

# PAC5220 Hall Sensor BLDC

*Power Application Controllers™*

Firmware / Graphical User Interface User Guide



[www.active-semi.com](http://www.active-semi.com)

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## OVERVIEW

The PAC522x BLDC Hall Sensor GUI is the Windows Application software employed to communicate with any of the PAC5220 or PAC5223 hardware platforms running the Hall Sensor FW algorithm. Said FW application has been tailored to control the motor in question while immediately reacting to hall effect sensor changes by using a simple algorithm which relies on the fast acting interrupt service routines behind some of the internal timer modules. For BEMF Sensor-less commutation, a different application and firmware combination must be used.

The BLDC Hall Sensor firmware has been written so the motor operates in one of two modes. Open Loop Mode will commutate the motor by reacting to hall sensor transitions. It is considered to be open loop as speed is not regulated. Closed Loop Mode will commutate the motor throughout speed regulation. The application enables the user to exercise the different modes.

The GUI is written in the Microsoft's Visual Studio C# Integrated Development Environment. This Graphical User Interface (GUI) can also be used as a tool during development for motor tuning as well as during firmware debug.

Some of the applications main features are:

- Parameter download via serial communications port.
- System's status can be polled on a continuous basis.
- The ability to monitor important variables in real time.
- Access to different firmware configuration aspects such as PI loop parameters, dead time control, open loop and close loop parameters.

The following sections provide information about the Windows application software features for Active-Semi's BLDC motor drive turnkey solution.

## **APPLICATION INSTALLATION**

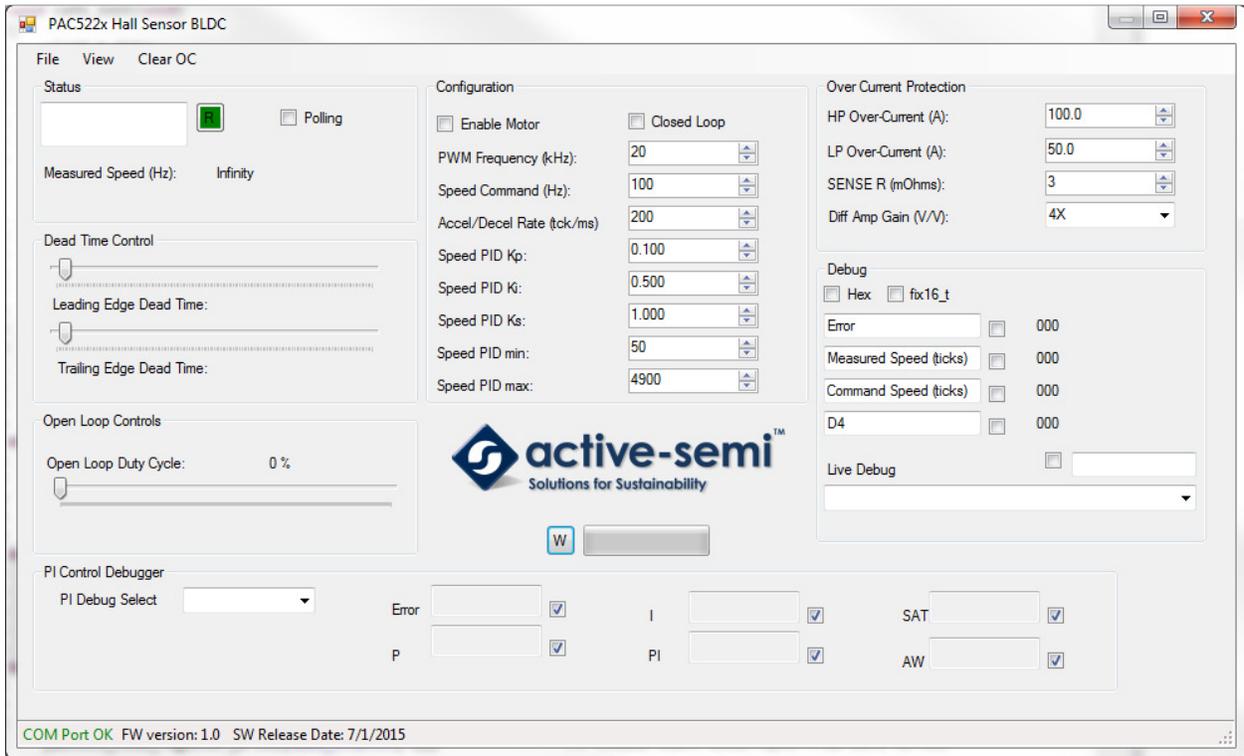
To install the PAC522x\_BLDC\_HallSensor\_GUI Windows Application, simply double click the “setup.exe” file inside the Windows Application folder. Follow application’s installer.

