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Control System for BLDC Motor using Back EMF Method

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Abstract: Existence of position sensor to identify rotor position in speed control of BLDC motor makes configuration more complex. In this paper, rotor position is detected via back e.m.f. zero crossing detector and by detecting phase terminal voltages, which reduces cost and volume of motor. Speed controlling of BLDC motor become flexible, simple and in reduced cost. BLDC motor has various applications in Medical, Automobile, Automation, home appliances used for teeth drilling, polishing and in medical instruments lathes, electric bikes, electric ships, wipers, small conveyors, fans, drones, spinning, BLDC motor fans convenient for electronic equipment, computers, mobile equipments, in vehicles and in spindle drives. BLDC motors are used in various types of actuators in advanced aircraft and satellite systems

Keywords: Brushless DC motor, Back EMF, Sensor less control, MOSFET Power module

I. INTRODUCTION

The most important feature of Brushless DC motor is the mechanical commutation configuration constituted by commutator and brushes are replaced by electronic commutation circuitry. It solves drawbacks caused by mechanical commutation. BLDC motor has less maintenance due to absence of brushes, enables operation at all speeds with rated load. Provide high efficiency, reduced size, and reduced maintenance and gives higher speed range; hence BLDC motors are used for large number of applications such as in medical field, fans, drones, transportation field, Electric vehicles, Electric ship, Automobile, Automation. In specialized fields such as when in high temperature position sensors does not work, this system plays important role. Brushless DC motors such as fans are smaller in size and weight than AC fans using shaded pole or universal motors. BLDC motors can work with the low voltage sources such as 24V or 12V DC supply, due to which BLDC motors can be used for small fans, in electronic equipment, spindle drives, mobile equipments, it has high efficiency and ability to reverse rapidly. Brushless DC motors in the fractional horsepower range have been used in various types of actuators in advanced aircraft and satellite systems. BLDC motors mainly consist of three phases which are controlled and driven by full bridge transistor circuits. Forces produced due to interaction of magnetic fields and shafts start to rotate. One magnetic field is of permanent magnet and one magnetic field is due to excitation. This system uses a MSP430 microcontroller and a rectified power supply, optocoupler is connected to trigger the MOSFET for driving BLDC. A BLDC motor of 12V DC is used to which control signals receive from controller through MOSFET circuit. A Back EMF circuit provides feedback and by using zero crossing detector rotor position can be detected. A speed command circuit can help to get variable frequency, variable speed system based on microcontroller MSP430, which provides a compact, flexible speed control for brushless DC motor using Back EMF and zero crossing detector without using position sensor at low cost. It consists of A. Main circuit B. Control circuit C. Command circuit D. Display circuit.

II. SYSTEM HARDWARE STRUCTURE

A. Main circuit

Main circuit consists of Power unit and MOSFET module, Power unit of this system consists of Two 12V fixed DC power supply which consists of a transformer which converts 230V AC supply into 12V AC, Bridge rectifier with four diodes to convert that 12V AC into 12V DC supply and RC filters. This 12V DC power supply is given to MOSFET module, display circuit, command circuit and control circuit. MOSFET module consists of six MOSFETs of IRF Z44N having fast switching and low on-resistance per silicon area. It provides the highest power capability and the lowest possible on-resistance in any existing surface mount package. For the MOSFET to carry drain current, a channel between the drain and the source must be created. This occurs when the gate to source voltage exceeds the device threshold voltage V_{Th} . For $v_{GS} > V_{Th}$, the device can be either in the triode region, which is also called “constant resistance” region, or in the saturation region, depending on the value of v_{DS} . For given v_{GS} , with small v_{DS} ($v_{DS} < v_{GS} \cdot V_{Th}$), the device operates in the triode region (saturation region in the BJT), and for larger v_{DS} . $v_{DS} > v_{GS} \cdot V_{Th}$, the device enters the saturation region (active region in the BJT). For $v_{GS} < V_{Th}$, the device turns off, with drain current almost equal to zero. Under both regions of operation, the gate current is almost zero. This is why the MOSFET is known as a voltage.

