AMC6821EVM and AMC6821EVM-PDK

This user's guide describes the characteristics, operation, and the use of the AMC6821EVM, both by itself and as part of the AMC6821EVM-PDK. This evaluation module (EVM) is a complete thermal management kit solution with several fan hardware configuration and temperature sensing options. This manual covers all pertinent areas involved to properly use this EVM board along with the devices that it supports, as well as the software tool in exercising the EVM. The physical printed-circuit board (PCB) layout, schematic diagram, and circuit descriptions are included.

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1 EVM Overview

This section gives a general overview of the AMC6821 evaluation module (EVM), and describes some of the factors that must be considered in using this module.

1.1 Features

This EVM features the AMC6821 Analog Monitoring and Control Circuit device. The AMC6821 EVM is a simple evaluation module designed to evaluate the functionality of this AMC device.

The AMC6821 supports the SMBus as its standard serial communication interface of up to 100 kHz of speed. The SMBus is based on the I^2C™ principles of operation, so the AMC6821 can communicate with any host microprocessor capable of the standard I^2C protocol.

The J1 header is included for easy plug-in of the standard connectors that comes with almost any cooling fans available. This header is a four-pin header to accommodate power, ground, tachometer signal, and pulse width modulation (P.M.) output signal. The J1 header is configured in such a way that most standard 2-wire, 3-wire, or 4-wire fans can plug directly into the header. But, in some instances, the fan connector configuration may change, so the connector configuration must be checked before plugging it into the J1 header.

The J5 header is also included to allow the 3-wire or 4-wire configuration as well as the 5-V or 12-V (depending on the jumper settings) power cooling fan configuration. This header provides the user with flexibility to choose between a 5-V or 12-V power as well as 3-wire or 4-wire cooling fans.

A 25-mm $\times$ 25-mm fan-mounting area is also included to secure the correct size fan to the EVM for handling and unit stability. The size of the mounting area is chosen because of the limitation with the EVM board space, and the popularity of the 25 mm cooling fans.

Two green LED indicators are provided to show that VDT and V.D. powers are on. Three red LEDs are used as alarm indicators. The alarm indicators are driven by the respective alarm pins of the AMC6821 via inverter buffers and MISFEED switches. When the alarm pins go low, the respective alarm indicator are turned on to indicate the user of an alarm condition.

The through-hole power resistor, R25, is provided so that the external remote temperature can be manipulated via the N-channel enhancement mode FET, Q5. Driving this switch via S1 heats up the power resistor, which is sensed by the temperature sensor of the AMC6821 via remote sensing transistor, Q1. In addition, a terminal, J3, is added so that any remote temperature sensor can be connected to the EVM for monitoring and control. The jumpers, W9 and W10, are also included, so that the onboard remote sensor can be disconnected from the analog input pins of the AMC6821, and allow the remote sensor that is attached to the J3 terminal to connect to the analog input pins of the AMC6821.

Note: If no remote sensor is connected to the J3 terminal upon power up of the EVM, and the jumpers W9 and W10 are open, the OVR alarm pin is triggered and creates an alarm condition that is visible via the D4 LED indicator.

1.2 Power Requirements

The following sections describe the power requirements of this EVM.

1.2.1 Supply Voltage

The dc analog power supply for the AMC6821 dt (V_{DT}) is selectable between +3.3VA and +5VA via jumper headers, W6. The +3.3VA comes from U4, and the +5VA comes from J6-3 terminal. These power supply voltages are referenced to ground through the J6-6 terminal.

The dc digital power supply requirement for V_{DD} is selectable between +3.3VD and +5VD via jumper header, W7. The +3.3VD comes from J6-9 or J12-3 (if installed) terminals, and the +5VD comes from J6-10 or J12-1 (if installed) terminals. All the digital power supplies are referenced to digital ground through J6-5 and J12-2 terminals. Some of the circuits are permanently tied to the +5VD, and this comes directly from the J6-10 or J12-1 terminals.

A 2.5 mm dc power jack connector is provided via J7. This connector is provided to route an external +12V supply into the EVM for fan supply, from a universal AC/DC power adapter such as the ADULT's MW117RA1203B01 medical power supply.

The green LED indicators, D1 and D5, for V_{DT} and V_{DD} respectively are included, to show that power is applied on the EVM board. The red LED indicators, D2, D3, and D4 are also installed to show THERM, FANFOLD, and OVR warnings respectively. See the data sheet for the conditions when these warning lights come on and go off.

CAUTION

To avoid potential damage to the EVM board, make sure that the correct cables are connected to their respective terminals as labeled on the EVM board. Stresses above the maximum listed voltage ratings may cause permanent damage to the device.

1.2.2 Reference Voltage

The AMC6821 comes with a fixed internal reference. No further control is provided for the reference.

1.3 EVM Basic Functions

The AMC6821 EVM is designed primarily as a functional evaluation platform to test certain functional characteristics of the AMC6821 analog interface circuit. Functional evaluation of the AMC6821 device is accomplished with the use of any microprocessor with SMBus or I^2C interface capability. A PC environment test evaluation kit using the USB-MODEM can be used as a standard coming out of the factory. This is covered in Section 4 of this manual.

The headers J2 (top side) and P2 (bottom side) are pass through connectors provided to allow the control signals and data required to interface the AMC6821 EVM to the USB-MODEM or any of the host processor platforms that supports the modular EVM standards available from Texas Instruments.

Another host processor platform that can be used for evaluating this EVM is the HPA449 from Softbaugh, Inc. The HPA449 is an MSP430 based platform that uses the MSP430F449 microprocessor from Texas Instruments. For more details or information regarding the different host platforms that this EVM can be evaluated on, call Texas Instruments Incorporated or email us at dataconvapps@list.ti.com.

The J4 header is specifically included for the customer to access the AMC6821 device using a custom built cable. In addition, most of the GPIO pins are mapped out to each of the alarm pins of the AMC6821 so that they can be monitored or controlled via software.

This EVM allows the user to fully control and monitor any cooling fans available in the market when used with the LabVIEW™-based EVM software evaluation tool. This tool is covered in Section 4 of this manual. See the AMC6821 data sheet for more information in configuring and controlling this device.

The EVM includes three LED alarm indicators to visually show the user whether an alarm condition does or does not exists. These LED indicators are directly driven by the AMC6821 alarm pins via Schmitt trigger invertors and MOSFET switches. The device alarm pins also go to the J2 and J4 header terminals, so that it can be connected to a GPIO for software monitoring and control.

2 PCB Design

This section covers the layout design of the PCB, thereby, describing the physical and mechanical characteristics of the EVM. The list of components used on the module is also included in this section.

2.1 PCB Layout

The AMC6821 EVM is designed using the double-wide modular EVM form factor develop by Texas Instruments. This EVM form factor allows direct evaluation of the AMC6821 operating characteristics, speeds up software development, and other prototyping needs.

The AMC6821 EVM board is RoHS complaint that is constructed on a four-layer printed-circuit board using a copper-clad FR-4 laminate material. The printed-circuit board has a dimension of 93,9800 mm (3.7000 inch) × 81,2800 mm (3.200 inch), and the board thickness is 1,5748 mm (0.0620 inch). Figure 1 through Figure 7 show the individual artwork layers.