### **Running the Windows Application**

To start the PAC522x\_BLDC\_HallSensor\_GUI Windows Application simply go to the Windows START Button and press the PAC522x\_BLDC\_HallSensor\_GUI icon.

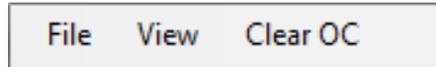
Alternatively, press the Start Button, go to All programs and press the PAC522x\_BLDC\_HallSensor\_GUI icon under the Active Semi folder.

# PAC522x BLDC Hall Sensor GUI Windows Application



The PAC522x BLDC Hall Sensor GUI Windows Application is the control panel behind the 3 phase motor driver. It can be used to control motor enablement/disablement, open and closed loop control, speed control, PI loop tuning, as well as gain insight as to some of the internal firmware features.

## Menu

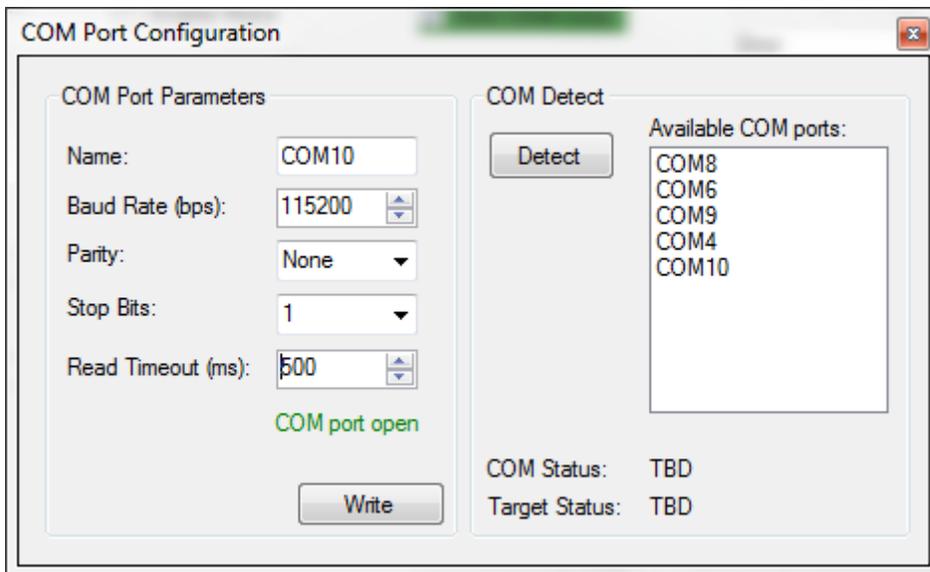


**File -> Quit:** Exits the Windows Application.

**View -> COM Port Configuration:** Displays the COM Port configuration Window

**Clear OC:** Clears an Over Current event. After an Over Current event takes place, H Bridges will remain disabled until this internal flag is cleared.

## COM Port Configuration

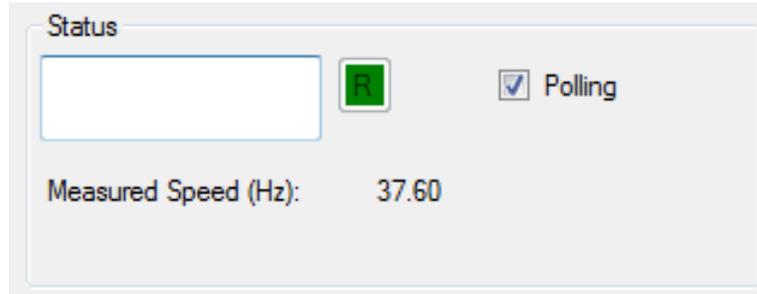


The first time the EVK-PAC5220QS-BLDCM1 is connected to the computer, the GUI must be configured to use the correct USB Port. To achieve this:

1. With the USB port connected to the computer, and the PAC5220 device powered up (LED D8 lights up), the board is discoverable.
2. If the COM Port is not show under the **Available COM Ports:** field, press the **Detect** button.
3. Press the **Write** Button

This process must only be performed once. Once the application exits, these parameters are stored within the User Parameters.