B. Control Circuit

The control circuit of this system is composed by MSP430G2253 microcontroller, Back EMF zero crossing detection circuit, speed command and display circuit. MSP430G2253 consist of several devices featuring different sets of peripherals targeted for various applications. It contains 16 RISC CPU, 16 bit registers and constant generator, digitally controlled oscillator(DCO), which change microcontroller from low power modes to active mode, 16 bit timers. These microcontrollers have 24 I/O capacitive touch enabled pins, a versatile analog comparator and built in communication capacity using the universal serial communication interface, 10 bit analog to digital convertor. This microcontroller works on 1.8V to 3.6V, having ultra low power consumption. Controller operates with its software energia which is based on c language. Controlled Signals to 12V BLDC motor getting from microcontroller. Controlled Signals are in pulse width modulated form. MOSFET module works as three phase inverter it's three phase output terminal voltages corresponds to ground act as terminal voltage, this terminal voltage is feed to controller trough Back- EMF zero crossing detector circuit. Pulse width modulation is employed to achieve varying voltage conveniently, reduce torque ripples also helps in enlarging speed controlling range.PWM mode we can set independently only if the value in the period registerer is constant, via changing the value in the compare registerers can modulate the width of the PWM output signals. By varying delay time we can change speed of motor for this time delay and speed calculation obtained from microcontroller.

