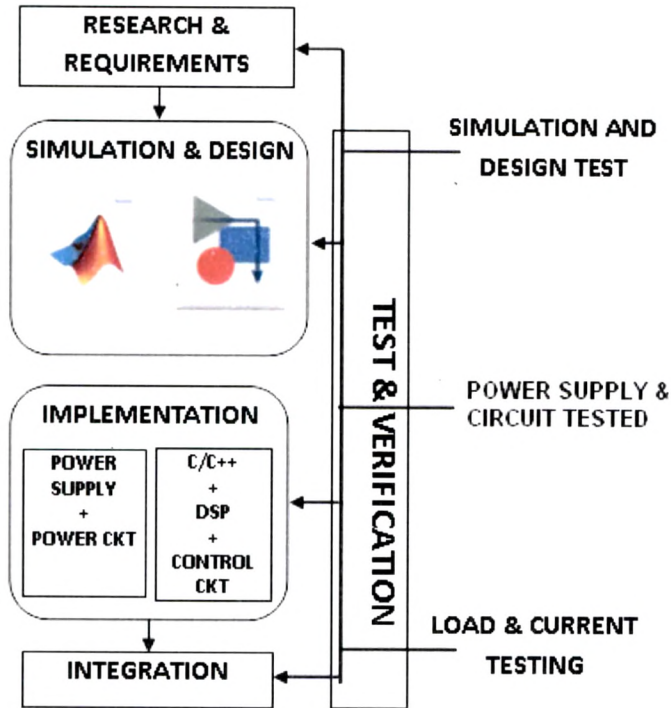


CHAPTER 6

CONTROL SIGNAL GENERATION

Following block diagram shows the procedure for the simulation, control signal generation and implementation.



Block diagram for simulation, control signal generation and implementation

- Simulink model generated and optimal THD is obtained.
- Building of Simulink model with CCS3.3, code generated is loaded to Emulator xds510usb, control signal generation from DSP28335.
- Control signals obtained applied to buffer, opto isolation and driver circuits.
- Control signals generated are given to power circuit.
- Power circuit results are observed on DSO.

This chapter discusses the processor used for gating signals applied to switches in power circuit. As discussed earlier 18 switches are there in 3 phase Hybrid Multilevel Inverter controlled separately with different modulation techniques as per requirement. Thus processor chosen should provide minimum 18 separate pulses at the output. Though complimentary pulses can be used but to avoid leg short circuiting and intentional delay separate pulses are used in this topology.

Analog control can be used but for implementation of various modulation techniques digital control is suggested. Control signals can be obtained using different high level languages like C/C++ programming. But as per advancement in technology control signals can directly be obtained using MATLAB SIMULINK Blocks with Code Composer Studio and Emulator. All these interfaces are discussed in detail.

This chapter describes steps involved in generation and application of control signals to power circuit.

6.1 DIGITAL SIGNAL PROCESSOR

Fig. 6.1 depicts EPB 28335. The EPB28335 is a stand-alone card allowing developers to evaluate the TMS320F28335 digital signal processor (DSP) to determine if it meets their application requirements. Furthermore, the module is an excellent platform to develop and run software for the TMS320F28335 processor. The EPB28335 is shipped with a TMS320F28335 DSP. The EPB28335 allows full speed verification of F28335 code. To simplify code development and reduce debugging time, a C2000 Code Composer Studio driver is provided. In addition, an onboard JTAG connector provides interface to emulators, with assembly language and 'C' high level language debug. Following features of EPB28335 and TMS320F28335 DSP can be summarized in brief [1-3].

- Fast, 150 MHz clock/instruction cycle.
- High speed A/D converter, 12.5 MHz max sample rate, 16 channels, 12-bits.
- 80-ns conversion rate (12.5 MHz)
- A/D includes two parallel sample and hold circuits.
- Nominally a 32-bit machine.
- 34 K words (16-bit) of on-chip static random access memory (RAM).
- 256 K words (16-bit) of flash read only memory (ROM).
- 6 high resolution (150 picosecond) pulse width modulators. Can readily be used to implement D/A converters.

