HT46R14A Single Phase AC Induction Motor Frequency Converter Application

D/N：HA0095E

Introductions

Initially the main reason for using frequency conversion technology was for speed control, however to consider the needs of power control, today's frequency converters in addition to being used for speed control are also used for energy conservation purposes.

Frequency conversion control technology is already being applied in many application areas, in home appliances such as fridges, washing machines, air-conditioners in addition to driving industrial motorised equipment etc. Frequency converters when used in electric motor control, are used to both control the frequency and voltage.

The Holtek HT46R14A MCU device is used here in an example to show how frequency conversion is used for electrical motor control. An actual circuit is supplied for the users consultation.

Frequency Converter Principles

The normal household power supply or industrial power supply voltage and frequency is well defined and not open to change. The device, which takes this fixed voltage and frequency AC power and converts it into a variable voltage or variable frequency AC supply, is known as a Frequency Converter. In order to generate a variable voltage and frequency, the system must first rectify the AC input power source into DC after which the DC will be reconverted back into AC using the converter. The device, which converts the DC back into AC, and which can be controlled in both voltage and frequency, is known as the frequency converter. The frequency converter′s output is a simulated sine wave whose main purpose is to control the speed of an asynchronous induction motor.

Because of the characteristics of electric motors, most frequency converters must supply a Voltage/Frequency means of control. When the frequency is changed the voltage must change with it, When the frequency is reduced the voltage must reduce as well. If the frequency is reduced but the voltage does not change, the electric motor can easily overheat and burn out. This is especially true for very low frequencies. Therefore the frequency converter must be able to produce both voltage and frequency changes. In addition, most frequency converters also provide an acceleration and deceleration function, for use in emergency increase or decrease applications and for slow increase and decrease speed applications.

Most frequency converter′s application area is for three phase AC induction motors. Fig. 1 shows a simple open-loop three phase output frequency converter block diagram. Most frequency converters supply single phase or three phase AC outputs. After bridge rectifying and filtering, the DC power is provided to the power drive circuits. The SMPS will convert the high voltage DC to the required isolated DC voltages and supply it to the protection circuits, drive converter interface circuits and the control circuits. The control circuits will provide the necessary control signals to drive the power circuits to control the motor's rotational speed and voltage. The frequency converter needs to provide protection circuitry for over-voltage, over-current, low-voltage, etc. which are used to protect the converter from adverse conditions. The driver converter frequency converter interface is an MCU control circuit and is an interface to the power drive circuit and provides voltage isolation. The usual way of providing isolation is with IC opto-couplers.

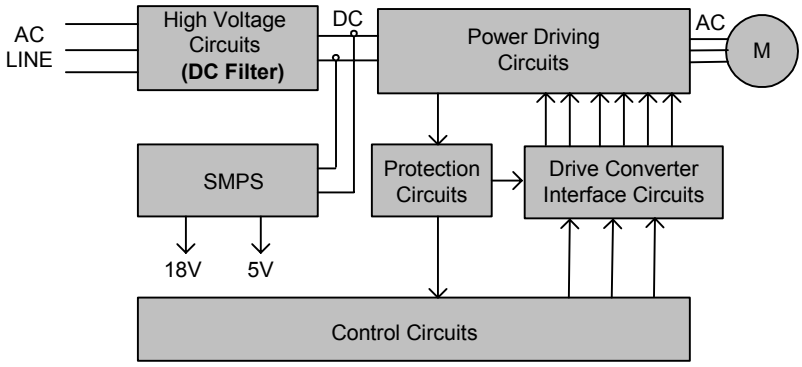
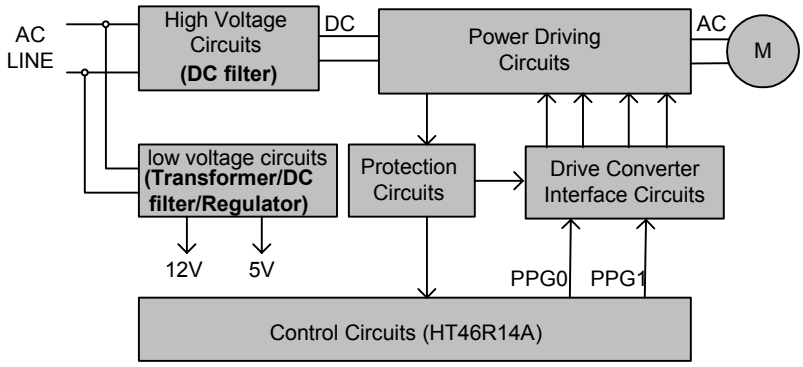


