

## FEATURES

- Reduces Systemic EMI.
- Modulates external source clock.
- 3 - 5 Volt power supply.
- 14 to 120 MHz. operating frequency range.
- Output is multiplied or divided by 1, 2 or 4.
- Digitally controlled modulation.
- TTL/CMOS compatible outputs.
- Fout modulation centered around reference.
- Compliant with all major CISC, RISC and DSP processors.
- Low short term jitter.
- Synchronous output enable.
- Power down mode for low current operation.
- Available in 16 pin SOIC package.

## APPLICATIONS

- Desktop/Laptop Computer
- Modems
- Scanners, Printers, Copiers, Fax Machines, MFP's
- Disk and CD-ROM Drives
- Automotive and Embedded Systems
- Networking, LAN/WAN
- Digital Cameras, Games
- LCD displays

## BENEFITS

- Time to Market
  - Lower cost of compliance
  - Programmable EMI reduction
  - No degradation in Rise/Fall times
  - Lower component and PCB layer count
- 

## GENERAL DESCRIPTION

The IMI SM532 is a Spectrum Spread Clock Modulator designed for the purpose of reducing the Electro- Magnetic Interference (EMI) found in today's high speed digital systems. The SM532 is well suited for a wide range of digital system applications that require a reduction of radiated energy. This unwanted radiated energy is usually found in the odd harmonics of digital system clocks. By modulating the frequency of the digital clock, measured EMI at the fundamental and harmonic frequencies is greatly reduced. This reduction in radiated energy can significantly reduce the cost of complying with regulatory requirements and time to market, without degrading clock and timing signals.

The IMI SM532 is extremely versatile and flexible in that program control is available for each of the operating modes. Program control is provided for Input Frequency, Output Frequency Multiplication, Output Bandwidth, Modulation ON/OFF and Fout state during Power Down Mode.

Depending on the range of operation, the output clock, Fout, can be a multiple (1, 2, 4) or a division (1, 1/2, 1/4) of the input frequency. The power-down mode adds the flexibility of operating in a completely static mode for reduced standby current and simplified system board testing.

There are many benefits to using the SM532 Low EMI Clock Modulator. The most important benefit is reducing the amount of clock related EMI by as much as 12 - 18 dB, depending on the application. SM532 is available with only Center-Spread frequency modulation. Refer to SM530 for Down-Spread frequency modulation and other functions.

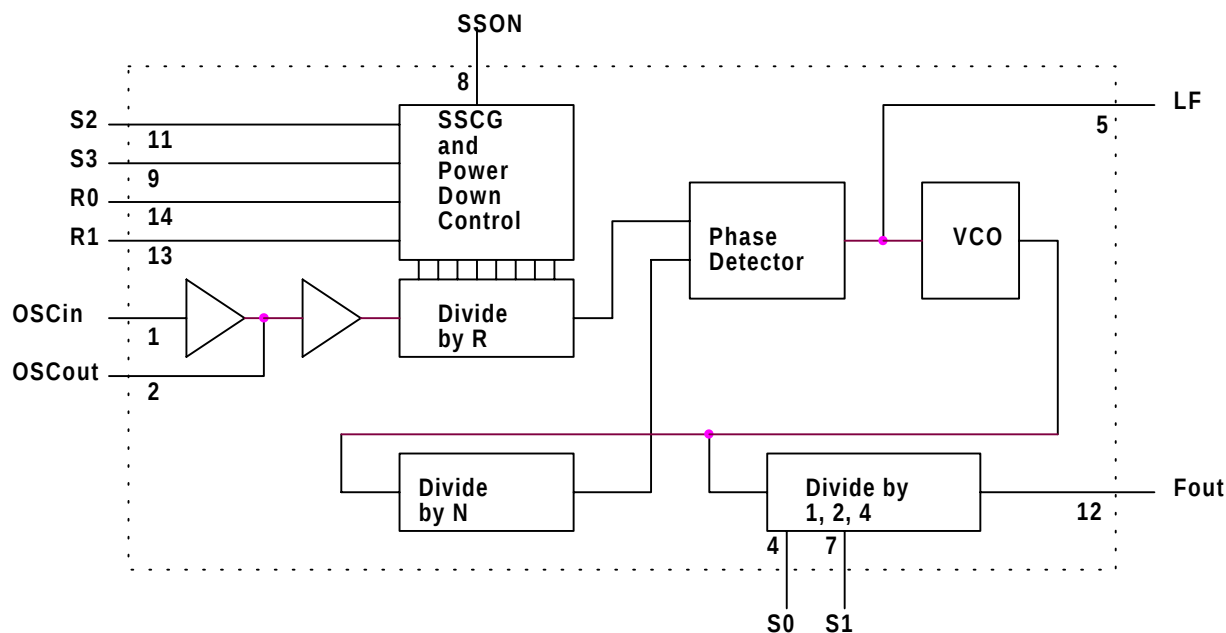
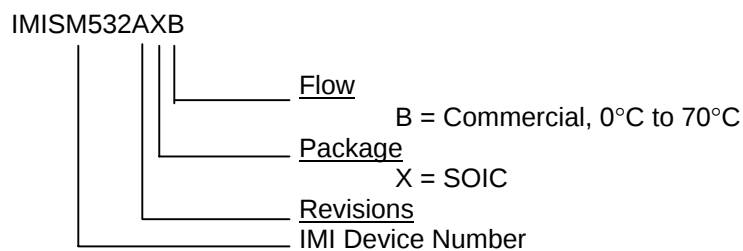


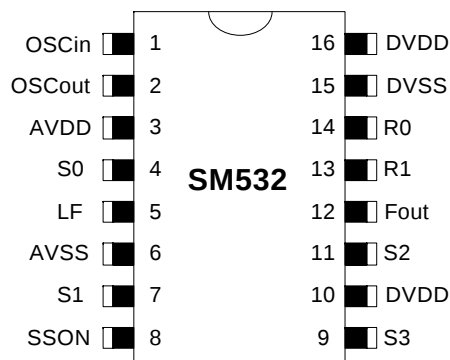
Figure 1. Block Diagram

## ORDERING INFORMATION

| Part No.    | Package     | Operating Temperature Range |
|-------------|-------------|-----------------------------|
| IMISM532AXB | 16 Pin SOIC | 0°C to 70°C                 |

