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# The Application of a Driving Circuit Based on 1ED020I12-FTA in PMSM

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Abstract: A new driving circuit based on the IGBT driving chip 1ED020I12-FTA is designed to drive the controller of the high power brushless DC motor in this article. The article has introduced overall design, the driving circuit and the experiments. The experiment results show that the driving circuit is able to drive PMSM motor very well, and it works well with good anti-disturbance, desaturation, electromagnetic isolation, overcurrent and overvoltage protection, Miller active clamp, and so on.

**Keywords:** high power driving; H bridge circuit; DC motor; pulse width modulation

## I. INTRODUCTION

With the characters of good linear characteristics, simple structure and easy control method, DC motor still plays an irreplaceable role in the market. H Bridge is a commonly way of controlling DC motor. It can achieve the motor four quadrant control: forward, forward brake, reverse, and reverse brake, and the circuit can make full use of the switching characteristics of the IGBT to emit the driving signal to control the IGBT on and off and adjust the sequence and frequency to the motor's steering and speed [1]. Thus, the motor's driving signal will directly affect the motor performance. A good driving circuit not only can reduce the switching time so as to reduce the switching losses, but also decrease the use of the switch tube life, or over current protection, over voltage protection, off protection, etc. Therefore, a good driving circuit is very important to optimize the performance of the motor!

This paper introduces a driving circuit which is based on one Infineon company production, 1ED020I12-FTA, which is a 2A rail to rail output driving chip. The driver not only has good isolation and switch but also owns a good integrated protection, such as the saturation detection, gate drive protection, and state transition switch protection. Experimental testing shows that the motor that applies the driving circuit has a good work performance.

## II. OVER DESIGN

The overall structure of the PMSM motor control system (Figure 1) can be divided into 4 parts: the upper computer, the control circuit, the driving circuit, and the main motor. When the system starts to work, the host computer sends the speed instruction to the DSP, the DSP produces three pairs of complementary SPWM wave after the CPLD logic control circuit to control the driving circuit, the driving circuit controls the 3 independent H bridge through will be on or off to control the motor. Rotary transformer can detect the motor's rotor position and speed, then it will feedback to the DSP through the SPI bus, the current sensor can detect motor phase current and main current, With the rotor position, rotor speed, phase current and main current signal, the vector control algorithm produces SPWM waves corresponding to control the motor to run, and these signals will be displayed on the host computer.

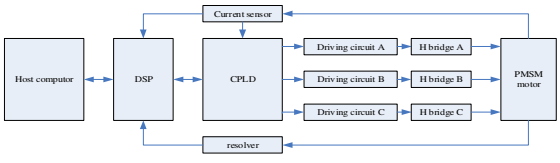


Fig. 1 Overall structure of PMSM motor

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## III. CHIP FUNCTIONS

1ED020I12-FTA is a single channel IGBT driver chip based on the noncore transformer, with input and output voltage protection, signal conversion monitoring, soft power off, Miller clamp, desaturation and short circuit protection and other internal state characteristics and external protection mechanism.

The RDY signal is a state indicator of the normal operation of the chip, which is equivalent to the DISABLE signal of the common driver chip.it will output a high level when the chip's state is normal, but when the output is low, it indicates that there are three main reasons as follows: chip internal logic conversion is not complete; the chip VCC supply voltage state is under voltage; the chip DESAT detection is abnormal.

The FLT signal is the state of the output of the VCE , when the output VCE or the switching current exceeds the normal threshold, the switch enters the saturated state, the pin DESAT works, while the FLT state indicates the high level signal, which can be reset by RST signal.

The DESAT signal is a signal that the saturation voltage of the driver chip is detected, which effectively prevents the occurrence of the switch. Since the saturation voltage of the IGBT emitter and collector voltage varies with the collector current, we can protect the VCE by detecting the flow. We can change the series resistor to regulate the protection switch overvoltage value, reset the capacitor size to set time blind. The chip has provided a constant current source of 500uA, it will charge the capacitor with the current, when the capacitor terminal voltage exceeds the sum of the diode and the switch tube collector voltage, the capacitor and the main circuit will form a path. We can take advantage of this to set the threshold voltage of the switch, when the voltage reaches the threshold voltage, the chip will be forced to shut off the output driving signal through the internal protection circuit [4].

CLAMP is the chip's Miller clamp port`, which is mainly used to ensure that the state switch will not be switched on as the internal parasitic charge and the circuit of the dVce/dt error trigger, which will lead the bridge. The chip has provided a constant voltage source of 2V, when the signal amplitude is less than 2V, the switch which is internal will be switched on, and the driving signal will be forced to shut off.

TLSET is the chip's protective port, it can be changed by changing the output signal voltage amplitude to limit the impact voltage which is caused by the off signal in the switch. So as to ease the switch off voltage impact, improve the service life of the switch, a circuit which is composed of a zener diode and a capacitor is designed, the diode is designed to limit the shutdown of instantaneous pressure drop, the capacitance is designed to set the driving signal's drop time.

## IV. CIRCUIT DESIGN

Because of the motor's three-phase winding, the motor is presented with inductive load, the step motor will performance that the output is low in high frequency, shock phenomenon in low frequency. When the motor is powered, with the control frequency increasing, the motor's speed is increasing, the average current will be reduced and the output torque will be decreased [5]. If you continue to increase the speed of the motor, it will cause the motor to block or lose step. Therefore, it is necessary to optimize the motor inductance and power supply. Only improving the current before and after along the gradient, we can ensure the motor to respond in a timely manner, even in the very high frequency control, the operation efficiency of motor can be improved finally.

