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Digital Signal Processor (DSP) Software Development For Closed Loop Control Of Power Supply

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***Abstract* -The closed loop control of a Power Supply is done in this project. The output voltage of the power supply is controlled which is operated in forward converter mode. The software required for receiving command, generation of error, PID processing of error, PWM generation and reading the actual voltage of power supply is developed for DSP. The DSP is used as the controller because it is very fast and also supports mathematics like multiplication, division etc in real time. The DSP generates Pulse Width Modulated (PWM's) signal to drive switches (metal oxide semiconductor field effect transistor- MOSFETS) of the Power circuit. The power circuit voltage is sensed and digitized by ADC. This signal is used as feedback signal. On board flash memory stores all parameters and control program. The control algorithm and software is developed for Texas DSP TMS320F28335 acting as the controller.**

Keywords- closed loop, dsp, feedback, hall sensor, open loop

I. INTRODUCTION

The Digital signal processor (DSP) processors are having much capabilities of controlling devices; DSP when

compared with general processors delivers batter performance & resolution. Now-a-days DSP processors are used in almost every field either to develop mobile phones or to control some devices and instruments. Here the DSP processor has been used to control the power supply by generating a train of pulses for controlling the MOSFETS used in power supply. Digital signal processor (DSP) basically process analog signals in the digital domain. Real-world signals, such as voltage is converted to its digital equivalent at discrete time intervals for processing by the CPU of a digital computer. A digital signal processor (DSP) is a type of microprocessor (one that is incredibly fast and powerful). DSP is useful in almost every application that requires the high-speed processing of a large amount of numerical data. The data can be anything from position and velocity information for a closed loop control system. A DSP is unique because it processes data in real time. This real-time capability makes a DSP perfect for applications where we won't tolerate any delays. Since the availability of computers, power supplies have relied on digital technology in some way, from such simple tasks as turning the supplies on and off to the supplying of computer-controlled references. This coupled with increasing demand for higher performance and monitoring capabilities, has made it appealing to integrate such technology into power supply designs. DSPs are processors or microcomputers whose hardware, software, and instruction sets are optimized for high-speed numeric processing applications and essential for processing digital data representing analog signals in real time. The DSP's high-speed arithmetic and logical hardware is programmed to rapidly execute algorithms like modeling the filter transformation.

Main advantages of digital signal processing over analog processing are:

1. Powerful: can do more things than one can do using analog hardware.
2. Cheap: similar to microprocessors, but lot of different functions into one chip.

An open-loop controller also called a non-feedback controller is a type of controller that computes its input into a system using only the current state and its model of the system. Systems that utilize feedback are called closed-loop control systems. The feedback is used to make decisions about changes to the control signal that drives the plant. The system developed is a closed loop system, through which the output is again fed back to the input of DSP which then forces the output of DSP to change. A closed loop control system is used to reduce the error coming at the output. The system developed also uses PID control action to minimize overshoot and to provide fast response, with appropriate gain .A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial_control_systems. A PID is the most commonly used feedback controller. A PID controller calculates an "error" value as the difference between a measured process variable and a desired set_point. The controller attempts to minimize the error by adjusting the process control inputs. In the absence of knowledge of the underlying process, a PID controller has historically been considered to be the best controller. By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point and the degree

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of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability.

II. GENERAL DESCRIPTION

A. Analog Signal Processing:

In analog signal processing, continuous-amplitude continuous-time signal are processed. Various types of analog signals are processed through low pass filters, high pass, band pass band reject filters to obtain the desired shaping of the input signal. Another example of analog signal processing is the production of modulated carrier using High Frequency (HF) oscillator, and the modulating audio signal and a modulator.

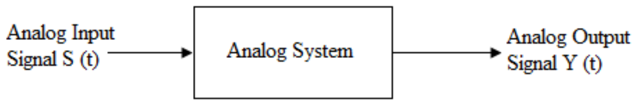

Fig 1. Block diagram of an Analog system

B. Digital Signal Processing:

Digital signal processing (DSP) is a numerical processing of signals on a digital computer or some other data processing machine. A digital system such as digital computer takes input signal in discrete-time sequence form and converts it in discrete-time output sequence.

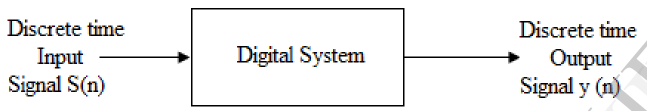

Fig 2. Block diagram of a Digital system.

