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ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (18): 4680-4686, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.4680.4686

Single Wheel Drive Orchard Agv Servo Controller Based on ADSP2188

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Abstract: Orchard AGV is a continuous, independent and real-time intelligent carrying goods vehicle in orchard. Differential speed control orchard AGV often lost control in complex work environments, leading to production interruptions. To solve the problem, a single wheel drive orchards AGV is proposed, hardware and software of a single wheel drive orchards AGV based ADSP2188 are designed. Experimental results show that servo system of the orchards AGV based on ADSP2188 can effectively improve its steady and dynamic performance.

Key words: Orchard automatic guided vehicle, lead-acid battery, BLDC motor, single wheel drive

INTRODUCTION

With the development of modern agricultural and industrial production, more and more automatic machine are widely used to replace human work.

An automated guided vehicle or Automatic Guided Vehicle (AGV) is a mobile robot that follows markers or wires in the floor, or uses vision or lasers. They are most often used in industrial applications to move materials around a manufacturing facility or a warehouse. Application of the automatic guided vehicle has broadened during the late 20th century (Mehdi *et al*., 2010; Watanabe *et al*., 2001).

Automated Guided Vehicle (AGV) are also the most flexible means to transport materials among agricultural production. AGV can be applied to move fruits in food processing, such as the loading of fruits and/or trays into sterilizers. AGV can load standard, over-the-road trailers with finished goods and unload trailers to supply raw materials or packaging materials to the plant. AGV can also store and retrieve foods in the warehouse (Maughan and Lewis, 2003) and (Collier, 2003).

AGV (automated guided vehicle) for its unmanned, flexible, strong carrying capacity, good safety performance, high efficiency and environmental protection and other good performances, are widely used in many modern intelligent production system.

The design and implementation of such AGV require answers to a number of problems, such as guide path design, controller devices and routing algorithms. However, Compared with developed countries, there is a huge gap. AGV used in our country has its limitations:s Domestic understanding and use of the AGV is not enough and the servo control technology has limited its use, especially in the case of agricultural mechanization; existing agricultural AGV more uses two same powered motor to drive it to run, by adjusting speed of the two motor to change its position and direction. In this mode, the wheel of AGV will lose control which generally affect the whole production. To solve the problem, a new structure of orchards AGV (as Fig. 1 shown) for special working environment is proposed: a single wheel drive AGV.

Two different motor were used in a single wheel drive AGV system: a small motor to adjust movement direction and the other motor to achieve its velocity, under this principle, speed and direction of AGV are decoupled.

In orchard, there are open space under big trees, this is a significant difference between orchard and other agricultural environment, especially for higher fruit tree which has a more wide open space under it which ideal for laying navigation marking line for single-wheel drive orchard AGV. The principle of the orchard AGV as shown in Fig. 2.

In the orchard, in order to facilitate irrigate fruit trees, there are many stones around a fruit tree to form a simple low fence, the fence was significantly higher than the ground under fruit trees, this height difference can be read AGV sensor, the signal from the sensor can be used for AGV navigation.

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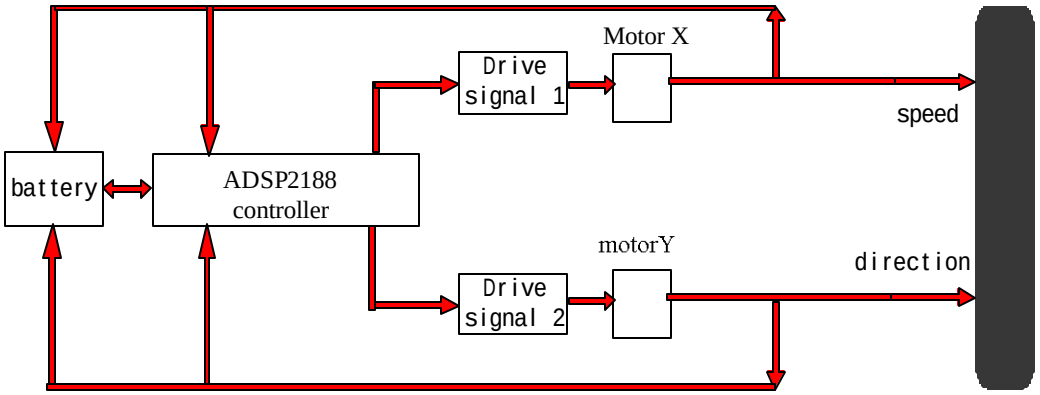

