Single Phase Full Bridge Inverter Control Circuit

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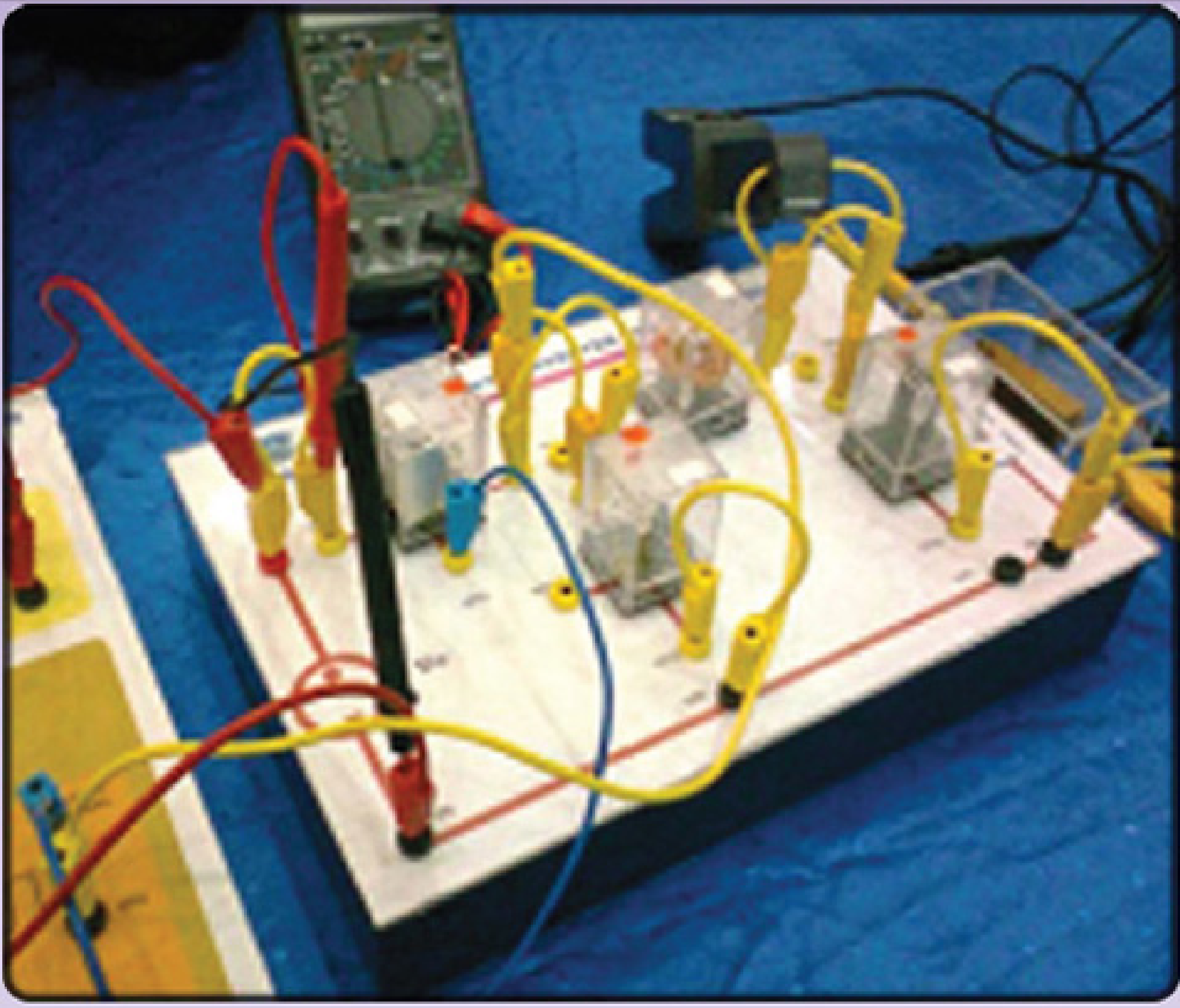