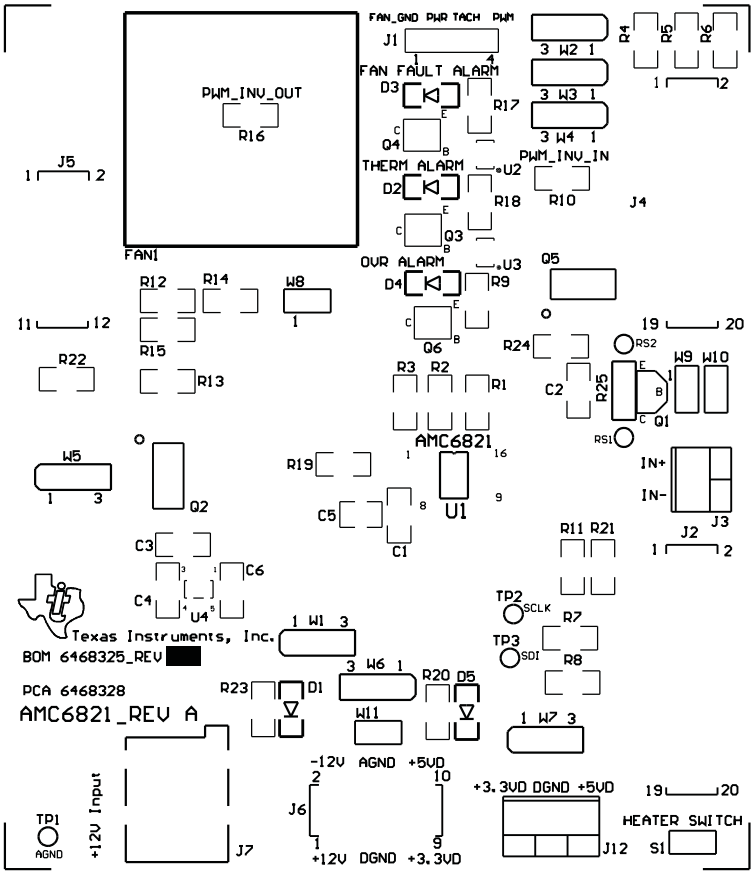


Figure 1. Top Silkscreen

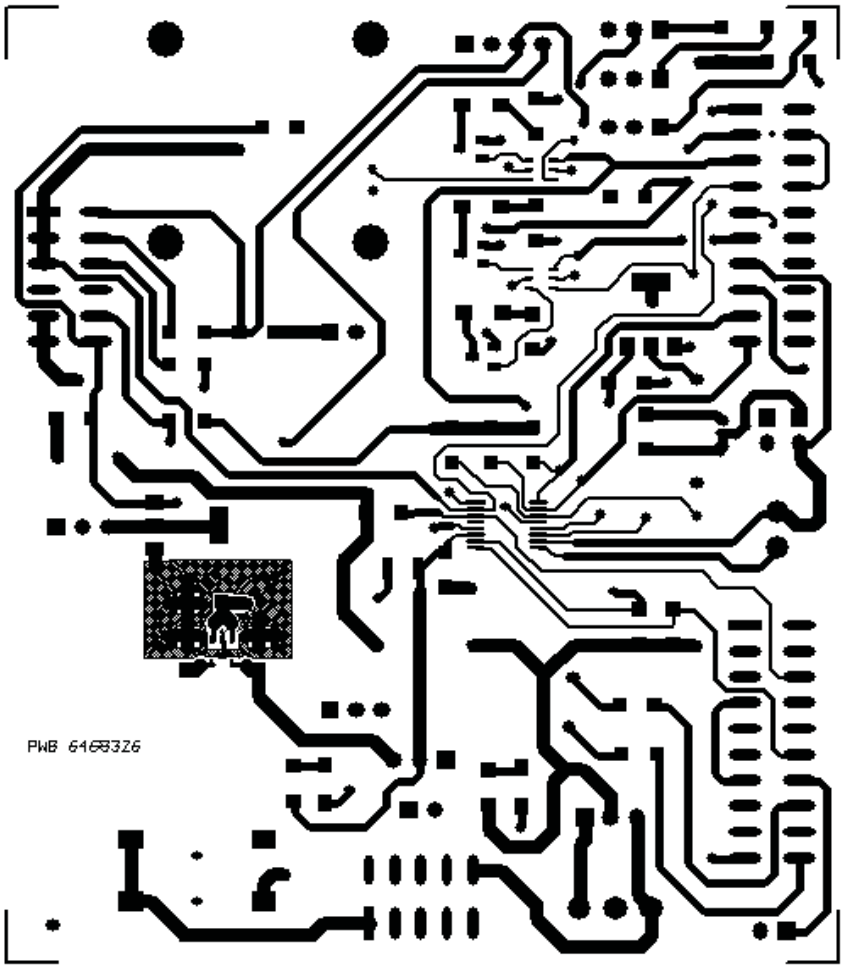


Figure 2. Top Layer (Signal Plane)

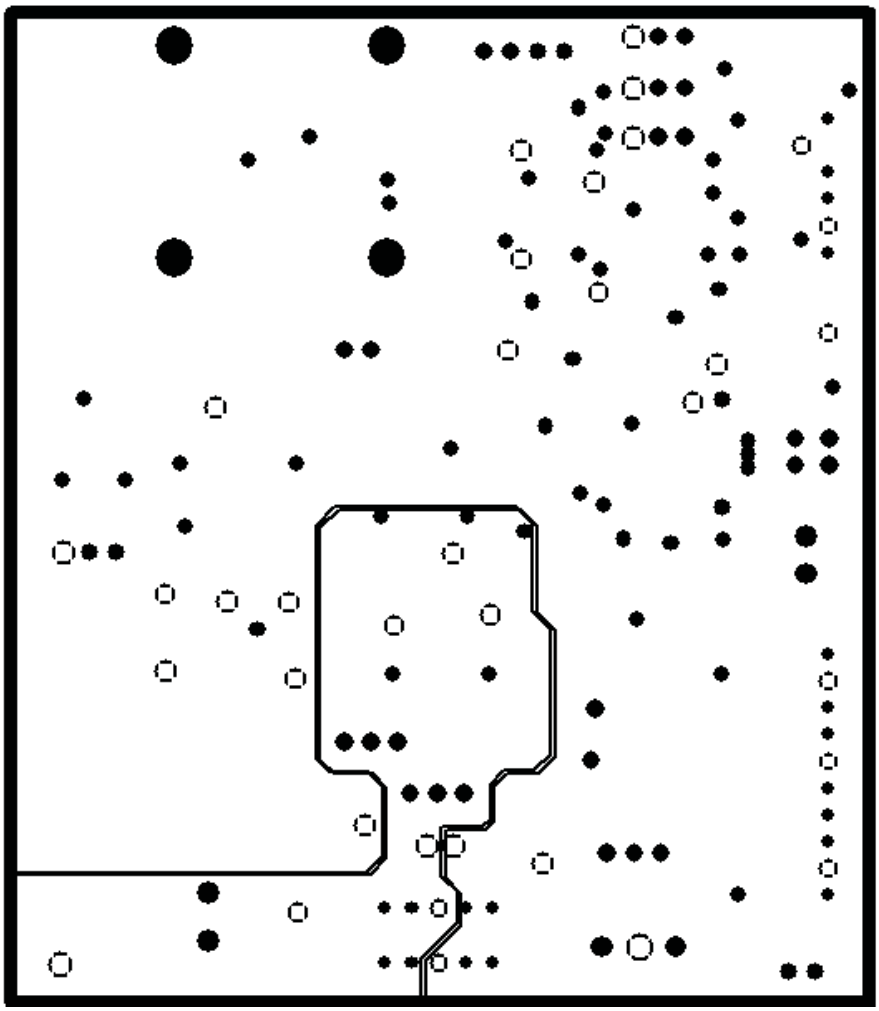


Figure 3. Internal Layer 1 (Split Ground Plane)