- Possesses a rich set of peripheral interface devices
- 6 high resolution pulse width modulator outputs
- Three 32-bit timers
- Serial port peripherals
- On chip 32-bit floating point unit
- 68K bytes on-chip RAM
- 512K bytes on-chip Flash memory
- On board 1M bytes (64kx16) off-chip SRAM memory
- 9-volt only operation with supplied AC adapter
- On board Power-On LED indication
- Connector for Watchdog timer output
- 20 Pin (10x2 header) Connector for 16 GPIO lines
- DB25 Connector for 8 Digital Input and 8 Digital Output interface with +5V compatibility
- Error + Trip +5V compatible connector for Inverter control module
- On board USB Connector for UART-A interface with LED indication
- On board USB for Flashing
- On board DB9 connector for UART-A interface
- On board LED indication for Transmit and Receive data at UART-A
- On board 3 pin header for UART-B interface
- On board DB9 connector for CAN-A interface (Loop back mode possible)
- On board 4 pin header for CAN-B interface (Loop back mode possible)
- On board DB9 connector for 6 channel capture interface
- On board DB25 connector for 12 channel PWM interface
- On board DB15 connector for 8 Channel On-Chip ADC-A interface (with 3V protection using Op-Amps with unity gain output)
- On board DB15 connector for 8 Channel On-Chip ADC-B interface (with 3V protection using Op-Amps with unity gain output)
- On board Potentiometer to test On-Chip ADC
- On board DB9 connector for 4 channel SPI based External DAC interface
- On board I2C based Off-Chip EEPROM interface
- On board I2C based Off-Chip RTC interface

- On board Reset Switch with LED indication
- On board Switch for Run/Program mode switching
- On board Switch for boot mode selection
- On board IEEE 1149.1 JTAG emulation connector (7x2 pins) with LED indication
- Test points for All the PWM channels
- Test points for All the ADC channels
- Test points for Power signals
- On board LED at GPIO Pin as GPIO Test point
- 88 configurable general purpose I/O (GPIO) pins

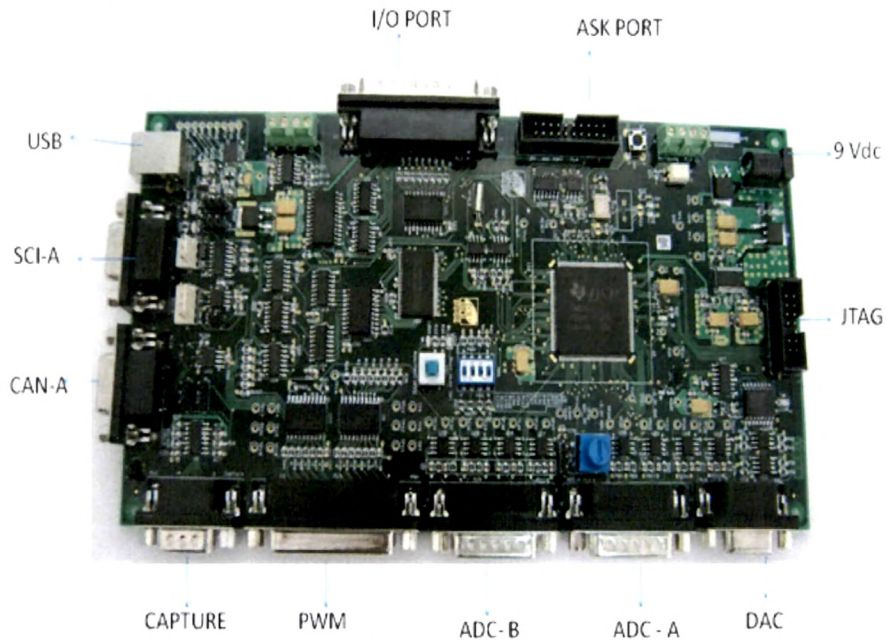


Fig. 6.1 EPB 28335 with peripherals

On the 2833x/2823x devices, the GPIO signals are assigned to 32-bit ports. The GPIO control and data registers have been moved from peripheral frame 2 (16-bit access only) to peripheral frame 1, which allows for 32-bit as well as 16-bit operations on the registers. The GPIO MUX logic has been redesigned to allow for a higher level of peripheral multiplexing. The 2833x/2823x GPIO MUX can multiplex up to three independent peripheral signals into a signal GPIO pin, in addition to providing individual pin toggling I/O capability. There are two MUX registers for each GPIO port. For each of the GPIO pins one can enable or disable an internal pullup resistor through software.