INTRODUCTION

Sinusoidal pulse width modulation (SPWM) is used to digitize power, such that a sequence of voltage pulses can be generated by the toggling of power switches. The pulse width modulation inverter has been the main stay, because of its circuit simplicity and rugged control scheme. SPWM is characterized by constant amplitude pulses with different duty cycles for each period. The modulated pulse widths enable inverter output voltage control and simultaneously reduce its harmonic content. A unipolar SPWM voltage modulation offers the advantage of effectively doubling the switching frequency of the inverter voltage which makes the output filter smaller, cheaper and easier to implement. Conventionally, a triangle wave as a carrier signal is compared with the sinusoidal wave, and the SPWM signal is generated.

Alternatively replacing it with a microcontroller allows the flexibility of changing control algorithms without changes in hardware. This also reduces cost and size of the control circuit of the inverter. An Atmel AT89S52 microcontroller is used, which is a low power, high performance CMOS 8 bit microcontroller with 4K bytes of programmable flash memory, and is compatible with the industry standard 80C51 instruction set and pin out. The microcontroller enables a simpler design, higher reliability and most importantly reduces dimensions and component count.

SYSTEM OVERVIEW

The block diagram of the whole system is shown in *Figure 1*. The system consists of microcontroller circuit for generating SPWM pulses, isolation circuit, gate drivers, inverter circuit, filter circuit and step up transformer. The microcontroller generates the SPWM signals and needs to be isolated from high voltage spikes and reverse currents. The signals are fed to the gate driver, with four independent electrically-isolated MOSFETs. The outputs are then distributed to power switches in a full bridge arrangement. The inverter output is a square waveform due to the switching and a sine wave signal is obtained via an LC filter which also reduces harmonic content. The sine wave is then fed to a step up transformer to obtain the required output level.

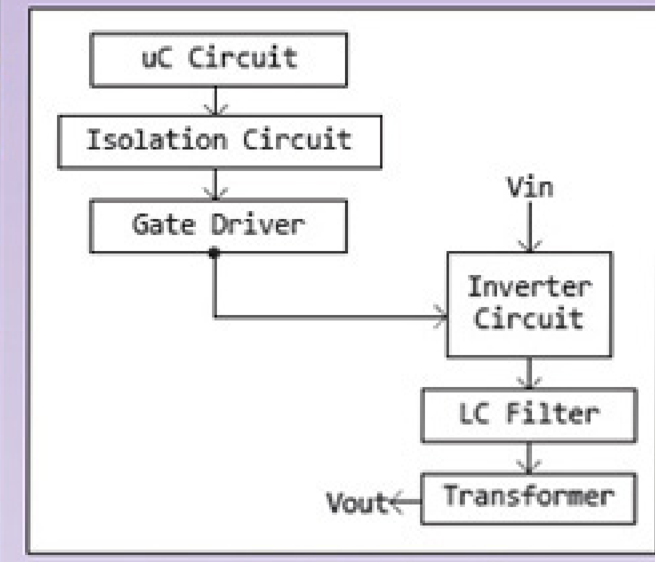

Figure 1. Inverter system overview

MODULATION CONTROL

Frequency modulation, *mf*, is the ratio of the frequencies of the carrier and the reference signals :

$$mf = \frac{f_{carrier}}{f_{reference}} = \frac{f_{tri}}{f_{\sin}} \tag{1}$$

Amplitude modulation, *ma*, is the ratio of the amplitude of the reference and carrier signals :

$$ma = \frac{V_{m,\,reference}}{V_{m,\,carrier}} = \frac{V_{m,\,\sin}}{V_{m,\,carrier}} \tag{2}$$

The PWM signal amplitude of the fundamental frequency is controlled by *ma*. In an unregulated DC voltage the value of *ma* can be adjusted to compensate for the variations in the DC voltage, thus producing a constant amplitude output. If *ma* is greater than 1, the amplitude of the output increases nonlinearly with *ma*.