Fig.1

Example Circuit Functional Description

The example circuit has at its centre a Holtek HT46R14A MCU. Its main function is to provide driving signals for a single phase AC induction motor. The important circuits include high voltage circuits, low voltage circuits, power driving circuits, drive converter interface circuits, protection circuits, control circuits etc.



High Voltage Circuits

The main parts here are a bridge rectifier and filter, to power the main power high voltage DC circuits.

Low Voltage Circuits

The AC first passes through a transformer to reduce the voltage and then a bridge rectifier, filter and regulator to provide two voltage levels, 12V and 5V, which are provided to the driver interface circuits, protection circuits and the MCU controller circuits.

Power Driving Circuits

The Power Driving Circuits are composed of power switches which are used to drive the load. Such applications usually utilise IGBTs or Power Mosfets. This circuit uses four IRF840 Power Mosfet transistors, to form a bridge driver circuit, which is used to drive a single phase AC induction motor load.

Driver Converter Interface Circuit

The driver converter interface circuits sits between the MCU controller circuit and the power driver circuits. It provides voltage interface conversion, supplies Dead Time protection and Shut Down function protection etc. The present circuit uses two IR2109 devices as a driver converter interface.

Protection Circuits

In the present example the protection circuits are for over-current protection and will protect the system from overload situations. The designer may wish to add further protection such as circuits for over-voltage, low-voltage etc. This circuit′s output is connected to the SD pin of the IR2109 device and the MCU INT pin. Should a situation of over-current present itself, then the protection circuit's output pin will go from high to low which will shut-down the IR2109 and generate an MCU interrupt. The MCU will then return to its reset condition and stop outputting information.

Controller Circuits

The controller circuit uses the Holtek HT46R14A MCU device′s PPG function as the central part of the system. The MCU controller circuit provides the following functions:

- Uses a VR for speed control, uses an ADC to monitor the desired speed
- Uses the PFD to control the 32kHz carrier wave output, uses the PPG to control the PWM duty cycle signal
- Controls the frequency output to have a range between 10Hz and 120Hz
- Provides a two stage V/F control for increased deceleration function
- Over-current stop motor protect function
- Display over-current and rotation status
- Start and stop switch functions