The digital signal processor is a large programmable digital computer or a small microprocessor. In some applications such as speech communication, we require digital signal in analog form at the receiver end. Here we need another interface, called digital-to- analog converter.

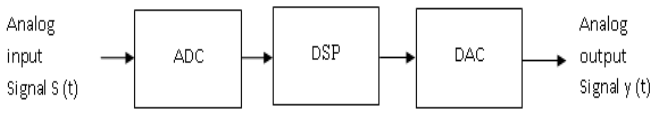

Fig 3. Illustrates the block diagram of a DSP system

*C. Analog Input***:** The analog signal is appropriately band-limited by the anti-aliasing filter and applied to the input of the ADC. At the selected sampling time, the converter interrupts the DSP processor and makes the digital sample available. The choice between serial and parallel interfacing between the ADC and DSP depends on the amount of data, design complexity trade-offs, space, power, and price.

D. Digital Signal Processing: The incoming data is handled by the DSP's algorithm software. When the processor completes the required calculations, it sends the result to the DAC. Because the signal processing is programmable, considerable flexibility is available in handling the data and improving system performance with incremental programming adjustments.

E. Analog Output: The DAC converts the DSP's output into the desired analog output at the next sample clock. The converter's output is smoothed by a low-pass, anti-imaging filter (also called a reconstruction filter), to produce the reconstructed analog signal.

F. Digital vs. Analog:

Today, nearly all electronic devices we use are digital. The main reason for the change from analog to digital is because digital signals are easier to transmit and are also more reliable. This is illustrated by the images below.

G. Analog Waveforms: Analog signals were first used in the 1800's. They were used in conjunction with copper telephone lines to transmit conversations. These involved using 2 conductors for each line (send and receive). As technology progressed, an increasing number of people started using the telephone making analog signals too expensive and troublesome to maintain.

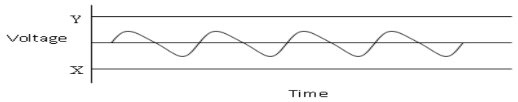

Fig 4. Analog waveform

*H. Digital Waveforms***:** The physics of digital signals are different than that of analog signals because they are discrete waveforms. Between the minimum (X) and the maximum (Y), there is a limit on how high the voltage will increase or decrease.

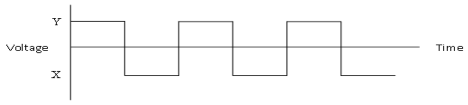

Fig 5.Digital waveform

Notice that the signal takes 2 basic forms: 'ON' (with a value of '1') and 'OFF' (with a value or '0'). Obviously digital signals are more complicated than this, but being an article on the basics of signals, we get the general idea. Notice that the signal is very uniform in composition. Here, we observe the main advantage of digital signals over analog signals. Since the signal is very uniform, noise has not severely altered its shape or amplitude. The digital signal shows a far less change to the actual waveform than the previous analog signal. They are both shown below for a close comparison.

I. Advantages of Digital over Analog Signal Processing

- Digital signal processing operations can be changed by changing the program in digital programmable system, i.e. these are flexible systems.
- Better control of accuracy in digital systems compared to analog systems.

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- Digital signals can be easily stored on magnetic media such as magnetic tape without loss of quality of reproduction of signal.
- Digital signals can be processed off line, i.e. these are easily transported.
- Digital circuits are less sensitive to tolerances of component values.
- Digital systems are less dependent on temperature, ageing and other external parameters.
- Digital circuit can be reproduced easily in large quantities at comparatively lower cost.
- Cost of processing per signal in DSP is reduced by time-sharing of given processor among a number of signals.
- Processor characteristics during processing, as in adaptive filters can be easily adjusted in digital implementation.
- Digital system can be cascaded without any loading problems.

J. Open loop control system: An open-loop control system also called a non-feedback control system is a type of controller that computes its input into a system using only the current state and its model of the system. A characteristic of the open-loop controller is that it does not use feedback to determine if its output has achieved the desired goal of the input. This means that the system does not observe the output of the processes that it is controlling. Consequently a true open-loop system can not engage in machine learning and also cannot correct any errors that it could make. It also may not compensate for disturbances in the system.