Fig. 1: Single wheel drive AGV

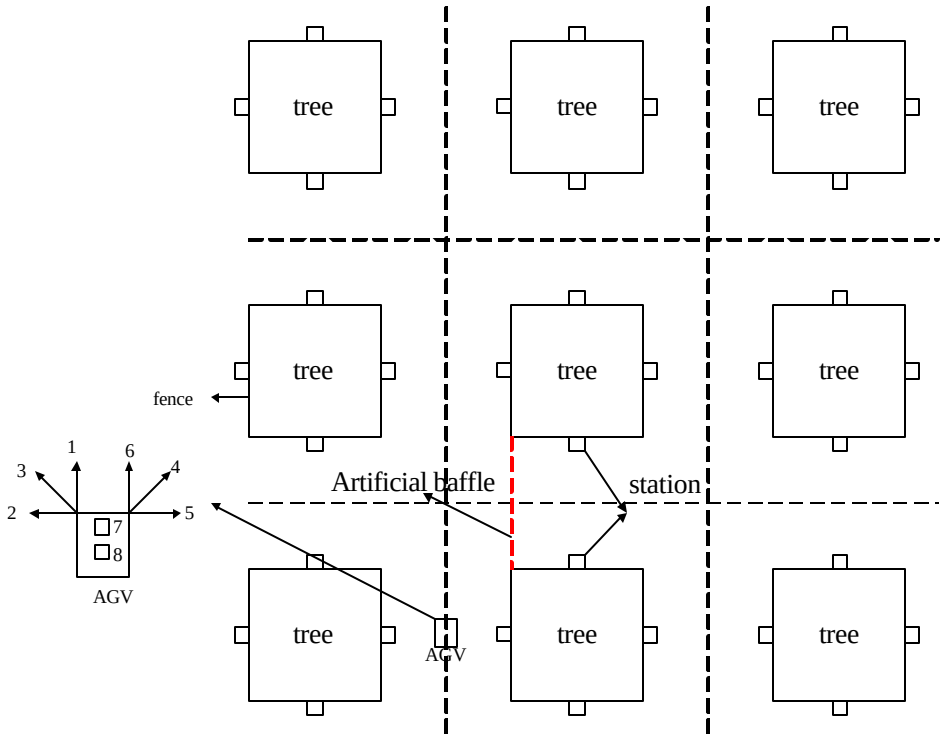

Fig. 2: Single wheel drive orchard AGV navigation

SYSTEM MANAGEMENT

In the complex orchard environment, AGV is a system often used in orchard to keep up, transport and connect smaller subsystems into one large production unit. AGV employ a lot of technology to ensure they do not hit one another and make sure they get to their destination. Loading and transportation of materials from one area to another is the main task of the AGV.

A locator panel is a simple panel was used in the system to see which area the AGV is in. If the AGV is in one area for too long, it could mean it is stuck or broken down. The panel can display where each vehicle is. It also gives a status of the AGV, its battery voltage, etc. Central logging used to keep track of the history of all the AGVs in the system. Central logging stores all the data and history from these vehicles which can be printed out for technical support or logged to check for up time.

According to the above discussed, an intelligent management system of single wheel drive AGV based on ADSP-2188 was designed as shown in Fig. 3.

