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Development of Software Using TMS320F28379D DSP

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***Abstract*: The project involves development of software for a TMS320F28339D digital signal processor (DSP) based system which controls and supervises a high temperature vacuum furnace. TMS320F28379D is a 32- bit floating point DSP. The software will be developed in C/C++ language. The system is working in the master slave mode. The communication between the master and slave is on RS-485 serial interface. The master initiates all the communication and waits for the response. Various interfaces of TMS320F28339D for which software will be developed are Serial interface (RS-232 and RS-485), Timers for generation of clock and programmed delays, on chip ADCs, Digital I/Os, Software interrupts and External interrupts handling Communication protocol. The combined software will be developed to provide functionalities to the system which are Generating programmable temperature profile reference for PID temperature controller, controlling of pumps and valves., Monitoring of temperature at various places inside vacuum chamber, monitoring of three phase supply voltage and currents, monitoring of voltage and current of heater, Digital Controls of parameters like ON, OFF, Hold etc., Safety interlocks.**

***Keywords*: TMS320F28379D, CCS, Serial communication, Command frame, Error checking.**

1. Introduction

The principle behind the vacuum furnace production is that by extracting vacuum with the absence of the air or other gases prevents the oxidation from the product through convection and forms a low pressure environment. It is a type of furnace that can heat the materials such as metals to very high temperature and carry out the process such as brazing, Sintering and heat treatment with high consistency. The product in the vacuum furnace is surrounded by vacuum. The functions of vacuum furnace are vacuum quenching (tempering, annealing) it is the method by heating and cooling the materials in the vacuum to achieve the desired performance. Vacuum brazing is the welding process at which the melting point of the filter metal by heating a group of weldments.

Vacuum sintering is the method of by diffusion and adhesion sintering the adjacent metal powder grains into parts when they are heated in the vacuum. Vacuum degassing furnace, water cooled double walled vertical type vacuum furnace, Controlled atmosphere vacuum brazing furnace are some facilities is there in vacuum Degassing and Brazing facility. Due to the dissolve of unwanted gas in the liquid produces imperfection and defects. Method to remove the unwanted gases is vacuum degassing. Inside the sealed vacuum vessel cooled double wall designed. Therefore, it is also suitable operation at positive pressure. Controlled atmosphere vacuum brazing furnace are capable of providing brazing environment which is only possible in vacuum furnace.

Vacuum method is to protect heated steel and metal parts from the negative influence of the air atmosphere. A vacuum furnace is for maintaining vacuum by electrically heating the furnace. Metals are heating at high temperature causes rapid oxidation. A vacuum furnace prevents this by removing the oxygen. In production industries and research laboratories.

Furnace maximum temperature and vacuum level depend upon the melting point and vapour pressure of the heated material. Some of the characteristics are

within the heated zone temperature can be controlled which is surrounded by heat shielding or insulation. By using this method can reduce the contamination of the product by carbon, oxygen and other gases. Some of the benefits of vacuum furnace are within a small area temperature can be controlled. The products are quickly cooling(quenching) within a short cycle of periods. there should not be oxidation of the components. Distortion of the large components can be reduced. There should be high temperature uniformity. The heat treatment process is fully automation. Also it is an eco-friendly device. Simple in structure and is easy to construct or modified. The volume of the vacuum chamber is smaller in volume and has less displacement and there is no need of insulation panel structure, etc. east to achieve high volume, there is no vacuum discharge problem since the electric heating element are heated externally. Simple operations and less failure. There is no possibility of chemical action since the work piece is not contact with the furnace. Also there are some defects also in thermal vacuum furnace.

The furnace heat transfer efficiency is low so that the heating speed of the material is slower. Heat loss is very large when the part of the furnace can be exposed to the atmosphere. The temperature is maintained below within the particular range. To control the vacuum furnace manually, it is difficult because the heat capacity and thermal inertia of the furnace is large. Also it

is difficult to always check the operations manually in order to overcome that development of software for a TMS320F28339D digital signal processor (DSP) based system which controls and supervises a high temperature vacuum furnace. TMS320F28379D is a 32- bit floating point DSP. The software will be developed in C/C++ language. The system is working in the master slave mode. Since the execution time and compilation of a C++ program is much faster. C++ is a low level language so that it is closer to the hardware system.