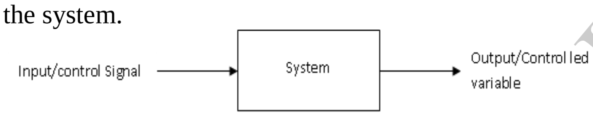


Fig 6. Open loop control system

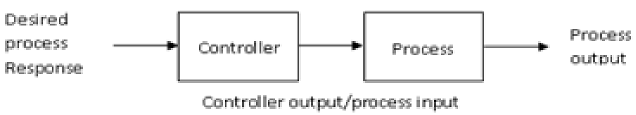


Fig 7.Open loop control system

For example, an irrigation sprinkler system, programmed to turn on at set times could be an example of an open-loop system as it does not measure soil moisture as a form of feedback. Even if rain is pouring down on the lawn, the sprinkler system would activate on schedule, result in wastage of water. Open-loop control is useful for well-defined systems where the relationship between input and the resultant state can be modeled by a mathematical formula. For example determining the voltage to be fed to an electric motor that drives a constant load, in order to achieve a desired speed would be a good application of open-loop control. If the load were not predictable, on the other hand, the motor's speed might vary as a function of the load as well as of the voltage, and an open-loop controller would therefore be insufficient to ensure repeatable control of the velocity.

K. Close loop control system: Systems that utilize feedback are called closed-loop control systems. The feedback is used to make decisions about changes to the control signal that drives the plant. An open-loop control system doesn't have or doesn't use feedback.

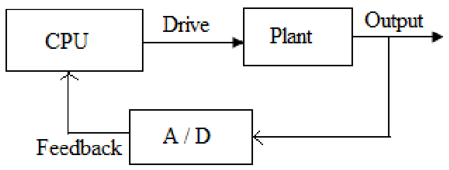


Fig 8.A closed-loop control system

A basic closed-loop control system is shown Fig 3.8 can describe a variety of control systems, including: driving elevators, thermostats, and cruise control. Closed-loop control systems typically operate at a fixed frequency. The frequency of changes to the drive signal is usually the same as the sampling rate, and certainly not any faster. After reading each new sample from the sensor, the software reacts to the plant's changed state by recalculating and adjusting the drive signal. The plant responds to this change, another sample is taken, and the cycle repeats. Eventually, the plant should reach the desired state and the software will cease making changes. Similarly, if your car is going too quickly, the cruise control system can temporarily reduce the amount of fuel fed to the engine. A closed-loop control system can be represented by the general block diagram shown below:

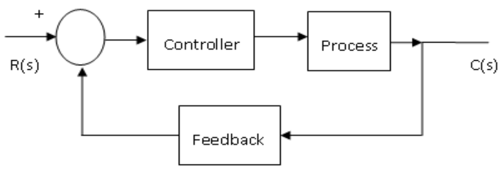


Fig 9. Closed-loop control system

In this Fig 3.9 configuration a feedback component is applied together with the input R(s). The difference between the input and feedback signals is applied to the controller. In responding to this difference, the controller acts on the process forcing C(s) to change in the direction that will reduce the difference between the input signal and the feedback component.

III. SCHEME OF THE SYSTEM

A. Block diagram of the system

Input:

1. Set value of voltage.
2. Actual voltage sensed from the power supply.

ISSN: 2278-0181

Output: PWM signal to drive MOSFETS of the power supply.

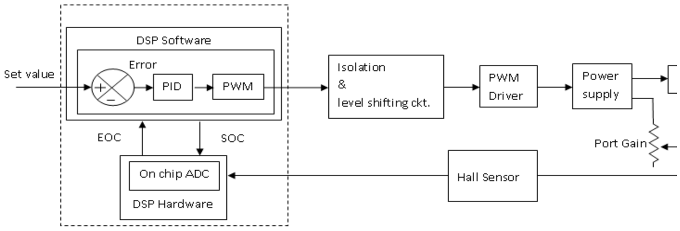


Fig 10. Block diagram of the system

The block diagram of the system is given in Fig 4.1 DSP hardware and software parts are shown in dotted block. The working of the project can be explained as:
The set value is received from hyper terminal, using serial communication interface (SCI) the error is calculated by finding the difference of set value and actual value of voltage. Actual value of voltage is received and digitized with the help of on chip ADC. The error is processed through proportional integral differential (PID) controller implemented in software. The output of the PID sets the width of the signal going to MOSFETS of power supply. Initially when system is at rest, no signal is available at output of ADC. So error signal equals the set value. The output of PID is given to generate PWM signal. The signal is given to the isolation and level shifting block. This block isolates the processor part from the power supply portion. For this optical isolation is used. The output of isolation and level shifting block is then given to PWM driver circuit. The PWM driver provides necessary current to PWM for driving the MOSFETS. The output of PWM driver is connected to the gates of MOSFETS of the power supply. By varying the pulse width of the gate signals output of the power supply is varied. The output voltage of power supply is sensed by using Hall sensor and processed by ADC present in DSP chip. The start of conversion signal (SOC) is given to the ADC through the compare event of the DSP timer.

