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## IRADK10 Motor Drive Reference Design Kit

3-phase 115-230V 0.5HP  
Variable speed Motor Drive  
control for Appliances and  
light Industrial Applications.

### Demo kit Board Features

- 115/230VAC input,
- 400W, 3 Phase, variable voltage output.
- NTC thermistor inrush current limiter.
- Micro controller 8-Bit with A/D converter.
- Constant volt-seconds control.
- Opto-isolated RS-232 serial link interface to the Graphic User Interface software.
- Fault protection for over current and over temperature.
- Integral aux. power +15V and +5V.
- AC input EMI filter and on/off switch.

### Plug<sup>n</sup>Drive™ Power Module

- 600V NPT IGBT technology.
- Current rating 5A @ T<sub>c</sub>=100°C.
- Monolithic IC Driver.
- Cross-conduction prevention logic.
- Optimized gate drive for reduced EMI.
- IMS substrate ground plane provides EMI shielding.
- Fully isolated screw mount package.

### Graphic User Interface Control Software

- Displays DC-link current and power module and heat sink temperatures.
- Displays Driver status.
- GUI user settable parameters:
  - Motor operating frequency.
  - IGBT conduction dead time.
  - Motor acceleration.
  - PWM frequency.
  - IGBT temperature limit.



Figure 1 IRADK10 Reference Design Kit

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### General Safety notes

This controller (frequency inverter, DC controller) operates at high voltage to control rotating machinery. The heat sink operates at elevated temperature. This equipment must be operated by qualified, skilled personnel conversant with all applicable safety standards.

### Installation

The Demo Board must be placed on an insulating surface with a suitable cooling fan to control heat sink temperature. Suitable mating connectors must be used for the GUI and motor interfaces. Do not make any alterations or soldered connections to the printed wiring board. Verify that the input selector switch matches the AC supply voltage.

### Protection

A flashing yellow LED indicates that DC bus voltage is present. Before handling the controller, check that this LED is not flashing and that the AC input voltage applied to J4 pin1 and pin2 is turned off.

**Note:** High voltage is present on the motor connections during operation.

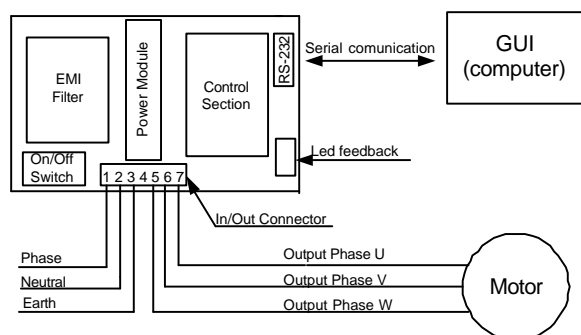


Figure 2 Typical Connection Diagram

### System Description

The IRAMS10UP60X is a complete 3 phase drive for appliance and other small motor drive applications. It is a power conversion unit for a 120V, 230V, 3-phase, 350W AC PWM (Pulse Width Modulated) drive. The system is based on an 8-Bit Micro controller used to generate the PWM information and implement the motor control loop. The power stage is the new IRAMS10UP60A, Advanced Intelligent Power module (AIPM) developed and optimized for electronic motor control in appliance applications, such as washing machines and refrigerators. This 600V power module contains 6 IGBTs with soft recovery commutation diodes, 3 bootstrap diodes and one 3-phase IC driver. There is also a thermistor to monitor IGBT temperature and an RC network for automatic fault trip reset.

Figure 1 shows the complete assembly of the IRAMS10UP60A Reference Design Kit. and Figure 2 illustrates a typical connection block diagram.

The printed wiring board has been designed to minimize ground loop currents with particular attention to reducing EMI generation. The use of the Graphical User Interface (GUI) enables the user to control motor speed and set the basic control parameters such as PWM frequency and shut down conditions via the serial link.