APPROACH AND METHOD

Figure 2 shows the single phase full bridge inverter and its switching strategy. While *Figure 3* shows the

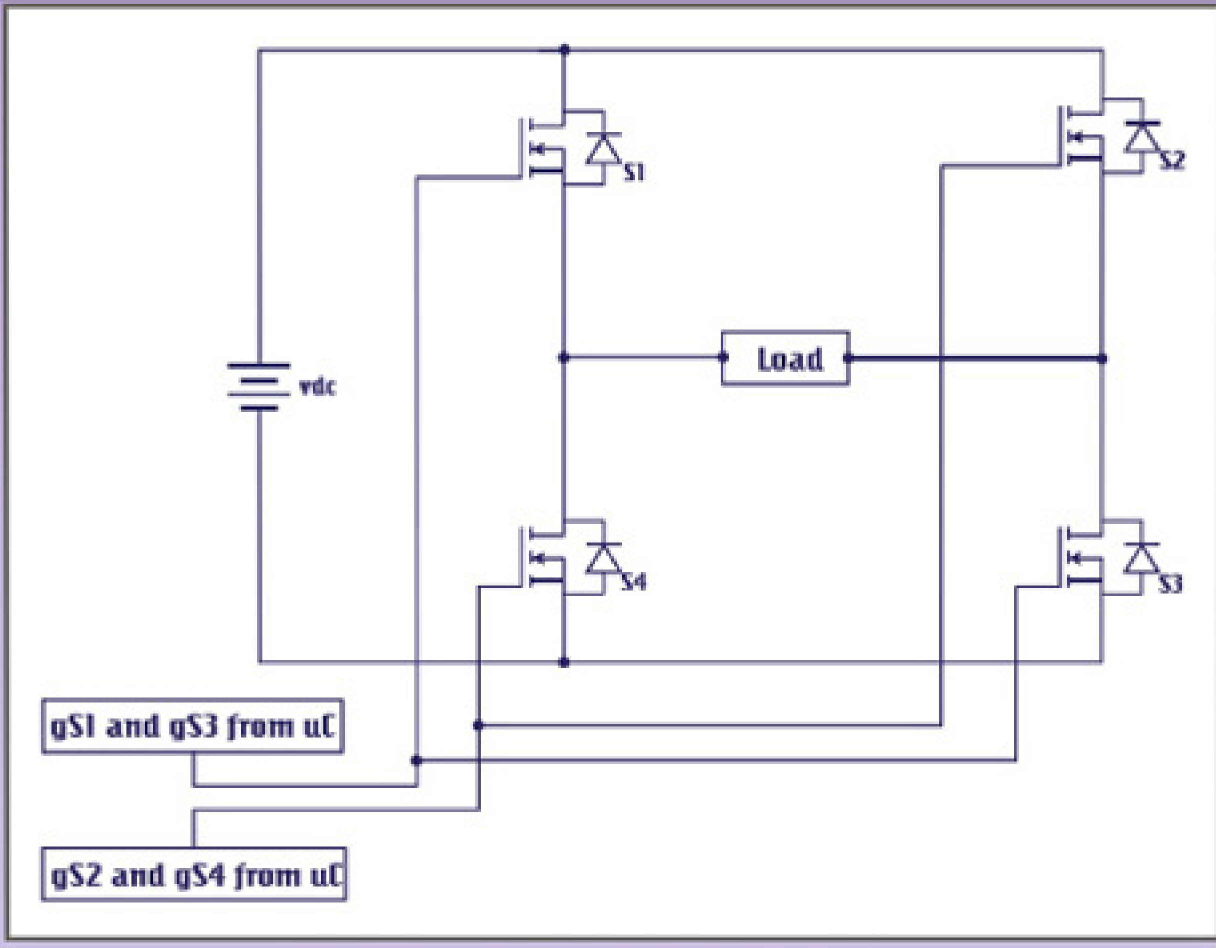

Figure 2. Single phase full bridge inverter and its switching strategy

control strategy of the switching technique for the inverter. The output gating signals gS1, gS2, gS3 and gS4 trigger the power switchers S1, S2, S3 and S4, respectively. Comparison of signals between carrier and reference signal, *Figure 3a*, creates the pulses for the power switchers, *Figure 3b*, which together output the waveform of *Figure 3c* before filtering.