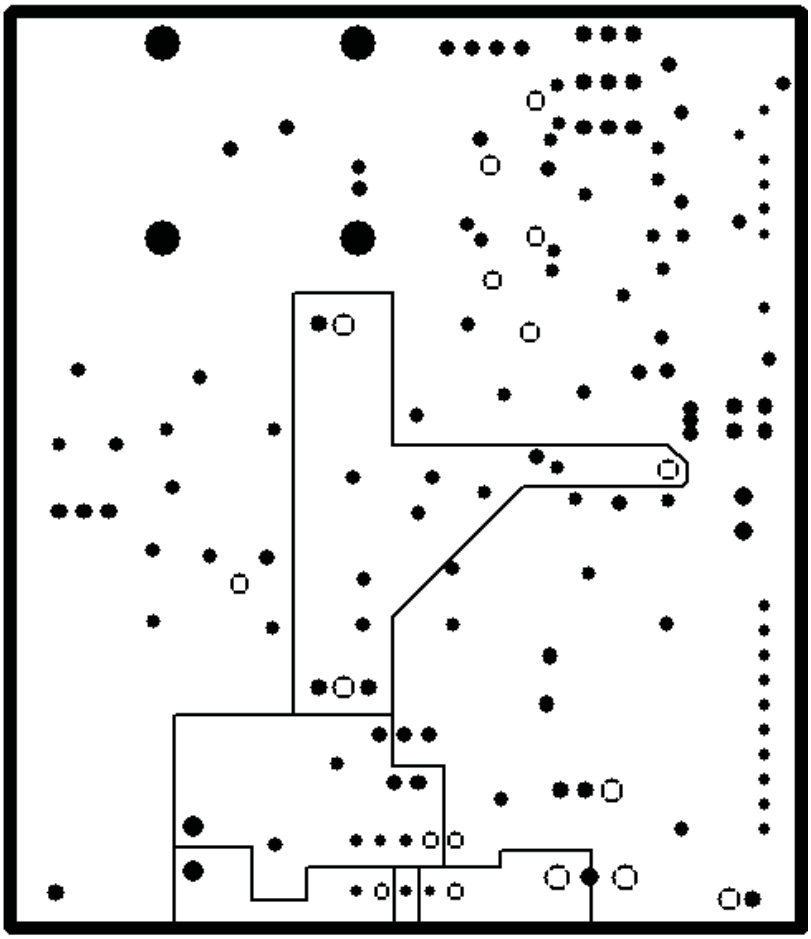


Figure 4. Internal Layer 2 (Split Power Plane)

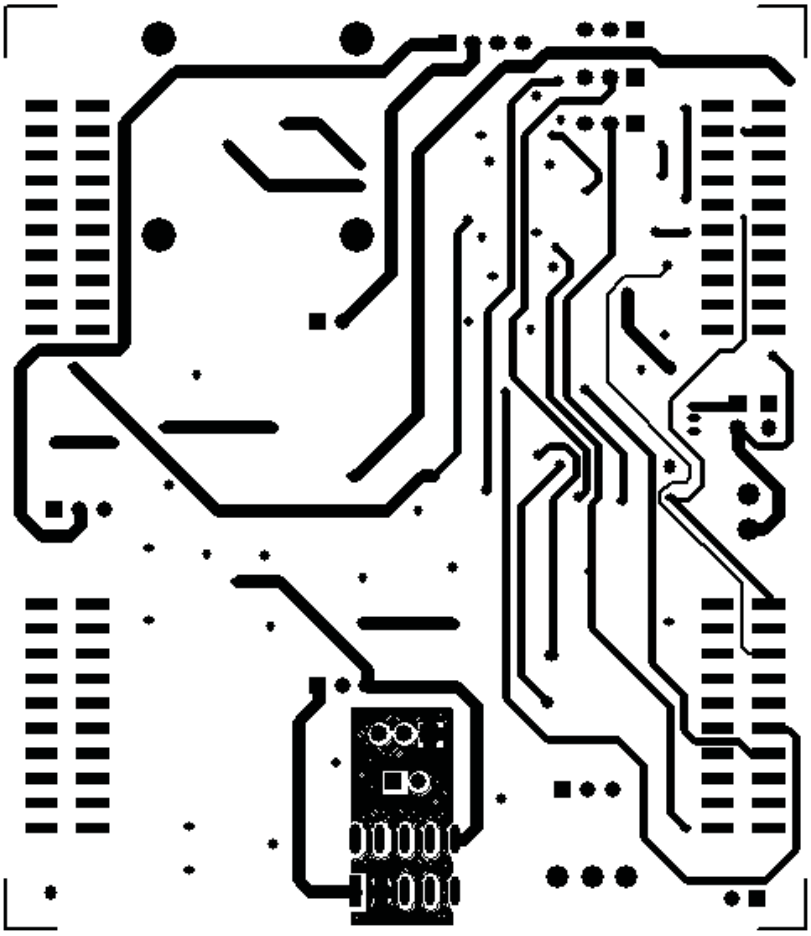


Figure 5. Bottom Layer (Signal Plane)

