IMPLEMENTATION OF SINGLE-PHASE INVERTER USING MC56F8322 DSP

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ABSTRACT

This paper deals with design of single-phase inverter using DSP56800E digital signal controller that provides AC output voltage with desired frequency and amplitude. Single-phase inverters are widely used in uninterruptible power supplies, standby supplies and single-phase induction motor drives.

1. INVERTER

1.1. CIRCUIT

Inverter schematic diagram is shown in fig. 1. Inverter consists of four switches which are represented by MOSFET transistors with parallel reverse diodes. Transistors are formed to a bridge with leg A and B. LC filter and load is connected between these two legs. The principle is to connect each side of load to positive or negative voltage (using pulse-width modulation). MOSFET transistor gates have to be driven by isolated gate drivers. Drivers are directly connected to output of PWM module of DSP.

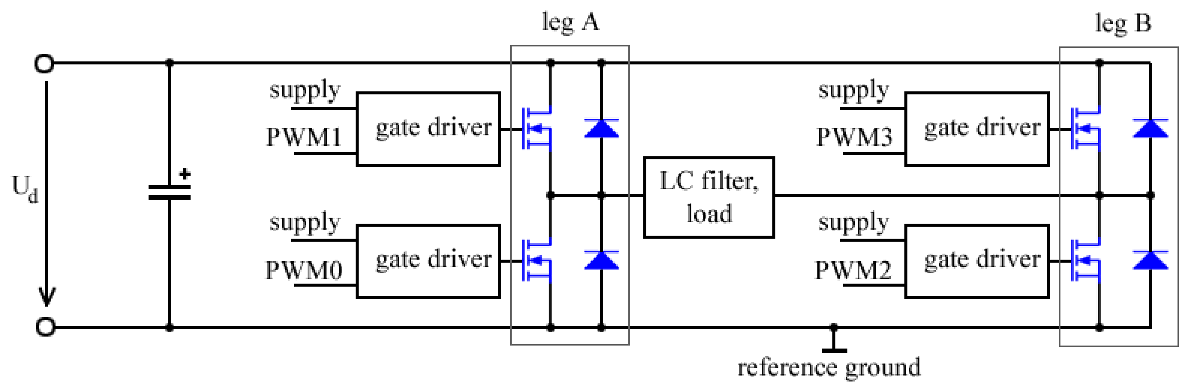

Fig. 1: Simplified inverter schematic diagram

1.2. UNIPOLAR CONTROL OF INVERTER

The principle is to generate appropriate control signal for MOSFET transistors using DSP PWM module. In leg A PWM generator sinusoidal reference waveform is compared with triangular waveform, in the leg B PWM generator inverted sinusoidal reference waveform is compared with same triangular waveform. Output AC voltage frequency can be changed simply by change of sinusoidal reference waveform frequency. Output RMS voltage of output is defined as

$$U_{OUTrms} = U_d \sqrt{\frac{2}{\pi} M} \tag{1}$$

where M is modulation index which is defined as

$$M = \frac{U_{ref\max}}{U_{tri\max}} \tag{2}$$

where $U_{ref\max}$ is amplitude of sinusoidal reference waveform, $U_{tri\max}$ is triangular waveform maximal value. Situation is shown in fig. 2.

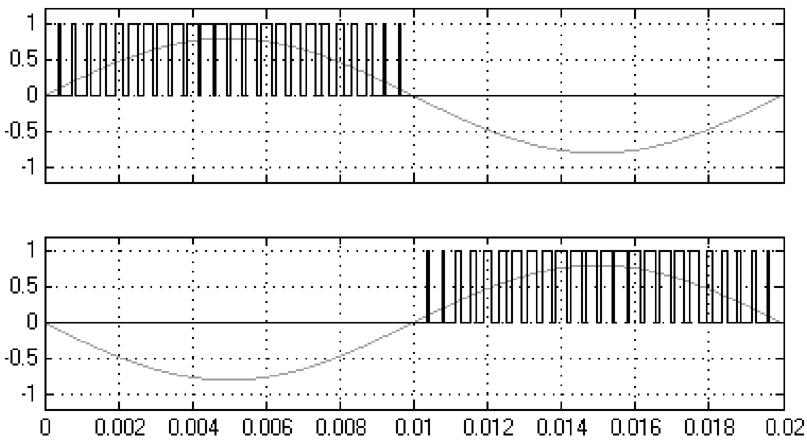

Fig. 2: PWM output signals simulation (M=0,8)