Marking Example: IMI  
SM532AXB  
Date Code, Lot#





**Figure 2. SOIC Package Pin Assignment**

| Pin Descriptions |               |        |        |                                                                                                                                                                                                                                                                                                                                                                   |
|------------------|---------------|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pin No.          | Pin Name      | I/O    | TYPE   | Description                                                                                                                                                                                                                                                                                                                                                       |
| 1,2              | OSCin, OSCout | I/O    | CMOS   | Pins form an on-chip reference oscillator when connected to terminals of an external parallel resonant crystal. OSCin may be connected to a TTL/CMOS external clock source. AC coupling may be required. If OSCin is connected to an external clock other than a crystal, leave OSCout (pin 2) unconnected. The input frequency range is 14 to 120 Mhz @ 5.0 VDC. |
| 3                | AVDD          | Power  |        | Analog circuit positive power supply.                                                                                                                                                                                                                                                                                                                             |
| 4, 7             | S0, S1        | I      | TTL    | Input control used to select the frequency multiplication at Fout, relative to the reference clock. See table on page 5. S0 has internal pull-down resistor, S1 has internal pull-up resistor.                                                                                                                                                                    |
| 5                | LF            | O      | Analog | Single ended tri-state output of the phase detector. A two pole passive loop filter is connected to LF. See table on page 7 for proper values.                                                                                                                                                                                                                    |
| 6                | AVSS          | Ground | Ground | Analog circuit ground.                                                                                                                                                                                                                                                                                                                                            |
| 8                | SSON          | I      | TTL    | Input control pin used to enable modulation at the Fout pin. SSON = 0 = Modulation ON. (default)<br>SSON = 1 = Modulation OFF.<br>Has internal pull-down resistor.                                                                                                                                                                                                |
| 9, 11            | S3, S2        | I      | TTL    | Input control pins used to set the amount of modulation at Fout. See table on page 6 for settings. S2 has internal pull-up resistor, S3 has internal pull-down resistor.                                                                                                                                                                                          |
| 10, 16           | DVDD          | Power  | Power  | Digital positive power supply. Should be kept separate from analog power for best performance.                                                                                                                                                                                                                                                                    |
| 12               | Fout          | O      | TTL    | Modulated clock output.                                                                                                                                                                                                                                                                                                                                           |
| 13, 14           | R1, R0        | I      | TTL    | Input pins control the input frequency range as described in table on page 5. R0 and R1 have internal pull-up resistor.                                                                                                                                                                                                                                           |
| 15               | DVSS          | Ground | Ground | Digital Circuit Ground                                                                                                                                                                                                                                                                                                                                            |

**Table 1.**

## ABSOLUTE MAXIMUM RATINGS

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, precautions should be taken to avoid application of any voltage higher than the absolute maximum rated voltages to this circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range,  $V_{SS} < (V_{in} \text{ or } V_{out}) < V_{DD}$ . All digital inputs are tied high or low internally. Refers to electrical specifications for operating supply range.

| Item                    | Symbol          | Min. | Max.     | Units          |
|-------------------------|-----------------|------|----------|----------------|
| Supply Voltage          | VDD             | 0    | 6.0      | VDC            |
| Input, relative to VSS  | VIRvss          | -0.3 | VDD +0.3 | VDC            |
| Output, relative to VSS | VORvss          | -0.3 | VDD +0.3 | VDC            |
| AVDD relative to DVDD   | $\Delta V_{pp}$ | -100 | +100     | mv             |
| AVSS relative to DVSS   | $\Delta V_{ss}$ | -100 | +100     | mv             |
| Temperature, Operating  | TOP             | 0    | + 70     | <sup>0</sup> C |
| Temperature, Storage    | TST             | - 65 | + 150    | <sup>0</sup> C |

**Table 2.**

| Electrical Characteristics                     |                  |         |      |      |         |
|------------------------------------------------|------------------|---------|------|------|---------|
| Characteristic                                 | Symbol           | Min.    | Typ. | Max. | Units   |
| Input Low Voltage                              | VIL              | -       | -    | 0.8  | Vdc     |
| Input High Voltage                             | VIH              | 2.0     | -    | -    | Vdc     |
| Input Low Current                              | IIL              | -       | -    | 100  | $\mu$ A |
| Input High Current                             | IIH              | -       | -    | 100  | $\mu$ A |
| Output Low Voltage IOL= 8mA, VDD = 5V          | VOL              | -       | -    | 0.4  | Vdc     |
| Output High Voltage IOH = 8mA, VDD = 5V        | VOH              | VDD-1.0 | -    | -    | Vdc     |
| Output Low Voltage IOL= 5mA, VDD = 3.3V        | VOL              | -       | -    | 0.4  | Vdc     |
| Output High Voltage IOH = 3mA, VDD = 3.3V      | VOH              | 2.4     | -    | -    | Vdc     |
| Input Capacitance (Pin-1)                      | C <sub>in1</sub> | -       | 3    | -    | pf      |
| Output Capacitance (Pin-2)                     | C <sub>in2</sub> | -       | 5    | -    | pf      |
| Pull-Up Resistor values (pins 7, 11,13 and 14) | Rpu              | 100K    | 167K | 300K | Ohms    |
| Pull-Down resistor values (pins 4, 8 and 9)    | Rpd              | 150K    | 250K | 350K | Ohms    |
| Tri-State Leakage Current (pins 5 and 12)      | IOZ              | -       | 5.0  | -    | $\mu$ A |
| Static Supply Current (Power Down mode)        | IDD              | -       | -    | 250  | $\mu$ A |
| 5 Volt Dynamic Supply Current (Operating mode) | ICC              | -       | 25   | 30   | ma      |
| 3 Volt Dynamic Supply Current (Operating mode) | ICC              | -       | 18   | 20   | ma      |
| Short Circuit Current (Fout)                   | ISC              | -       | -    | 30   | ma      |

