Digital proportional amplifier of linear DC electromagnet

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Abstract— Digital Signal Processor (DSP) based embedded code generation which is obtained automatically in PSIM software for Permanent Magnet Synchronous Motor (PMSM) control system. The simulation model of the PMSM control system is developed in PSIM environment using Motor Control Blocks and Embedded Target for TI 2000805 block. This control block diagram is send to Sim Coder to generate C-code that is ready to run on the DSP hardware, Sim Coder also creates the complete project files for the TI Code Composer Studio development environment where the code will be compiled, linked, and uploaded to the DSP using High Voltage Motor Control-PFC Kit. So, embedded code generation provides a very quick way to design a motor drive system from user specifications also programming greatly simplifies the generation, prototyping and modification of DSP based design, thus decreasing the development cycle time.

Index Terms— Digital Signal Processing Motor Control, PMSM, DSP, Embedded Code Generation, PSIM.

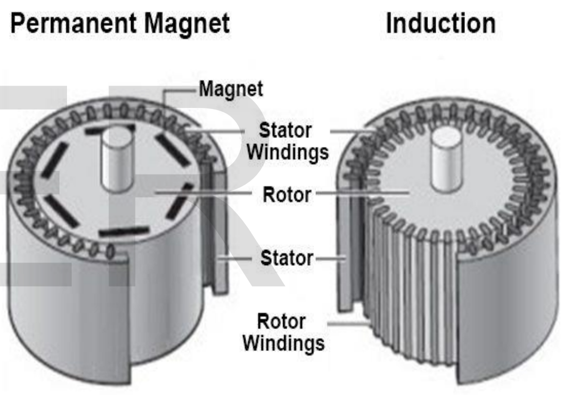
I. INTRODUCTION

High capacity and qualification in industry, the permanent magnet synchronous motor (PMSM) has greatly accepted between the various types of alternative current motors. The PMSM's have been increasingly applied for drive applications, such as robotics and weapon servo-control systems, due to their high power density, torque to inertia ratio and high efficiency [1]. But, the rotor speed and back indication it are measured by a speed sensor or an optical encoder to the controller to provide the precision speed control in traditional PMSM control technics.

Electronics devices hold substantial promise for making distributed energy applications more efficient and cost effective. There is a need to develop advanced power electronics interfaces for the distributed applications with increased functionality (such as improved power quality, voltage/volt-amperes reactive (VAR) support), compatibility (such as reduced distributed energy fault contributions), and flexibility (such as operation with various distributed energy sources) while reducing overall interconnection costs. The use of voltage source inverters is increasing [1]. They are used both for feeding power from distributed generators to the transmission grid and power to various types of electronic loads. In recent years, the number of different power resources connected to power systems

(Voltage grids).

WM control is the most powerful technique that offers a simple method for control of analog systems with the processor's digital output [5]. With the availability of low cost high performance DSP chips characterized by the execution of most instructions in one instruction cycle, complicated control algorithms can be ecuted



with Fast speed, making very high

Figure 1: Permanent magnet synchronous motor (PMSM)

sampling rate possible for digitally-controlled inverters.

Fig.1, shows the configuration of the DVR consists an inverter, series or injection transformer, an inverter, control system and energy storage. The main function of a DVR is the protection of sensitive load from any disturbances coming from network. In this paper, a three-phase voltage will be generated through the proposed control using TMS320F2812 DSP. The voltage produced by the inverter must be controlled in order to be in phase with the disturbance in main voltage or supply.

Some inspection technics like this nonlinear control for speed and position control of PMSMs become a substantial issue and changing sensor less control tactics have been researched, such as, neural networks control, adaptive fuzzy control, the sliding mode observer.