IV. REQUIREMENT GATHERING

A. *Hardware used*

- DSP based CPU board
- JTAG-based emulators – XDS510USB
- DC supply boards (+12V,-12V, +5V) for powering various boards.
- Feedback signal (voltage) generator board.
- PWM driver board
- Power Supply

B. DSP based CPU board:

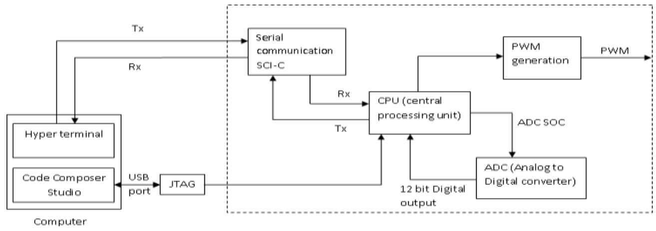


Fig 11. Block diagram part of DSP hardware

Fig 5.1 shows the block diagram part of DSP hardware used in this project. There are four main blocks by which the hardware working of DSP has been described. These blocks are:

- Central processing unit (CPU)
- Serial communication interface (SCI)
- PWM generation
- Analog to digital converter (ADC)

V. HALL SENSOR

C. Hall Effect

The Hall Effect is due to the nature of the current in a conductor. Current consists of the movement of many small charge carriers, typically electrons, holes, ions or all three. When a magnetic field is present that is not parallel to the direction of motion of moving charges, these charges experience a force, called the Lorentz force. When such a magnetic field is absent, the charges follow approximately straight, 'line of sight' paths between collisions with impurities, phonons, etc. However, when a magnetic field with a perpendicular component is applied, their paths between collisions are curved so that moving charges accumulate on one face of the material. This leaves equal and opposite charges exposed on the other face, where there is a scarcity of mobile charges. The result is an asymmetric distribution of charge density across the Hall element that is perpendicular to both the 'line of sight' path and the applied magnetic field. The separation of charge establishes an electric field that opposes the migration of further charge, so a steady electrical potential is established for as long as the charge is flowing.

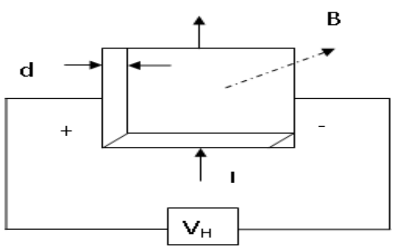


Fig 12.Hall Effect sensor

In the classical view, there are only electrons moving in the same average direction both in the case of electron or hole conductivity. This cannot explain the opposite sign of the Hall Effect observed. The difference is that electrons in the upper bound of the valence band have opposite group velocity and wave vector direction when moving, which can be effectively treated as if positively charged particles (holes) moved in the opposite direction to that of the electrons.

D. Hall Effect sensor

A Hall Effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall Effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications. In its simplest form, the sensor operates as an analogue transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced. Electricity carried through a conductor will produce a magnetic field that varies with current, and a Hall sensor can be used to measure the current without interrupting the circuit. Typically, the sensor is integrated with a wound core or permanent magnet that surrounds the conductor to be measured.

E. JTAG based emulators – XDS510USB:

The XDS510USB JTAG Emulator allows the user direct access between the host computer and the DSP using the IEEE 1149.1 IEEE JTAG Interface. A JTAG emulation connection is required for debugging software, downloading code and flash programming Texas Instruments JTAG DSP.