Test measurements performed at VDD = 3.3V +/-5% and 5V +/-10%, TA = 0°C to 70°C

**Table 3.**

| Timing Characteristics                                                                                  |        |     |      |     |       |
|---------------------------------------------------------------------------------------------------------|--------|-----|------|-----|-------|
| Characteristic                                                                                          | Symbol | Min | Typ  | Max | Units |
| Output Rise Time Measured at 10% - 90% @ 5 VDC                                                          | tTLH   | 3.3 | 3.5  | 3.8 | ns    |
| Output Fall Time Measured at 10% - 90% @ 5 VDC                                                          | tTHL   | 2.1 | 2.3  | 2.5 | ns    |
| Output Rise Time Measured at 0.8V - 2.0V @ 5 VDC                                                        | tTLH   | 0.7 | 0.75 | 0.8 | ns    |
| Output Fall Time Measured at 0.8V - 2.0 V @ 5 VDC                                                       | tTHL   | 0.6 | 0.7  | 0.8 | ns    |
| Output Rise Time Measured at 10% - 90% @ 3.3 VDC                                                        | tTLH   | 4.8 | 5.0  | 5.4 | ns    |
| Output Fall Time Measured at 10% - 90% @ 3.3 VDC                                                        | tTHL   | 2.9 | 3.2  | 3.4 | ns    |
| Output Rise Time Measured at 0.8V - 2.0V @ 3.3 VDC                                                      | tTLH   | 1.6 | 1.75 | 1.9 | ns    |
| Output Fall Time Measured at 0.8V - 2.0 V @ 3.3 VDC                                                     | tTHL   | 1.1 | 1.3  | 1.5 | ns    |
| Output Duty Cycle                                                                                       | TsymF1 | 45  | 50   | 55  | %     |
| Peak-to Peak Jitter One Sigma (SSON = 1)                                                                | tj1s   | -   | 250  | 500 | ps    |
| Measurements performed at VDD = 3.3V +/-5% and 5V +/-10%, TA = 0°C to 70°C, CL = 15pF, Fout = 50.0 MHz. |        |     |      |     |       |

**Table 4.**

## FREQUENCY SELECTION TABLE

The following table provides the necessary information for setting the control lines for proper operation of the SM532 and for any frequency within its operating range. Note that the table includes operating frequencies at 3.3 and 5.0 VDC. The 3.3 VDC columns are lower in frequency than the 5.0 VDC operation due to the characteristics of the VCO.

| VDD = 5           |     | Volts    | +/- 10%            |     | Multiplier Settings |    | Input Range Settings |    | VDD = 3.3         |      | Volts    | +/- 5%             |      |
|-------------------|-----|----------|--------------------|-----|---------------------|----|----------------------|----|-------------------|------|----------|--------------------|------|
| Fin (Range) (MHz) |     | Fout/Fin | Fout (Range) (MHz) |     |                     |    |                      |    | Fin (Range) (MHz) |      | Fout/Fin | Fout (Range) (MHz) |      |
| MIN               | MAX | X        | MIN                | MAX | S1                  | S0 | R1                   | R0 | MIN               | MAX  | X        | MIN                | MAX  |
|                   | See | Note     |                    |     | 0                   | 0  | X                    | X  |                   | See  | Note     |                    |      |
| 14                | 30  | 1        | 14                 | 30  | 0                   | 1  | 0                    | 1  | 14                | 22.5 | 1        | 14                 | 22.5 |
| 14                | 30  | 2        | 28                 | 60  | 1                   | 0  | 0                    | 1  | 14                | 22.5 | 2        | 28                 | 45   |
| 14                | 30  | 4        | 56                 | 120 | 1                   | 1  | 0                    | 1  | 14                | 22.5 | 4        | 56                 | 90   |
|                   |     |          |                    |     |                     |    |                      |    |                   |      |          |                    |      |
| 30                | 60  | 0.5      | 15                 | 30  | 0                   | 1  | 1                    | 0  | 25                | 45   | 0.5      | 12.5               | 22.5 |
| 30                | 60  | 1        | 30                 | 60  | 1                   | 0  | 1                    | 0  | 25                | 45   | 1        | 25                 | 45   |
| 30                | 60  | 2        | 60                 | 120 | 1                   | 1  | 1                    | 0  | 25                | 45   | 2        | 50                 | 90   |
|                   |     |          |                    |     |                     |    |                      |    |                   |      |          |                    |      |
| 60                | 120 | 0.25     | 15                 | 30  | 0                   | 1  | 1                    | 1  | 50                | 90   | 0.25     | 12.5               | 22.5 |
| 60                | 120 | 0.5      | 30                 | 60  | 1                   | 0  | 1                    | 1  | 50                | 90   | 0.5      | 25                 | 45   |
| 60                | 120 | 1        | 60                 | 120 | 1                   | 1  | 1                    | 1  | 50                | 90   | 1        | 50                 | 90   |

**Note:** Selects Power Down state, see table 7. X = don't care condition.

**Table 5. Frequency Selection Table**

## MODULATION AND POWER DOWN SELECTIONS

The bandwidth of the modulation applied to Fout is controlled by two input control lines, S2 and S3. Also, S2 and S3 control the state the SM532 will go to when the Power Down mode is selected. The Power Down mode is selected when both S0 and S1 are set to a logic state 0. Refer to the tables below for the proper selection of Modulation Bandwidth and Power Down state.

| Modulation Selection Table |                  |    |                   |          |
|----------------------------|------------------|----|-------------------|----------|
|                            | Control Settings |    | Spread Percentage |          |
| Total Bandwidth            | S3               | S2 | Low               | High     |
| 1.25 %                     | 0                | 0  | 99.375 %          | 100.625% |
| 2.50 %                     | 0                | 1  | 98.75 %           | 101.25 % |
| 5.00 %                     | 1                | 0  | 97.50 %           | 102.50 % |
| 10.0 %                     | 1                | 1  | 95.00 %           | 105.00 % |