The communication between the master and slave is on RS-485 serial interface. Modbus is a standard communication protocol in industry for connecting the industrial electronic devices. When device communicate in Modbus RTU mode, 8bit byte in a message contains two 4-bit hexadecimal character. It uses for transmit the signal from slave device or control device and send back to the main controller. For example, it measures the temperature and pressure from the measuring device and send the result to the computer. Modbus message frame is the combination PDU (Protocol Data Unit) and ADU (Application Data Unit). PDU includes function code and data whereas ADU contains additional address, function code data, error check. Data is sent by Modbus over serial lines as series of ones and zeros called bits. Each slave device in a network have a unique address which is range from 1 to 247 bits. Function code is the second byte sent by the master function code number tells whether to read or write the command.

Signals are transmitted serially over Modbus as bits, which contains ones and zeros. RS-485 can communicate with one or more device. The signal which is transmitted through the RS-485 is mor faster and can transmit longer distance. Interrupt Service Routine (ISR) is a software process raised by an interrupt request from a hardware device. Interrupting the active process by handling the request and send it to the CPU. By receiving a valid start bit receiver begins the operation. The combined software will be developed to provide functionalities to the system are Controlling of pumps and valves, monitoring of temperature at various places inside vacuum chamber, Digital Controls of parameters like ON, OFF, Hold etc.

2. Proposed System

The project involves development of software for TMS320F28379D Digital Signal processing (DSP) based system. For controls and monitoring a high temperature vacuum furnace. TMS320F28379D is 32bit floating point DSP. C++ language is used for this software. This dual real time control system are based on Texas Instrument 32 bits C28x floating point CPUs each core which provide 200 MHz of signal processing. For enable of fast execution of algorithm C28x CPUs are further boosted by TMU accelerator. TMS320F28379D supports 1MB flash memory with error correction code up to 204KB.

It is an independent 32bit floating point processor which runs at the same speed of the CPU. The main feature of the CLA is it responds to the peripheral triggers and execute the algorithm at the same speed of the CPU. To extend the connectivity peripherals such as CAN modules, EMIFs will use. It has up to four Analog to digital converters. In 16bit mode differential inputs with 12 external channel. In 12bit mode single ended input with 24 external channel.

Code Composer Studio is a software which supports the Texas Instrument microcontroller family. CCS is an Integrated Development Environment (IDE). Integrated Development Environment (IDE) refers to an environment that brings the tools which is needed to develop software Code Composer Studio comprises to make an appropriate tool used to develops an embedded application. It includes the most effective use of C/C++ compiler, Debugger, profiler, project build environment, source code editor. CCS combines the advantage of Eclipse software framework. Workbench is the main user interface; it contains different types of resources used for development the software.

The main working folder for the Code Composer Studio is the workspace. All the projects for the reference are stores in the workspace. The user information such as user interface preference and settings also can be used to store in the workspace folder. Perspective defines in the workbench window the layout of views, menus and toolbars. The software will be developed in C/C++ language. While compare to other general programming language the compiling and execution time of the C++ program is much faster. C++ language is one of the most important programming language. Because it plays an important role in almost all application that we use. C++ connects very well with hardware. Here C++ use as compiler because of it is a lower level language and are closer to hardware. This is much useful in those areas where software is closely paired with the hardware. System is working in the mater slave mode.

Master initiates the requests and waits for the response from the slave devices corresponding to the commands. The messages or the commands are send in packets or frames. Messages are send serially or bit by bit at time over the communication channel. Here Modbus RTU protocol version are used, In Modbus RTU master initiates the request and wait for response from the slave devices. In RTU mode 8bit byte message are send in two 4bit hexadecimal character. The format of each byte (11 bits) in RTU mode 1 start bit,8 data bit, 1 odd or even parit,1 stop bit. Characters are transmitted serially from left to right. That is least significant bit is first and most significant bit is last. RTU message frame contains1 byte code, 0 to 252 data, 2byte Cyclic Redundancy Check (CRC).