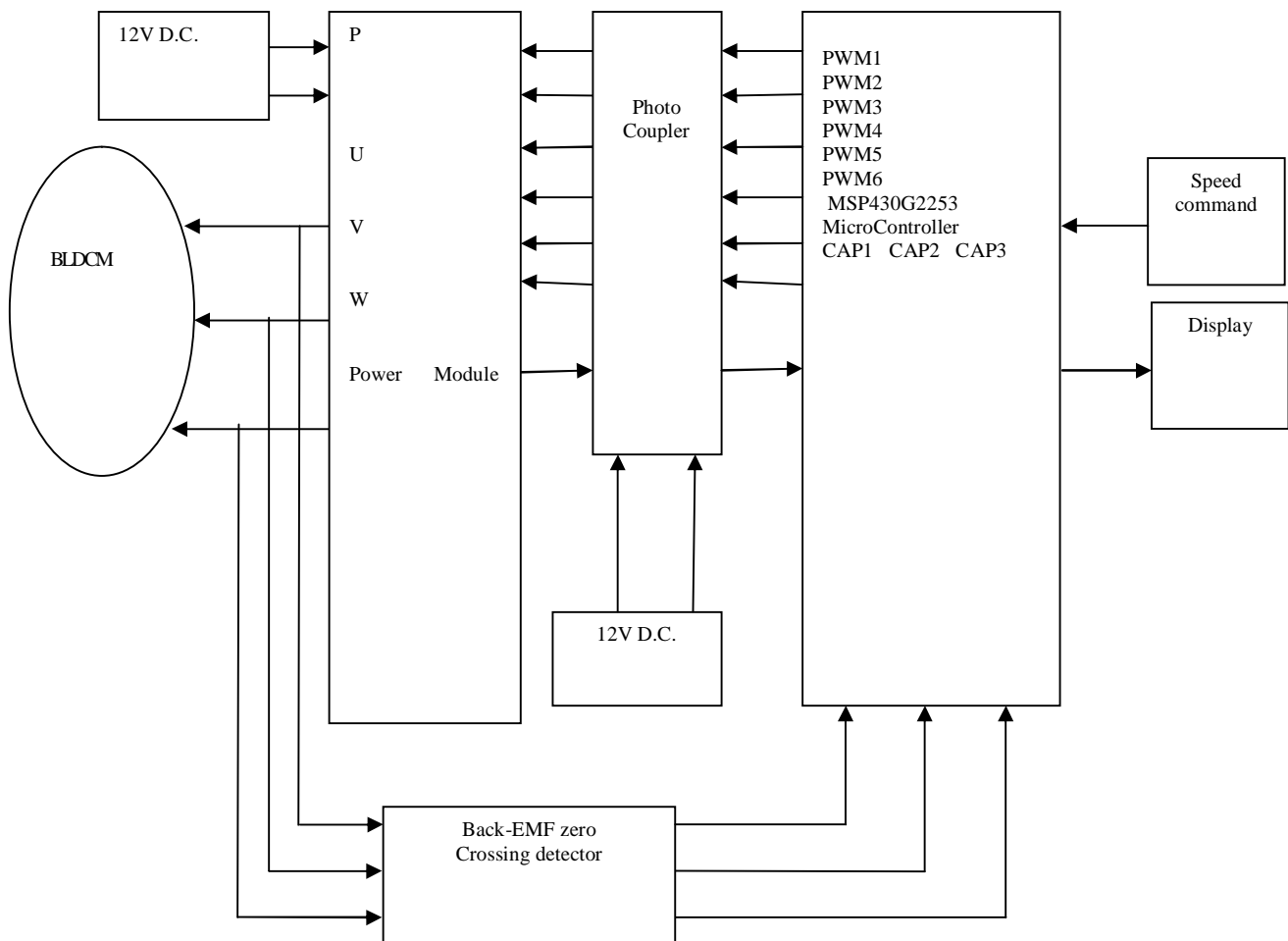


Fig.1 Block diagram of system

C. Command Circuit

Command circuit consist provides controlled signal to controller It consist touch pad with keys, by pressing keys we can increment or decrement values of parameters. Here we are fiddling angle and speed by pressing keys

D. Display Circuit

It consist seven segment LCD display which indicates the angle of rotation of motor speed .