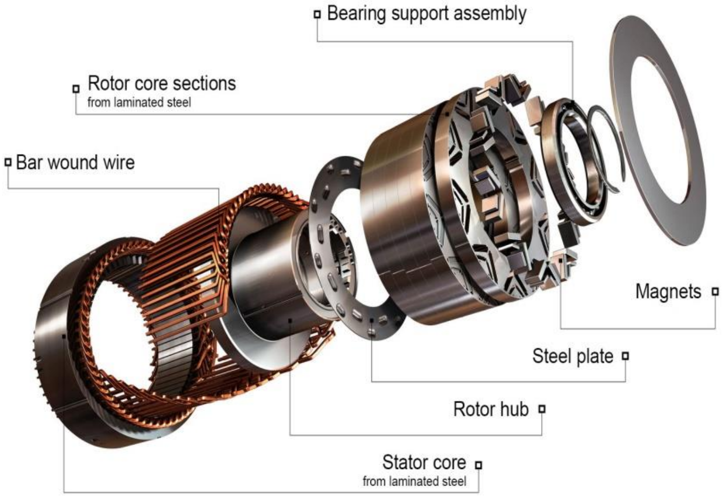


Figure 2: Working Components of Permanent magnet synchronous motor (PMSM)

2. CONTROLLER DESIGN OF PMSM:

The block diagram of the field oriented control method with sliding mode controller for PMSM control is shown in Fig.1. Primarily, two motor phase currents are measured. The Clarke transformation module in Fig.1 is fed by these measurements (ib and ic). These two elements of the current is and is are the inputs of the Park transformation module. The is d and I sq elements are analogized to the references id (the flux reference) and iq (the torque reference). The outputs of the current regulators are Vd and Vq. They are applied to the inverse Park transformation module. The outputs of this projection are Vi and V, which are the elements of the stator vector voltage in the (Ḭ) stationary orthogonal reference frame. These are the inputs of the space vector PWM. The outputs of this block are the signals that control the 3 phase inverter. Both Park transformation module and inverse Park transformation module need the rotor flux location (theta). This rotor flux location is acquired from sliding mode observer. Modern design mutual development and motor control, motor manufacturing technology, microelectronics, power electronics technology combine to produce a number of new motors, such as brushless DC motors, inverter-fed AC motor, switched reluctance motor, an ultrasonic motor ..The new motor is an electric motor and electronic control part organically combine to form a indivisible whole, form a system, leaving the control circuit, the motor itself cannot run alone. Naturally, people want to control some of these motors can be integrated.

2.1 SIMULATION MODEL OF PMSM CONTROL SYSTEM

The process of embedded code generation is signified in overall system model generated by using motor control and Embedded Target for TI F28335 blocks from PSIM library and Sim Coder sub-programme of PSIM. Afterwards, TI Code Composer Studio generates suitable C codes from this model and sends DSP by emulator which is exist on High Voltage Motor Control-PFCK it. The DSP algorithms are presented using PSIM block sets. It is used to motor control blocks which includes a number of suggest templates for induction motor or linear and nonlinear PMSM. Such as PMSM drive system includes space vector PWM current control, and maximum torque per ampere (MTPA), dynamic torque limit control, speed control. With Motor control blocks and embedded target for TI 28335 are used to make all of the PMSM control system. Sim Coder is used to generate C-code from the embedded target for TI 28335 block diagram through the Code Composer Studio (CCS) and downloads the operable codes into the TMS320F28335 in High Voltage Motor Control-PFC Kit, together with other supporting files.

The simulation model, which is developed in PSIM for PMSM control system with SMC method, is shown in Fig.3. In this figure upper blocks which are connected with red lines represent High Voltage Motor Control-PFCK it and its components and PMSM. Lower blocks which are connected with black lines represent DSP and its modules and FOC. Control Algorithm. The sub-block is given in Fig.4. In this sub block, simulation model of FOC control algorithm with SMO which is described in third section represented. The simulation model, which is developed in PSIM for PMSM control system with SMC method, is shown in Fig.3. There is a block which named Parameter File.