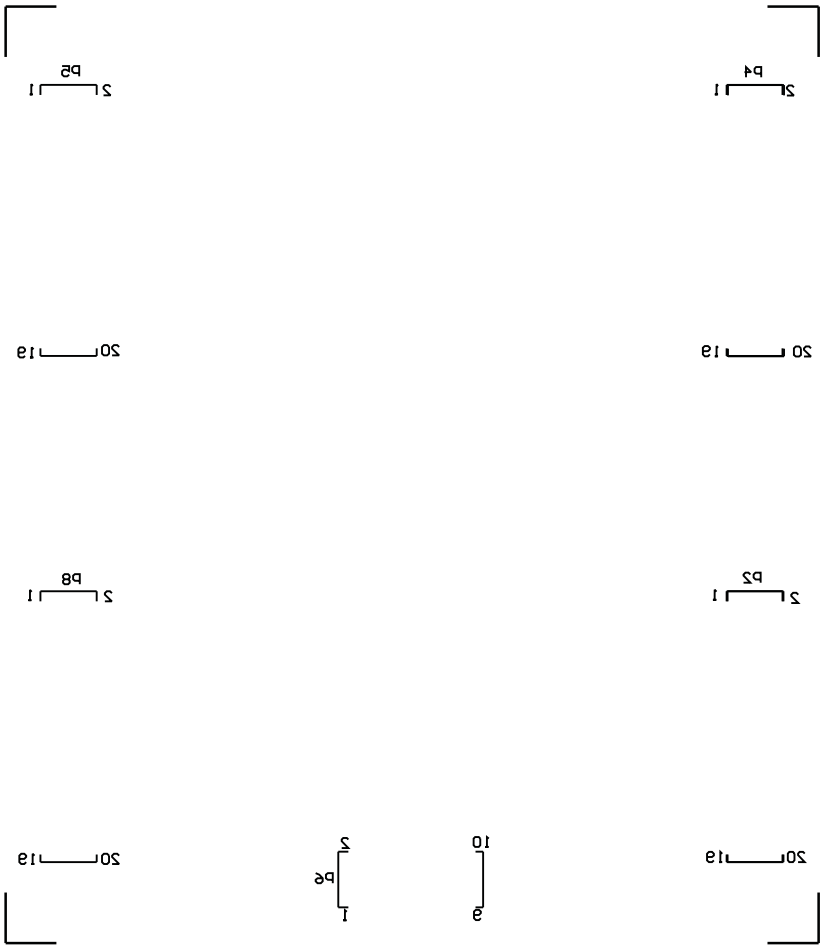


Figure 6. Bottom Silkscreen

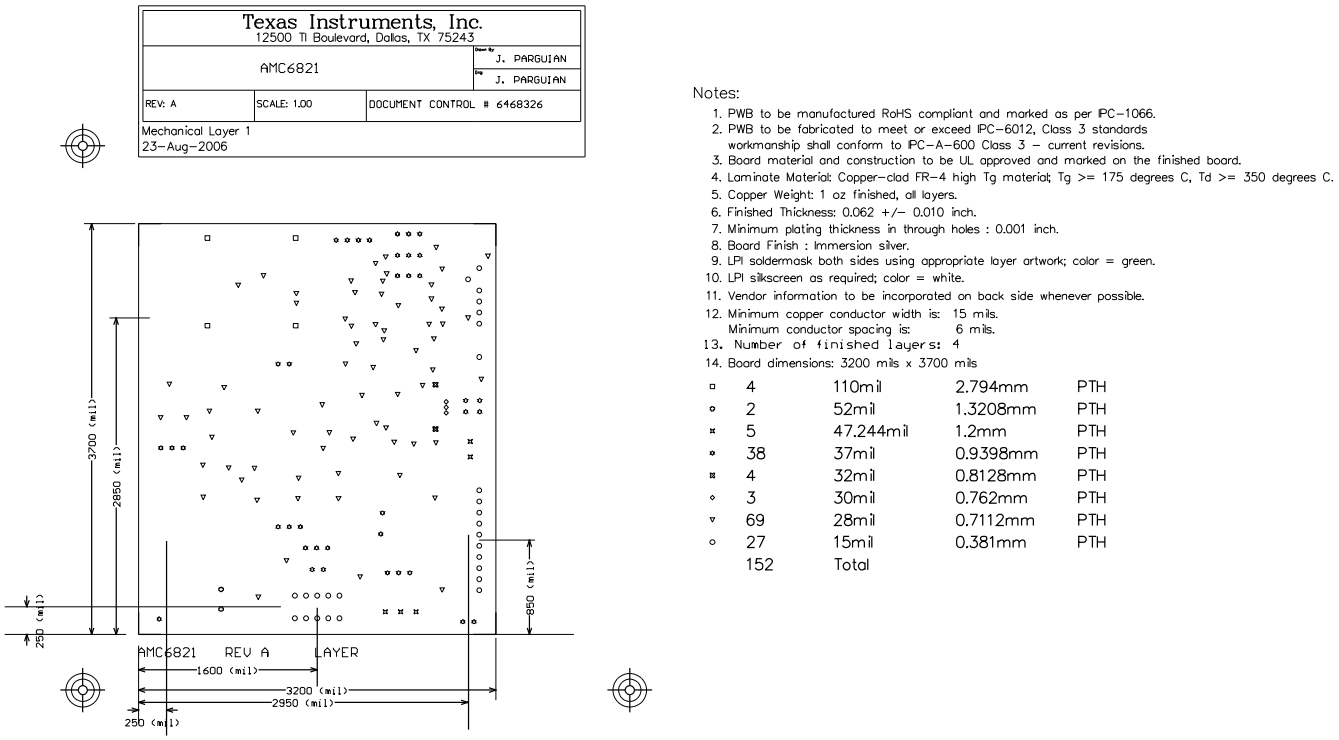


Figure 7. Drill Drawing

2.2 Bill of Materials

Table 1. Parts List

ITEM	Qty	Value	Designators	Description	Vendor	Vendor Part No.
1	1	1nF	C2	Multilayer Ceramic Chip Capacitor, 1206 SMD, 630V, ±15% TC, ±10% Tol	TDK	C3216X7R2J102KT
2	3	0.1µF	C1 C3 C4	Multilayer Ceramic Chip Capacitor, 1206 SMD, 25V, ±15% TC, ±10% Tol	TDK	C3216X7R1H104KT
3	1	10µF	C5	Multilayer Ceramic Chip Capacitor, 1210 SMD, 25V, ±15% TC, ±10% Tol	TDK	C3225X7R1E106KT
4	1	2.2µF	C6	Multilayer Ceramic Chip Capacitor, 1206 SMD, 25V, ±15% TC, ±10% Tol	TDK	C3216X7R1H224KT
5	2	574nm Super Ultra Green	D1 D5	Green LED, 1206 SMT	Lumex	SML-LX1206SUGC-TR
6	3	660nm Super Red	D2 D3 D4	Red LED, 1206 SMT	Lumex	SML-LX1206SRC-TR
7	1	7000 RPM at 5V	FAN1 (1)	3-Wire, 25mm x 10mm 5VDC Fan with TACH	JMC	2510-5LB
8	1	4 × 1 × 0.1	J1	4 Circuit Header, 0.100 STRAIGHT	Molex	22-03-2041
9	1	2 × 1 × 0.138 TH	J3	2 Terminal Screw Connector	On-Shore Tech.	ED555/2DS
10	2	10 × 2 × 0.1 SMT Male	J2 J4	20PIN SMT Terminal Strip 0.100 inch	Samtec	TSM-110-01-S-DV-M
11	1	6 x 2 x 0.1 SMT Male	J5	12PIN SMT Terminal Strip 0.100 inch	Samtec	TSM-106-01-S-DV
12	1	5 × 2 × 0.1 SMT Male	J6	20PIN SMT Terminal Strip 0.100 inch	Samtec	TSM-105-01-T-DV
13	1	2,1 × 5,5 mm SMD Female	J7	DC Power Jack Connector, 2.5 Center Post	Kycon	KLDX-SMT2-0202-B
14	1	3 × 1 × 0.138 TH	J12	3-Pin Terminal Connector	On-Shore Tech.	ED555/3DS

(1) FAN1 is not installed. R25 leads must be cut and bent to fit through-hole mounts.

Table 1. Parts List (continued)

ITEM	Qty	Value	Designators	Description	Vendor	Vendor Part No.
15	4	10 × 2 × 0.1 SMT Female	P2 P4 P5 P8 (2)	20PIN SMT Socket Strip 0.100"	Samtec	SSW-110-22-S-D-VS-P
16	1	5 × 2 × 0.1 SMT Female	P6 (2)	10PIN SMT Socket Strip 0.100"	Samtec	SSW-105-22-F-D-VS-K
17	1	NPN Transistor	Q1	TO-92, NPN General Purpose Amplifier	Fairchild Semiconductor	2N3904
18	2	N-Channel MOSFET	Q2 Q5	4-SOT223, N-Channel Logic LEMFET	Fairchild Semiconductor	NDT3055L
19	3	N-Channel MOSFET	Q3 Q4 Q6	3-SOT23, N-Channel MOSFET	Fairchild Semiconductor	2N7002
20	7	0Ω	R4–R8 R10 R16	1/4W 1206 thick film chip resistor, ±5% Tol	Panasonic	ERJ-8GEY0R00V
21	5	150Ω	R9 R17 R18 R20 R23	1/4W 1206 thick film chip resistor, 5% Tol	Panasonic	ERJ-8GEYJ151V
22	1	4.7kΩ	R15	1/4W 1206 thick film chip resistor, 1% Tol	Yageo America	9C12063A4701FKHFT
23	3	10kΩ	R12 R14 R24	1/4W 1206 thick film chip resistor, ±1% Tol	Panasonic	ERJ-8ENF1002V
24	8	2.2kΩ	R1–R3 R11 R13 R19 R21 R22	1/4W 1206 thick film chip resistor, 1% Tol	Yageo America	9C12063A2201FKHFT
25	1	50Ω	R25 (1) (3)	1W Axial Wirewound Resistor, ±1% Tol	Phoenix	230632755009
26	2	0.100" Centerline	RS1, RS2 (3)	Socket strip, resistor holder	Samtec	SS-101-G-1A
27	3	0.040 in. Mounting Hole	TP1 TP2 TP3	Through hole mount test point, black	Keystone Electronics	5001
28	1	Temp Sensor/PWM fan controller	U1	Analog Interface Circuit	Texas Instruments	AMC6821DBQ
29	2	6-Pin SOT23 Schmitt Trigger	U2 U3	Dual Schmitt Trigger Inverter	Texas Instruments	SN74LVC2G14DBVR
30	1	5-Pin SOT23, 200mA LDO	U4	Ultralow-Noise, High PSRR, Fast RF 200mA LDO linear regulator	Texas Instruments	TPS79333DBVR
31	5	2 × 1 × 0.1 TH	S1 W8–W11	2 Circuit Header, 0.100 STRAIGHT	Molex	22-03-2021
32	7	3 x 1 x 0.1 TH	W1–W7	3 Circuit Header, 0.100 STRAIGHT	Molex	22-03-2031

(2) P2, P4, P5, P6, and P8 parts are not shown in the schematic diagram. All the P designated parts are installed in the bottom side of the PC Board opposite the J designated counterpart. Example, J2 is installed on the topside while P2 is installed in the bottom side opposite of J2.