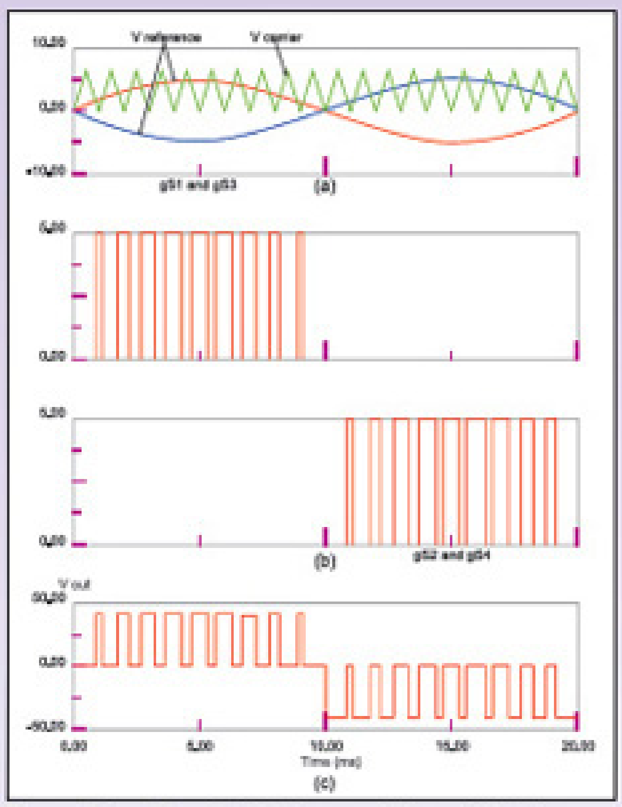

Figure 3. Control strategy of the switching technique

Every pulse for gS1- 4 is calculated via :

$$a_k = a_n - \delta_k \quad (3)$$

$$a_{k+1} = a_n - \delta_{k+1} \quad (4)$$

Where:

$$\delta_k = 2\delta_0 m_a \sin(a_n - \delta_0) \quad (5)$$

$$\delta_{k+1} = 2\delta_0 m_a \sin(a_n + \delta_0) \quad (6)$$

Figure 4 illustrates comparison of signals between carrier and reference, and the gating pulses using the Volt-second technique for k^{th} PWM. The pulse widths depend on the carrier-reference signal comparison. When *ma* is different, the pulse widths also differ. Gating signals (gS1 and gS3) or SPWM 1 and (gS2 and gS4) or SPWM 2 use the same control signal generated by the microcontroller. The difference being in (gS1 and gS3) leading (gS2 and gS4) by 180° of the switching signal.

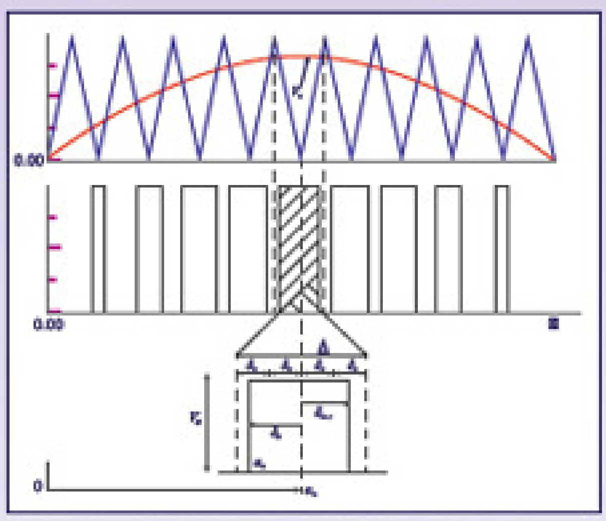

Figure 4. Signal comparison and gating pulses using Volt-second technique for k^{th} PWM

EXPERIMENTAL RESULT

The experimental results from microcontroller output port, as measured via a Tektronix TPS 2014, is shown in *Figure 5*. SPWM 1 is leading SPWM 2 by half cycle of the switching signal. *Figure 6* shows the voltage and current output waveform of the inverter before the filter and *Figure 7* shows the voltage and current output waveform from single phase inverter after the filter with a resistive load. The final output waveform is purely sinusoidal with an amplitude of 240 Vrms, 50Hz and THD below 3%.