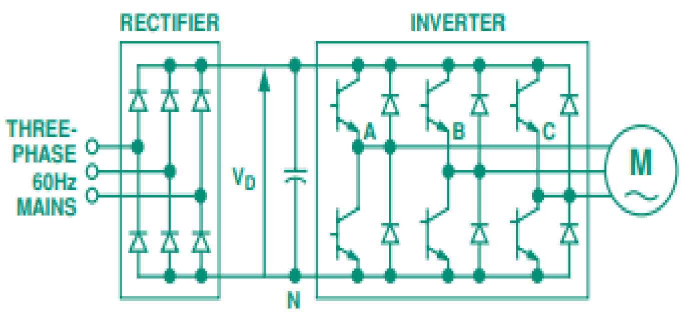


Figure 3: Model of PMSM Control System

3. DIGITAL SIGNAL PROCESSOR FOR MOTOR CONTROL

Cause develop motor control integrated, modern design mutual development and motor control, motor manufacturing technology, microelectronics, power electronics technology combine to produce a number of new motors, such as brushless DC motors, power inverter AC motors, switched reluctance motors, ultrasonic motors. The new motor is an electric motor and 2nd International Conference on Machinery, Materials Engineering, Chemical Engineering and Biotechnology (MMECEB2015) electronic control part organically combine to form a indivisible whole, form a system, leaving the control circuit, the motor itself cannot run alone. Naturally, people want to control some of these motors can be integrated. Motor Control predetermined control algorithm to convert into a desired mechanical movement, the controlled mechanical motion control system to achieve precise position control, speed control, acceleration control, torque control, the amount of the controlled machine integrated control. Motor Control reflects the combination of motor technology, sensor, technology, power electronics technology, microelectronic technology, automatic control technology and computer.

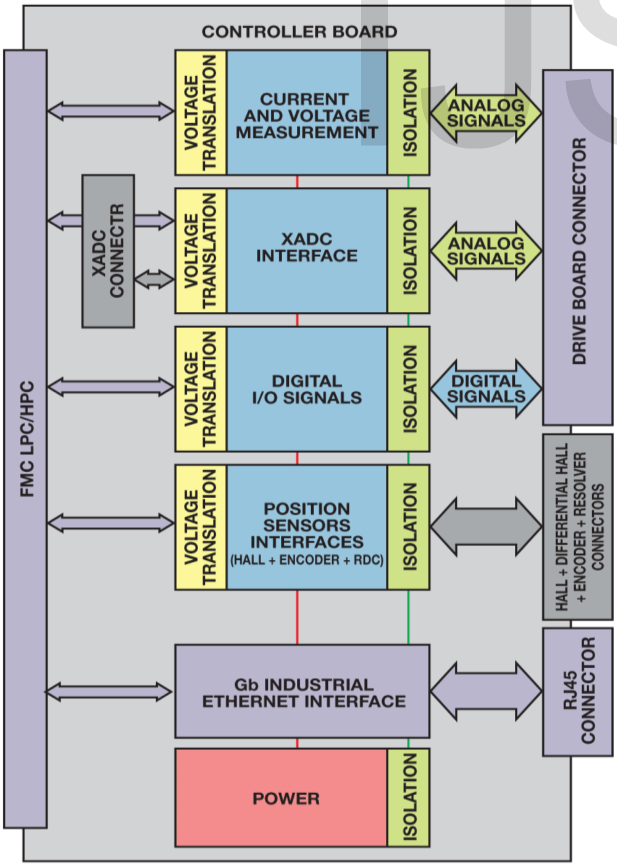


Fig 4: Digital Motor System

4. PROPOSED METHODOLOGY

The Modeling of the Electric Motors. Induction motor and a suitable power converter speed and position feedback, in many complex control applications have become popular. Players' design and compensation system needs an accurate mathematical model of all the components and systems. Excitation coil permanent magnetic actuator by the power electronic control module storage capacitor discharge, completed the closing operation, and a permanent magnet lock, is the perfect combination of electromagnetic systems and permanent magnet systems, and requires force-trip features and vacuum circuit breakers very close. It greatly reduces the transmission links, improve the reliability of response speed, accuracy and running, which is more far-reaching significance is greatly improved controllability, decentralized control of time in milliseconds from the original mechanical system into an electric signal control microseconds progress, from the mechanical energy storage, energy storage mechanical trip progress, the electronic trip signal directly trigger 994 action. This study presents a simple modeling approach to meet the characteristics of the three-phase induction motor, and discussed the relationship between static and dynamic driving circuits and the actual movement.