**Table 6. Modulation Selection Table**

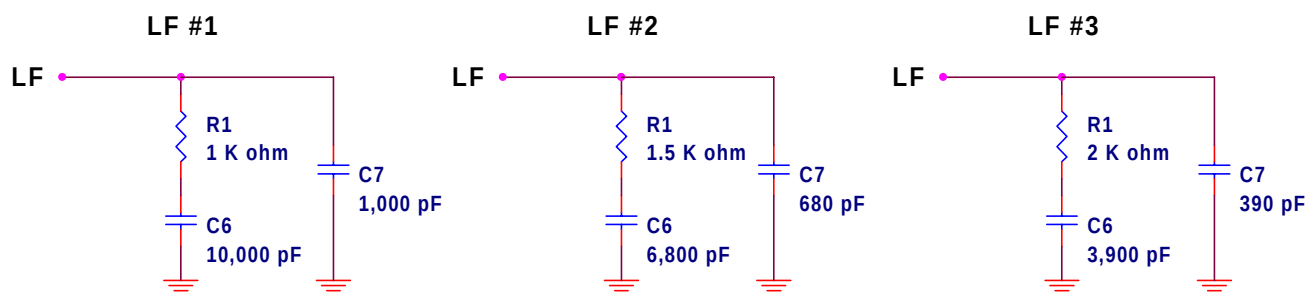
| Power Down Selection Table |    |    |    |    |
|----------------------------|----|----|----|----|
| Fout State                 | S0 | S1 | S2 | S3 |
| Factory Test               | 0  | 0  | 0  | 1  |
| Hi-Z                       | 0  | 0  | 1  | 1  |
| 0                          | 0  | 0  | 0  | 0  |
| 1                          | 0  | 0  | 1  | 0  |

**Table 7. Power Down Selection Table**

## Loop Filters

The SM532 requires an external loop filter to provide the proper operation and modulation profile for a given input frequency. The loop filter is connected to pin 5 (LF) of the SM532 and is a typical 2 pole low pass filter. Since the SM532 operates over such a wide range of frequencies, the loop filter will change depending on the frequency of operation. The following loop filter values are recommended for best performance and modulation profile at 3.0 volts and 5.0 volts VDD. Operating voltage is measured at the VDD pin of the SM532.

**Notice that the selection of Loop Filter values only depends on the input frequency and VDD voltage, and**



does not depend on the R and S settings.

Figure 3. Recommended Loop Filters

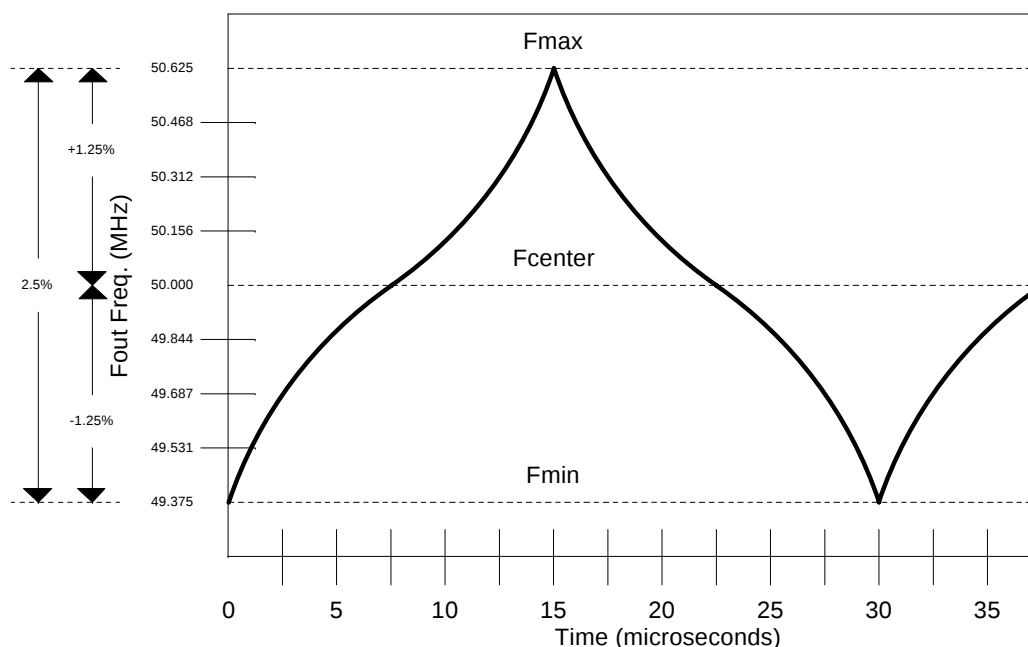
| <b>Recommended Loop Filter Values</b> |            |                             |         |         |         |               |
|---------------------------------------|------------|-----------------------------|---------|---------|---------|---------------|
| Input Range                           | VDD +/-5%  | Input Frequency Range (MHz) | R1 (KΩ) | C6 (pF) | C7 (pF) | Loop Filter # |
| Low                                   | 3.3        | 14.0 to 22.5                | 1.0     | 10,000  | 1,000   | 1             |
| Middle                                | 3.3        | 25.0 to 45.0                | 1.0     | 10,000  | 1,000   | 1             |
| High                                  | 3.3        | 50.0 to 90.0                | 1.0     | 10,000  | 1,000   | 1             |
| Input Range                           | VDD +/-10% | Input Frequency Range (MHz) | R1 (KΩ) | C6 (pF) | C7 (pF) | Loop Filter # |
| Low                                   | 5.0        | 14.0 to 19.9                | 1.0     | 10,000  | 1,000   | 1             |
| Low                                   | 5.0        | 20.0 to 24.9                | 1.5     | 6,800   | 680     | 2             |
| Low                                   | 5.0        | 25.0 to 29.9                | 2.0     | 3,900   | 390     | 3             |
| Middle                                | 5.0        | 30.0 to 39.9                | 1.0     | 10,000  | 1,000   | 1             |
| Middle                                | 5.0        | 40.0 to 49.9                | 1.5     | 6,800   | 680     | 2             |
| Middle                                | 5.0        | 50.0 to 59.9                | 2.0     | 3,900   | 390     | 3             |
| High                                  | 5.0        | 60.0 to 79.9                | 1.0     | 10,000  | 1,000   | 1             |
| High                                  | 5.0        | 80.0 to 99.9                | 1.5     | 6,800   | 680     | 2             |
| High                                  | 5.0        | 100.0 to 120.0              | 2.0     | 3,900   | 390     | 3             |