Top PWM waveform should be used for controlling leg A, bottom PWM waveform should be used for controlling leg B. DSP PWM module output channels are configured as complementary pairs (see fig. 3).

When using unipolar inverter control only appropriate leg transistors are switched if sinusoidal reference waveform has positive value as shown in fig 2. When value is negative bottom transistor is on and top is off.

2. DSP56F8322 PWM MODULE

The PWM can be configured as three complementary pairs, six independent PWM signals, or their combinations, such as one complementary and four independent. Both edge-aligned and center-aligned pulse width control from 0 to 100 percent modulation are supported.

A 15-bit common PWM counter is applied to all six channels. PWM resolution is one clock period for Edge-Aligned operation and two clock periods for Center-Aligned operation. The clock period is dependent on the IPBus frequency and a programmable prescaler.

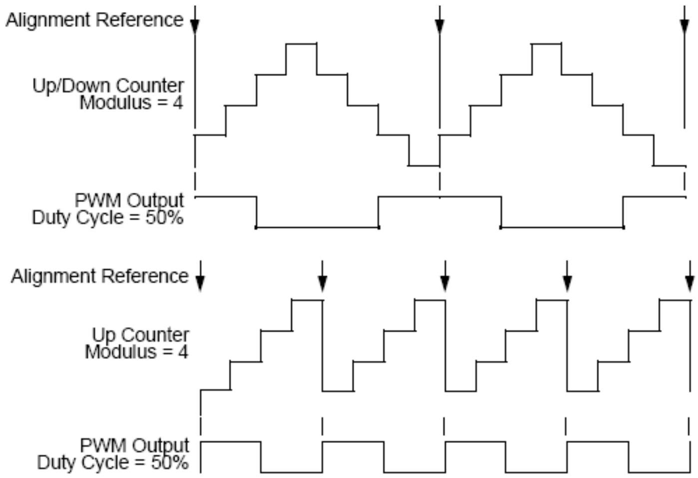

Fig. 3: Center-aligned (top) and edge-aligned (bottom) modulation

When generating complementary PWM signals, the module features automatic deadtime insertion to PWM output pairs. Each PWM output can be controlled by PWM generator or software manually.

Two pairs of PWM outputs are configured as complementary pairs as shown in fig. 4. A deadtime insertion is also applied.

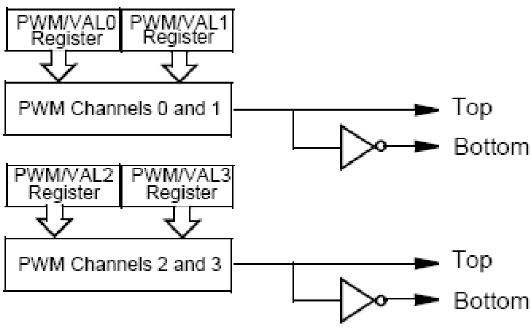

Fig. 4: PWM channels configuration

3. EXPERIMENTAL

A DSP56F8322 evolution board has been used for implementation of inverter control thus the implementation of control and connection of control with power transistors was quick and simple. STP4NC60 bridge MOSFET transistors and UF4007 ultra-fast reverse diodes were used. Because in both legs top transistor source is floating against reference ground, output of every gate driver has to be insulated and gate driver must have special power supply. High speed optocoupler and CMOS gate driver was used.