The micro controller generates the constant volt-seconds PWM signals from the instructions entered into the GUI. The GUI also displays all the micro controller parameters. This feature enables the user to monitor the actual operation parameters in real time. Three LEDs are used to monitor the electrical status of the control board:

- Yellow flashing: DC bus voltage present.
- Green: Drive operational.
- Red: Fault condition.

All the protection functions are enabled by the software. The micro controller monitors the DC bus voltage and current and the heat sink temperature. Shut down is activated if one of the following conditions is present:

- DC bus over voltage.
- DC bus over current.
- DC bus undervoltage.
- IGBT over temperature.
- Heat sink over temperature.

The GUI will display which fault has been detected and guarantees complete protection for the power stage. The maximum case temperature can be set through the GUI from 25°C to 100 °C.

The auxiliary power supply uses a UC3842D single ended current mode PWM controller in a buck topology with linear post regulators to deliver 5V and 15V DC referenced to the DC bus return. The auxiliary power supply operates open loop at 50KHz with a fixed duty cycle. Voltage regulation is maintained over a DC bus voltage variation from 60VDC to 400VDC.

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## Electrical and mechanical description

The Printed wiring board is a double sided 100 x 160 mm board using a mixed technology of SMT and through hole components.

The layout of the connectors, indicators and user controls is shown below in Figure 3.

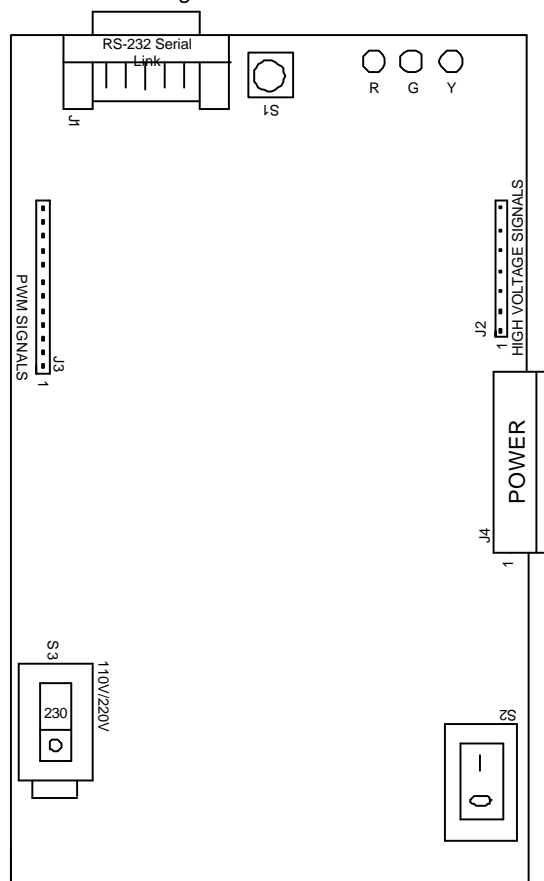


Figure 3 Connectors and indicators layout

**RS-232 Serial Link:** 9-pin female standard shell (DB9) connector provides for an opto-isolated RS232 serial link with the PC at a fixed rate of 2400 Baud, no parity, 1S + 1S.

**R, G and Y** are three LED diodes (red, green, yellow) to reflect the drive status.  
The yellow diode blinks when the bus voltage is present. The red diode lights on fault and the green one lights when the drive is ON.

**PWM SIGNALS** is the strip of pins with low voltage (TTL) signals.

**HIGH VOLTAGE SIGNALS** is the strip of pins with high voltage PWM signals (i.e. the motor voltages).

**POWER (J4)** is the main connector with the AC 115/230V power supply, earth connections and the motor (A-B-C) connections.

**110V/220V(S3)** is the selector switch for the input voltage

**Power Switch (S2)** is the power switch to turn ON/OFF the system

## RS-232 Serial Link:

A standard 9 pin D connector is used for the RS-232 serial link. The pins used on this connector are the RxD, TxD, GND, RTS, and DTR. The RTS and DTR signals provide sufficient current to drive the opto-couplers. The current drawn from these pins is far below permissible limits for the RS232 drivers. The board will communicate with the GUI tool (supplied with the board), if the drivers for the serial link are already installed. Notice that either the COM1 or COM2 port of your PC has to be available, the code will not work with COM3 or COM4. The serial cable may be connected or disconnected at any time without having to restart the computer.