Data is sent by Modbus over serial lines as series of ones and zeros called bits. Each slave device in a network have a unique address which is range from 1 to 247 bits. Function code is the second byte sent by the master function code number tells whether to read from the slave devices. In RTU mode 8bit byte message are send in two 4bit hexadecimal character. The format of each byte (11 bits) in RTU mode 1 start bit, 8 data bit, 1 odd

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Data is sent by Modbus over serial lines as series of ones and zeros called bits. Each slave device in a network have a unique address which is range from 1 to 247 bits. Function code is the second byte sent by the master function code number tells whether to read or write the command. CRC is for error detection of the Modbus message by adding 2byte at the end of the message. Modbus message are transmitting in the form of frame that has a known beginning and end point. Frames are separated at the interval of atleast3.5 character times. The function code in the request tells action to be performed to the addressed slave device.

Some function code numbers and their corresponding status.

- Read Coil Status
- Read Input Status
- Read Holding Register
- Read Input Register
- Write Single Coil
- Write Single Register

program is much faster. C++ language is one of the most important programming language. Because it plays an important role in almost all application that we use. C++ connects very well with hardware. Here C++ use as compiler because of it is a lower level language and are closer to hardware.

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RTU message frame contains1 byte slave address, 1byte function code, 0 to 252 data, 2byte Cyclic Redundancy Check (CRC). Data is sent by Modbus over serial lines as series of ones and zeros called bits. Each slave device in a network have a unique address which is range from 1 to 247 bits. Function code is the second byte sent by the master function code number tells whether to read or write the command. CRC is for error detection of the Modbus message by adding 2byte at the end of the message. Modbus message are transmitting in the form of frame that has a known beginning and end point. Frames are separated at the interval of atleast 3.5 character times.

A. Command frame

Serial communication is data is sending bit by bit at a time serially or sequentially over a communication channel. In fig.10 shows that data is transmitted serially. The protocol version which is used here is Modbus RTU. Since the system is working in the master slave mode, on Modbus RTU master may initiate a command all other slave devices responds to request and command

Each slave in a network is assigned a unique unit which address from 1 t0 247. When master request the data the first byte sends is the slave address. The second byte is send by the master is the function code. The number which tells whether the slave to send from or write to. Function code 05 is used to turn ON/OFF digital output of the modbus slave device. Slave address of the control system is 01 the function code 05 is write a single coil. This command is writing ON/OFF status and each data have a unique address and data can be either ON/OFF for on condition bit will be high or 1and for off condition bit will be low or 0. Thus by combining slave address, function code, starting data address, data a complete frame can be generated.

Table 1
Command frame

Command	SA	FC	Starting data address	Data	Command Frame
ON	01	05	0001	0001/0000	010500010001/0
OFF	01	05	0002	0001/0000	010500020001/0
HALT	01	05	0003	0001/0000	010500030001/0
P1	01	05	0004	0001/0000	010500040001/0
P2	01	05	0005	0001/0000	010500050001/0
V1	01	05	0006	0001/0000	010500060001/0
V2	01	05	0007	0001/0000	010500070001/0
V3	01	05	0008	0001/0000	010500080001/0
FS1	01	05	0009	0001/0000	010500090001/0
FS2	01	05	000A	0001/0000	0105000A0001/0
FS3	01	05	000B	0001/0000	0105000B0001/0
FS4	01	05	000C	0001/0000	0105000C0001/0

B. RTU message frame

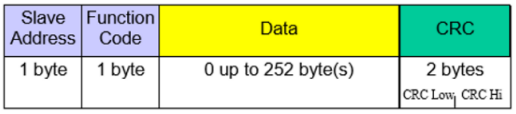


Fig. 1. RTU message framing

Modbus RTU message are a simple 16-bit structure with CRC (Cyclic Redundancy Check). RTU message are binary code. RTU message are a smaller-size which allows more data exchange.

Modbus message frame consists of one byte of start bit, one byte of function code, 0 to 252 bytes of data and 2 bytes of CRC.

Each slave devices in a network have unique address which ranges from 1 to 247.The requested data send from the master, the first byte is slave address. The second byte is function code each number in the function code tells that whether to read or write.