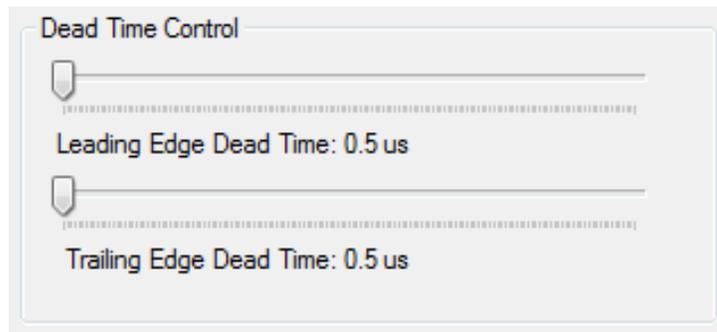
## Status Frame



The status frame offers system information in a real time fashion. The Status box will indicate when the motor is operating in open or closed loop as well as when an over current event is triggered.

In order to sample system status information, the user can enable the polling mode by checking the **Polling** checkbox. When the **Polling** checkbox is unchecked, the user can still poll the latest data packet by pressing the **R** button.

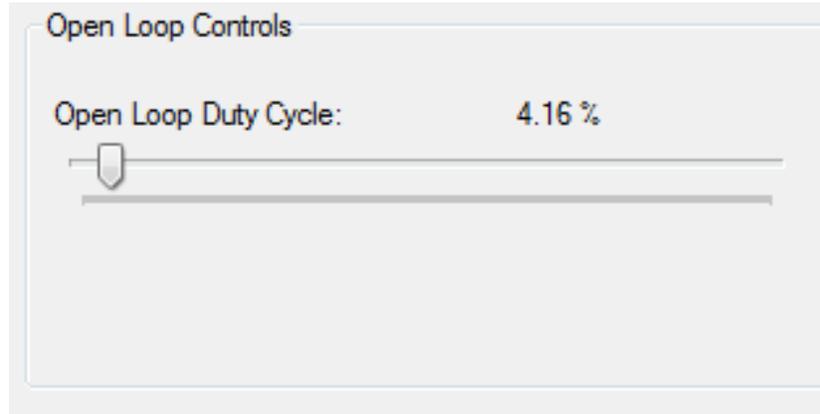
## Dead Time Control Frame



One of the advantages offered by the PAC family of devices driving external FETs, is the availability of a Dead Time delay superimposing block, which allows for the FETs on any given Half H Bridge leg to go through a disconnect/connect switching topology in a safely manner. This ensures shoot-through occurrence to be eliminated on a per switching cycle.

Dragging the Leading Edge or Trailing Edge Dead Time sliders, will configure the dead time for the three half H Bridge legs.

## Open Loop Controls Frame



When in Open Loop Mode (Close Loop Checkbox unchecked), this slider can be used to modify the 3 phase inverter duty cycle. To avoid jerky motion during startup, it is recommended for system's duty cycle to be set to 0%.

When in Closed Loop Mode (Close Loop Checkbox checked), this slider is disabled.

When system changes from Closed Loop Mode to Open Loop Mode, the 3 phase inverter will be supplying the duty cycle as specified by the speed regulation engine. The slider will not match this duty cycle value. User can change slider value as desired and system will be updated accordingly.

## Configuration Frame

The Configuration Frame GUI contains the following parameters:

Parameter	Value
<input type="checkbox"/> Enable Motor	<input type="checkbox"/> Closed Loop
PWM Frequency (kHz):	20
Speed Command (Hz):	100
Accel/Decel Rate (tick/ms)	200
Speed PID Kp:	0.100
Speed PID Ki:	0.500
Speed PID Ks:	1.000
Speed PID min:	50
Speed PID max:	4900

The Configuration frame contains important parameters such as main system parameters, as well as Closed Loop Mode parameters. The PI loop parameters and writing method are also treated under this region.