## LED board displays:

Yellow, Green and Red LEDs are mounted at the edge of the board. At power-up, the auxiliary power supply will operate if the input voltage exceeds 85% of rated voltage. The yellow LED will flash for normal bus voltages above 60VDC indicating "DC bus voltage present". If the drive is enabled and the motor is being driven, the green LED stays ON indicating "Drive operational". In the event of a fault condition, the red LED activates indicating "Fault condition" and the green LED extinguishes.

To restart the system the user can perform one of the following operations:

- 1) Press the RESET push-button on the board (see below);
- 2) Click on the reset command in the GUI (PC);
- 3) Remove and re-apply AC power.

The reset button is located next to the serial link connector. Press and hold this button for 1 second to restart the micro processor.

### **PWM phase command signals**

This carries the signals as shown below. Note that these signals are referenced to the negative DC power rail which is **not** at ground potential. **Beware of electric shock hazard and do not connect any grounded test equipment such as an oscilloscope to these test pins.**

- Pin 1:** Phase A upper switch ON command, inverted
- Pin 2:** Phase B upper switch ON command, inverted
- Pin 3:** Phase C upper switch ON command, inverted
- Pin 4:** Phase A lower switch ON command, inverted
- Pin 5:** Phase B lower switch ON command, inverted
- Pin 6:** Phase C lower switch ON command, inverted
- Pin 7:** ITRIP signal
- Pin 8:** SP1 spare digital input
- Pin 9:** SP2 spare digital input
- Pin 10:** GROUND (0V) referred to - DC bus
- Pin 11:** Spare analog input referred to -DC bus rail
- Pin 12:** +5V auxiliary power supply referred to - DC bus rail

### **High voltage signals J2**

This connector J2 carries the motor drive voltages and the DC bus voltage. Use the same cautions as referenced above for the PWM phase command signals.

- Pin 1:** Phase A motor voltage
- Pin 3:** Phase B motor voltage
- Pin 5:** Phase C motor voltage
- Pin 7:** MINUS DC bus rail
- Pin 10:** PLUS DC bus rail

### **Power Connector J1**

Power connector provides the input AC power and the motor connections.

- Pin 1:** Input AC voltage (115V or 220V) phase
- Pin 2:** Input AC voltage (115V or 220V) neutral
- Pin 3:** Ground connection ( has to be connected to reduce the EMI noise)
- Pin 4:** Ground connection
- Pin 5:** Phase C motor connection
- Pin 6:** Phase B motor connection
- Pin 7:** Phase A motor connection

### **110V/220V selector switch S3**

S3 is the selector switch to set the correct rectifier configuration to the AC input.. Prior to connecting the system to the AC input, carefully check the position of S3. **Operate the switch only when the AC is OFF.** The drive will be damaged and the user could be injured by ignoring this warning.

### **Connecting the inverter to the motor.**

Use a 3-phase 115V Y connected or 220V delta connected induction motor rated at ½ HP or less. Provide a 3 wire, 2A minimum rated cable for the motor connection, and a 3 wire 2A minimum rated cable for the AC mains connections. Make sure you also attach the ground connection. The motor phase connections can be connected in any sequence, only the rotation direction will be affected. Make all the necessary connections, including the serial link with the PC before applying AC power.

### **Operating the motor via the GUI tool.**

After connecting all the cables and selecting the desired settings in the GUI, apply the AC power via S2 in position 1. After a few seconds, provided the main voltage is within tolerances, the yellow LED diode will flash denoting the presence of the DC-bus voltage.

Start the GUI tool. The first screen will prompt you for the COM port used for PC to DEMO board communication as is showed in the figure 4. Select either COM1 or COM2 for this purpose.