III. SOFTWARE DESIGN OF THE CONTROL SYSTEM

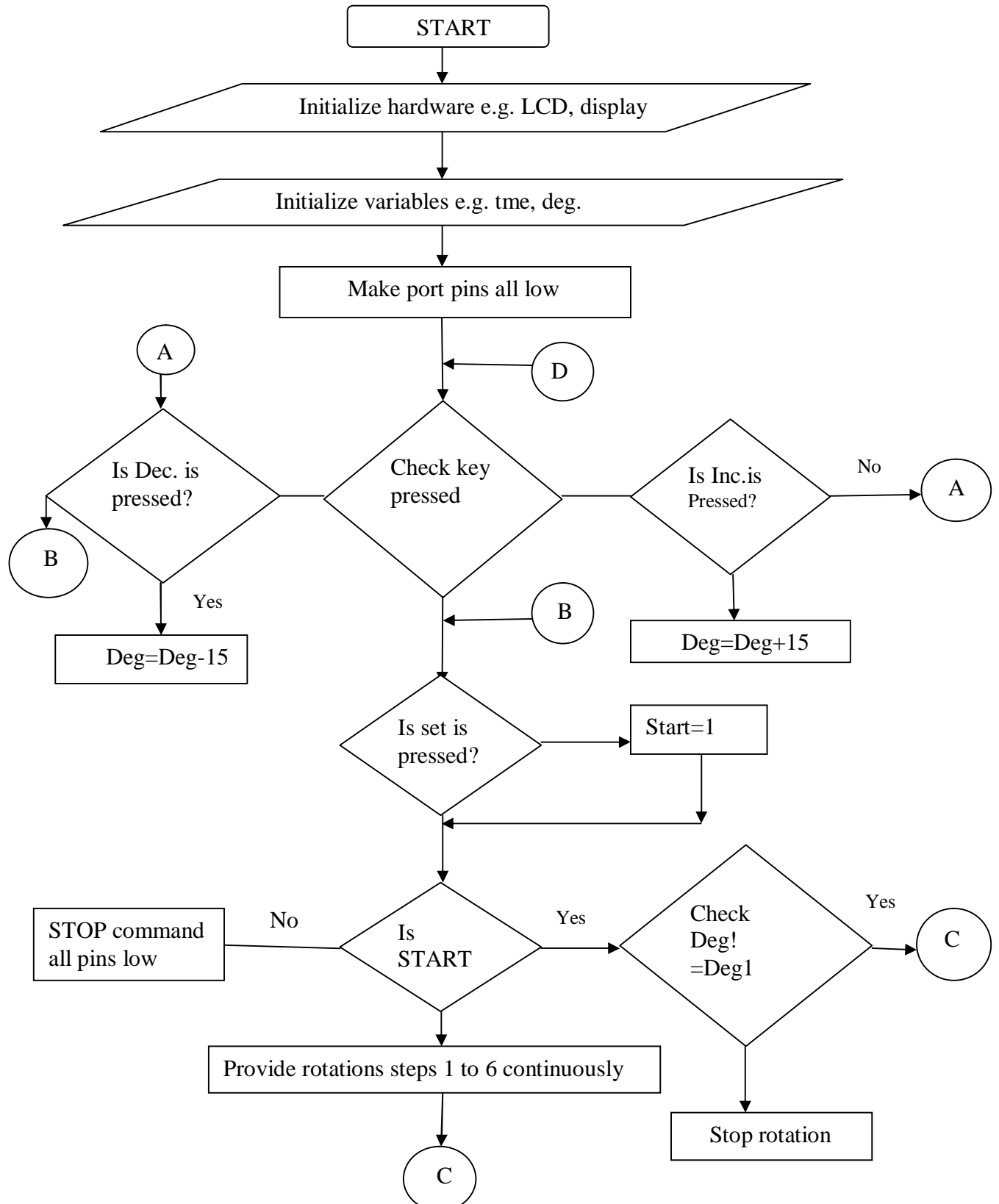


Fig.2 System software flow chart

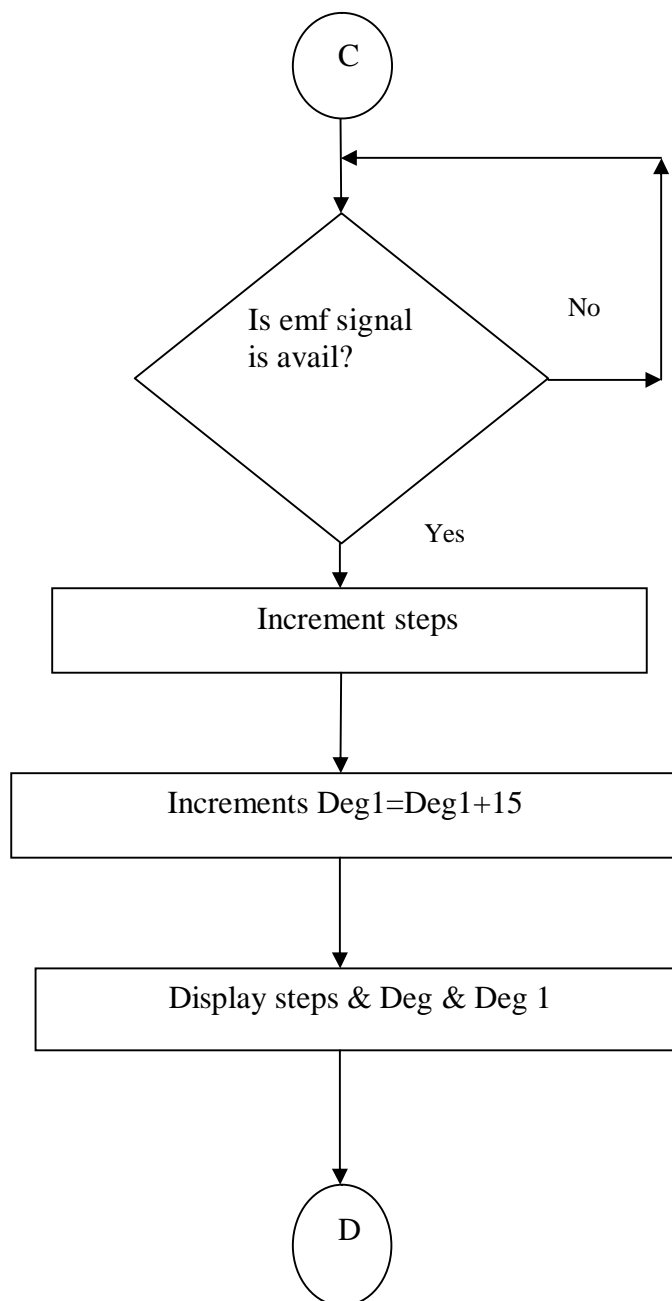


Fig.4 System software flow chart

Fig.3 and Fig.4 is the software flow chart of system. In which Fig.3 shows main flowchart of system the while Fig.4 shows flowchart of system between C and D. Whole control system software is composed by the main program and the interrupt service subsystem. Main program consist system initialize program, motor start program, check commands, interrupt program, and interrupt service subprogram. Interrupt program consist checking for back e.m.f. zero crossing instants and time interval between capture. Delay and degree of rotation is read, by considering increment or decrement in delay, degree and speed start or stop command given to controller. Degree which indicates angle of rotation and speed given by keys according that motor start and stop commands generates. Time consumed by rotor for rotating 360 degree angle divided into 12, the relating average time to 15 degree angle can be obtained. The average time is used as the time delays between the lower half period zero-crossing point and the related communication point. Initial position of motor is detected by back-emf and zero crossing circuit.

