Better control and quiet solution using Infineon 8-bit microcontroller solutions for Air-conditioner outdoor fan

Abstract:

A simplified sinusoidal control of air-conditioner outdoor fan is proposed using Infineon 8bit MCU XC866. Outdoor fan needs to be started reliably and consistently under different climate condition. Strong wind facing outdoor unit will force fan blade to spin in the reverse direction. Infineon solution can brake fan blade firstly, and start it with stronger power which is calculated according to the initial running speed. Sinusoidal control proves to reduce audible noise effectively comparing to traditional trapezoidal method. Meanwhile, this special simplified method is independent of motor parameters, and hence suitable for a range of fan models. This shortens development period and provides great convenience for production.

Application Background

Split type air-conditioner normally consists one outdoor unit and several indoor fan coils. The outdoor unit contains the compressor which carries out the heat exchange process. To regulate the amount of heat exchange in outdoor unit according to variations in outdoor temperature, a fan is used. Normally outdoor fan operates within a speed range from 250rpm to 1000rpm with the power consumption less than 100W, eg. 70W typically. The speed command is given in analog format and a FG (frequency generation) signal is feedback to the main controller board.

Fig 1. Air-conditioner out-door unit.

There is a special requirement for outdoor fan control. It needs to be started reliably and consistently under different climate condition. Strong wind facing outdoor unit will force fan blade to spin in the reverse direction and motor could reach half of the maximum speed in violent typhoon. There are other requirements for the purpose of production convenience. Control method which is independent of motor parameters, insensitive to components tolerance or manufacturing variation is favored.

Traditionally outdoor fan is a BLDC motor and controlled by trapezoidal commutation. There are advantages of trapezoidal control, such as easy control, strong torque and reliable performance. However, due to intrinsic torque ripples, trapezoidal commutation induces audible noise especially when motor is operated at low speed. To reduce the audible noise and meanwhile to meet all application requirements, a simplified sinusoidal control is proposed using Infineon 8bit micro-controller XC866.

Infineon Outdoor Fan Solution

XC866 is a member of the high-performance XC800 family of 8-bit microcontrollers.
It is based on the XC800 Core that is compatible with the industry standard 8051 processor. XC866 is equipped with a dedicated 3-phase motor control unit – capture compare unit 6 (CCU6), and a 10bit Analog-to-Digital Converter (ADC) with extended functionalities. These features make XC866 very suitable for low-end 3-phase motor control, eg. BLDC and Induction motor. Other features of XC866 include one UART, one SPI interface, and three 16bit timers. Block diagram of XC866 8bit micro-controller is shown in Figure 2.

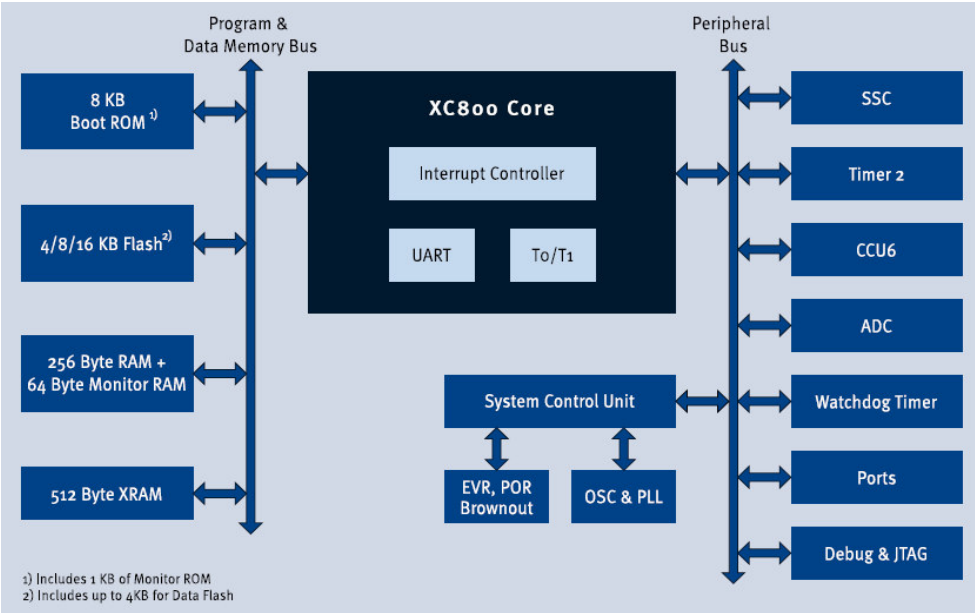

Fig 2. Block diagram of XC866 8bit micro-controller.