**Enable Motor:** When checked, the motor is enabled. The motor will start in Open Loop Mode and enter Closed Loop Mode if the Auto Close Loop box is checked. When the motor is moving at speed, if the checkbox is unchecked, the motor decelerates to Shutdown Speed and then is disabled. If an Over Current event has taken place before the motor is disabled, unchecking this checkbox will clear the Over Current event.

**Closed Loop:** Defines whether the motor is operating in Open Loop Mode or Closed Loop Mode. When checked, the motor operates in Closed Loop Mode and speed is regulated according to the Speed Command. When unchecked, the motor operates in Open Loop Command and the Open Loop Duty Cycle slider defines output PWM duty cycle.

**PWM Frequency (KHz):** H Bridge PWM frequency in Hz. The GUI transforms the frequency in KHz into clock cycles by following the equation:

$$PWM \# \text{ Clock Cycles} = \frac{TIMERA \text{ FREQ}}{PWM \text{ Freq} * 1000}$$

Where:

PWM # Clock Cycles is the total number of clock cycles Timer A will count up to.

TIMERA\_FREQ is Timer A's frequency; in this case initialized to 100 MHz in the firmware.

PWM\_FREQ is the value specified by the GUI

**Speed Command (Hz):** Specifies the Closed Loop Mode speed in Hz. Changing this field during normal run time, will change the motor operating speed.

**Speed PID Kp:** Control loop Proportional gain term.

**Speed PID Ki:** Control loop Integral gain term

**Speed PID Ks:** Control loop Anti Windup gain term

**Speed PID Min:** Control loop output minimum value

**Speed PID Max:** Control loop output maximum value

## Over Current Protection Frame

Over Current Protection	
HP Over-Current (A):	100.0
LP Over-Current (A):	50.0
SENSE R (mOhms):	3
Diff Amp Gain (V/V):	4X

The PAC522x devices have a series of built in protection schemes to allow the device to safeguard itself against high current conditions such as those encountered during short between power outputs (PHASES U, V and W) and power rails (VIN and GND). The HP and LP blocks grant two ways of disabling the H Bridge power stage in the event output current exceeds a pre-programmed value. This frame offers access to pre-programming the Over Current Protection Set Points.

**HP Over Current (A):** Specifies the current value at which, if reached, an HP Over Current event is triggered. On this firmware implementation, an Over Current event will disable the 3 phase H bridge in its entirety, disable the PWM generation, and clear system flags. An Over Current status bit will be asserted. In order to clear an Over Current event, the Clear Over Current menu item must be actuated.

**LP Over Current (A):** Specifies the current value at which, if reached, an LP Over Current event is triggered. On this firmware implementation, an Over Current event will disable the 3 phase H bridge in its entirety, disable the PWM generation, and clear system flags. An Over Current status bit will be asserted. In order to clear an Over Current event, the Clear Over Current menu item must be actuated.

**SENSE R (mOhms):** Specifies the SENSE resistance in milli Ohms

**Diff Amp Gain (V/V):** Specifies the Differential Amplifier Gain utilized to compute the LPDAC Over Current Set Point. This parameter must match the FW configuration. Default is 4X, but user may modify this parameter as required by the application.

Over current is defined by the SENSE resistor. On the HYDRA-X BLDC Head (EP-BLDCM1-1), the default value for the SENSE resistor is 3 mOhms.

HP Over Current Counts must be a value between 0 and 255 and it is given by the equation:

$$HP\ Over\ Current\ Counts = \frac{Amps * \frac{RSENSE}{1000} * 255}{2.5V}$$

Where:

HP Over Current Counts: is the number of counts for the internal 8 Bit DAC which will be compared against the voltage reading coming from the analog input AIO1.

Amps: is the decimal value provided by the GUI (**HP Over Current (A):**), and is directly proportional to the motor current at which an Over Current event is initiated.

