**Using the SG3525 PWM Controller - Explanation and Example: Circuit Diagram / Schematic of Push-Pull Converter**

PWM is used in all sorts of power control and converter circuits. Some common examples include motor control, DC-DC converters, DC-AC inverters and lamp dimmers. There are numerous PWM controllers available that make the use and application of PWM quite easy. One of the most popular of such controllers is the versatile and ubiquitous SG3525 produced by multiple manufacturers – ST Microelectronics, Fairchild Semiconductors, On Semiconductors, to name a few.

SG3525 is used extensively in DC-DC converters, DC-AC inverters, home UPS systems, solar inverters, power supplies, battery chargers and numerous other applications. With proper understanding, you can soon start using SG3525 yourself in such applications or any other application really that demands PWM control.

Before going on to the description and application, let’s first take a look at the block diagram and the pin layout.

[Diagram

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[Table

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Pins 1 (Inverting Input) and 2 (Non Inverting Input) are the inputs to the on-board error amplifier. If you are wondering what that is, you can think of it as a comparator that controls the increase or decrease of the duty cycle for the “feedback” that you associate with Pulse Width Modulation (PWM).

This functions either to increase or decrease the duty cycle depending on the voltage levels on the Inverting and Non-Inverting Inputs – pins 1 and 2 respectively.

* When voltage on the Inverting Input (pin 1) is greater than voltage on the Non-Inverting Input (pin 2), duty cycle is decreased.
* When voltage on the Non-Inverting Input (pin 2) is greater than voltage on the Inverting Input (pin 1), duty cycle is increased.

The frequency of PWM is dependent on the timing capacitance and the timing resistance. The timing capacitor (CT) is connected between pin 5 and ground. The timing resistor (RT) is connected between pin 6 and ground. The resistance between pins 5 and 7 (RD) determines the deadtime (and also slightly affects the frequency). RD = discharge resistor for CT (?). Deadtime = ?

The frequency is related to RT, CT and RD by the relationship:

[A picture containing diagram

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With RT and RD in Ω and CT in F, f is in Hz.

Typical values of RD are in the range 10Ω to 47Ω. The range of values usable (as specified by the manufacturers of SG3525) is 0Ω to 500Ω.

RT must be within the range 2kΩ to 150kΩ. CT must be within the range 1nF (code 102) to 0.2µF (code 224). The oscillator frequency must be within the range 100Hz to 400kHz. There is a flip-flop before the driver stage, due to which your output signals will have frequencies half that of the oscillator frequency that is calculated using the above mentioned formula. So, if you are looking to use this for a 50Hz inverter, you require drive signals of 50Hz. So, the oscillator frequency must be 100Hz.

A capacitance connected between pin 8 and ground provides the soft-start functionality. The larger the capacitance, the larger the soft-start time. This means that the time taken to go from 0% duty cycle to the desired duty cycle or maximum duty cycle is larger. So, the duty cycle increases more slowly initially. Keep in mind that this only affects initial rate of increase of duty cycle, ie, the rate of increase of duty cycle after the SG3525 starts up.

Typical values of the soft-start capacitance lie within the range 1µF to 22µF depending on the desired soft-start time.

Pin 16 is the output from the voltage reference section. SG3525 contains an internal voltage reference module rated at +5.1V that is trimmed to provide a ±1% accuracy. This reference is often used to provide a reference voltage to the error amplifier for setting the feedback reference voltage. It can be directly connected to one of the inputs or a voltage divider can be used to further scale down the voltage.

Pin 15 is VCC – the supply voltage to the SG3525 that makes it run. VCC must lie within the range 8V to 35V. SG3525 has an under-voltage lockout circuit that prevents operation when VCC is below 8V, thus preventing erroneous operation or malfunction.

Pin 13 is VC – the supply voltage to the SG3525 driver stage. It is connected to the collectors of the NPN transistors in the output totem-pole stage. Hence the name VC. VC must lie within the range 4.5V to 35V. The output drive voltage will be one transistor voltage drop below VC. So when driving Power MOSFETs, VC should be within the range 9V to 18V (as most Power MOSFETs require minimum 8V to be fully on and have a maximum VGS breakdown voltage of 20V). For driving logic level MOSFETs, lower VC may be used. Care must be taken to ensure that the maximum VGS breakdown voltage of the MOSFET is not crossed. Similarly when the SG3525 outputs are fed to another driver or IGBT, VC must be selected accordingly, keeping in mind the required voltage for the device being fed or driven. It is common practice to tie VC to VCC when VCC is below 20V.

Pin 12 is the Ground connection and should be connected to the circuit ground. It must share a common ground with the device it drives.