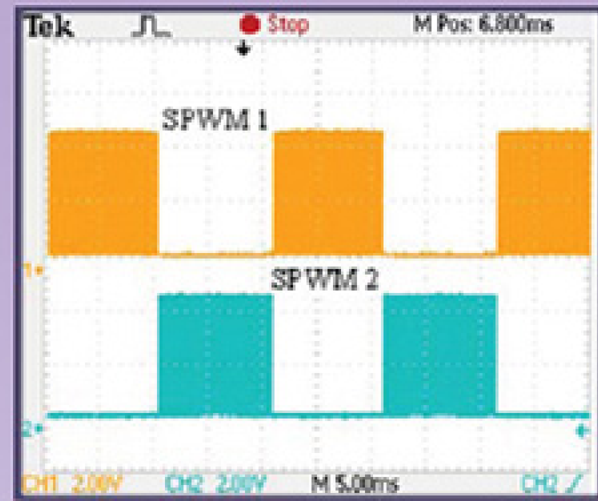

Figure 5. SPWM 1 and SPWM 2 waveform (2V/div) generating pulses from microcontroller

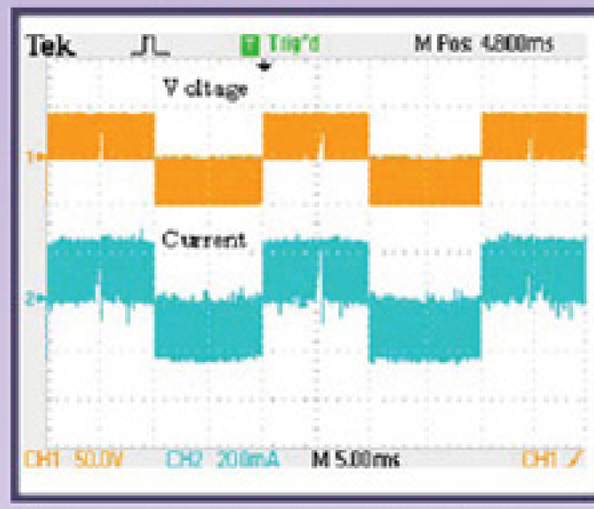

Figure 6. Voltage output waveform (50V/div) and current output waveform (200mA/div) from single phase inverter before filter

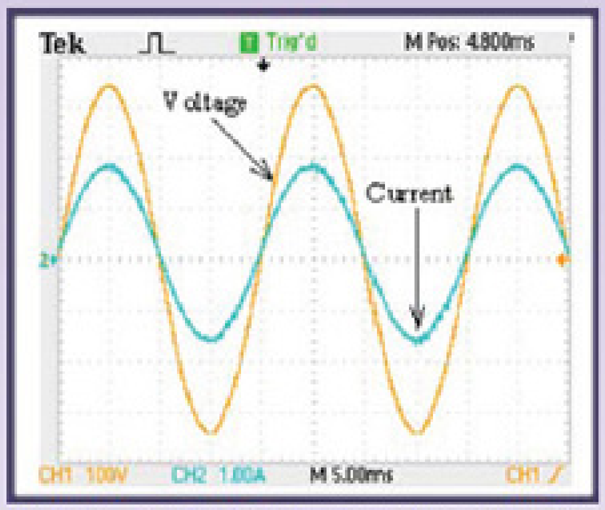

Figure 7. Output voltage waveform (100V/div) and output current waveform (1A/div) with resistive load

CONCLUSION

The implementation of a single phase full bridge inverter with SPWM switching signal from a microcontroller minimizes hardware requirement, with many functions performed via software. A 300W prototype single phase full bridge inverter has been successfully constructed to study the validity of the switching signals, with the output voltage and current of very low THD and an average efficiency of 88%.

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