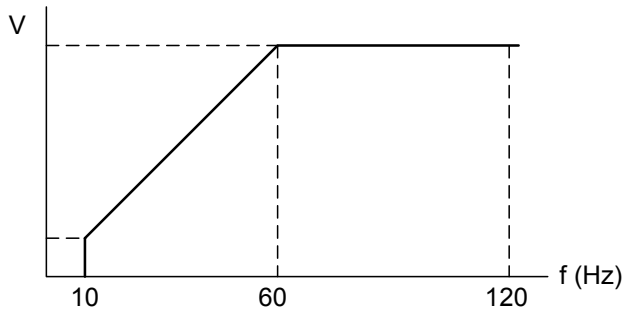
Software Description

MCU Hardware Function Description

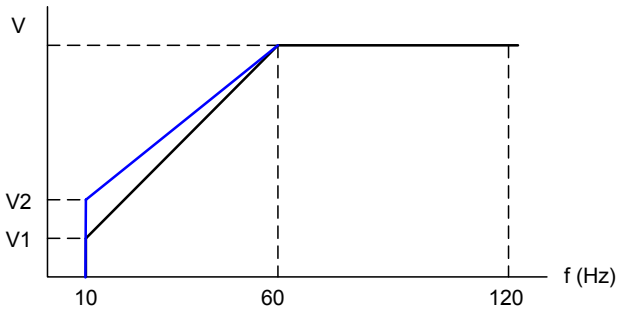
The HT46R14A MCU has an operating frequency of 16MHz and a PFD output function connected to COMP1 and negative terminal C1VIN- and the INTOB pin to act as the PPG0 and PPG1 signal source. A VR is used to control the speed. INT0B is used as an over-current interrupt input source. When a situation of over-current exists, an interrupt will be generated which will stop the system from operating and illuminate an LED to indicate an over-current status has occurred. The system also provides a system running LED. A start and stop switch is provided to control the motor start and stop function.

MCU Software Function Description

- Timer 1 is the PFD clock source. The main function of the PFD is to generate a carrier wave frequency to supply a signal source for PPG0 and PPG1. The carrier wave in this example is setup using the program to be 32kHz. The designer can setup different values according to their requirements, by changing this value. When changing this value, the PPG0 and PPG1 preload value must also be changed.
- Timer 0 is used to control the output frequency which is used to control the rotational speed of the motor. Its prescaler and internal values are setup by the VR rotational position. After an ADC conversion the value is placed into the Timer 0 register.
  Timer 0 internal register value is:
  Timer 0 = 16M/25/128/2/VR actual rotational value = 2500/VR
  ″16M″ is the system frequency
  ″25″ is the steps of the 180° degree sine wave
  ″128″ is the Timer 0 prescale value
- PPG0 and PPG1 are PWM outputs, which create sine wave positive and negative half period outputs. A PWM output has a fixed frequency but has a variable pulse width. The system has a sine pointer which reads a sine stable step by step. When the actual rotational frequency is greater than 60Hz, the PPG0 and PPG1 values will be the values read from the sine table. When the frequency is less than 60Hz, then the PPG0 and PPG1 values will be equal to the VR actual value × sine table value ÷ 60. The sine table values are a 180° degree sine wave divided into 25 rotational sections.
- Rotational speed is controlled by the VR. After conversion by the A/D it will obtain a value of between 10 and 120, and after some manipulation will be placed into the Timer 0 register. This allows the rotational speed to have a range between 10Hz and 120Hz.
- The software outputs a frequency between 10Hz to 60Hz which is controlled by the V/F relationship. There are two settings for the V/F which is selected by jumper JP2, to select either the standard V/F or a V/F2 setting as shown in the diagram. If the jumper JP2 is shorted then the V/F2 setting is selected.