(3) RS1 and RS2 are not installed. R25 is permanently soldered.

3 EVM Operation

This section covers in detail the operation of the EVM to provide guidance to the user in evaluating the onboard AMC6821, and how to interface the EVM to a specific host processor.

See the AMC6821 data sheet, SBAS386, for information about its serial interface and other related topics.

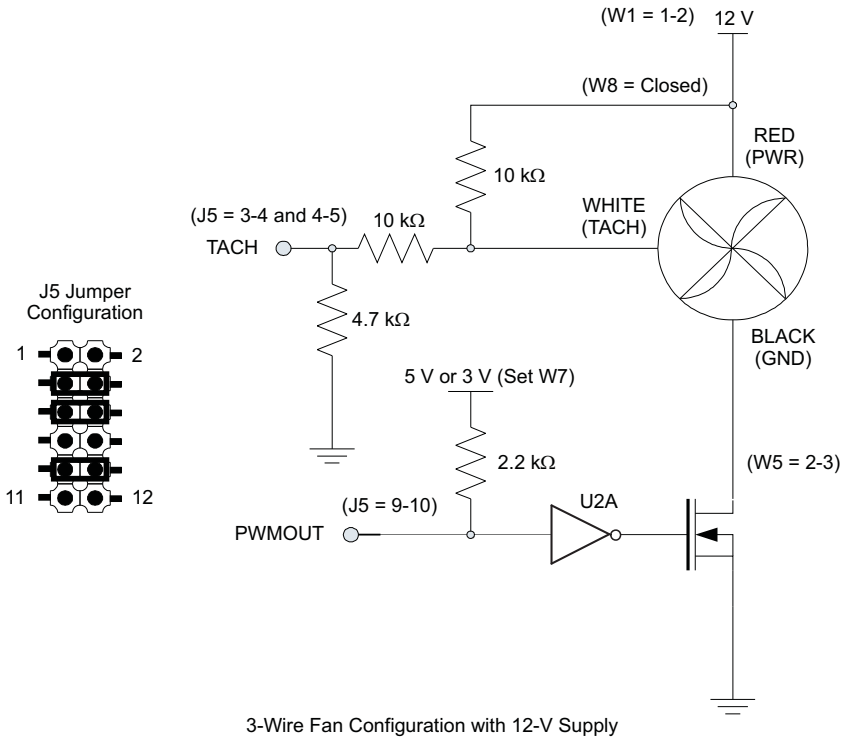
The EVM board is tested and configured to operate a 12-V, 3-wire fan and the onboard external remote temperature sensor selected from factory.

3.1 Factory Default Setting

The EVM board is set to its default configuration from factory as described on the table below for proper monitoring and control mode of operation. The jumper configuration is shown in Figure 8 and Figure 9 for clarity.

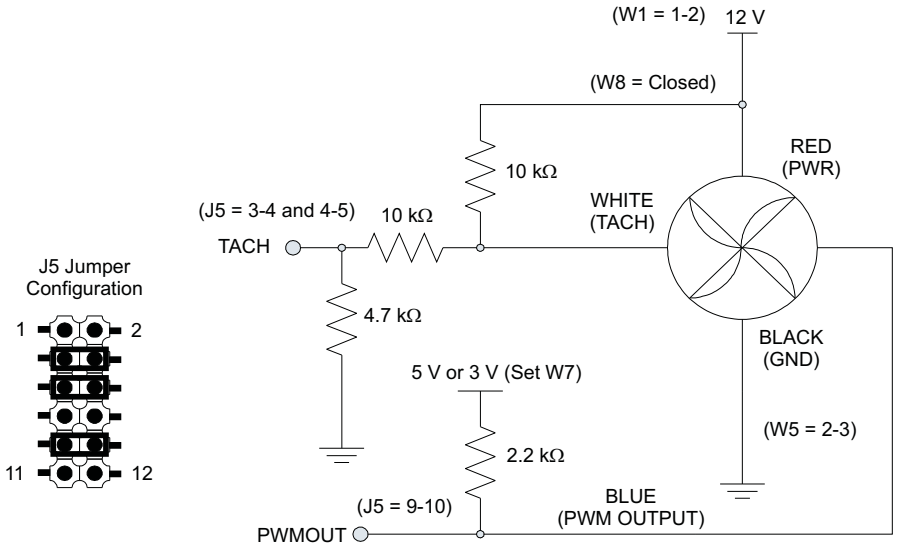
Table 2. Factory Default Jumper Setting

Reference	Jumper Position	Function
W1	1-2	+12V is selected to supply power for the FAN. Fan must be a 12-V fan.
W2	2-3	A0 is tied to ground.
W3	2-3	A1 is tied to ground.
W4	1-2	PWM_MODE is tied high. Selects low frequency mode of PWM.
W5	2-3	For 3-wire fan configuration.
W6	1-2	V_{DUT} of AMC6821 is powered by +5VA.
W7	2-3	V_{DD} is powered by +5VD.
W8	CLOSE	Selected for 12-V, 3-wire fan configuration.
W9	CLOSE	Analog IN+ is sensed via Q1 sensing transistor.
W10	CLOSE	Analog IN– is sensed via Q1 sensing transistor.
W11	CLOSE	Analog ground and digital ground are tied together.
J5	3-4	Enable 12-V fan TACH voltage divider circuit.
J5	5-6	Enable 12-V fan TACH voltage divider circuit.
J5	11-12	Configure PWM output for 3-wire fan mode.
J4	1-2	Connect TACH pin to GPIO pin for monitoring.
J4	3-4	Connect PWM-OUT pin to GPIO for monitoring.
J4	5-6	Connect FAN-FAULT pin to GPIO for monitoring.
J4	11-12	Connect THERM pin to GPIO for monitoring.
Note: See Figure 8 and Figure 9 for the different fan configurations, particularly when applying shorting jumpers for J5.		



3-Wire Fan Configuration with 12-V Supply

Figure 8. Jumper Setting for 12-V Fan Configuration (3-Wire)



4-Wire Fan Configuration with 12-V Supply

Figure 9. Jumper Setting for 12-V Fan Configuration (4-Wire)

3.2 Host Processor Interface

As mentioned in Section 1 of this manual, the AMC6821 EVM is compatible with the USB-MODEVM, and other host platforms available from Texas Instruments, as well as the HPA449 demonstration board from SoftBaugh, Inc. Using these boards alleviates the task of building customize cables, and allows configuration of an evaluation system. The USB-MODEVM comes standard if the AMC6821EVM-PDK is purchased as a kit. If the USB-MODEVM is selected as the host controller, the headers in Figure 10 are mapped out to directly interface the EVM to the USB-MODEVM, which will ease the task of connecting the EVM to the host controller. The setup only requires a few connections.

If another system is used that is not directly compatible with this EVM, a custom cable can be made specific to the host interface platform. The EVM allows interface to the host processor through J2 and J4 header connectors for the serial control signals and the serial data input. However, header J4 alone can be used for the purpose of interfacing this EVM with a host interface platform other than the USB-MODEVM or other platforms from Texas Instruments.