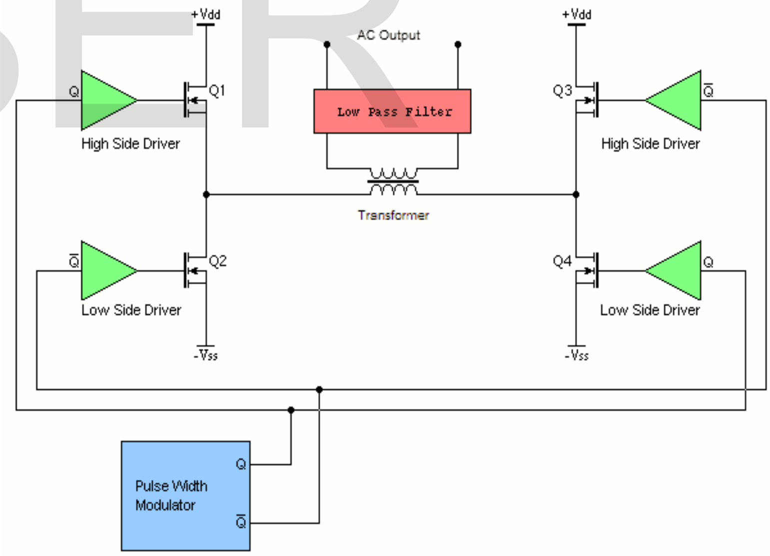


Fig 5: Analog to Digital Converter

Above figure shows that Analog to Digital Conversion. Power converter current and / or voltage feedback, requires that the analog input. Essence synchronization control circuit breaker is open circuit voltage or current phase or near desired. According ungrounded capacitor reactive power compensation in the Star Media Group, for example, the analysis describes the zero reference voltage synchronous switching control method.

5. PROPOSED ELECTRICAL MOTOR

Different types of electrical motor can be used in air compressor. Synchronous reluctance machine, wounded rotor induction motor or synchronous permanent magnet motor with concentrated flux can be found. The main drawback of almost configurations is the torque ripple nand some configurations present a low e–ciency. Taking into account the previous constraints, surface-mounted permanent magnet motor with concentrated coils is proposed for driving the compressor. Permanent magnet synchronous motors present attractive features due the good mass/power ratio and due to lack of excitation windings (no magnetizing currents and lower Joule losses). In addition the proposed structure permits to have very low values for the no-load torque ripple and it shows the constant winding inductance. Permanent magnet synchronous motors present attractive features due the good mass/power ratio and due to lack of excitation windings (no magnetizing currents and lower Joule losses). In addition the proposed structure permits to have very low values for the no-load torque ripple and it shows the constant winding inductance.

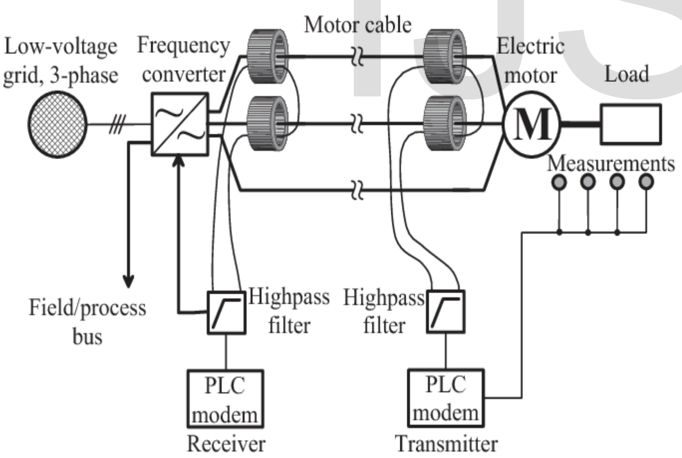
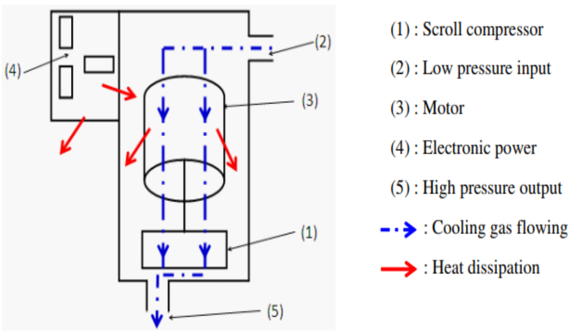
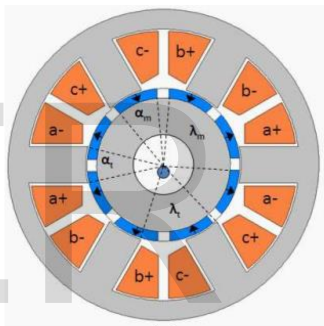