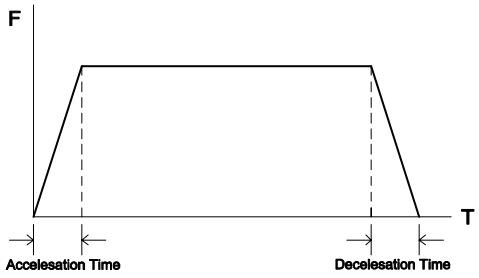


V/F Relationship



Modified V/F2 Relationship

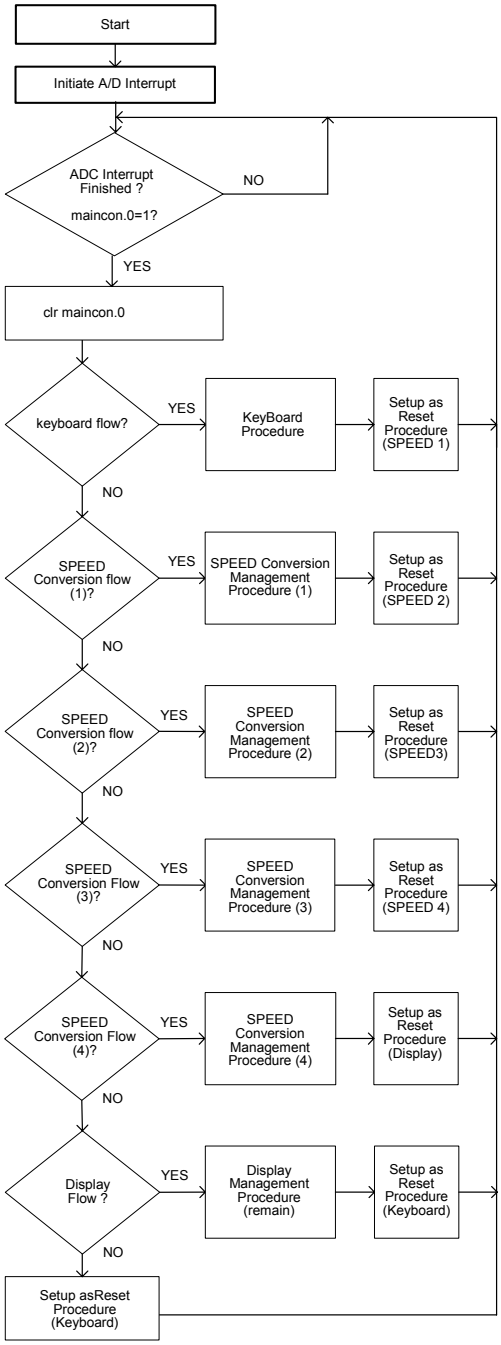
- When changing the time of the acceleration and deceleration, the motor driver′s startup acceleration rate can be used to obtain more gentle acceleration and deceleration. The AC motor driver will, according to the acceleration time, allow for different acceleration and deceleration curves.



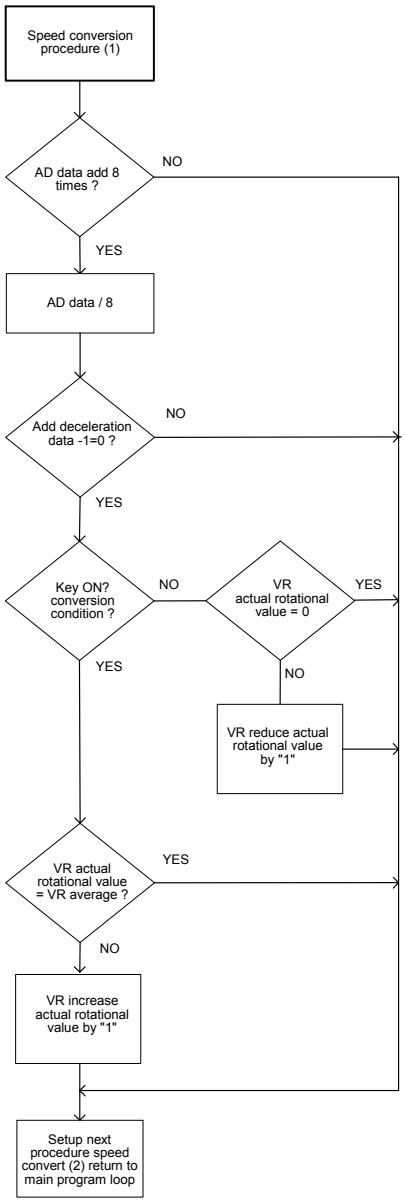
- INT0B is used for the over-current interrupt input source. When an over-current situation occurs an interrupt will be generated and the software will stop the PPG0 and PPG1 outputs and return to the initial conditions to protect the system.