Pins 11 and 14 are the outputs from which the drive signals are to be taken. They are the outputs of the SG3525 internal driver stage and can be used to directly drive MOSFETs and IGBTs. They have a continuous current rating of 100mA and a peak rating of 500mA. When greater current or better drive is required, a further driver stage using discrete transistors or a dedicated driver stage should be used. Similarly a driver stage should be used when driving the device causing excessive power dissipation and heating of SG3525. When driving MOSFETs in a bridge configuration, high-low side drivers or gate-drive transformers must be used as the SG3525 is designed only for low-side drive.

Pin 10 is shutdown. When this pin is low, PWM is enabled. When this pin is high, the PWM latch is immediately set. This provides the fastest turn-off signal to the outputs. At the same time the soft-start capacitor is discharged with a 150µA current source. An alternative method of shutting down the SG3525 is to pull either pin 8 or pin 9 low. However, this is not as quick as using the shutdown pin. So, when quick shutdown is required, a high signal must be applied to pin 10. This pin should not be left floating as it could pick up noise and cause problems. So, this pin is usually held low with a pull-down resistor.

Pin 9 is compensation. It may be used in conjunction with pin 1 to provide feedback compensation.

Now that we’ve seen the function of each pin, let’s design a circuit with the SG3525 and see how it is put to use practically.

Let’s make a circuit running at 50kHz, driving MOSFETs (in a push-pull configuration) that drive a ferrite core which then steps up the high frequency AC and then is rectified and filtered to give a 290V regulated output DC that can be used to run one or more CFLs.

For the turns calculation, check out my article "Ferrite Transformer Turns Calculation for High-Frequency/SMPS Inverter": <http://tahmidmc.blogspot.com/2012/12/ferrite-transformer-turns-calculation.html>

So here’s the circuit (click on the circuit to enlarge the image):

[Diagram, schematic

Description automatically generated](http://2.bp.blogspot.com/-IGrcj4RjyYs/UOqa9ISSgXI/AAAAAAAAAYY/PpmE6sGtLck/s1600/circuit+50kHz.png)

Let’s analyze it and see what I’ve done.

You can firstly see that the supply voltage has been provided and ground has been connected. Also notice that VC has been connected to VCC. I’ve added a bulk and a decoupling capacitor across the supply pins. The decoupling capacitor (0.1µF) should be placed as close to the SG3525 as possible. You should always use this in all your designs. Do not omit the bulk capacitor either, although you may use a smaller value. Bulk capacitor = ?

Let’s see pins 5, 6 and 7. I’ve added a small resistance RD (between pins 5 and 7) that provides a little deadtime. I’ve connected RT between pin 6 and ground and CT between pin 5 and ground. RD = 22Ω, CT = 1nF (Code: 102) and RT = 15kΩ. This gives an oscillator frequency of:

[Text, letter

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As the oscillator frequency is 94.6kHz, the switching frequency is 0.5 \* 94.6kHz = 47.3kHz and this is close enough to our target frequency of 50kHz. Now if you had needed 50kHz accurate, then the best way would have been to use a pot (variable resistor) in series with RT and adjust the pot, or to use a pot (variable resistor) as RT, although I prefer the first as it allows for fine tuning the frequency.

Let’s look at pin 8 now. I’ve connected a 1µF capacitor from pin 8 to ground and this provides a small soft-start. I’ve avoided using too large a soft-start as the slow duty cycle increase (and thus the slow increase in voltage) causes problems when using CFLs at the output.

Let’s look at pin 10 now. Initially it’s pulled up to VREF with a pull-up resistor. So, PWM is disabled and does not run. However, when the switch is on, pin 10 is now at ground and so PWM is enabled. So, we’ve made use of the SG3525 shutdown option (via pin 10). Thus the switch acts like an on/off switch.

Pin 2 is connected to VREF and is thus at a potential of +5.1V (±1%). The output of the converter is connected to pin 1 through a voltage divider with resistances 56kΩ and 1kΩ. Voltage ratio is 57:1. At feedback “equilibrium”, voltage at pin 1 is 5.1V as well as this is the target of the error amplifier – to adjust the duty cycle to adjust the voltage at pin 1 so that it is equal to that of pin 2. So, when voltage at pin 1 is 5.1V, voltage at output is 5.1V \* 57 = 290.7V and this is close enough to our 290V target. If greater accuracy is required, one of the resistors can be either replaced with a pot or in series with a pot and the pot adjusted to give required reading.

The parallel combination of the resistor and capacitor between pins 1 and 9 provides feedback compensation. I won’t go into detail into feedback compensation as it is a vast topic on its own.

Pins 11 and 14 drive the MOSFETs. There are resistors in series with the gate to limit gate current. The resistors from gate-to-source ensure that MOSFETs don’t get accidentally turned on. Accidentally turned on?