Fig 6: Digital Motor System



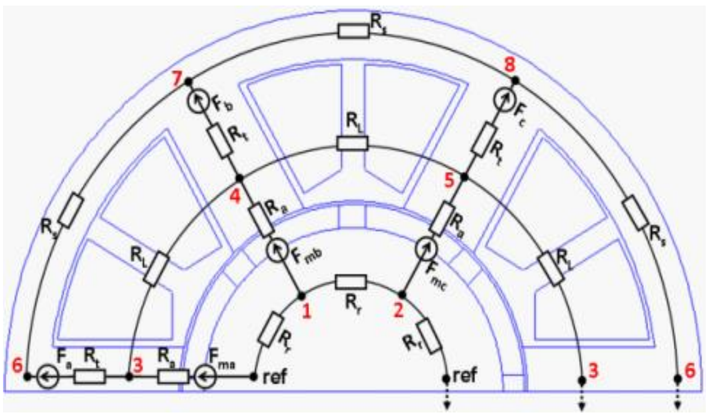
6. ANALYTICAL MODEL

The analytical model is presented under the form of a 2D reluctance network. Only half part of the motor is taken into account due to the magnetic symmetry. In this model, the stator yoke and teeth reluctance are represented by Rs and Rt respectively. The flux leakage between the teeth is modeled by RL. The reluctance Ra represents the air gap and magnet thickness and is calculated using Carter factor. The magneto motive force due to the \n" coil is given by fn and the one due to the \p" magnet is given by fmp. The magneto motive forces due to the magnets are function of the rotor displacement (sinusoidal waveform). All the reluctance values are constant. The following procedure has been applied to size the motor. The motor length this flexed (do not exceed 50 mm) and also the air gap (do not exceed 1 mm), thus only two parameters define entirely the geometry: ra (radius in the middle of the air gap) and lm (magnet thickness). The variations of theses parameters give the maximal electromotive force value (emf) for one phase and torque ranges in Figure 3. The model was built around initial values (ra = 19:2 mm and lm = 2:9 mm).



(a)

Figure.7. 2D Reluctance Network (a,b)



Strains in term of emf and torque values. The number of coil turns is decreased from 108 to 45. To validate the analytical model and obtain more accurate results, a finite element study is propose afterwards.

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7. SYSTEM DESCRIPTION

Overcurrent protection devices such as circuit breakers protect equipment's from drawing excessive current. These protective devices are designed to keep the current flow in a circuit at a safe level to prevent the circuit conductors from overheating. Relays are integral parts of any switchgear equipment as they connect and disconnect the mains to and from the protected equipment through coil energization and contacts. Contactors are primarily used to make (connect) or break (disconnect) contact in the conducting element. Contactors are used in systems where the break-and-make connection is either frequent or unchanged for long periods of time. Direct online starters are one such example of contactors. Applications such as refrigeration, air conditioning and hydraulic systems use valves to control the flow of fluid and air. Solenoid coils operating with nominal current consistently raise the temperature in the coil due to higher power dissipation. This reference design provides a solution to control the solenoid current as well as monitor the proper operation of the plunger in valves using pulse width modulation-based (PWM) controllers along with a Back-EMF sensing circuit.