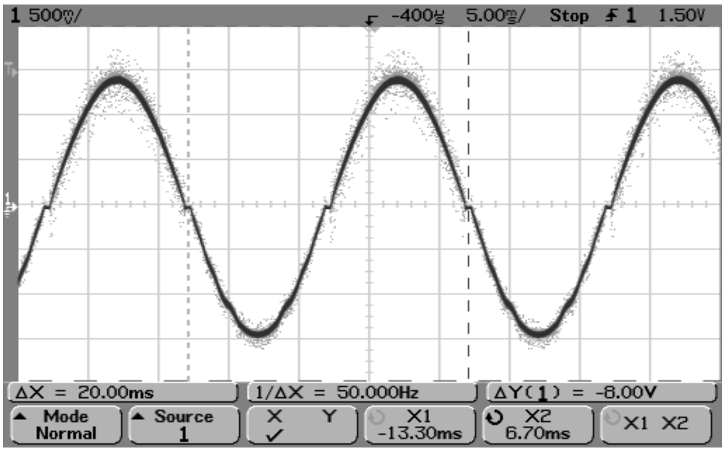

Fig. 5: Output AC voltage

Output AC voltage waveform is shown in fig. 5. MOSFET switching frequency is 40kHz, output frequency is 50Hz. Experimental circuit photo is in fig. 6.

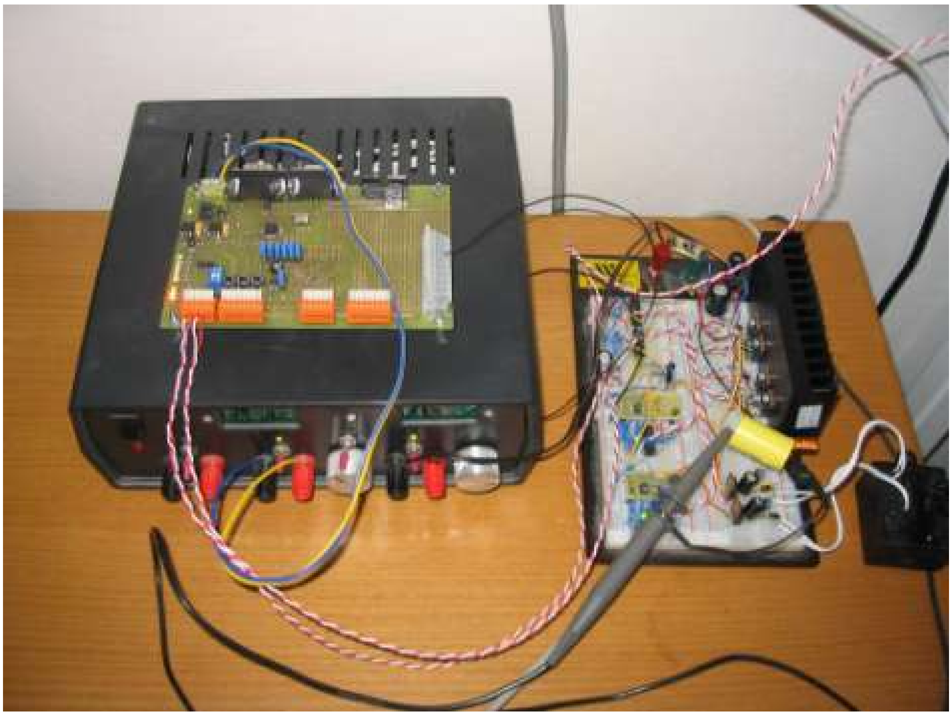

Fig. 6: Experimental circuit photo

4. CONCLUSION

A single-phase inverter laboratory model was designed using DSP56800E digital signal controller family and successfully tested. Inverter consists of four MOSFET power transistors, reverse diodes and low cost gate driver. Principles of this model can be used in further design and development of UPS, standby supply or single-phase induction motor controller. Inverter can be also simply modified to three-phase version.

REFERENCES

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