F. Hardware Features

- USB bus powered, no power supply required
- Operates off PC/laptop USB port, no internal adapter required
- Advanced emulation controller provides high performance
- Compatible with +1.8V to +5V processors
- One LED provides operational status
- Replaceable JTAG cables
- 14-pin Target Adapter Cable

G. Application

Debug hardware
Debug software
Flash programming

H. Software tools used, Code Composer Studio IDE

The Code Composer Studio is the IDE used for coding and programming the TMS320F28335.
The key components of the Code Composer Studio IDE include:

- Tuning tools for optimizing applications
- C/C++ Compiler, Assembly Optimizer and Linker (Code Generation Tools)
- Real-Time Operating System (DSP/BIOS)
- Ability to dynamically connect and disconnect from targets
- Real-Time Data Exchange between host and target (RTDX)
- Update Advisor

The Code Composer Studio integrates all host and target tools in a unified environment. It also simplifies DSP system configuration and application design to help designers get started faster than ever before. Code Composer Studio Setup is a utility that is used to define the target board or simulator the user will use with the Code Composer Studio IDE. The DSP/BIOS kernel provides an efficient set of kernel, real-time analysis, and peripheral configuration services, eliminating the need to develop and maintain custom DSP operating systems. Code Composer Studio IDE’s open plug-in architecture reduces time-consuming system integration for anyone trying to include algorithms into their DSP system.

Code Composer Studio is the IDE used for coding and programming C/C++ language. C/C++language is a general purpose and structured programming language developed by 'Dennis Ritchie' at AT&T's Bell Laboratories in the 1972s in USA. It is also called as “Procedure oriented programming language”. It has some various features like control structures, loop statements, arrays, macros required for these applications. The C language has following numerous features as:

- Portability
- Flexibility
- Effectiveness and efficiency
- Reliability
- Interactivity

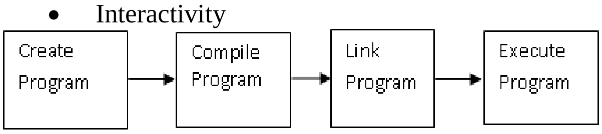


Fig 13.C program executes in following 4 (four steps).

C is called a compiled language. This means that once we write our C program, we must run it through a C compiler to turn our program into an executable that the computer can run (execute). The C program is the human-readable form, while the executable that comes out of the compiler is the machine-readable and executable form.

VI. SOFTWARE FOR THE PROJECT WORK

The complete control algorithm and software is developed in C- language for the closed loop control of power supply. This is modular i.e. different modules are developed for the on chip peripherals like RS-232, Timers, PWM generators, PID, ADC etc. Each module can be modified very easily.

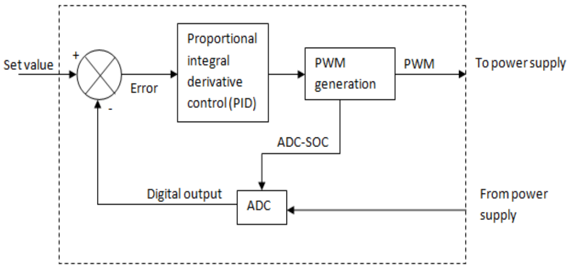


Fig 14.Block diagram part of DSP software

A. Serial communication Interface (SCI):

Baud rate of serial port: SCI port - C Select (DB-9), SCI TX pin2 connect DSP GPIO62 RX pin, SCI RX pin3 connect DSP GPIO63 TX pin, MUX used in O/P enable & select line (OE=0, SET1=1) used. Switch S3 pin7 is set to logical '1'& pin8 is grounded; all others are given a logical '1'.

SCI 16-bit baud selection Registers SCIHBAUD (MS byte) and SCILBAUD (LS byte) are concatenated to form a 16-bit baud value, BRR. The internally-generated serial clock is determined by the low speed peripheral clock (LSPCLK) signal and the two baud-select registers. The SCI uses the 16-bit value of these registers to select one of 64K serial clock rates for the communication modes. The SCI baud rate is calculated using the following equation:

SCI Asynchronous Baud = LSPCLK/ (BRR + 1)*8

Alternatively,

BRR = (LSPCLK/SCI Asynchronous Baud*8) – 1

Note that the above formulas are applicable only when 1 <= BRR <= 65535. If BRR = 0, then

SCI Asynchronous Baud = LSPCLK/ 16

Where:

BRR: the 16-bit value (in decimal) in the baud-select registers.

In SCI program calculations: SYSCLKOUT=100MHz, LSPCLK=25MHz, SCI Asynchronous baud = 9600bps.