7.1 CHARACTERISTICS OF SOLENOID COILS

Electromechanical solenoids consist of an electromagnetically inductive coil wound around a movable steel or iron slug called the armature, or plunger. The coil is shaped such that the armature can be moved in and out of its center, altering the coil's inductance as well as becoming an electromagnet. The armature provides a mechanical force to activate the control mechanism, for example opening and closing of a valve.

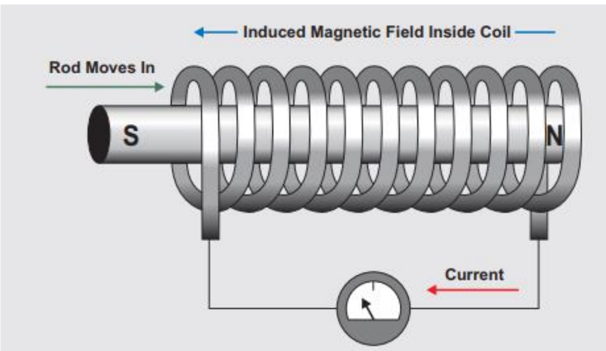

Fig 8: Solenoid Coils

8. EXPERIMENTAL SYSTEM

The overall block diagram of PMSM control system is illustrated in Fig.1, and its experimental system is shown in Fig. 6. The experimental system includes a TMS320F28335 DSP controller; a voltage source IGBT inverter and a PMSM The TMS320F28335 involve multiple channels of 16-bit pulse-width modulators (HR-EPWM) with high resolution 8- bit part with probability to arrange the PWM in remainder of the digital clock ("micro-steps").

Such PWM works at clock high frequencies and can be used as precise digital-to-analog converters (DAC). The inverter has 6 sets of IGBT power transistors. The collector-emitter voltage of the IGBT is rating 600V, the gate emitter voltage is rating 320V, and the collector .current is rating 20A DC and in short time (1ms) is 40A.

Table 1. Parameter File block window

Stator Resistance	RS(Ohm)	4,7
Stator Inductance	LS(Hr)	0,0133
Motor PWM Switching Frequency	MotorFreq (Hz)	10K
Period	T	1/MotorFreq
Speed Loop Frequency	SpdFreq(Hz)	1K
Speed Change Step	MinDelta	0,0000305
spdPID Parameter Values	SpdKp	0,5
	SpdKi	T*100,2
	SpdKd	0
	SpdKc	0,2
idPID Parameter Values	idKp	1
	idKi	T*10,04
	idKd	0
	idKc	0,2
iqPID Parameter Values	iqKp	1
	iqKi	T*10,04
	iqKd	0
	iqKc	0,2
SpdEst Parameter Values	spdEstFc	2,5
	spdEstFb	200
	spdEstRpm	3000
SMO Parameter Values	smoCg	0,25
	smoFg	0,105708

9. RESULTS AND DESCUSIONS

The experimental setup composed of PC, DSP board, IGBT driver circuit, full bridge inverter circuit, DC power supply, LC filter, and oscilloscope (shown in Fig.10). The proposed system is designed to provide a 50-Hzsinusoidal waveform on the load with varying carrier signal 5 KHz). The sampling frequency of the DSP controller is set at 5-KHz. The design parameters of the test device.

Table2: Main Specification of the DVR

PARAMETER	VALUE
Nominal grid voltage	120V (L-L)
Nominal load voltage	120V(L-L)
Switching/sampling frequency	5 KHz
Max. inverter dc-bus voltage	120 V
Capacitor of dc- bus	26uF
Filter inductance	3.947mF
Filter capacitance	6.417uF

The below Diagram shows that the prototype consists of three-phase Inverter and filtering scheme has been developed the phase voltage before connecting the filter. The output of the phase voltage after connecting filter is shown in Fig. 10. THD for the voltage and current are shown in the balance currents after load connection.