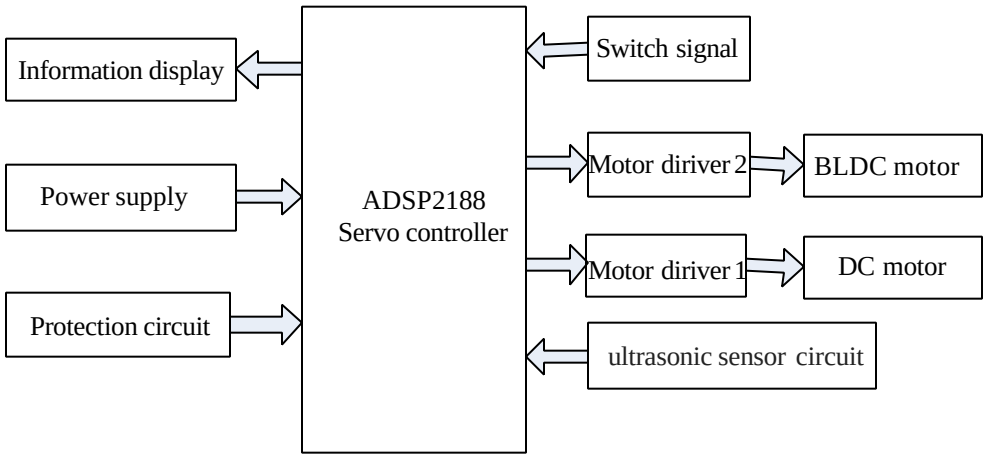

Fig. 3: Single wheel driving orchard AGV system management

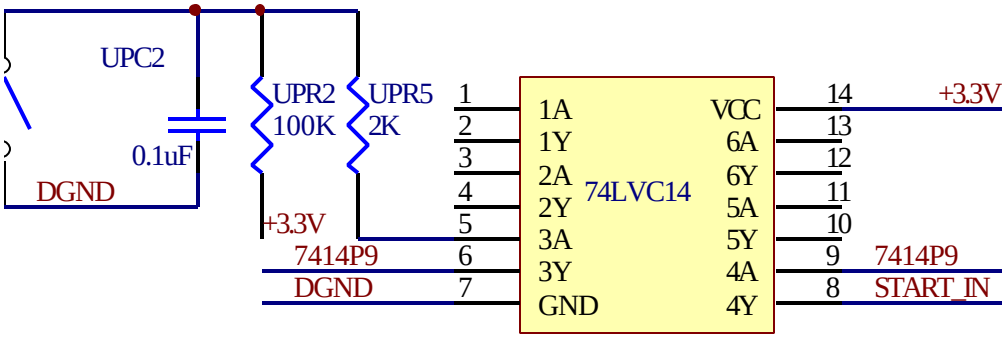

Fig. 4: Switch signal input circuit

HARDWARE DESIGN

The hardware circuit of this intelligent servo management system comprise: switching signal input circuit, power supply circuit, motor drive circuit, ultrasonic sensors collection circuit, battery circuit and motor protection circuit, etc.

Switching signal input circuit: In the single wheel driving orchard AGV requires two separate switching input signal, respectively, the signal is connected to ADSP-2188's pin, one is to start the system, the other is to reset the system when it is lost memory. In order to reduce interference, switch button signal is shaped by 74VC14 before connected to ADSP-2188, start switch signal input circuit as shown in Fig. 4.

Power supply circuit: The AGV used in orchard powered by secondary rechargeable lead-acid battery, the average voltage of the power supply is 36V, the most highest voltage is 40.8V. In order to meet the DSP 3.3V voltage, lead-acid battery is reduced down by chip L4973D, 5V voltage then achieved, Then 5V voltage is converted to 3.3V, where 5V power supply circuit as shown in Fig. 5.

Table 1: Parameters of motor

Nominal voltage	36 V	Weight	1000 g
Output power	250 W	Diameter	80.0±0.5 mm
Efficiency	89%	Length	24.2±0.5 mm
No load speed	6000 rpm	Shaft diameter	12.0±0.1 mm
Torque	10 Nm	Encoder	1024.0 lines

Motor and its driver: Brushless DC motor with permanent magnet has the merits of a small volume, high efficiency, high power density and low pulsating torque, a good working torque characteristic in low-voltage, strong torque characteristic under overload, big starting torque, small starting current, etc., it is widely used in small and medium power servo system; In the orchard AGV servo system a three-phase four-pole permanent magnet brushless DC motor is used, the motor uses three Hall sensors to realize electronic commutation of motor.

Some parameters of the motor are shown in Table 1.