Note that header J2 shows the SMBus interface as SCL and SDA (J2-16 and J2-20 respectively), while J4 shows these pins as SCLK and SDI (J4-17 and J4-19 respectively). This is generic terminology used for net listing to avoid conflict between the two headers for interfacing purposes, but they serve the same purpose and functionality. The jumper resistors, R7 and R8, should be removed to use header J4, to avoid conflict between the two headers during interface communication.

The pin out mapping for both headers is shown in Figure 10.

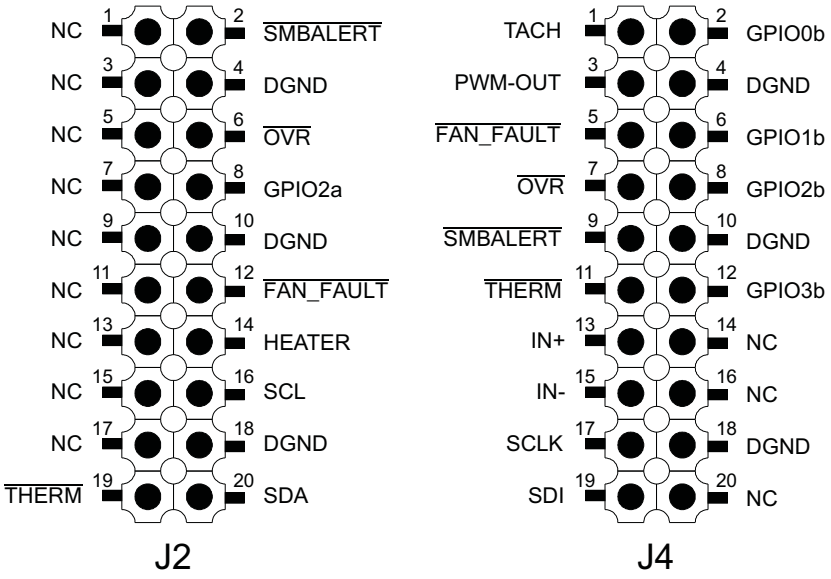


Figure 10. Digital Serial Interface Pinout

As shown in Figure 11, the AMC6821EVM mates directly into the USB-MODEVM through the standard header mating connectors provided for both boards. The only required equipments are the USB cable, a 12-V power supply that can be in the form of a standard ac-dc power adapter rated at least one ampere, a 12-V/3-wire fan, and a PC to control the hardware setup via the LabView based GUI software evaluation tool.

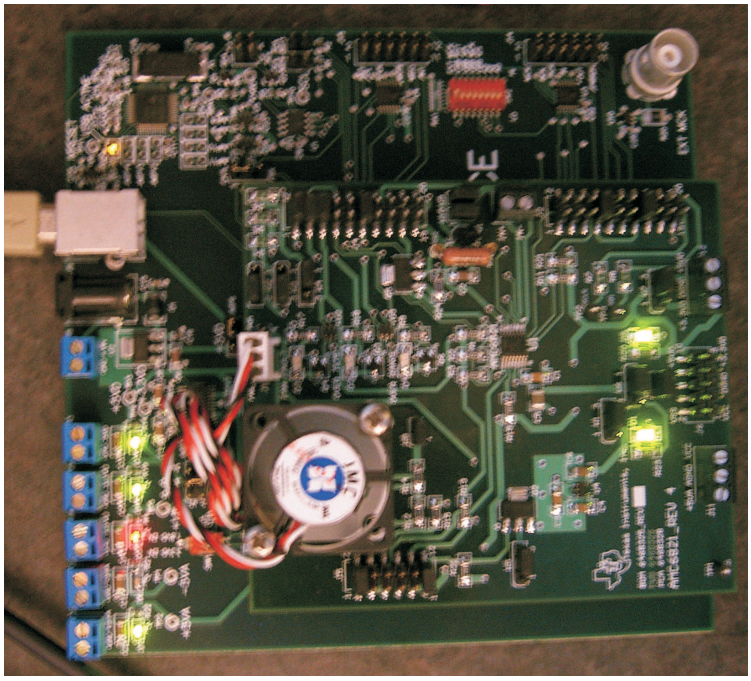


Figure 11. AMC6821EVM and USB-MODEVM Hardware Setup

This type of setup is the simplest configuration to interface the AMC6821EVM fan controller for evaluation purposes. It speeds up the evaluation cycle, and provides greater control over the EVM hardware tool with the least amount of equipment. The software evaluation tool's operation is covered in Section 4.

3.3 AM6821EVM-PDK Block Diagram

The AMC6821EVM-PDK is a complete evaluation kit, which includes a universal serial bus (USB)-based motherboard called the USB-MODEVM Interface board, an AMC6821EVM board, and evaluation software for use with a personal computer running the Microsoft Windows™ operating system (Win2000 or XP).

3.3.1 Connection

The AMC6821EVM-PDK consists of two separate printed-circuit boards, the USB-MODEVM and the AMC6821EVM. The USB-MODEVM is built around the TAS1020B USB controller with an 8051-based core. The motherboard features two positions for modular EVMs, or one double-wide serial modular EVM can be installed. The AMC6821EVM is one of the double-wide modular EVMs that is designed to work with the USB-MODEVM.

The simple diagram of Figure 12 shows how the AMC6821EVM is connected to the USB-MODEVM. The USB-MODEVM Interface board is intended to be used in USB mode, where control of the installed EVM is accomplished using the onboard USB controller device .