BRR = (LSPCLK/SCI Asynchronous Baud*8) – 1

B. Proportional integral derivative control (PID):

The C code is developed for the PID block in Fig 6.1 for Allen Bradley Logix5550 Independent PID equation:

$$CO = K_p*e+K_i \int e*dt+K_d\,(de/dt)$$

Where CO the controller output, e=SP-PV, SP the set point, PV the process variable. Differentiating both sides gives

$$dCO = K_p*de + K_i*e*dt + K_d*[d(de)/dt]$$

Using difference to approximate the differential we get discrete PID equation in Type A:

CO = CO(K-1) + K_P*[e(K)-e(K-1)] + Ki*T*e(K) + [Kd/T]*[e(K)-2*e(K-1) + e(K-2)]

C. *PWM Generations:* HSPCLKDIV = 1, CLKDIV = 1, PLLCR for 100MHz CPU CLK = 10L, PLLSTS DIVES = 2, OSCCLK = 20 MHz crystal

- SYSCLKOUT = (OSCCLK*PLLCR)/PLLSTS

SYSCLK OUT = (OSCCLK*10)/2

= $(20\times 10^6*10)/2$

= 100MHz

- $F_{PWM} = 1/(T_{PWM})$
- F_{TBCLK} = SYSCLKOUT/ (HSPCLKDIV*CLKDIV)

= 100MHZ/ (1*1)

= 100MHz

ADC (SOC): For Up and Down Count use

F_{PWM} = 25 KHz

$T_{PWM} = 2 \text{ x TBPRD x } T_{TBCLK}$

TBPRD = $0.5*(T_{PWM}/T_{TBCLK})$

TBPRD = $0.5*(F_{TBCLK}/F_{PWM})$

= 0.5*(100 MHz/25KHz)

= 2000

PWM OUTPUT: For Up Count use

F_{PWM} = 33 KHz

TBPRD = $(T_{PWM}/T_{TBCLK}) - 1$

= 3000

D. Analog to Digital converter (ADC):

Analog to digital converter is used to convert the signal coming from power supply into 12-bit digital data. For conversion the SOC signal is generated by using PWM of constant duty cycle, which provides a periodic SOC signal to ADC. While converting the data, the ADC sets BUSY signal high; it indicates the data conversion is in process. When the conversion is finished, an interrupt is generated by DSP and the converted data has been taken in register. This data is then compared with the Set value given by the hyper terminal.

VII. ALGORITHM:

Step.1: Initialize the GPIO, Serial communication, PWM, ADC, Interrupt, proportional gain (K_p),integral gain (K_i),derivative gain(K_d).

Step.2: Get set value of voltage given by hyper terminal window.

Step.3: Give start of conversion pulse to ADC (ISR).

Step.4: Generate the error signal (e=sp – pv), initially PV will be zero.

Step.5: Error signal is given to PID.

Step.6: Output of PID will update PWM wave by varying its duty cycle (according to output of PID control loop).

Step.7: Generated PWM wave form will control the power supply.

Step.8: Power supply control output will be given to the ADC, via hall sensor.

Step.9: Output of ADC is given to the digital value (PV).

Step.10: The Error signal is calculated by comparing digital value (PV) with Set value.

Step.11: And the process will continue (from Step 4) till the output of power supply reaches the set value.

VIII. FLOW CHART:

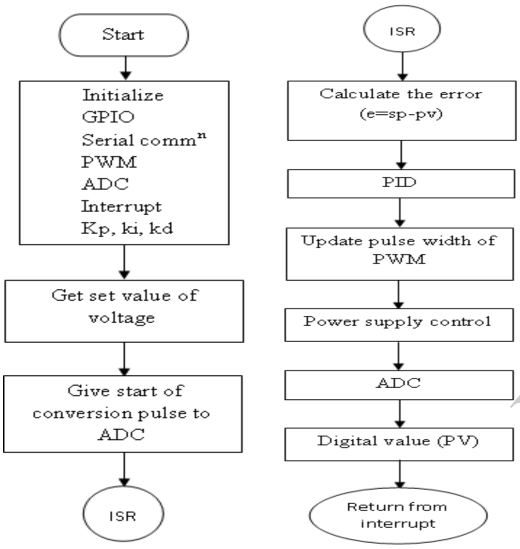


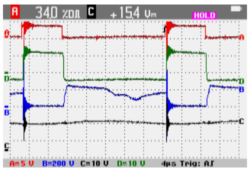
Fig 15.Flow Chart of the Main Program & Interrupt service routine.