Table 8

The component values listed in Table 8 are recommended values using commonly manufactured components. Note that there are actually 3 different sets of loop filter values. Due to the VCO characteristics, the table is divided in to 3 volt operation and 5 volt operation. Referring to the table above, it is apparent that one set of loop filter values is all that is needed in the 3 volt operation. In the 5 volt operation, each input operating range is divided into 3 sections which require a different loop filter for optimal performance. The best loop filter for any application is the one that, provides the greatest EMI reduction, maintains system integrity, has a modulation profile shown on page 7 and uses commonly available components.

### SSCG Modulation Profile

The modulation rate of the SM532 within any range is typically 20 - 40 kHz. With the correct loop filter connected to pin 5, the following profile will provide the best EMI reduction. This profile can be seen on a Time Domain



Analyzer.

**Figure 4. Modulation Profile**

## THEORY OF OPERATION

The SM532 is a Phase Lock Loop (PLL) type clock generator using Direct Digital Synthesis (DDS). By precisely controlling the bandwidth of the output clock, the SM532 becomes a Low EMI clock generator. The theory and detailed operation of the SM532 will be discussed in the following sections.

### EMI

All digital clocks generate unwanted energy in their harmonics. Conventional digital clocks are square waves with a duty cycle that is very close to 50 %. Because of the 50/50 duty cycle, digital clocks generate most of their harmonic energy in the odd harmonics, i.e.; 3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup> etc. It is possible to reduce the amount of energy contained in the fundamental and harmonics by increasing the bandwidth of the fundamental clock frequency. Conventional digital clocks have a very high Q factor, which means that all of the energy at that frequency is concentrated in a very narrow bandwidth, consequently, higher energy peaks. Regulatory agencies test electronic equipment by the amount of peak energy radiated from the equipment. By reducing the peak energy at the fundamental and harmonic frequencies, the equipment under test is able to satisfy agency requirements for Electro-Magnetic Interference (EMI). Conventional methods of reducing EMI have been to use shielding, filtering, multi-layer PCB's etc. The SM532 uses the approach of reducing the peak energy in the clock by increasing the clock bandwidth, and lowering the Q.

### SSCG

SSCG uses a patented technology of modulating the clock over a very narrow bandwidth and controlled rate of change, both peak and cycle to cycle. The SM532 takes a narrow band digital reference clock in the range of 14 - 120 MHz and produces a clock that sweeps between a controlled start and stop frequency and precise rate of change. The bandwidth of the output clock is programmable. Using two control lines on the SM532, the bandwidth of the modulated clock can be controlled over four discrete settings, 1.25, 2.50, 5.0 and 10%. To understand what happens to an SSCG clock, consider that we have a 50 MHz clock with a 50 % duty cycle. From a 50 MHz clock we know the following;

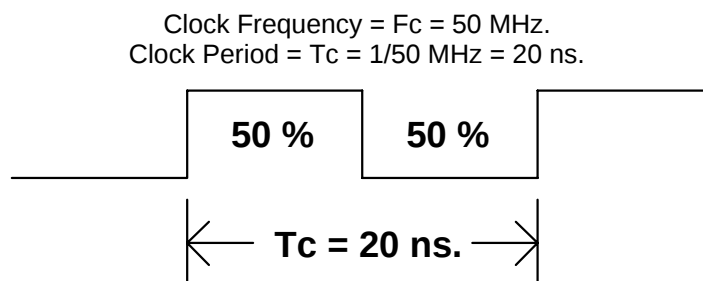


Figure 5. Unmodulated Clock

Consider that this 50 MHz clock is applied to the OSCin input of the SM532, either as an externally driven clock or as the result of a parallel resonant crystal connected to pins 1 and 2 of the SM532. Also consider that the SM532 is programmed for the following operation;

|                         |      |                   |
|-------------------------|------|-------------------|
| Range (R0, R1) =        | 0, 1 | Mid Range         |
| Multiplier (S0, S1) =   | 0, 1 | X1                |
| D_C =                   | 1    | Center Spread     |
| SSON =                  | 1    | Modulation is OFF |
| % Modulation (S2, S3) = | 1, 0 | 2.50 % Spread     |

From the above parameters, the output clock at Fout will be 50.625 MHz. With modulation turned off, the frequency of Fout will always rest at the high end of the programmed spectrum. In this case, +1.25 % of 50 MHz is .625 MHz, equals 50.625 MHz.

When modulation is turned ON, the clock at Fout begins sweeping downward to the minimum extreme of -1.25 % of 50 MHz which is 50 MHz - .625 MHz = 49.375 MHz. When the clock reaches 49.375, the SM532 begins sweeping back up to the maximum extreme of 50.625 MHz. If we were to look at this clock on a spectrum analyzer we would see the picture in figure 6. Keep in mind that this is a drawing of a perfect clock with no noise.

We see that the original 50 MHz reference clock is at the Center frequency, Cf, and the minimum and maximum extremes are positioned symmetrically about the center frequency. This type of modulation is called **Center-Spread**. Note that when modulation is turned off, the Fout clock is at the maximum extreme of the bandwidth.