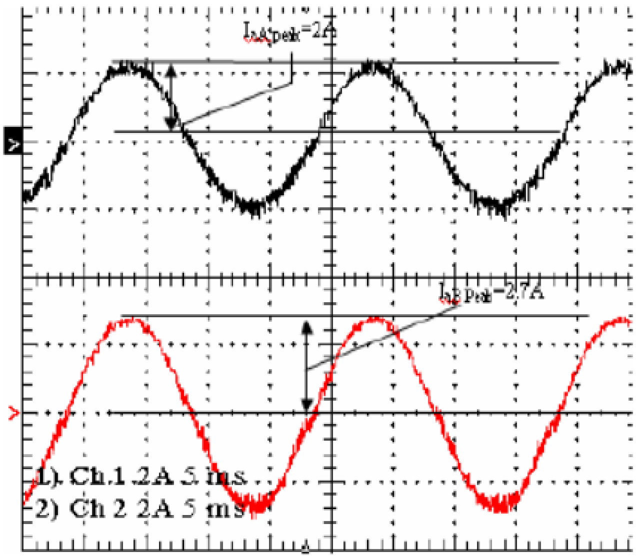

Fig 9: Phase Inverter and Filtering

9.1 SOLENOID TESTING RESULT

The solenoid is characterized using a 24-V DC source with maximum current rating of 1.5 A.

9.1.1 EFFECT OF TEMPERATURE ON SOLENOID EXCITATION CURVE

Figure below shows the characterization curves of a typical solenoid at different temperature. The curves shift up as the temperature decreases because of the reduction in resistance of the solenoid. However, the difference between the peak and valley of the solenoid current dip due to excitation Back-EMF remains constant irrespective of the temperature. This difference is used as the threshold in detecting the excitation of the solenoid. The detection logic circuit senses the solenoid current, and when it detects a dip in current, that dip is interpreted as the excitation of the solenoid.