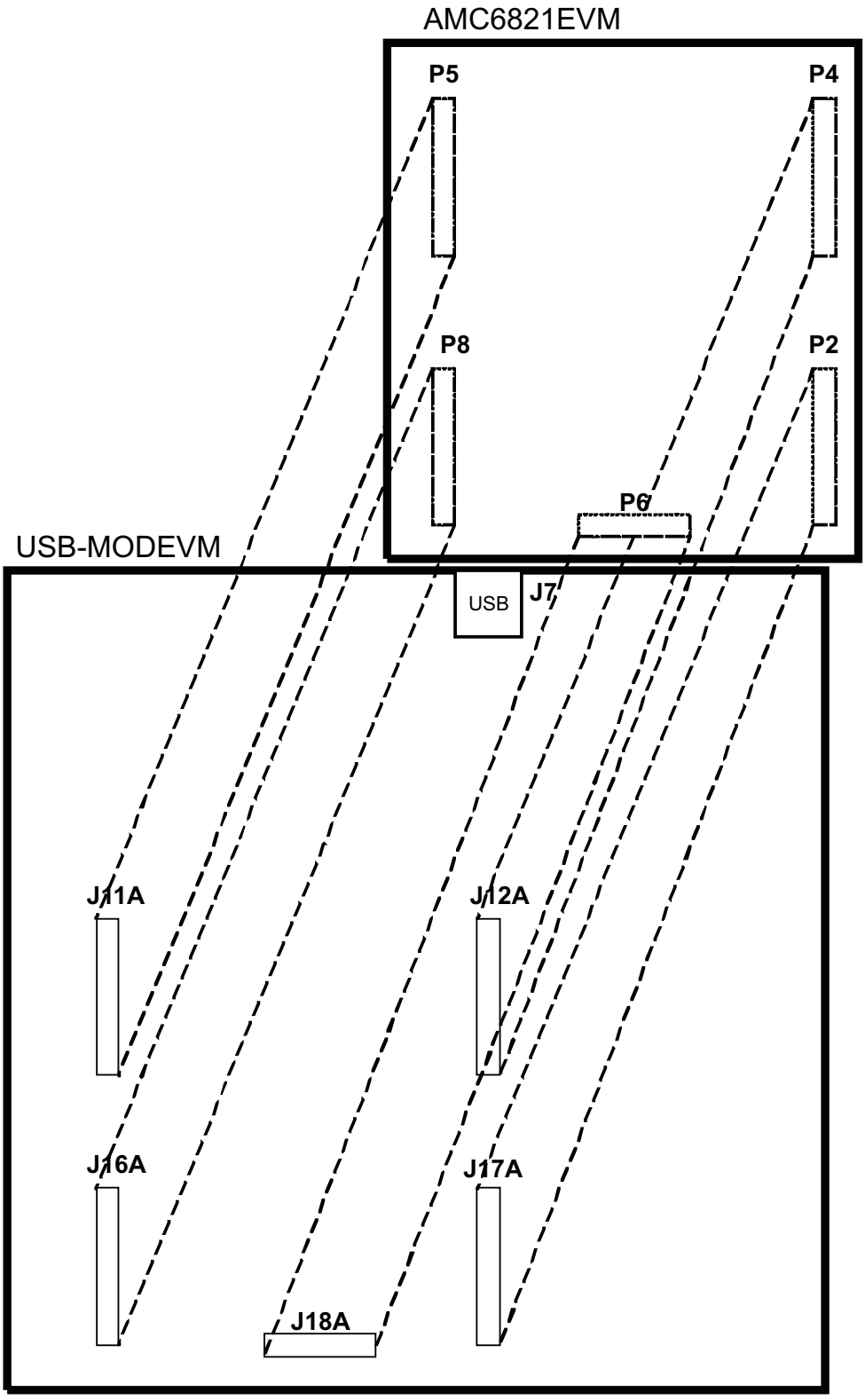


Figure 12. AMC6821EVM-PDK Connection

3.3.2 USB-MODEVM Settings

To work with AMC6821EVM, the SW2 on the USB-MODEVM board needs to be set up so that the processor (TAS1020B) on the motherboard (USB-MODEVM) can interface properly with AMC6821 on the daughterboard (AMC6821EVM).

Table 3 provides a list of the SW2 settings on the USB-MODEVM. The SW-2 positions 1 to 7 must be set to ON, as highlighted in yellow in Table 3.

Table 3. USB-MODEVM SW2 Settings

SW-2 Switch Number	Label	Switch Description	Default Setting	Setting for Working With AMC6721
1	A0	USB-MODEVM EEPROM I^2C Address A0 ON: A0 = 0 OFF: A0 = 1	ON	ON
2	A1	USB-MODEVM EEPROM I^2C Address A1 ON: A1 = 0 OFF: A1 = 1	OFF	ON
3	A2	USB-MODEVM EEPROM I^2C Address A2 ON: A2 = 0 OFF: A2 = 1	ON	ON
4	USB I2S	I^2S Bus Source Selection ON: I2S Bus connects to TAS1020 OFF: I^2S Bus connects to USB-MODEVM J14	ON	ON
5	USB MCK	I^2S Bus MCLK Source Selection ON: MCLK connects to TAS1020 OFF: MCLK connects to USB-MODEVM J14	ON	ON
6	USB SPI	SPI Bus Source Selection ON: SPI Bus connects to TAS1020 OFF: SPI Bus connects to USB-MODEVM J15	ON	ON
7	USB RST	RST Source Selection ON: EVM Reset Signal comes from TAS1020 OFF: EVM Reset Signal comes from USB-MODEVM J15	ON	ON
8	EXT MCK	External MCLK Selection ON: MCLK Signal is provided from USB-MODEVM J10 OFF: MCLK Signal comes from either selection of SW2-5	OFF	OFF

3.3.3 USB-MODEVM Interface Power

The USB-MODEVM Interface board can be powered from several different sources:

- USB
- 6-Vdc to 10-Vdc ac/dc external wall supply (not included)
- Laboratory power supply

When powered from the USB connection, JMP6 should have a shunt from pins 1–2 (this is the default factory configuration). When powered from 6 Vdc–10 Vdc, either through the J8 terminal block or J9 barrel jack, JMP6 should have a shunt installed on pins 2–3. If power is applied in any of these ways, onboard regulators generate the required supply voltages, and no further power supplies are necessary.

If lab supplies are used to provide the individual voltages required by the USB-MODEVM Interface, JMP6 should have no shunt installed. Voltages are then applied to J2 (+5VA), J3 (+5VD), J4 (+1.8VD), and J5 (+3.3VD). The +1.8VD and +3.3VD can also be generated on the board by the onboard regulators from the +5VD supply. To enable this configuration, the switches on SW1 must be set to enable the regulators by placing them in the ON position (lower position, looking at the board with text reading right-side up). If +1.8VD and +3.3VD are supplied externally, disable the onboard regulators by placing SW1 switches in the OFF position.

Each power supply voltage has an LED (D1-D7) that lights when the power supplies are active.

3.4 AMC6821EVM Jumper Setting

Table 4 shows the function of each specific jumper setting of the EVM.

Table 4. Jumper Setting Function

Reference	Jumper Position	Function
W1		Selects the +12V supply for the FAN.
		Selects the +5VD supply for the FAN.
W2		Connects A0 to VDD (A0 = high).
		Connects A0 to DGND (A0 = low).
W3		Connects A1 to V_{DD} (A1 = high).
		Connects A1 to DGND (A1 = low).
W4		Connects PWM_MODE to V_{DD} (PWM_MODE = high, Low Frequency PWM is selected).
		Connects PWM_MODE to DGND (PWM_MODE = low, High Frequency PWM is selected).
W5		Configures fan circuit for 4-wire fan operation.
		Configures fan circuit for 3-wire fan operation.
W6		Selects the +5VA supply to V_{DUT}, which is used to power the AMC6821.
		Selects the +3.3VA supply via U4 to V_{DUT}, which is used to power the AMC6821.
W7		Selects the +3.3VD supply to V_{DD}, which is used to power the digital circuits of the AMC6821 EVM.
		Selects the +5VD supply to V_{DD}, which is used to power the digital circuits of the AMC6821 EVM.
W8		Disconnects the selected fan supply from the fan circuit.
		Connects the selected fan supply from the fan circuit.
W9		Disconnects the collector and base of the sensing transistor, Q1 from the analog IN+ pin of the AMC6821.
		Connects the collector and base of the sensing transistor, Q1 to the analog IN+ pin of the AMC6821.
W10		Disconnects the emitter of the sensing transistor, Q1 from the analog IN- pin of the AMC6821.
		Connects the emitter of the sensing transistor, Q1 to the analog IN- pin of the AMC6821.

Table 4. Jumper Setting Function (continued)

Reference	Jumper Position	Function
W11		Digital ground is not connected to analog ground.
		Digital ground is connected to analog ground.
S1		Heater switch is OFF.
		Heater switch is ON.
Legend: Indicates the corresponding pins that are shorted or closed.		

3.5 Fan Spin-Up Implementation

The AMC6821 powers up with specific default values as listed in the data sheet. One issue to consider is how the fan spin-up is implemented. This depends on the device driver (i.e. PMOS or NMOS) that is used to drive the fan, which affects how the active state of the PWM output is set. This issue is only relevant during power up and reset. Upon power up, the PWMINV bit of configuration register 1 (address 0x00) is reset to zero, which assumes the PMOS device driver polarity. Since the EVM implements an NMOS FET for the fan driver, the PWM output's active state (ON and OFF cycle) is reversed. Therefore, the spin-up function that is applied to the fan is the opposite of the original intention of the spin-up operation. The DCY value of the spin-up process is shown in Figure 13.