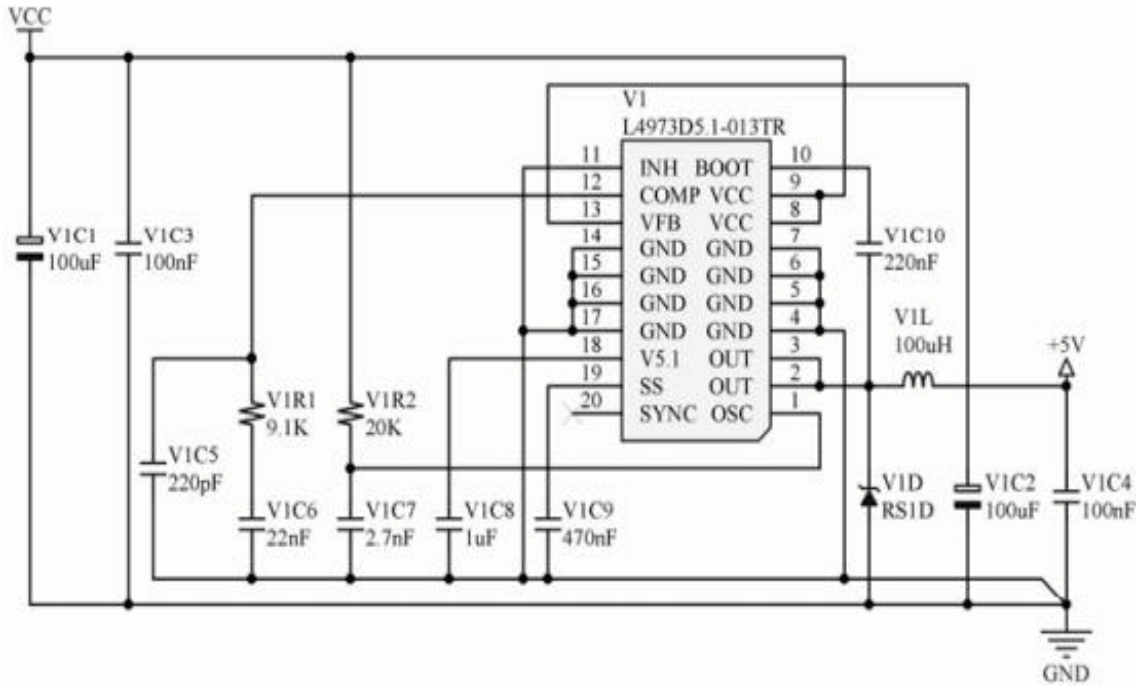

Fig. 5: 5v power supply circuit

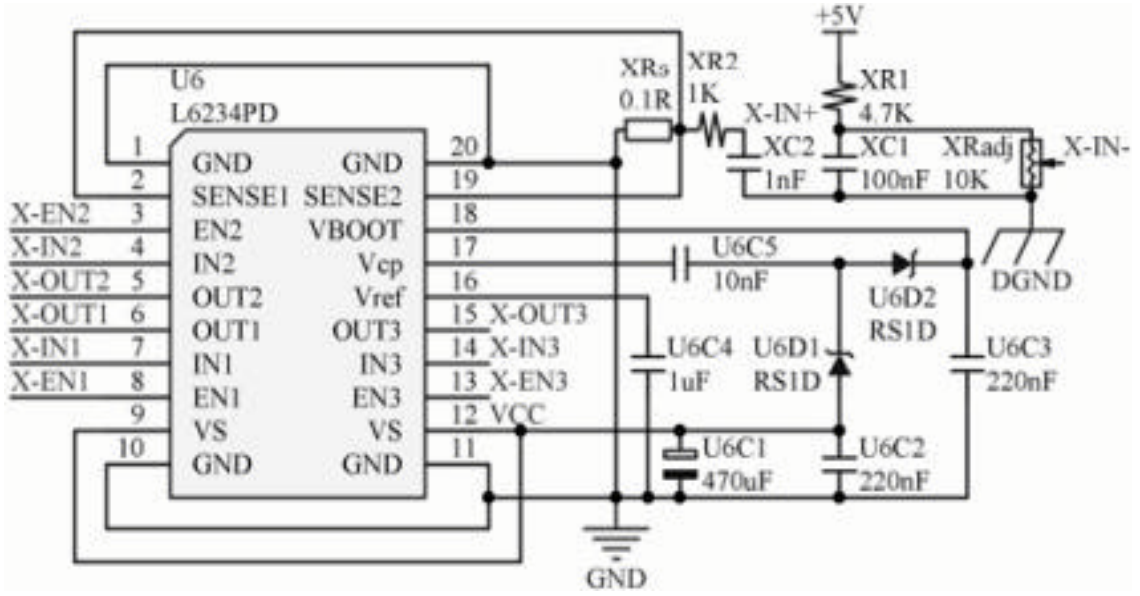

Fig. 6: Motor driver circuit

Since a larger three-phase brushless DC motor was used in the single wheel drive AGV, PWM generated by ADSP2188 can not directly drive the motor, PWM drive signal required to improve its ability by the power drive unit, in this study, three phase motor driver L6234PD is adapted, power driver principle as shown in Fig. 6, wherein, the drive signal X-IN1, XIN-2, XIN-3, the enable signal X-EN1, XEN-2, XEN-3 signals are from ADSP-2188.

Ultrasonic transmitter circuit: In order to accurately locate the AGV and meet the requirements of long-range detection, ultrasonic sensors are used in the AGV

