

Package Diagram

16-Pin Small Outlined Integrated Circuit (SOIC, 300 mils, wide body)



Note: All linear dimensions are in inches and parenthetically in millimeters, min. – max.

THIS TABLE IN INCHES

SYMBOL	COMMON DIMENSIONS			NOTE	NOTE VARIATIONS	3 D			5 N
	MIN.	NOM.	MAX.			MIN.	NOM.	MAX.	
A	.097	.101	.104		AA	.402	.407	.412	16
A_1	.0050	.009	.0115		AB	.451	.456	.461	18
A_2	.090	.092	.094		AC	.500	.505	.510	20
B	.014	.016	.019		AD	.602	.607	.612	24
C	.0091	.010	.0125		AE	.701	.706	.711	28
D	SEE VARIATIONS			3					
E	.292	.296	.299						
e	.050 BSC								
H	.400	.406	.410						
h	.010	.013	.016						
L	.024	.032	.040						
N	SEE VARIATIONS			5					
∝	0°	5°	8°						
X	.085	.093	.100						

THIS TABLE IN MILLIMETERS

SYMBOL	COMMON DIMENSIONS			NOTE	NOTE VARIATIONS	3 D			5 N
	MIN.	NOM.	MAX.			MIN.	NOM.	MAX.	
A	2.46	2.56	2.64		AA	10.21	10.34	10.46	16
A_1	0.127	0.22	0.29		AB	11.46	11.58	11.71	18
A_2	2.29	2.34	2.39		AC	12.70	12.83	12.95	20
B	0.35	0.41	0.48		AD	15.29	15.42	15.54	24
C	0.23	0.25	0.32		AE	17.81	17.93	18.06	28
D	SEE VARIATIONS			3					
E	7.42	7.52	7.59						
e	1.27 BSC								
H	10.16	10.31	10.41						
h	0.25	0.33	0.41						
L	0.61	0.81	1.02						
N	SEE VARIATIONS			5					
∝	0°	5°	8°						
X	2.16	2.36	2.54						

Document Title: W155 Spread Spectrum Frequency Timing Generator Document Number: 38-07147				
REV.	**ECN NO.**	**Issue Date**	**Orig. of Change**	**Description of Change**
**	110256	12/15/01	SZV	Change from Spec number: 38-00785 to 38-07147
*A	122685	12/27/02	RBI	Added power up requirements to maximum ratings information.