As it is shown in Figure 1, a driving circuit is given to drive the bridge. The input stage receives the signal from the control board which follws a low pass filter, then the signal reaches the input terminal of the driving chip. The VCC1 port provides the input voltage for the drive chip [2]. The basic principle of the circuit is shown in figure 2. When the circuit works, the control circuit sends out PWM signal tothe 1ED020I12-FTA pin IN-/+ input, through the internal transformer to achieve the function of electromagnetic isolation, then to the output port to the IGBT gate, thus controlling the switch on and off. From Figure 2 we can see the driving signals are a pair of complementary PWM waves, in fact we can also use only a IN+ to realize the control of the switch, IN is connected to GND, thus it will increase control circuit's redundancy and further ensure the reliability of the circuit.

On the power supply of the drive chip, the upper arm bridge of the driving circuit is supplied with the +15V bootstrap mode. Bootstrap mode is one of the most widely used methods for driving upper gate driver circuit in high voltage gate driver(IC). Advantages of the bootstrap power supply circuit are its simple and low cost [6]. However, it is limited by some conditions: firstly, because of the duty cycle is limited by the time required to refresh the self-lifting capacity; second, the voltage of the gate and source will increased if the source voltage of the switch device is supplied with a negative power. Because of the general grid voltage of Vgs is less than 30V, therefore we choose the +15V

power for the comprehensive consideration. Due to the driving chip's output current only 2A, the 2A driving out may be unable to meet the demand of higher power circuit, in order to improve the drive's output, we can adopt a cascade of push-pull circuit in the output of the drive system, which will double push-pull the current of the driving circuit amplification, to meet the demand of greater power circuit.

In order to improve the speed of the driving signal's response, we can improve the speed of the switch's response by adjusting the gate drive of the switch. When we take small series gate resistance in the circuit and the gate current will be relatively large, the gate capacitance will be charged and discharged much sooner, the switch's wastage and the speed of the switch's response are greatly improved, but it will make the circuit's anti-noise capability greatly reduce, it is possible to cause gate circuit in concussion. When the gate resistance increases, the output current will be less, the rise time of the switch will increase, and the di/dt of the switch also will be reduced, so as to the peak voltage of the switch. Taking the gate voltage, the switching frequency and the gate's source capacitance (which can be queried) into consideration, it is good to take 10 euro as the gate resistance [3].

The pair of reverse diode at the bottom of the driving chip is to ensure that the bootstrap capacitor does not appear over voltage [8].

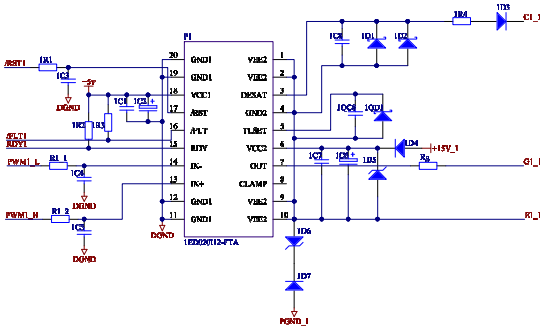

Fig. 2 Design of drive circuit

## V. POWER SUPPLY

Due to the isolation requirements of the drive chip, the former input and the latter output level power supply must be separated, so the former input we use control board to provide +5V input power. The output is supplied with+15V power. We choice the 3W power module (just like the Fig.3 shows) which is produced by Jin Sheng Yang company, the module can be efficiency, small package size, and has the function of isolation and the function of voltage regulator in power supply. The module can be supplied +28V input, +15V output isolated, and fully meet the power our chip needed.

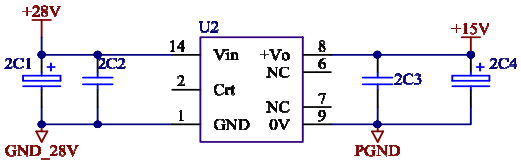


Fig. 3 Design of power supply

## VI. DRIVE OUTPUT CIRCUIT TEST

Through the actual motor running test (Fig.4), we have learnt that we have a good working condition of the driving circuit. According to the gate waveform of the actual working state of the motor, we can know that the output of the driving signal is very fast change, and can be very good control the switch. From Fig.4 we also can see the rise time of the switch is very short, and the duty also is very equilibrium, so the output driving signal could very perfect to control the motor.

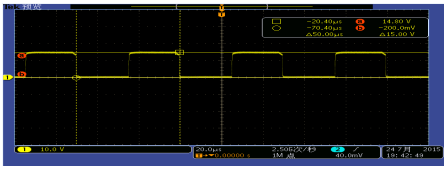

Fig. 4 Driver Output

## VII. APPLACATION TEST

We have not only analyzed the driving core, but also we have analyzed the test to the application in actual motor work. The results of the test (Fig.5) can be seen in the follow running results which is in the range of the expected measurement error. During the test, when we have set the given speed 100 in the upper computer, we can see the actual speed of the motor is 94. In the same way, we also have set the given speed 500, 1000, 5000 and 10000, similarly we get the actual speed 506, 994, 5005 and 10004, they just as the Fig.5 show. Compared the two sets of data, it indicates that we have stable controlled the motor with very little speed error.

| Given speed | 100 | 500 | 1000 | 5000 | 10000 |
|---|---|---|---|---|---|
| Actual speed | 94 | 506 | 994 | 5005 | 10004 |

Fig. 5 Given speed and Actual speed

## VIII. CONCLUTION

To drive the controller of the high precious PMSM, a new driving circuit base on the IGBT driving chip is designed. The structure of the circuit is simple and easy to be realized. Taking advantage of good under voltage protection of the chip 1ED020I12‐FTA, overcurrent and overvoltage protection of IDBT, Miller active clamp protection integration, and so on, the circuit achieves the perfect control to the motor. The practical application of the circuit reflects very good performance.

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