Thus features utilised are GPIO and I/O ports for 18 control signals. JTAG for interfacing emulator with DSP.

6.2 FLOW OF CONTROL SIGNALS

As discussed control signals are obtained in following steps:

Step 1 : Open CCSSTUDIO Setup as shown in Fig. 6.2.

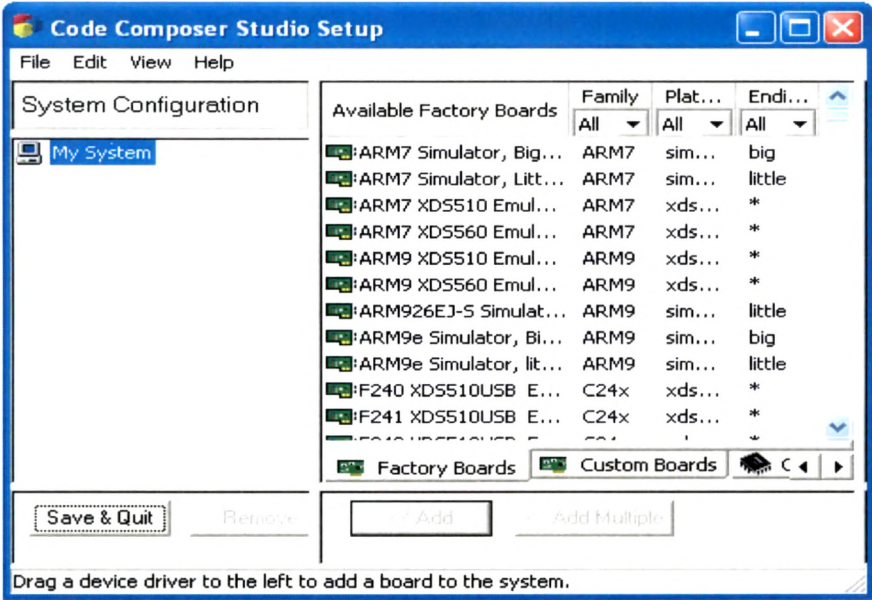


Fig. 6.2 CCS setup

Step 2: Select family, platform and add to system Do the settings as shown in Fig. 6.3.

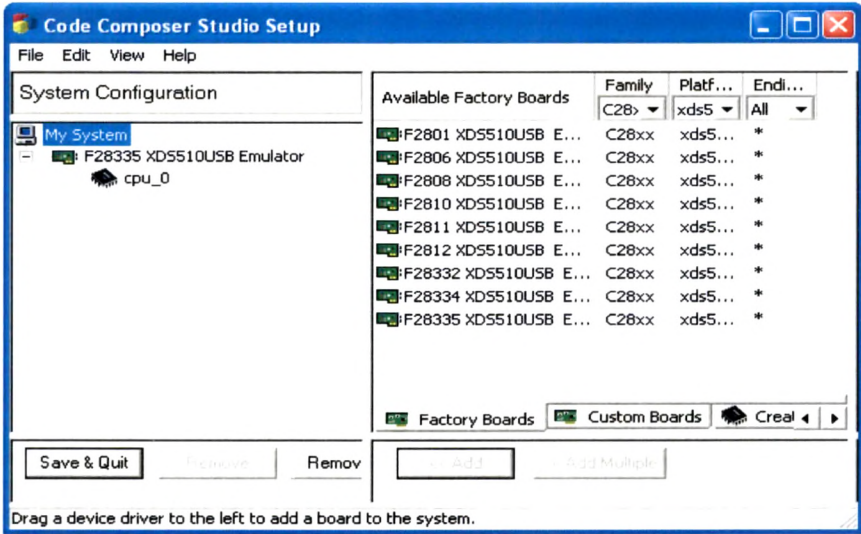


Fig. 6.3 Emulator selection

Step 3: Save and quit.

Step 4: MATLAB SIMULINK model execution(.mdl file).