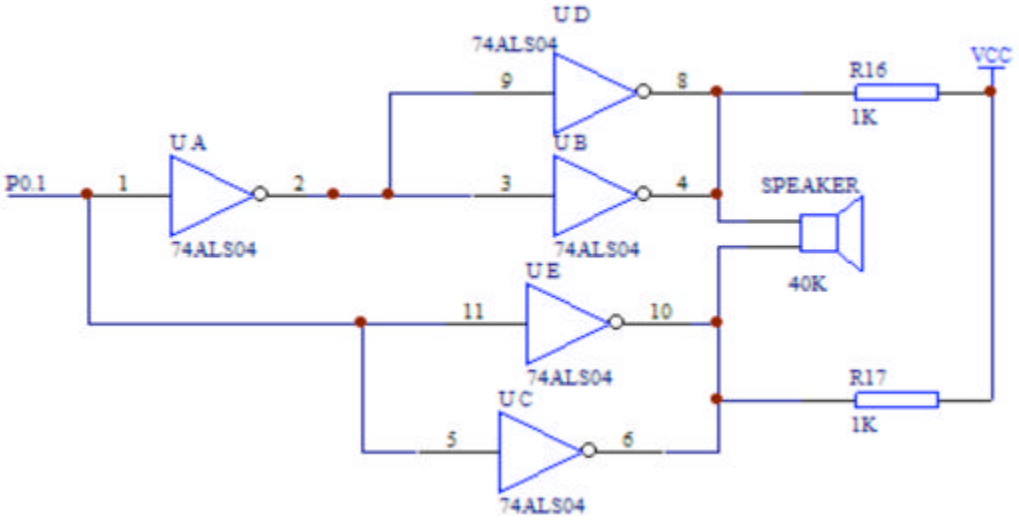

Fig. 7: Ultrasonic transmitter circuit

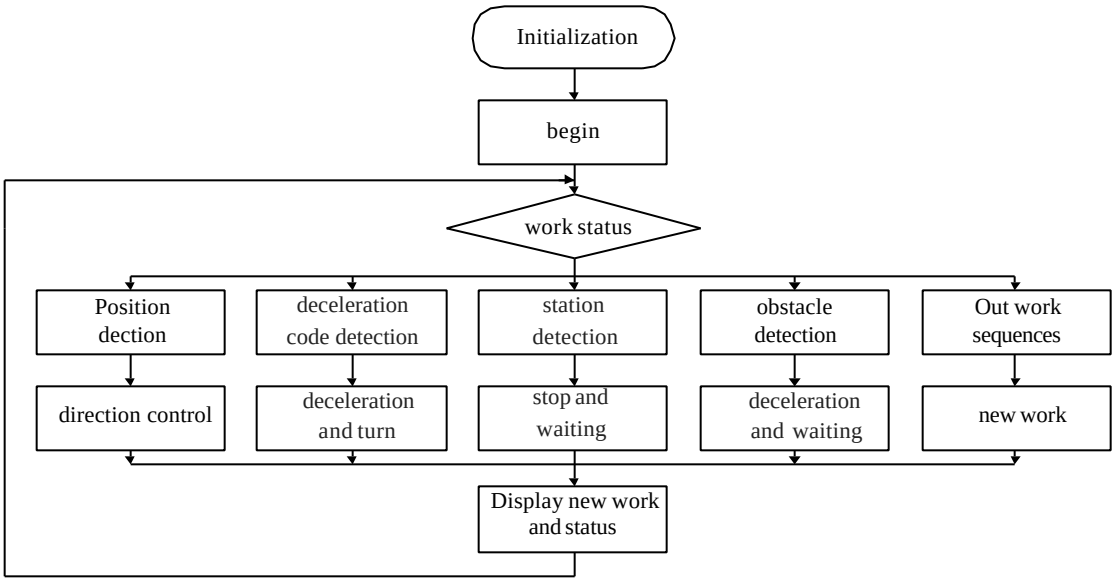

Fig. 8: Flowchart of orchard AGV system software

detection circuit. In the detection system three pair sensors are installed according to different directions: Front, left and right. Ultrasonic detection system provides running environment for the AGV when carry goods.Ultrasonic sensor including an ultrasonic probe and ultrasonic amplifier. ADSP2188 generates square wave, ultrasonic probe converts the electrical signals into mechanical waves then emits while the electrical signal need be amplified by the ultrasonic probe. Ultrasonic transmitter circuit as shown in Fig. 7.

SOFTWARE DESIGN

The ADSP-218xN series consists of six single chip microcomputers optimized for digital signal processing applications. All series members are pin-compatible and are differentiated solely by the amount of on-chip SRAM. This feature combined with ADSP-21xx code compatibility provide a great deal of flexibility in the design decision. Specifically, ADSP-2188N (48K PM/56K DM), 16-Bit, 80 MIPS, 1.8V, 2 Serial Ports, Host Port, 256 KB RAM. The ADSP-2188N offers the highest performance