FlowChart：Time Division Multiplexing

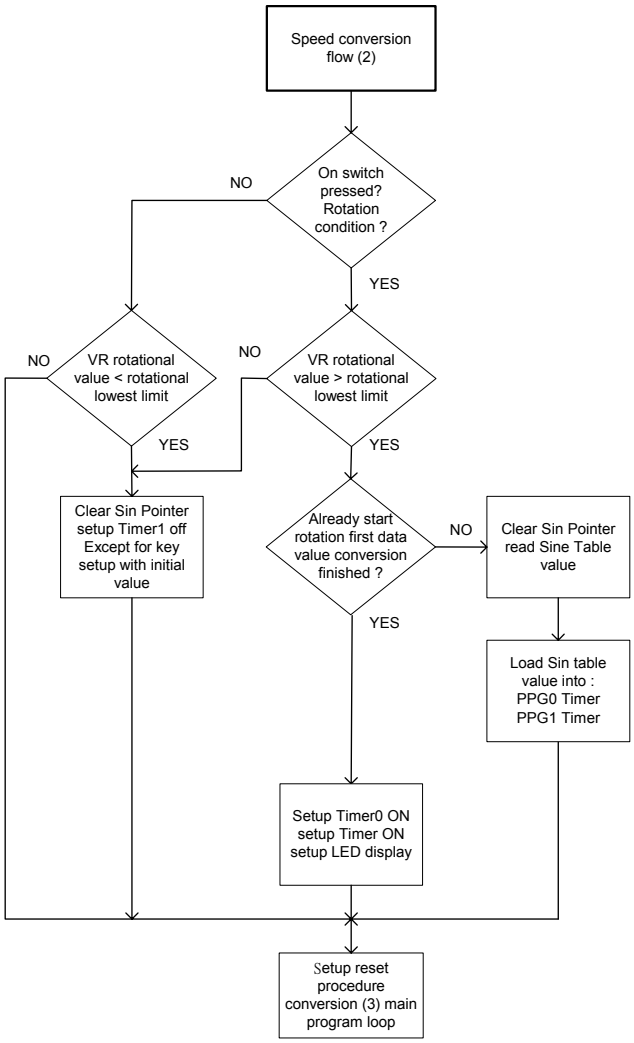
a. Main Flowchart



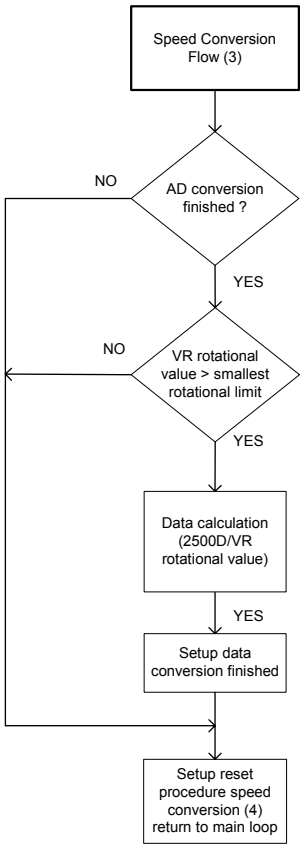
a-1. Speed Conversion Flow (1)



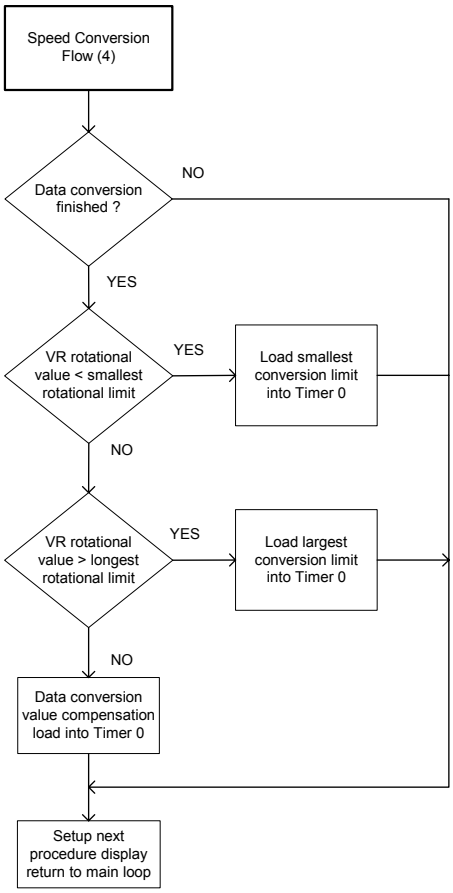
a-2. Speed Conversion Flow (2)