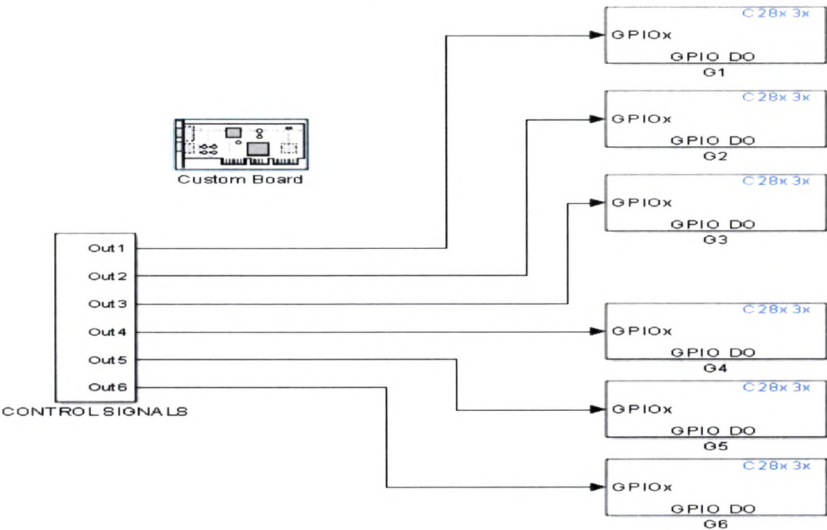


Fig. 6.4 MATLAB SIMULINK model for control signals

Custom board is selected from target preferences and as DSP is 28335 hence board selected is C2000 and processor is F28335. Fig. 6.4 shows MATLAB SIMULINK model for generation of control signals.

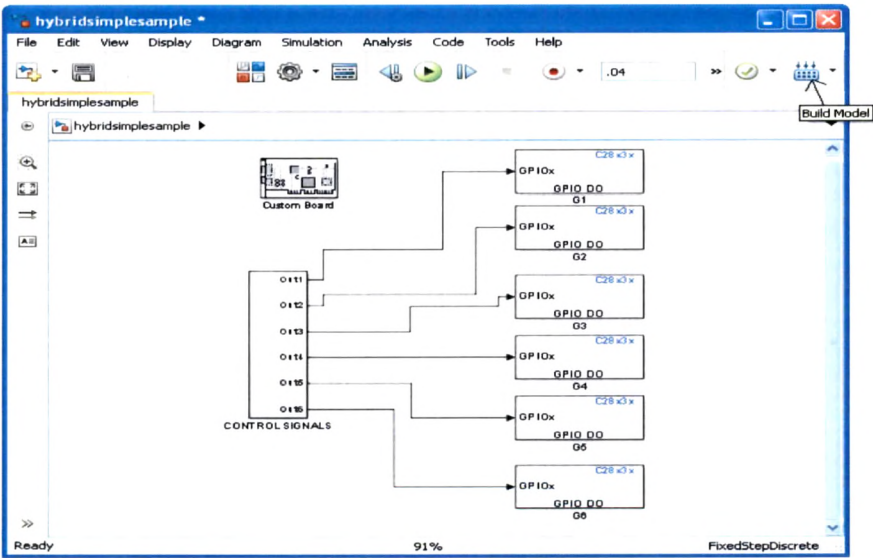


Fig. 6.5 Building model in MATLAB SIMULINK

In Fig. 6.4 six signals are shown similarly 18 signals can be obtained. GPIO pins and PWM port used for obtaining pulses are summarized as below: GPIO 48-52, 54,

57,59-63 and PWM 1A,1B,2A,2B,3A and 3B configured to GPIO 0,1,2,3,4 and 5 are used for control signals.

Step 5: After execution of .mdl file build model as shown in Fig. 6.5. Project is built in CCS as shown in Fig. 6.6 and loaded to emulator with no error and control signals are loaded in DSP. Thus 3.3V pulses are obtained GPIO pins specified.