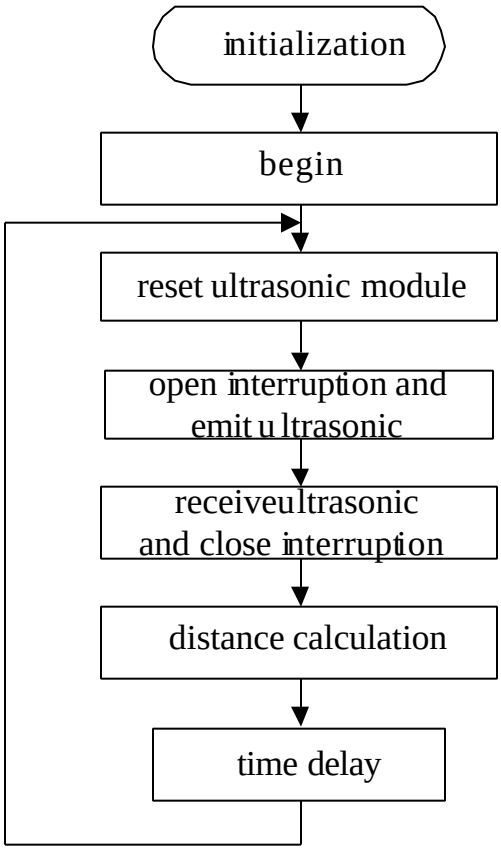

Fig. 9: Ultrasonic calculate distance module

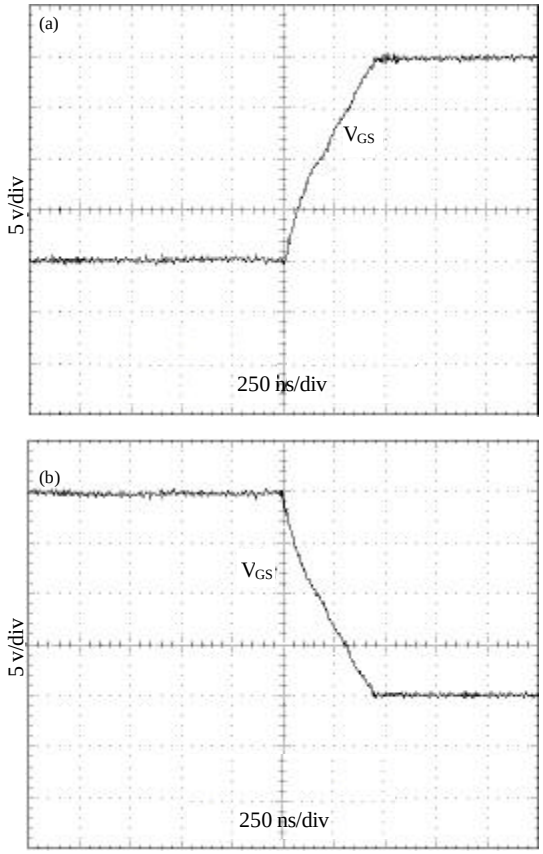

Fig. 10(a-b): Drive signal, (a) Rising edge of drive signal to IGBT and (b) Falling edge of drive signal to IGBT

(80 MHz/MIPS) and lowest power consumption (0.55 mW/MIP @ 1.8V). the chip are offered in a 100-lead LQFP and 144-Ball MBGA packages.

In this orchard AGV intelligent servo management system project ADSP-2188 is chosen to handle data. Software flowchart of the system based on the ADSP-2188 as shown in Fig. 8.

The orchard AGV system software includes position detection module, the deceleration code detection module, station detection module, obstacle detection and control module, these modules are realized by ultrasonic sensor, ultrasonic calculate distance module principle as shown in Fig. 9.

EXPERIMENT

Three-phase brushless DC motor drive waveform as shown in Fig. 10: Fig. 10a shows waveform of the drive signal rising edge and Fig. 10b shows waveform of the drive signal falling edge, can be seen from the figure, the drive signal amplitude (-5V~15V) allows power IGBT for reliable turn-on and turn-off, the rise time and fall time of drive signal are all less than 500 ns which can meet small and medium power IGBT fast drive requirements.