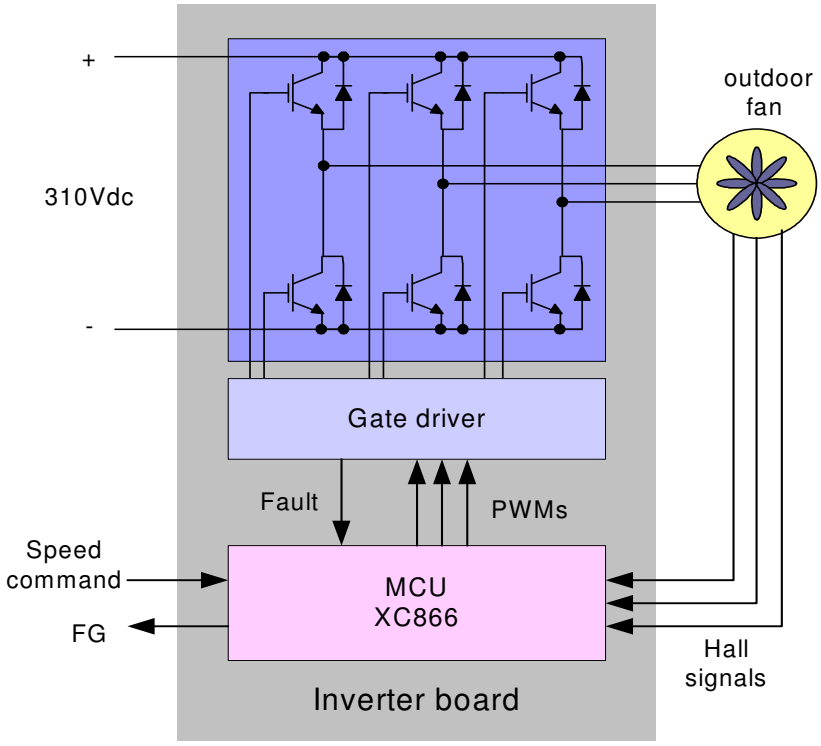

Fig 3. System block diagram of outdoor fan inverter board.

Figure 3 shows the system block diagram of the fan inverter board. Micro-controller, gate driver and six IGBTs are assembled on the same inverter board. Normally this board is mounted within motor casing. 310V DC voltage is supplied to the inverter board directly and hence no rectifier stage is required. Infineon discrete IGBT IKD04N60R and gate driver 6ED003L06-F are selected for this application due to their suitable features and reliable quality.

During real operation, fan motor may run at one of the following states: STOP, CHECK_DIR, BRAKE, RAMP and SINU. Upon power up, a routine (state CHECK_DIR) is called to check the spinning status of fan motor. In case of standstill, motor will be started using trapezoidal commutation (state RAMP), since this method can provide stronger starting torque. After successful startup, control switches to sinusoidal modulation (state SINU) to reduce audible noise. However, if motor spins in the reverse direction upon power up, software will brake motor until it becomes standstill (state BRAKE). Braking force is calculated basing on the initial spinning speed. For example, if fan blade spins at 400rpm, more current will be drawn to stop motor than the current needed to stop motor running at 200rpm.

Motor speed and direction information are provided by three Hall sensors, which are of 60 degree resolution. XC866 is integrated with hardware Hall input logic (within CCU6 module) which avoids software polling of Hall signals and hence saves CPU overhead. Motor speed is calculated and ready to be used for rotor angle calculation. Within every PWM interrupt, rotor angle is updated and used as sinusoidal look-up table index. Speed command is sampled via ADC channel and the conversion result is given as voltage norm. Finally, CCU6 output 6 PWM signals basing on the sinusoidal look-up table value and voltage norm. Figure 4 shows the control block diagram of stable operation.

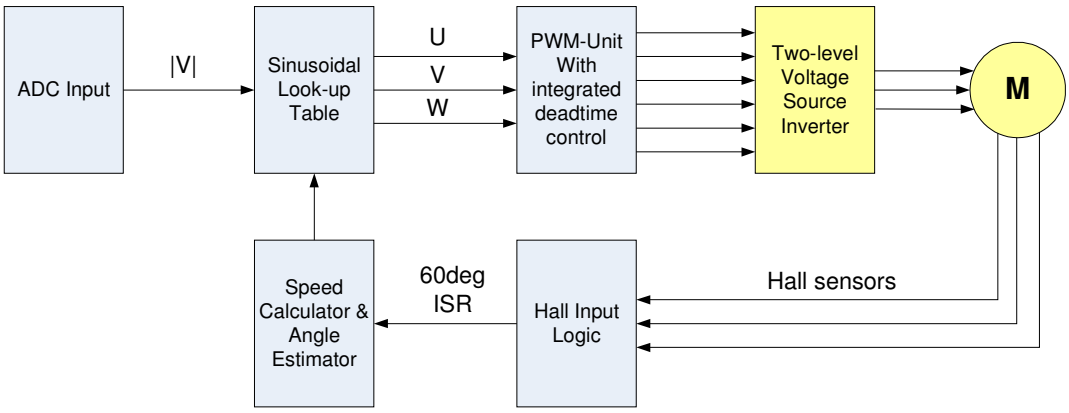

Fig 4. Control block diagram of stable operation.

To reduce switching loss of modulation, a special method is used. Within one electrical cycle, there are 6 states and each one lasts for 60 degree. Two out of six states are not modulated, eg. S5 and S6 for Phase U. This is similar to trapezoidal control, while the other four states are modulated by sinusoidal function, eg. S1 and S2 using *sin(□)* and S3 and S4 using *sin(120-□)* for Phase U.

Tests have been conducted at the customer site with satisfactory result on noise reduction, reliable reverse brake and startup, and good efficiency. Meanwhile, this method is independent of motor parameters, and hence suitable for a range of fan blade models. This shortens development period and provides great convenience for production.