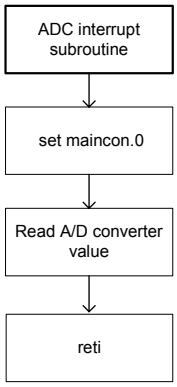
a-3. Speed Conversion Flow (3)



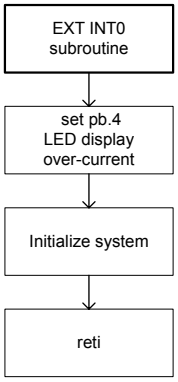
a-4. Speed Conversion Flow (4)



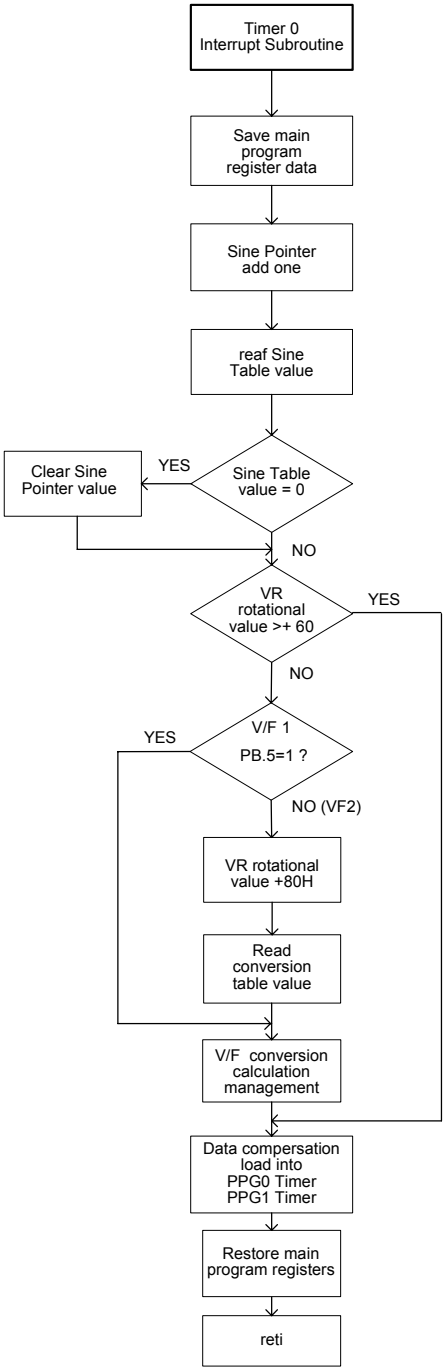
b. AD Interrupt Subroutine



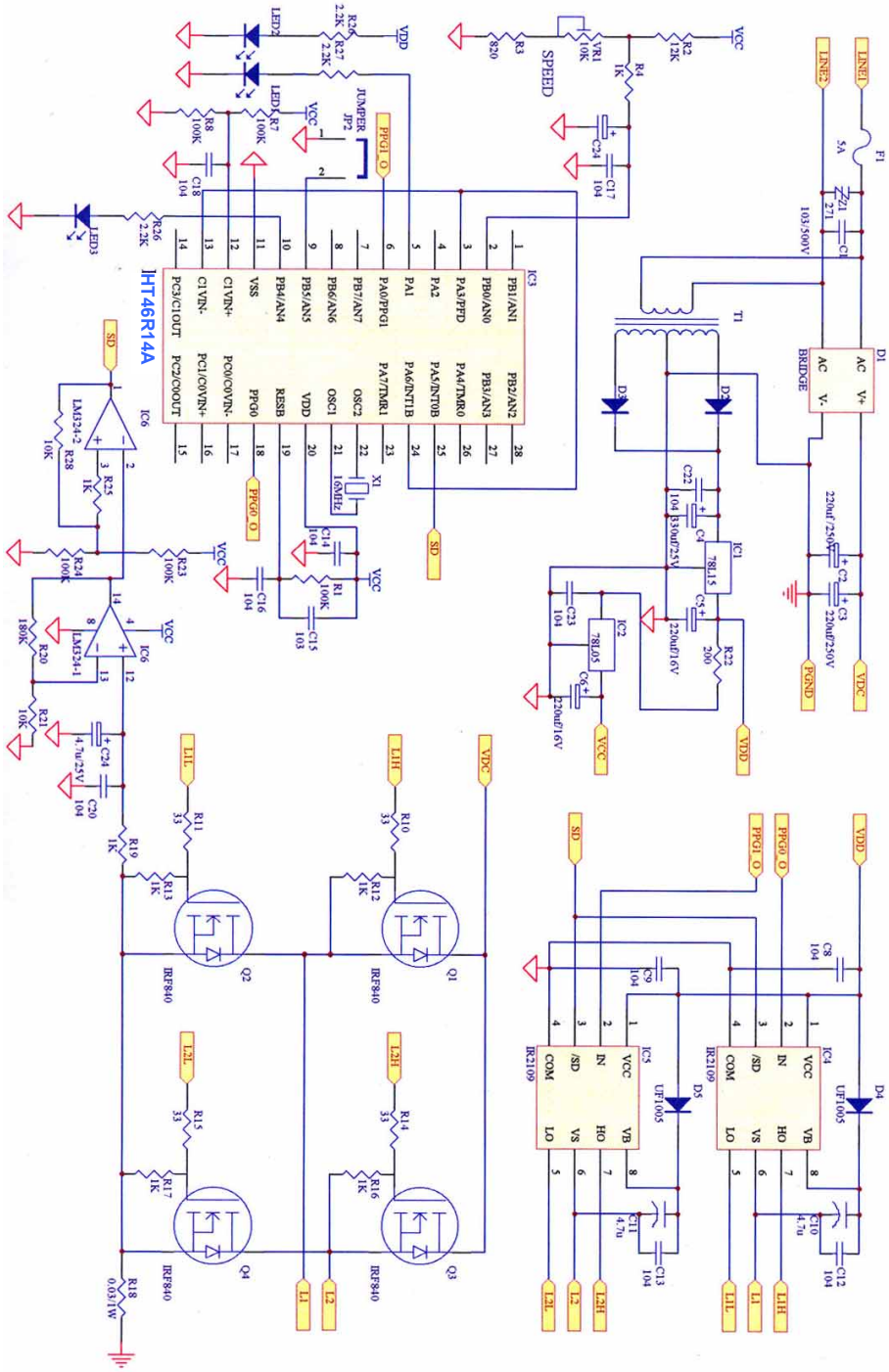
c. EXT INT0 Interrupt Subroutine



d. Timer0 Interrupt Subroutine



Application Circuit Example

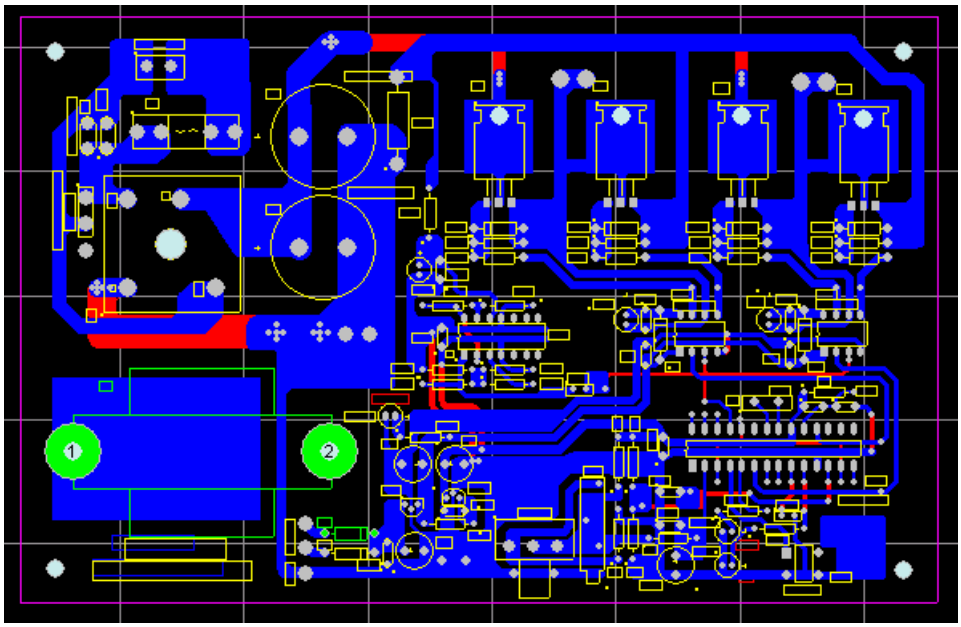