IX. RESULT

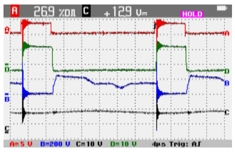
The power supply is controlled using the developed DSP based system. The set value is given as a command to the system and output voltage of the power supply is recorded on the oscilloscope. From the recorded waveforms it is clear that as the set value changes, the pulse width of the PWM signal automatically adjusts itself to make the output voltage equal to the set value. About 6-7% error is there between the set value and actual output voltage. This error is because of the on-chip ADC which is used for digitizing the actual output voltage. The recorded waveforms are given here.

Input DC voltage to Power Supply: 210 Volts, Gain of the system is 17.06

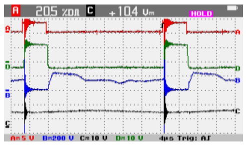
A. Set Value : 275
Output Voltage : 15.4 x 17.06 =262
PWM pulse width : 34%



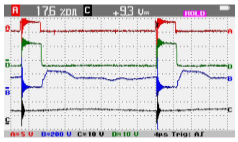
B. Set Value : 225
Output voltage : 12.9 x 17.06=220
PWM pulse width : 26.9%



C. Set Value : 175
Output voltage : 10.4x17.06=177
PWM pulse width : 20.5%



D. Set Value : 150
Output voltage : 9.3x17.06 = 158
PWM pulse width : 17.6%



X. CONCLUSION

The DSP software is developed for closed loop control of power supply. The system is tested using the developed software. The step response of the system is observed on the oscilloscope. The output is obtained without overshoot.

XI. FUTURE SCOPE

The software is developed and tested for the power supply operated as forward converter to generate set voltage. The scheme can be extended for controlling other modes of power supplies.
The features like setting of PID gains can be added in software for reconfiguration and tuning.
Off chip ADC of higher bits can be utilized for better accuracy.

XII. APPLICATIONS

There are a variety of application areas of digital signal processing because of the availability of high resolution spectral analysis. It requires high speed processor to implement the Fast Fourier Transform (FFT).

- Millitary: Sonar, Radar, Battlefield acoustics

- Scientific
  - Seismic data (first industry to go digital)
  - Signal detection (project Phoenix)
  - Embedded systems
- Commercial/Entertainment
  - CD/DVD players
  - mp3, music, sound, and video compression.
  - Speech recognition, Communications (phone)
  - Motor control, Power supply control
- Speech processing, Image Processing, Radar signal processing.
- Digital communications.
- Transmission lines.
- Advanced optical fiber communication.
- Very Large Scale Integration (VLSI) technology.
- Telecommunication networks.
- Microprocessor systems.
- Satellite communications: Telephony transmission.

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REFERENCES

[1] A. M. Wu et al., "Digital PWM Control: Application in Voltage Regulation Modules," IEEE Power Electronics Specialists Conference, 1999.

[2] A. Produce, D. Maksimovic and R. W. Erickson ,"Design and implementation of a digital PWM controller for a high-frequency switching DC-DC power converter", The27th Annual Conference of the IEEE Industrial Electronics Society, Vol. 2, pp. 893 - 898, Nov 2001.

[3] www.ti.com this website will review current trends in the use of such advanced technology. The paper entitled as" Digital Power Supply Control" is has been referred, to introduce digital power supply control to the practicing power supply design community.

[4] Du Baojiang, GuoJingmin, JiChangqin, Wei Xiong & Sun Anbo, has presented a paper entitled as "Design of Voltage Regulating Control Device of Improved PID Algorithm for the Vehicle AC Generator Based on DSP". This gives us a reference about PID control action used in this project.

[5] Power supply design: David Bell (Tata McGraw Hill) Publication;

[6] Digital signal processing (Covers Signals and Systems): S Salivahanam, A Vallavaraj (Tata McGraw Hill) Publication;

[7] Digital signal processing(C & DSP Processors Assembly Programming): N.G.Palan (Tech-Max) Publication;

[8] Mar, A., Babst, J., eds. Digital Signal Processing Applications Using the ADSP-2100 Family Volume 2, Englewood Cliffs, NJ: Prentice Hall, 1994. Available for purchase from ADI.

[9] Mar, A., Rempel, H., eds. ADSP-2100 Family User's Manual, Norwood, MA: Analog Devices, Inc., 1995. Free.