For the error detection 2 byte CRC added at the end of the message. CRC is use for calculating every byte in the message. Both receiving and sending device need to calculate the CRC. Receiving device calculate the CRC by comparing CRC with the sending device. It checks every bit if there is any error in the even one bit in the message received the CRC will be different and it shows the error.

C. Serial communication interface

Serial communication interface module maintains the digital communication between the CPU and other asynchronous peripherals. RS485 serial communication interface is use for communicate between master and slave. RS485 can communicate with one or more devices. Maximum up to 32 devices can communicate with RS485. Signals which is send through the RS485 is much faster and can be transmitted longer distance possible with a single wire. RS 485 each driver can switch off the multiple units that is the main feature of the RS 485. By this arrangement signal can be transmitted as faster and longer distance. Serial communication interface modules support digital communication between CPU and other peripheral devices. The SCI interface are shown in figure.

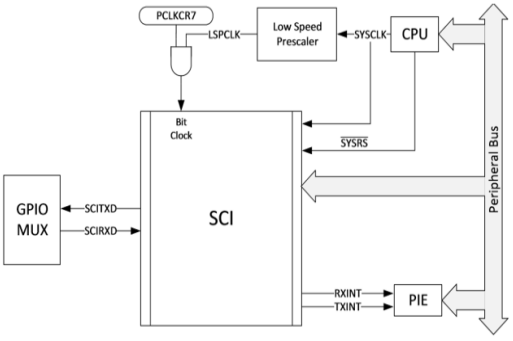


Fig. 2. SCI CPU interface

Some features of the SCI modules are it has two external pins SCITXD (SCI transmit output pin, SCIRXD (SCI receive input pin). Data format of SCI module is it has one start bit, data word length from 0 to 8 bit, odd/even parity bit, one or two stop bit.

The major characteristic parts of the operation are:

Transmitter and its register.

1. SCITXBUF – Transmitter data buffer it contains the data to be transmitted.
2. TXSHF register – transmitter shift register, it shifts the data one bit at a time and the data from the register SCITXBUF into SCITXD pin

Receiver and its major Registers:

3. RXSHF register- receiver shifts register, Shifts the data from SCIRXD pin one bit at a time.

SCIRXBUF – Receiver data buffer register contains the data to be read and then it is shifted into the registers SCIRXBUF from RXSHF.

3. Hardware

A. TMS320F28379D

Fig. 3. TMS320F28379D microcontroller

In fig. 3 shows Launchpad of TMS320F28379D. The Mega 2560 is a microcontroller board. It has 54 digital input/output pins of which 15 pins can be used as PWM outputs, 16 pins are available for analog inputs., 4 UART pins for serial ports. It has a 16MHz crystal oscillator, and a USB connection. It can be simply connected to any personal computer with the USB cable or it can be powered up by using any AC-to-DC adapters or batteries.

B. SN75176A

Fig. 4. SN75176A

Fig. 4. shows SN75176A is a RS-485 interface IC differential bus transceiver. It is a bidirectional transceiver. It is designed for transmission on long bus in noisy environment. Its receiver input impedance 12 kohm Min and receiver input sensitivity +_200mV. It requires only low power and it operates from single 5-V supply. It's main application for low speed RS-485 communication (5 Mbps or less). Also SN75176B can use for 10 Mbps. Fig. 4, shows the top view of SN751765A.

C. RS485

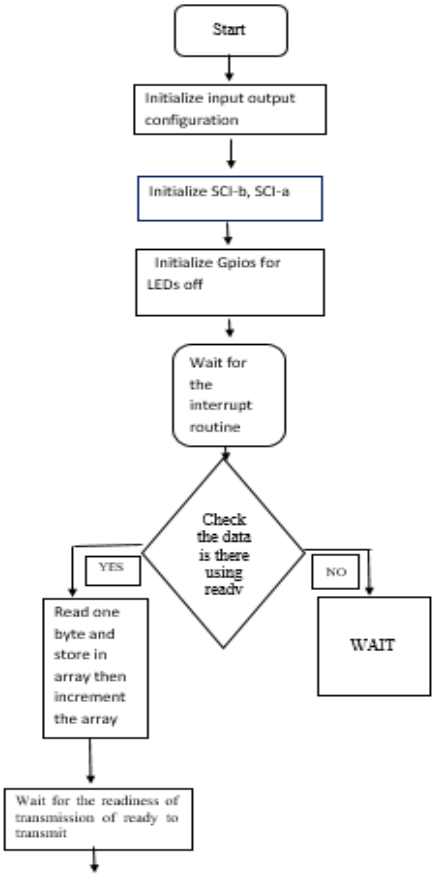
Fig. 5. RS485

Fig. 5 shows RS485 serial interface. The communication between the master and slave is on RS-485 serial interface. It

can communicate with one or more device. The signal which is transmitted through the RS-485 is faster and can transmit longer distance.