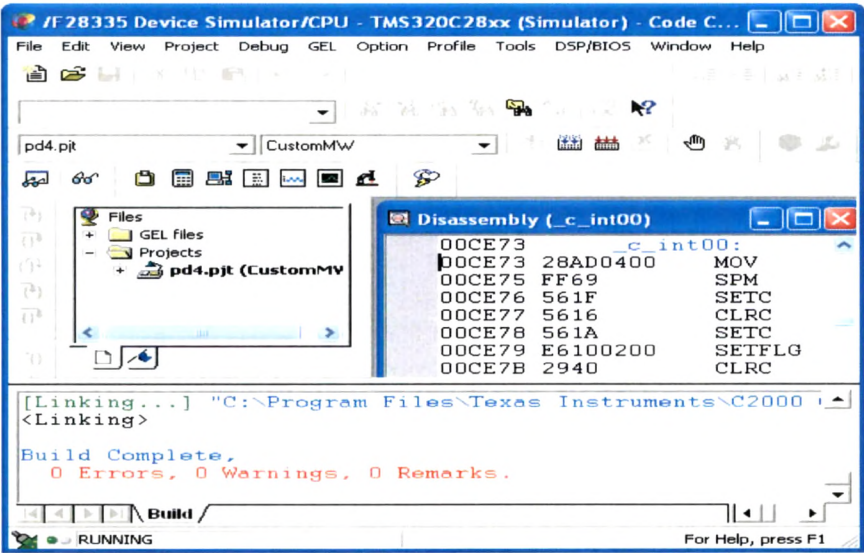


Fig. 6.6 Project built in CCS

6.3 DRIVER CIRCUIT

The gate pulses obtained from DSP go through buffer, isolation and driver stage before reaching to the power devices. As DSP can drive maximum up to 200mA current and signals taken are 18 hence buffer is required. The isolation is must when gate pulses are given to power devices connected in inverter configuration. The isolation is normally provided to gate pulses through optocouplers, which isolates power circuit and low power control circuit optically. Further these optically coupled signals are given to the driver circuit. The gate pulse, which is given to the MOSFET, is with respect to the source terminal. Fig. 6.7 shows circuit for buffer, isolation and driver which are described in brief.

Circuit is designed as per requirement of gate pulse. Buffer selected [4] can drive maximum 6 signals hence for 18 pulses three buffers are used. Buffer supply is 5V. 4049 inverting buffer is used. Component list is given in Table 6.1. R₁, R₂, R₃ and R₄ are selected as standard current limiting, pull-up resistors. Similarly C₁ and C₂ are by pass capacitors while C₃ is used for floating supply as per requirement of driver IC IR2110

[5]. Diode D₂ is fast switching diode for boost up. High speed opto isolator 2630 is used for isolation [6].

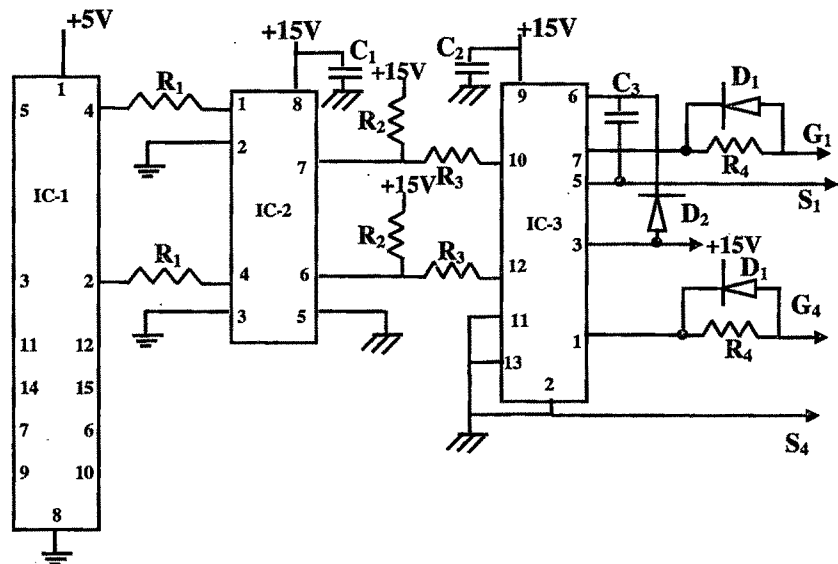


Fig. 6.7 Control circuit for generating gating signal

Table 6.1 Component List

Component	Value
R ₁	330 Ω
R ₂	10 kΩ
R ₃	1 kΩ
R ₄	3.3 kΩ
C ₁	0.1 μF
C ₂	0.47 μF
C ₃	100 μF
D ₁	IN4148
D ₂	11DF4
IC-1	4049
IC-2	2630
IC-3	IR2110

6.4 SUMMARY

In this chapter, procedure to obtain control signals is described. Signals obtained from DSP are 3.3V compatible which are not enough for gate drive hence buffer and driver circuits are introduced. As power circuit operates at very high voltage, isolation is compulsory hence opto isolator is used.