So that’s about it. You can see that this is quite an easy circuit to design. If you’ve understood all of this, you can now design circuits with SG3525 yourself. Try to make a few, eg for 50Hz output and with isolated feedback. If you can’t don’t worry, I’ll put up another article with a few more circuits using SG3525 so that you become completely clear with it (if you haven’t already).

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Reference documents:

SG3525 datasheet: [www.onsemi.com/pub/Collateral/SG3525A-D.PDF](http://www.onsemi.com/pub/Collateral/SG3525A-D.PDF)

Ferrite Transformer Turns Calculation for High-Frequency/SMPS Inverter: <http://tahmidmc.blogspot.com/2012/12/ferrite-transformer-turns-calculation.html>

Quiero construir un circuito PWM y parece que el SG3525 es un buen candidato para el trabajo, sin embargo, no entiendo completamente todos los pines y no puedo encontrar información comprensible (para mi nivel de habilidad) en Internet .

Esto es, por ejemplo, un sitio con explicaciones: [enlace](http://tahmidmc.blogspot.be/2013/01/using-sg3525-pwm-controller-explanation.html)

Todo está claro, excepto por lo que hacen exactamente los pines 1 y 2. Cito:

Los pines 1 (Entrada inversora) y 2 (Entrada no inversora) son las entradas al amplificador de error incorporado. Si se está preguntando qué es eso, puede pensar en él como un comparador que controla el aumento o la disminución del ciclo de trabajo para la "retroalimentación" que asocia con la Modulación de Ancho de Pulso (PWM).

No entiendo para qué se usa esto, o si es necesario tener un circuito en funcionamiento. ¿De qué tipo de "retroalimentación" estamos hablando? ¿Por qué no puedo simplemente conectar el voltaje de entrada, definir la frecuencia y el tiempo muerto usando el condensador y la resistencia como se muestra en el diagrama y usar la salida del IC?

Lo mismo para el pin 9:

Pin 9 es compensación. Se puede usar junto con el pin 1 para proporcionar una compensación por retroalimentación.

¡Gracias por tu ayuda!

Primero, debe hacerse una pregunta para saber cómo funciona el PWM analógico.

Este diagrama explica todo lo que necesitas saber.

[Diagram, schematic

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Como puede ver, temenos un comparador y dos señales en la entrada.

En la no inversion aplicamos el voltaje de "error" y en la entrada inversora, aplicamos la forma de onda de diente de sierra desde el oscilador interno / externo.

Y al cambiar el voltaje en la entrada no inversora, podemos cambiar la duración del pulso de salida. Observe que cuando el valor de la señal de "error" de entrada es mayor que el de la onda de diente de sierra, la salida del comparador es alta. De lo contrario, la salida del comparador es baja.

SG3525 tiene el oscilador de diente de sierra interno. Y puede configurar la frecuencia del oscilador seleccionando los valores correspondientes para el condensador RT y CT. Y la forma de onda de salida del oscilador es "enviar" al comparador PWM.

Esta onda de diente de sierra oscila entre 0.9V y 3.2V.

Así es como se ve el voltaje en el condensador CT (pin 5) y la salida OSC (pin 4) en el circuito de trabajo.

[Graphical user interface

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Y aquí tienes el voltaje a través del condensador CT y dos salidas. El Pin11 (OutA) y el Pin14 (OutB).

Graphical user interface

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La señal de "error" se puede aplicar directamente al pin 9 o si desea utilizar el opamp adicional al pin 2. Pero en este caso, debe conectar el pin 1 junto con el pin 9. No entnedi la primera oración.

Y tenga en cuenta que el voltaje en estos pines no debe ser mayor a 5V.

Aquí puedes encontrar un diagrama de ejemplo [enlace](http://www.twovolt.com/wp-content/uploads/2016/07/DC-MOTOR-SPEED-CONTROLLER-1.pdf)

Son básicamente un control de aceleración; Normalmente, intentas alcanzar algún objetivo, como un voltaje de salida o una velocidad del motor. Si está fuera de ese objetivo, un sensor de voltaje o velocidad conectado a ese "amplificador de error" le avisa al controlador PWM, por lo que ajusta el PWM hasta que ese error sea 0 (está en el objetivo).

La compensación es el arte de controlar la respuesta de frecuencia de ese amplificador de error para evitar sobrepasos y oscilaciones.

Ese es el esquema; Ahora bien, debe aprender mucho sobre la teoría de los sistemas de control, los amplificadores de retroalimentación y la estabilidad, o seguir muy de cerca uno de los diseños de ejemplo.

Un enfoque simple para los experimentos sería conectar un voltaje ajustable en el pin 2, y simplemente cortar los pines 1 y 9 convirtiendo el "amplificador de error" en un búfer de ganancia unitaria. Entonces debería poder ver el cambio del ciclo de trabajo a medida que ajusta el voltaje en el pin 2.