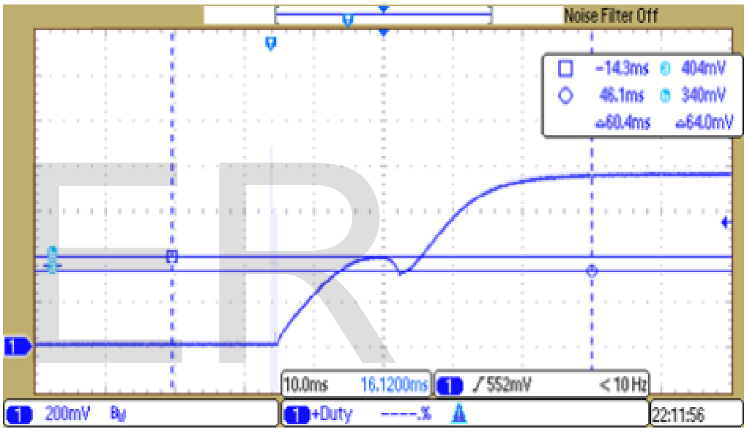

Fig 10: Solenoid Excitation Characteristics at 30°C

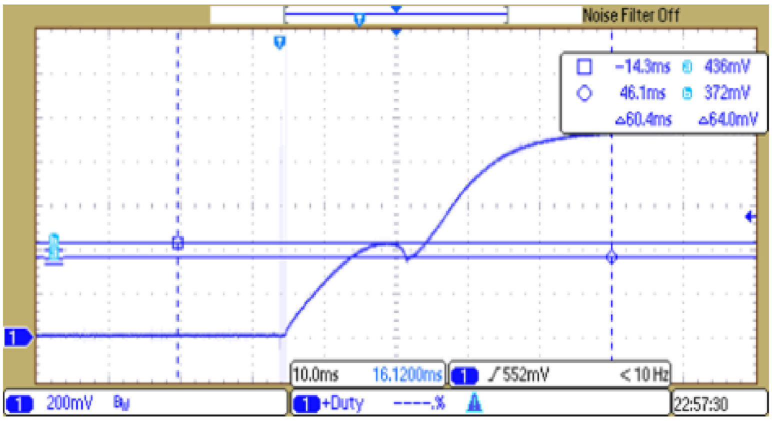

Fig 11: Solenoid Excitation Characteristics at 45°C

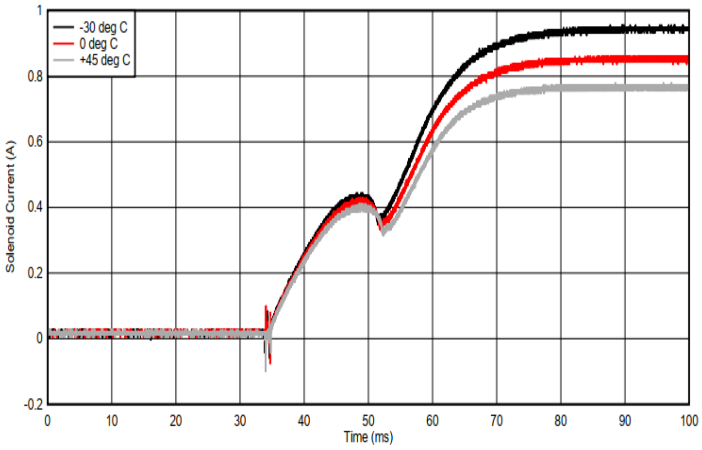

Fig 12: Solenoid Current Curves at Different Temperatures

9.1.2 FUNCTIONAL TEST

Figure below shows the regulated power supply voltage (VIN), EN pin voltage of the DRV110, and gate signal from the OUT pin of DRV110. The EN pin voltage increases proportional to VIN, and when VIN reaches 12.6 V, the DRV110 is enabled and it starts providing gate drive signal through the OUT pin

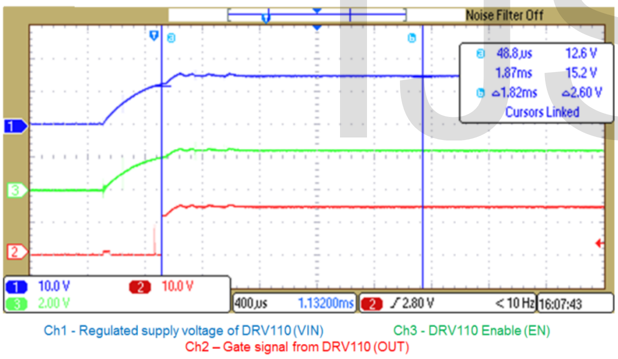

Fig 13: DRV110 Enable and Gate Voltage

9.1.3 CONDUCTED EMISSION TEST RESULTS

This reference design has been tested for conducted emission (CE) as per EN55011 class A limits. The EMC filter in the input power supply section has been modified for the CE test.

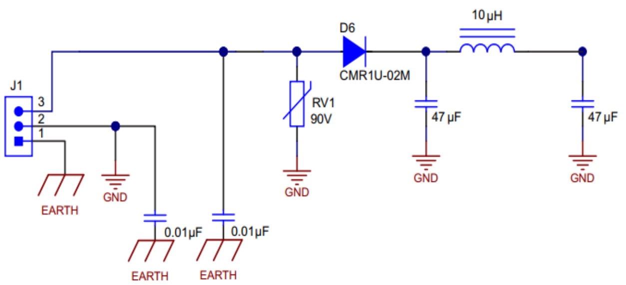

Fig 14: DRV110 Enable and Gate Voltage

10. CONCLUSION:

This paper presents the analysis and design of a digitally controlled three-phase PWM inverter based on DSP control application in order to generate three-phase voltage for dynamic voltage restorer application. The basics of software optimization and hardware installation for proposed system have been presented in detail. The detailed architecture and signal processing components of the Zdsp F2812 from Texas Instruments have been clearly described. The proposed technique achieves voltage regulation with low total harmonics distortion (THD) for both voltage and current. The very close agreement of experimental results illustrates the efficiency, accuracy and dynamic response of DSP based PWM inverter design. Three-phase voltages produced by inverter will be used to inject the missing voltage through injection transformer which will be discussed in the next paper. Modern DSP-based control of three-phase ac motors continues to flourish in the market place, both in established industrial automation markets and in newer emerging markets in the home appliance, office automation and automotive markets. Efficient and cost-effective control of these machines requires an appropriate balance between hardware and software, so that time-critical tasks such as the generation of PWM signals or the real-time interface to rotor position transducers are managed by dedicated hardware units.

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