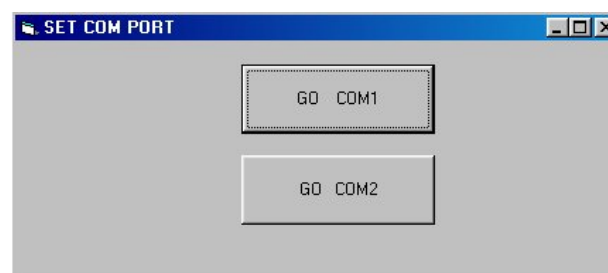
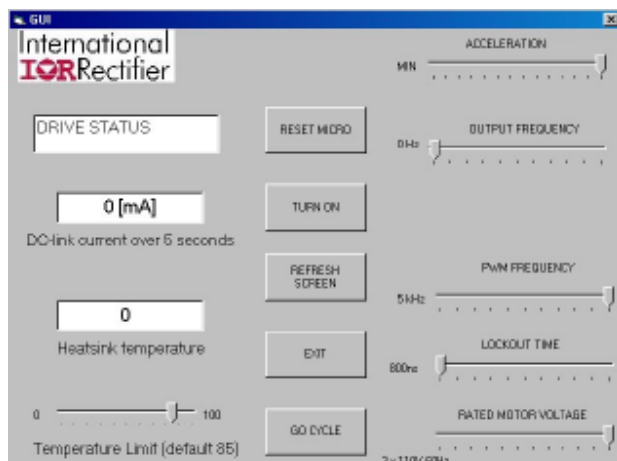


Figure 4. GUI serial connection selections

This will lead you to the next screen. Observe at the top-left a white field with the "DRIVE STATUS" label. Pressing the "REFRESH SCREEN" button will read the drive status (ON, OFF, eventual SC, OV, UV, I2T, and heat sink over temperature) and print a message in the top-left white field. Below the "DRIVE STATUS" field, another white field is observed with the caption "DC-link current average value over 5 seconds". Pressing the "REFRESH SCREEN" button will read the drive DC-link current averaged over 5 seconds and display the value in mA units. Further below, in the same far left column, another white field is observed with the caption "Heat sink temperature". Pressing the "REFRESH SCREEN" button will read the drive heat sink temperature and display the value in degrees Centigrade.

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Below said field, at the bottom left, observe the slider with the caption "Temperature limit (default 85)". Using this slider you may adjust the temperature threshold for the thermal protection. A default value is 85 degrees Centigrade, but you may change this value<sup>1</sup>. Figure 5 shows GUI control screen.

## The Command Buttons

The **"RESET MICRO"** button will reset the microprocessor when pressed, restarting the board after a fault conditions. You may want to use this button to stop the motor immediately when a dangerous situation occurs.

The **"TURN ON"** button will enable the inverter and set the green LED diode ON (unless a fault is present).

The **"REFRESH SCREEN"** button is used for updating the drive variables displayed on the screen.

The **"EXIT"** button is used to exit the GUI tool and go back to the operating system.

The **"GO CYCLE"** will bring you to the next form, wherein the drive cycle control may be adjusted, programmed, started and stopped.

Observe the 5 sliders on the right side of the screen used for adjusting:

- The drive acceleration constant.
- The drive frequency (i.e. speed) command expressed in [Hz].
- The IGBT PWM frequency selection (5 kHz or 10 kHz).
- The IGBT inverter lockout time selection (800ns or 1600 ns).
- The motor rated voltage and frequency selection.

All these sliders are in their default position at start. Moving the appropriate slider handles into new position will automatically activate the serial link and pass the new parameter to the drive.

<sup>1</sup> When using sliders for the parameter adjustment, bring the mouse pointer over the slider handle, press and hold the mouse button, move the handle observing small yellow-framed numbers that will appear indicating the current slider handle position, place the handle precisely to the position wanted and release the mouse button. Carrying the slider handle away from the range and releasing the mouse button there will have NO effect on the drive parameter change.