RSENSE: is the SENSE resistance in mOhms (**SENSE R (mOhms):**).

NOTES:

1. The GUI will only update the HPDAC register when the **HP Over Current (A):** numeric up/down box is updated. Changing the **SENSE R (mOhms):** parameter will not update the HPDAC register.
2. If the combination of **SENSE R (mOhms):** and **HP Over Current (A):** parameters yield a number larger than 255, the result will not be transmitted and a warning will be shown. User must updated parameters before a successful write to the HPDAC takes place.

LP Over Current Counts must be a value between 0 and 1023 and it is given by the equation:

$$LP\ Over\ Current\ Counts = \frac{Amps * \frac{RSENSE}{1000} * Gain * 1023}{2.5V}$$

LP Over Current Counts: is the number of counts for the internal 10 Bit DAC which will be compared against the voltage reading coming from the analog differential amplifier (analog inputs AIO10).

Amps: is the decimal value provided by the GUI (**LP Over Current (A):**), and is directly proportional to the motor current at which an Over Current event is initiated.

RSENSE: is the SENSE resistance in mOhms (**SENSE R (mOhms):**).

Gain: is the differential amplifier gain (**Diff Amp Gain (V/V):**)

NOTES:

1. The GUI will only update the LPDAC register when the **LP Over Current (A):** numeric up/down box is updated. Changing the **SENSE R (mOhms):** parameter will not update the LPDAC register.
2. If the combination of **SENSE R (mOhms):** and **LP Over Current (A):** parameters yield a number larger than 1023, the result will not be transmitted and a warning will be shown. User must update parameters before a successful write to the LPDAC takes place.

## Debug Frame

The image shows a software interface titled "Debug". At the top, there are two checkboxes: "Hex" and "fix16\_t", both of which are unchecked. Below these are four rows, each consisting of a text box on the left and a numerical value on the right. The rows are labeled "Debug 0", "Debug 1", "Debug 2", and "Debug 3", and all numerical values are "0.00". At the bottom of the interface, there is a "Live Debug" section. It contains a text box with the value "0.00" and a dropdown menu. The dropdown menu is currently open, showing the selected item "7 App PWM Duty".

The Debug frame offers some valuable information which can aid the designer during real time motor operation. Users modifying the firmware can take advantage of this feature to see variable content without needing to stop code execution.

The firmware contains a series of variables specifically tailored to aid during debugging. The variables are called *debug\_1*, *debug\_2*, *debug\_3* and *debug\_4*. The debug frame offers a portal into the content within these variables. These variables are polled on a continuous basis whenever the **Polling** check box is checked, or can be sampled once when the **R** button is pressed.

**HEX:** When checked, specifies data will be presented in hexadecimal data format.

**Fix16\_t:** When checked, specifies data will be presented in fixed 16 data format.

**Debug 0,1,2,3 (Text Box):** Text Boxes specifying the name for the respective debug function. User can change this content according to preference.

**Debug 0,1,2,3 (Label):** debug value read from the system.

**Live Debug (Combo Box):** offers a selection of variables which can be sampled on a real time basis.

**Live Debug (Text Box):** shows the read value, as selected from the Combo Box counterpart.

## ABOUT ACTIVE-SEMI

Founded in 2004 in Silicon Valley and headquartered in Allen, Texas, Active-Semi is a rapidly emerging leader in the multi-billion dollar power management IC and intelligent digital motor drive IC markets. The company's portfolio of analog and mixed signal SoCs (systems-on-chips) are scalable core platforms used in charging, powering and embedded digital control systems for end applications such as industrial, commercial and consumer equipment. The company offers power application microcontrollers, DC/DC, AC/DC, PMU and LED drivers that significantly reduce solution size and cost while improving system-level reliability. Active-Semi's turnkey solutions deliver energy-saving power conversion architectures that minimize energy usage and compress system development cycle-time by greater than 50 percent. Active-Semi ships 50 million power ICs per quarter and reached the "one billion units shipped" milestone in May 2012. The multi-national company focuses on commercializing industry leading power management IC solution platforms and has developed broad intellectual property with over 150 patents granted and pending. For more information visit: <http://active-semi.com/>

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