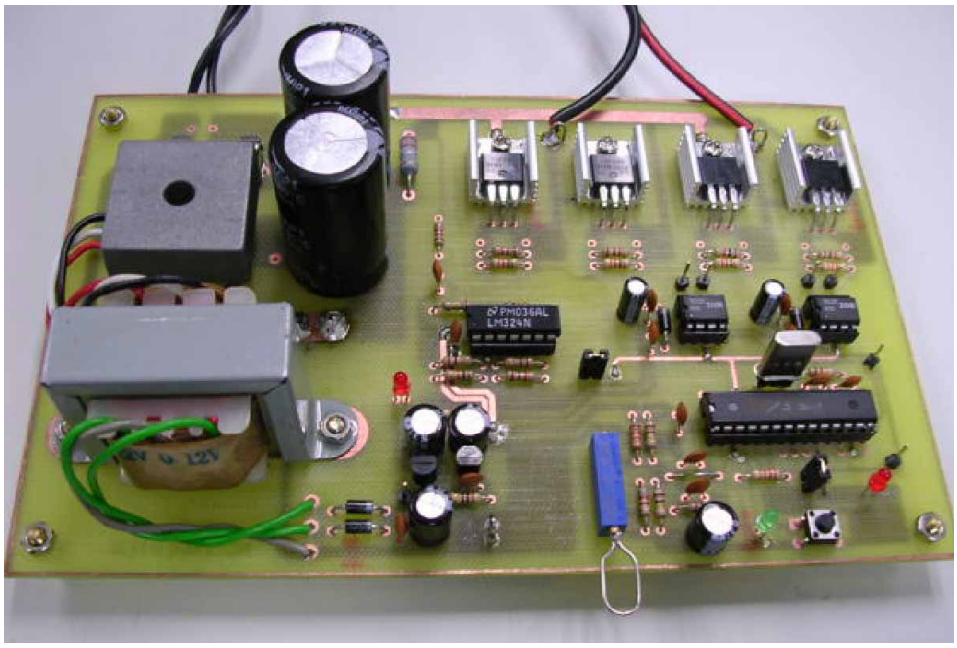
Option Table

PA3/PFD	Enable PFD
PPG1	Enable
Pull-high PC0~PC3	Non-Pull-high
PFD Clock Source	from Timer 1
OSC	Crystal
XTAL OSC	>10MHz Mode
WDT	Enable
WDT Time out select	WDT Clock source/2^{16}
WDT Clock Source	WDTOSC (12kHz)
CLRWDT	One clear instruction
LVR	Enable
PPG0 output	Active high
PPG0 timer	Synchronized with clock
PPG1 output	Active high
PPG1 timer	Synchronized with clock

Bit	7	6	5	4	3	2	1	0	
Pull-high PA0	0	0	0	0	0	1	0	0	1=Pull-high; 0=Non-pull-high
Wake-up PA0	0	0	0	0	0	0	0	0	1=Wake-up; 0=Non-wake-up
Pull-high PB0	0	0	1	0	0	0	0	0	1=Pull-high; 0=Non-pull-high

PCB and Demo Board





Revision History

Revision: V1.10

Updated Date: 2007/07/16

Modified Contents: The original HT46R14 part number has been modified to HT46R14A.