### Cycle control description

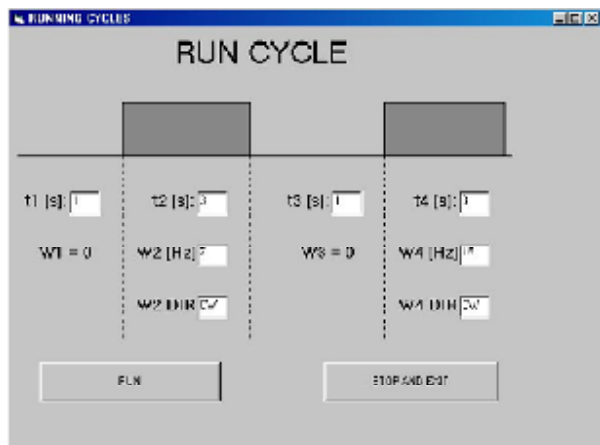


Figure 6. GUI control panel screen

As stated above, the “GO CYCLE” command button of the GUI tool will bring you to the next form, wherein the drive cycle control may be adjusted, programmed, started and stopped.

Observe 4 time intervals (t1, t2, t3, t4) and the frames where their duration may be adjusted by editing the number written in the appropriate fields. When adjusting these numbers, make sure you enter an integer number of seconds not exceeding 30.

For the time intervals t1 and t3, the assumed speed reference is zero. Intervals t2 and t4 will have non-zero speeds. Their speeds W2 and W4, expressed in [Hz] may be adjusted by editing the fields indicated by W2 [Hz] and W4 [Hz] labels.

You must enter an integer number between 0 and 100. for both intervals, the direction of rotation is adjusted by writing into the CW/CCW fields.

When a CW string is found in above fields (default), the CW direction of the motor shaft is commanded. Otherwise, for whatever string other than CW, the drive assumes a CCW direction. The cycle begins by pressing the “RUN” button. Whenever the user wants to stop the cycle, the STOP button has to be pressed. The “STOP” button will decelerate the motor. During deceleration a “WAIT!!!” message will appear across the form, and the GUI will revert to the previous frame once the speed reaches zero. While the cycle is running, the user may observe the DC-link current and the heat sink temperature.

### Drive Status Feedback

The “DRIVE STATUS” display is the field where the GUI indicates what caused the drive to shut down protecting the power module. The micro controller will shut down the system if one of the following faults occurs:

- **Short Circuit:** is shown when a short circuit is applied from phase to phase at the output connections.
- **Over Voltage:** is shown when the DC bus voltage exceeds 400V. Note The bus voltage can climb to a shut down condition if the deceleration setting is set too high.
- **Under voltage:** When the input AC voltage at the rectifier is insufficient to provide a bus voltage of 100VDC, the system shuts down and cannot start the motor.
- **I<sup>2</sup>T:** This is the IGBT SOA protection. If the output power exceeds 400W for over 2 minutes, the power inverter will shut down preventing the power module from over-heating.
- **Heat sink over temperature:** If the heat sink temperature rises more than “Heatsink temperature” set by the user, the system will shut down.