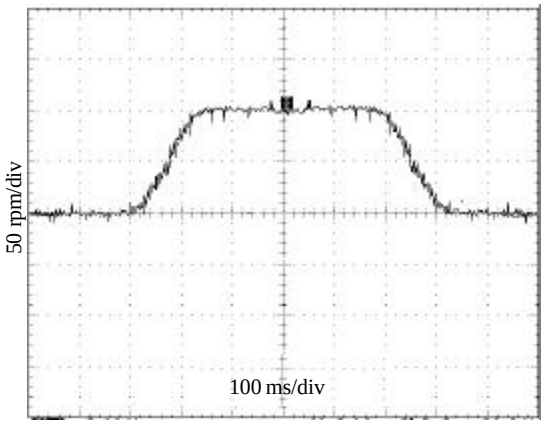

Fig. 11: Speed step

Make BLDC motor do a 0~100 rpm speed step, test waveforms as shown in Fig. 11. Can be seen from the

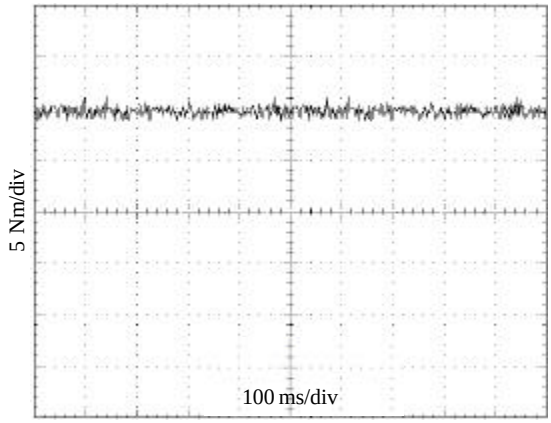

Fig. 12: Torque waveform

figure response time of the speed step is about 120 ms, so fast step response will help improve the AGV start and stop dynamic performance.

The torque waveform of motor at low speed (50rpm) as shown in Fig. 12, Can be seen from the waveform that the torque ripple is very low which help to improve the dynamic performance of the brushless motor and reduce vibration of orchard AGV.

CONCLUSION

- There are many stones around a fruit tree which can form a simple low fence, the fence can be read by AGV sensor and used for AGV navigation
- The single wheel drive orchard AGV with full-digital servo driver based on ADSP2188 can control two brushless DC motor and a directional DC motor in the same time which is conducive to further improve the AGV system stability and dynamic performance.

ACKNOWLEDGMENT

It is a project supported by basic research programs of Suzhou science and Technology Department-industrial application part (SYG201327).

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