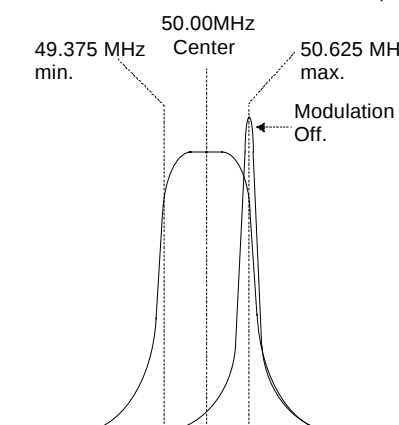
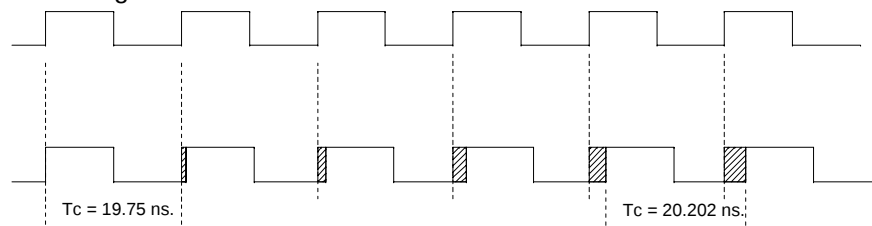


Figure 6.

Figure 7 shows the clock from figure 6, as displayed on an oscilloscope. Modulation can be seen as the rising and falling edges of the clock moving back and forth in time.



**Figure 7. Period Comparison Chart**

There are certain cases where center spread modulation is not applicable. If the maximum design frequency of the intended application is 50 MHz and becomes unstable above 50 MHz, then increasing the clock to 50.625 MHz might cause unwanted system problems. To accommodate this situation, it is recommended that the **SM530** be used in the **Down Spread** mode.

Referring to figure 6, you will note that the peak amplitude of the 50 MHz non-modulated clock is higher than the wideband modulated clock. This difference in peak amplitudes between modulated and unmodulated clocks is the reason why SSCG clocks are so effective in digital systems. The illustration in figure 6 refers to the fundamental clock frequency. A very important characteristic of the SSCG clock is that the bandwidth of the harmonics is multiplied by the harmonic number. In other words, if the bandwidth of a 50 MHz clock is 1.35 MHz, the bandwidth of the 3<sup>rd</sup> harmonic will be 3 times 1.35, or 4.05 MHz. The amount of bandwidth is relative to the amount of peak energy in the clock. Consequently, the wider the bandwidth, the greater the energy reduction of the clock. Most applications will not have a problem meeting agency specifications at the fundamental frequency. It is the higher harmonics that usually cause the most problems. With an SSCG clock, the bandwidth and peak energy reduction increases with the harmonic number. Consider that the 11<sup>th</sup> harmonic of our 50 MHz clock is 550 MHz. With a total spread of 1.35 MHz at 50 MHz, the spread at the 11<sup>th</sup> harmonic would be 14.85 MHz which greatly reduces the peak energy content. It is typical to see as much as 12 or 18 dB. of reduction at the higher harmonics, due to a modulated clock. Referring to figure 6, you can see that the peak amplitude of the non-modulated clock is much higher than the peak amplitude of the modulated clock. This is the reason the SM532 is used for EMI reduction. The amount of EMI reduction is dependent on the application. The difference in the peak energy of the modulated clock and the non-modulated clock in typical applications will see a 2 - 3 dB. reduction at the fundamental and as much as 8 - 10 dB. reduction at the intermediate harmonics, 3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup> etc. At the higher harmonics, it is quite possible to reduce the peak harmonic energy, compared to the unmodulated clock, by as much as 12 - 18 dB. The dB reduction for a give frequency and spread can be calculated using a simple formula. This formula is only helpful in determining a relative dB reduction for a given application. This formula assumes an ideal clock with 50% duty cycle and therefore only predicts the EMI reduction of even harmonics. Other circumstances such as non-ideal clock and noise will affect the actual dB reduction. The formula is as follows;

$$\text{dB} = 6.5 + 9(\text{Log}_{10}(\text{F})) + 9(\text{Log}_{10}(\text{P}))$$

Where; F = Frequency in Mhz, P = total % spread (2.5% = .025)

Using a 50 Mhz clock with a 2.5% spread, the theoretical dB reduction would be;

$$\text{db @ 50 MHz (Fund)} = 6.5 + 15.29 - 14.42 = 7.37$$

$$\text{dB @ 150 MHz (3rd)} = 6.5 + 19.58 - 14.42 = 11.66$$

$$\text{dB @ 550 MHz (11th)} = 6.5 + 24.66 - 14.42 = 16.74$$

### Modulation Profile

The SM532 moves from max. to min. frequencies of its bandwidth at a pre-determined rate and profile. The modulation frequency is determined by the input frequency and an internal divider. All 3 operating ranges modulate the Fout clock at from 20 to 40 kHz. The three operating ranges are 14 - 30 MHz, 30 - 60 MHz and 60 to 120 MHz. If OSCin = 15 MHz, the modulation rate is 20 kHz. If OSCin is 60 MHz, in mid-range, the modulation rate would be 40 kHz. To provide the proper modulation rate the input reference frequency is divided by a fixed number in each range. The input reference frequency is divided by 750 in Low Range, 1500 in Mid Range and 3000 in the High Range. From these numbers, the modulation rate can be determined for any input frequency.

Example:

OSCin = 45.378 MHz, Input Range = Mid, Input divisor = 1500

$F_{mod} = OSCin / 1500$

$F_{mod} = 30.252 \text{ kHz}$

If you have a clock frequency that was on the boundary of the Mid-range and the High range of operation, the choice of selecting which range to use would be determined by which modulation rate is desired. If you choose the Mid-range, the modulation rate would be 40 kHz, while choosing the High range would yield a 20 kHz modulation rate. There is some operational overlap between ranges, such that 58 MHz in the Mid-Range would give the same results as 58 MHz in the High-Range, except for the modulation rate. This type of operation is not recommended unless it is thoroughly tested.