IV. EXPERIMENTAL RESULT

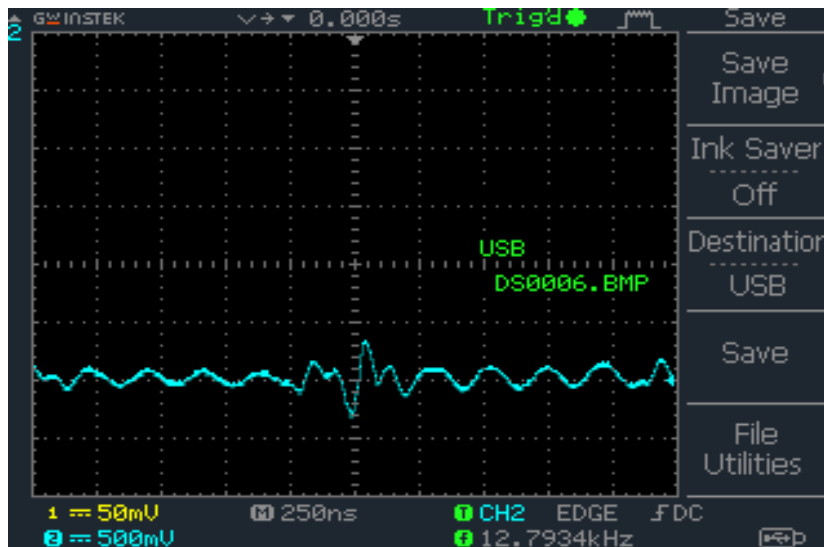


Fig.5 Terminal voltage waveform

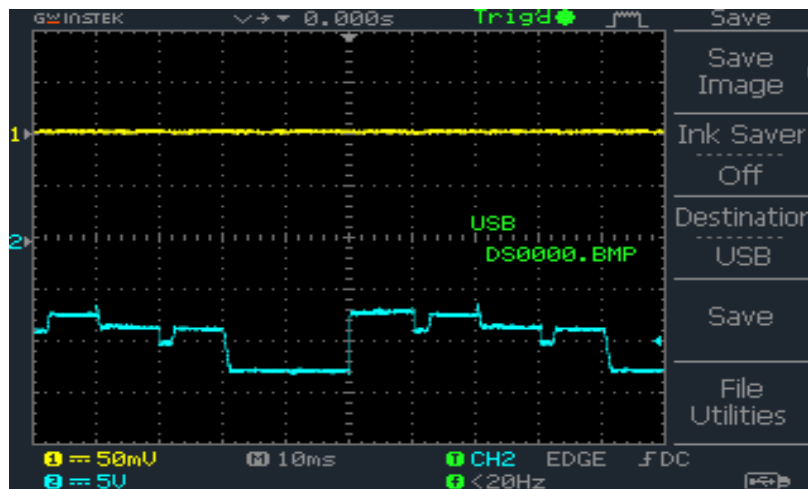


Fig.6 Terminal voltage waveform

Fig.5 Shows pre-phase terminal voltage waveform for continuous rotation program and when motor operates at stable state. Fig.6 is the expanded waveform. As we increase speed of motor by pressing keys on speed command circuit, terminal voltage and terminal current increases due to which speed of motor increases. In Motor speed control for rotation in particular degree also, as terminal voltage and terminal current increases motor rotation speed increases but rotation done for particular angle.

V. CONCLUSIONS

This is microcontroller based variable speed control system of sensor less brushless DC Motor. Microcontroller MSP430G2253 provide flexible control with quick and accurate response. MOSFET Power module gives good switching actions. Sensor less configuration makes whole system configuration compact and gives flexible control. System failure chances less due to sensor less configuration. Variable speed control can achieve, such as motor speed control over total speed range, motor speed control over certain speed range, motor rotation in degree.

VI. ACKNOWLEDGMENT

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