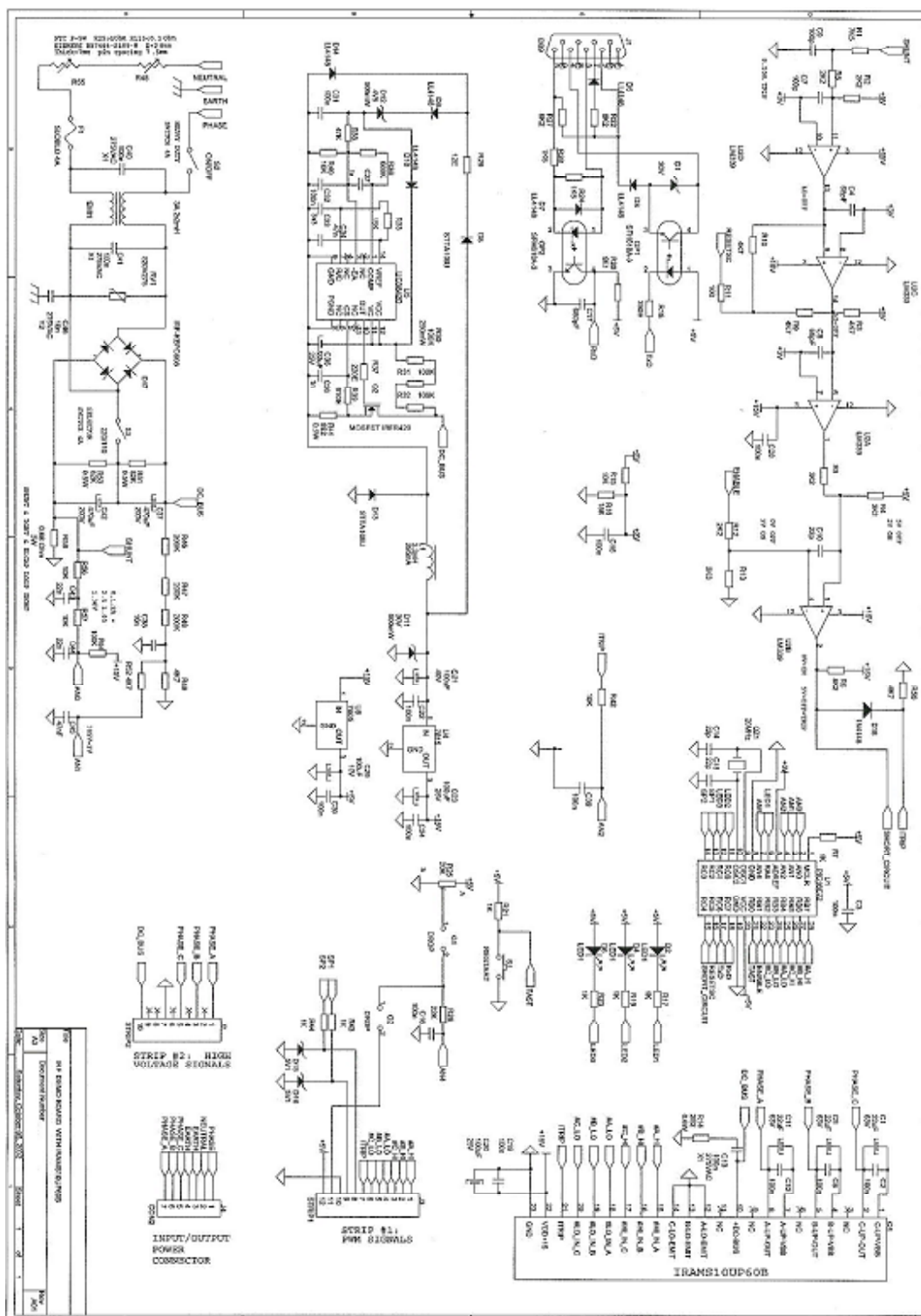
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## Technical Data

Electrical Specification:	Input Voltage 230 V/50Hz and 115 V/60Hz single Phase.
	Output for 3-phase 0.5 HP AC Induction Motor.
	Soft start with relays on the Board.
	Surge absorber.
	High frequency input EMI filter following the CISPR 14.
	On-board power switch.
	Input fuse.
	Light indicator when DC bus voltage is present.
	Input/output terminal strips - IR to provide catalogue number.
	Opto=isolated RS-232 serial interface to outside world.