The modulation profile of the SM532 is not a linear sweep from max to min and back. The OSCin reference clock determines the modulation frequency but the internal SSCG control logic determines the actual modulation profile. The modulation profile can best be described by comparing the instantaneous frequency at Fout with time. The illustration in figure 9 below is a representation of the modulation profile of the SM532 as displayed on a Time Domain Analyzer.

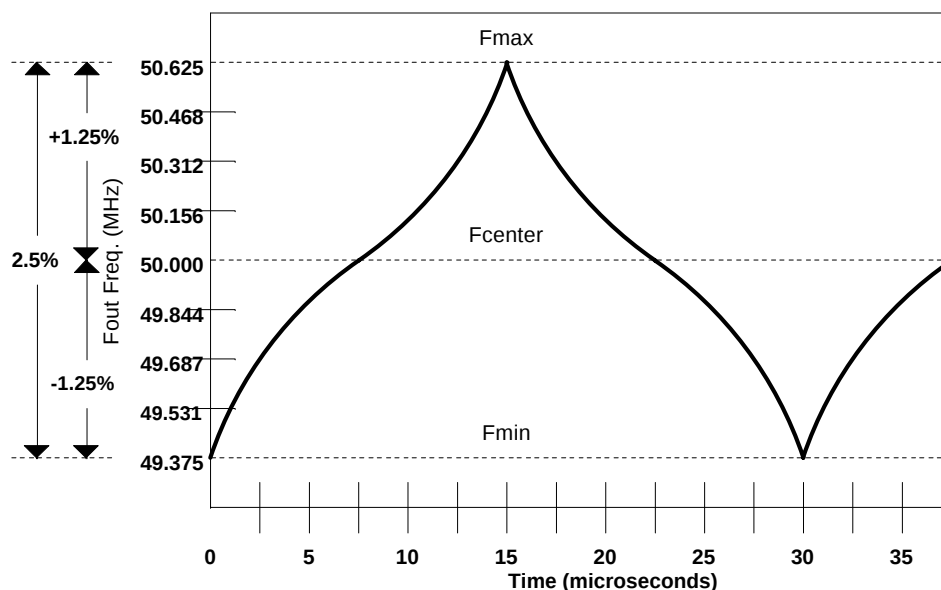


Figure 8. Frequency Profile in Time Domain

## Approved Product

## Low EMI Spectrum Spread Clock

As can be seen from the figure above, the Fout/Time profile progresses through frequencies depending on where it is in the sweep. If the frequency is in the middle of the sweep, the rate of change is slower compared to the rate at the extremes of the band. When the frequency is nearing the end of the band, it is moving through these frequencies faster, since it has to sweep through these same frequencies again after reversing direction. This modulation profile is one of the key elements to the SM532. Using a linear sweep through all frequencies would not give as good of results in EMI reduction.

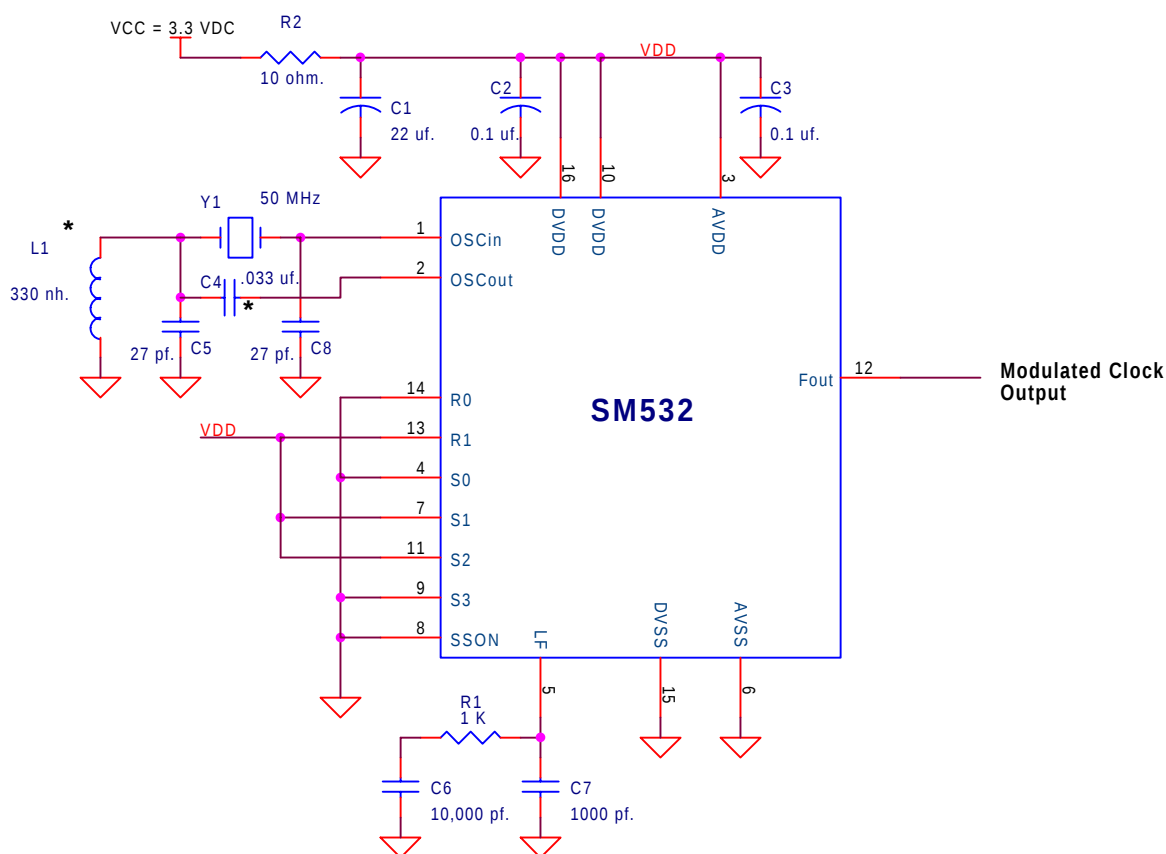
### APPLICATION NOTES AND SCHEMATICS

The schematic figure shown below is a simple minimum component application example of an SM532 design. In the case shown below, the control lines are configured for the following parameters;

Input Frequency: Mid-Range Multiplier: X1 Modulation: 2.50% SSON: On

Refer to loop filter values on Table 8, for operation at 3.3 Volts DC.