4. Working

Interrupt Service Routine (ISR) is a software process raised by an interrupt request from a hardware device. Interrupting the active process by handling the request and send it to the CPU. By receiving a valid start bit receiver begins the operation. In order to enable the receiver, flag bit RXENA goes high. When the data appears on the SCIRXD pin start bit detected. When an interrupt is requested data is shifted from RXSHIF to the receiver buffer register (SCIRXBUF). When a new character has been received, the flag bit RXRDY goes high. During the time of SCIRXBUF reads program, flag RXRDY is automatically cleared. The start bit is detected after arrival of next byte of data on SCIRXD pin, then cleared. Bit RXENA is brought low to disable the receiver. After reading the message transmit the response or signal in communication mode. To transmit the signal in communication mode, first enable the transmitter to send data by TXENA pin goes high. TXRDY goes low when SCITXBUF is written to, thus the transmitter is no longer empty. And this data is transfer to the shift register (TXSHF). TXRDY goes high when the transmitter is ready for a second character, and the program is writes to.



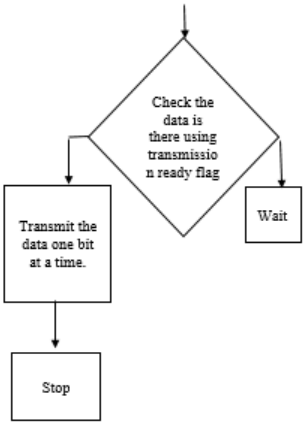


Fig. 6. Flowchart

5. Results

Development of software for TMS320F28379D digital signal processor(DSP) based system for controls and supervises a high temperature vacuum furnace. Code Composer Studio is a software that supports TI's microcontroller. The software developed in C++ language. Since the execution time and compilation of a C++ program is much faster. C++ is a low-level language so that it is closer to the hardware system. The combined software developed to provide functionalities to the system such as Controlling of pumps and valves by reading the command frame corresponding to the command if it is correct it responds as ok, otherwise it send error. Also by checking the command of the request data and by sending the responsible to digitally controls of parameters like on, off, Hold etc. of the vacuum furnace.

6. Conclusion

Vacuum method is to protect heated steel and metal parts from the negative influence of the air atmosphere. A vacuum furnace is for maintaining vacuum by electrically heating the furnace. Metals are heating at high temperature causes rapid oxidation. A vacuum furnace prevents this by removing the oxygen. In production industries and research laboratories. Furnace maximum temperature and vacuum level depend upon the melting point and vapour pressure of the heated material. The functions of vacuum furnace are vacuum quenching (tempering, annealing) it is the method by heating and cooling the materials in the vacuum to achieve the desired performance. Vacuum brazing is the welding process at which the melting point of the filter metal by heating a group of weldments.

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transmitted as bit by bit serially. Modbus communication protocol are used, in modbus transmitting the information over serial lines between the devices. The system is communicate in master slave mode.

In Modbus RTU protocol version master may initiate the request and all other slave devices responds to the commands. Serial communication interface supports communication between CPU and other electronic peripheral devices. RS 485 supports the communication between master and slave. RS 485 can communicate between one or more devices. Maximum up to 32 devices can communicate with this interface. Signal which is transmit through RS 485 is much faster and it can transmit over a long distance with single wire. When device communicate in Modbus RTU mode, 8bit byte in a message contains two 4bit hexadecimal character. Interrupt service routine is a software process raised by an interrupt request from hardware device. Interrupting the active process by handles the request and send to the CPU. If there is no any interrupt request the computer remains its current state.

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