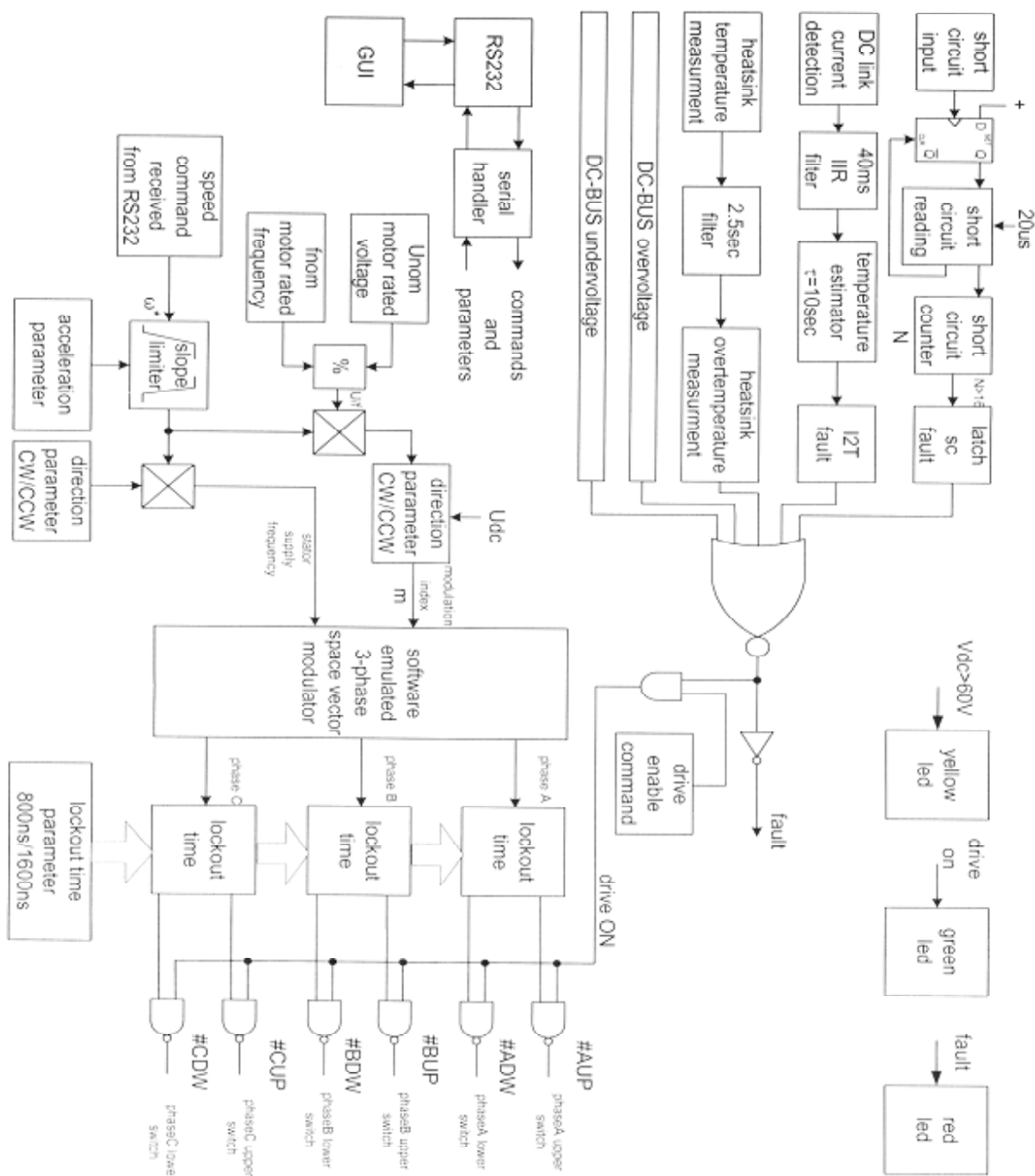
**Schematic:**



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## Software block diagram:



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Printed in U.S.A. 11/08

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WORLD HEADQUARTERS: 233 KANSAS ST., EL SEGUNDO, CA 90245, USA

N.A.	N.E. US	+1 203 355 1228
	S. US	+1 919 844 5499
	S.W. US	+1 949 838 0161
	N.W. US	+1 303 469 6303

EUROPE

ITALY	+39 011 451 0111
GERMANY	+49 6102 884 400
GREAT BRITAIN	+44 20 8645 8000

TECHNICAL ASSISTANCE CENTER : N.A. +1 310 252 7105  
EUROPE: +44 20 8645 8015  
ASIA: + 65 6838 4632  
[HTTP://TAC.IRF.COM](http://TAC.IRF.COM)