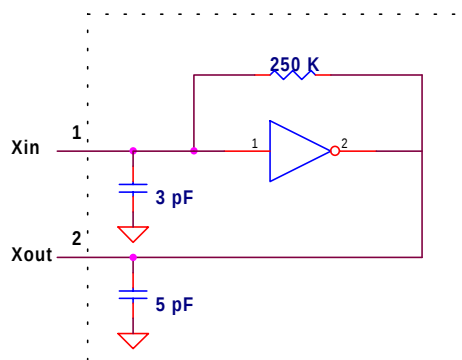
\* L1 and C4 are required when Y1 is a 3rd. overtone crystal.



**Figure 9. Application Schematic**

The SM532 has an internal Analog Power and Ground and a Digital Power and Ground. In the example above, the digital and analog circuits are connected together. If noise is a concern, it is recommended that the Analog and Digital Power and Grounds be separated. The loop filter shown above is recommended for operation at 3.14 - 3.47 VDC. This filter can also be used in 5.0 VDC operations when operating in the low frequency end of each of the three input frequency ranges. Refer to table 8 on page 6 for complete information. Also note, the crystal, Y1, is a third overtone 50 Mhz crystal, which requires an inductor and decoupling capacitor to OSCout.

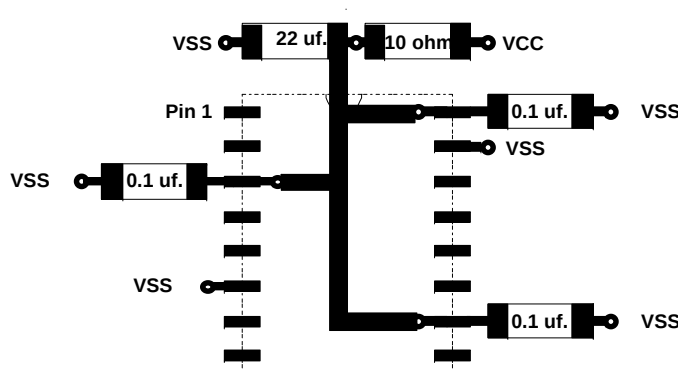
Figure 10 shows the internal oscillator equivalent circuit for the SM532.



**Figure 10. Internal Oscillator Equivalent Circuit**

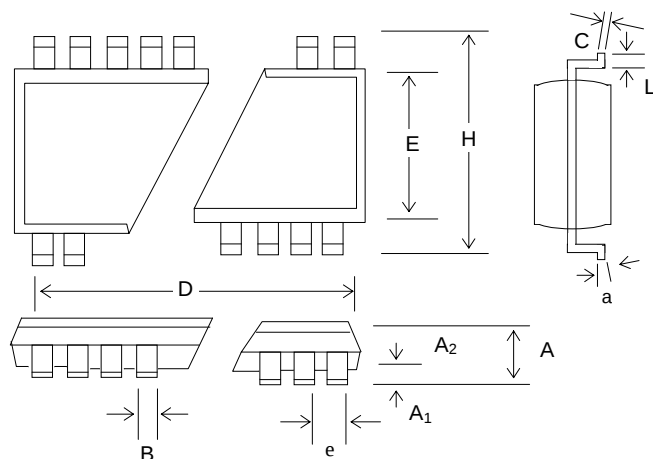
## PCB Layout Example

The SM532 Spectrum Spread Clock is a PLL type hybrid circuit. This means that it contains both digital and analog circuits on the same die. The Phase Detector, Loop Filter and VCO are analog circuits that must operate in a very low noise environment for best performance. There are several ways to keep this noise to a minimum, such as bypass capacitors on all power pins and separating the analog and digital power and ground planes. The figure below uses the first approach of placing bypass capacitors as close to every power pin as possible. In addition, all ground pins should be connected directly to the ground plane with little or no trace length. Note also that only the power and ground circuits of the SM532 have been shown. Other circuits such as the Loop Filter components must be located as close to the Loop Filter pin as possible, for best performance.



**Figure 11. SM532 Single Power Plane PCB Layout**

## Package Dimensions and Drawings



| 16 PIN SOIC DIMENSIONS |           |       |        |             |       |       |
|------------------------|-----------|-------|--------|-------------|-------|-------|
| SYMBOL                 | INCHES    |       |        | MILLIMETERS |       |       |
|                        | MIN       | NOM   | MAX    | MIN         | NOM   | MAX   |
| A                      | 0.097     | 0.101 | 0.104  | 2.46        | 2.56  | 2.64  |
| A <sub>1</sub>         | 0.0050    | 0.009 | 0.0115 | 0.127       | 0.22  | 0.29  |
| A <sub>2</sub>         | 0.090     | 0.092 | 0.094  | 2.29        | 2.34  | 2.39  |
| B                      | 0.014     | 0.016 | 0.019  | 0.35        | 0.41  | 0.48  |
| C                      | 0.0091    | 0.010 | 0.0125 | 0.23        | 0.25  | 0.32  |
| D                      | 0.402     | 0.407 | 0.412  | 10.21       | 10.34 | 10.46 |
| E                      | 0.292     | 0.296 | 0.299  | 7.42        | 7.52  | 7.59  |
| e                      | 0.050 BSC |       |        | 0.127 BSC   |       |       |
| H                      | 0.400     | 0.406 | 0.410  | 10.16       | 10.31 | 10.41 |
| L                      | 0.024     | 0.032 | 0.040  | 0.61        | 0.81  | 1.02  |
| a                      | 0°        | 5°    | 8°     | 0°          | 5°    | 8°    |

## NOTES:

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