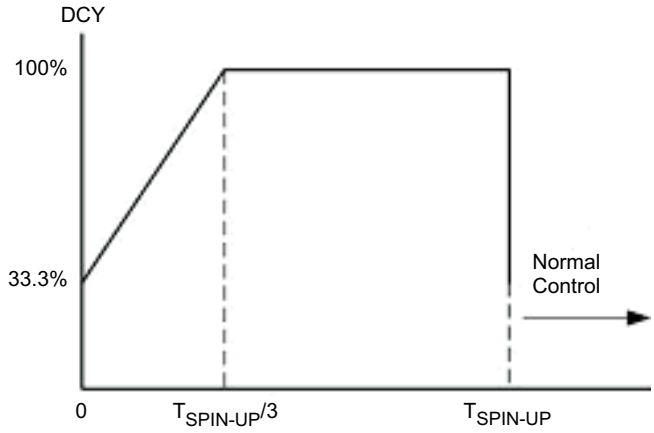


Figure 13. Spin-Up Process

Figure 14 demonstrates the activity of the PWM output signal for both PMOS and NMOS drivers for comparison. The figure shows the PWM output's activity as time lined with the DCY chart. The PWM_{PMOS} is the actual PWM output signal during power up, by default. The PWM output's polarity follows that of a PMOS device driver where the T_{ON} period is the low cycle of the PWM output and the T_{OFF} period is the high cycle of the PWM output. Because the EVM is equipped with an NMOS driver, the T_{ON} period and the T_{OFF} period of the PWM output are reversed as shown by the PWM_{NMOS}. Therefore, instead of the fan spinning up as intended, the fan comes to a complete stop when the DCY value reaches 100% duty cycle.

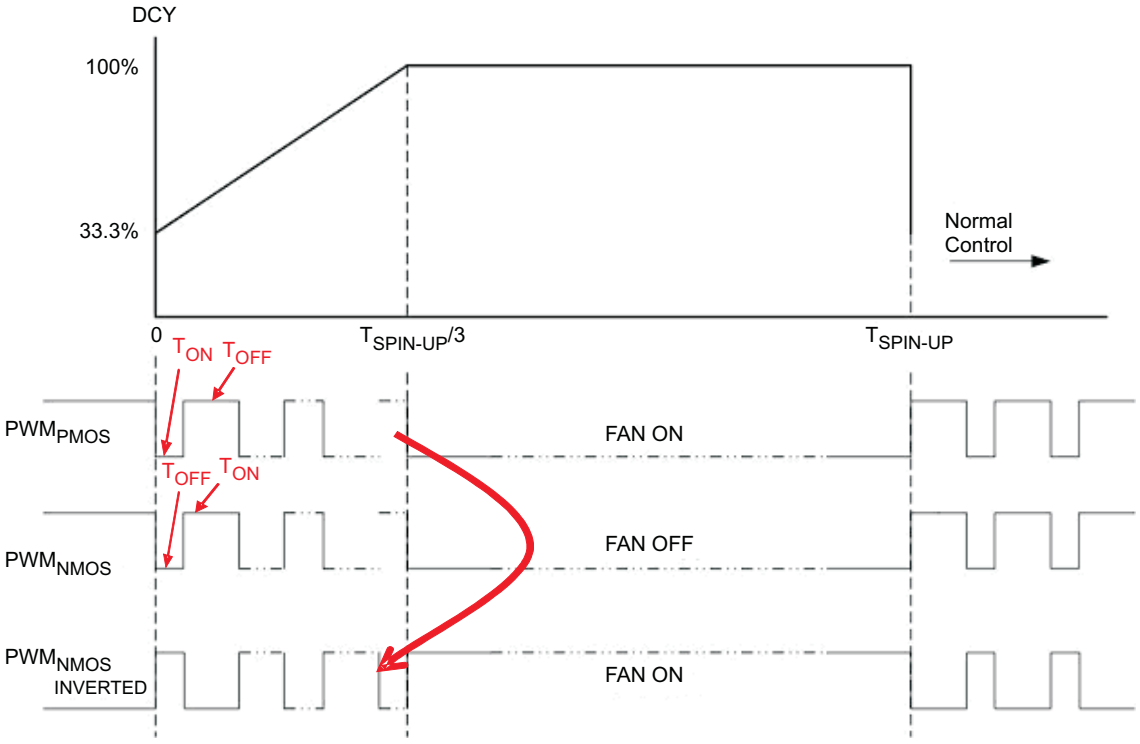


Figure 14. PWM Output Comparison During Spin-Up Process

Hence, the actual spin-up process of the fan with the current EVM configuration is shown in Figure 15.

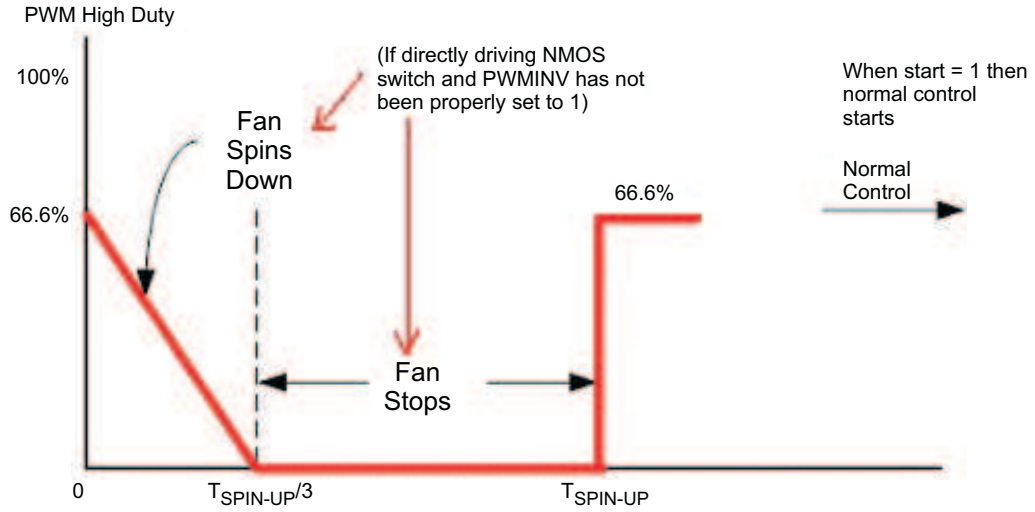


Figure 15. Spin-Up Process (with NMOS Driver on Power-Up)

If the spin-up process as shown in Figure 15 presents a problem with the application, it can be corrected to follow the PMOS spin-up characteristics. To implement the correction on this EVM, invert the PWM output to drive the NMOS FET device, Q2. This is accomplished through a hardware solution where the spare inverter, U2A, is used to invert the PWM output to drive the NMOS FET. Populate R10 and R16 on the AMC6821 EVM board with 0-Ω resistors, and disconnect the shorting jumper that shunts pins 11 and 12 of the J5 header. Make sure that J5 pins 9 and 10 are shunted by a shorting jumper so that the open collector PWM output is pulled high. A snapshot of the hardware configuration is shown in Figure 16. Refer to the schematic for further information

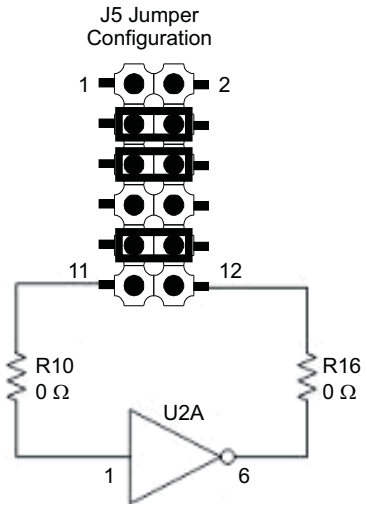


Figure 16. Hardware Configuration Spin-Up Using NMOS FET Drive

When the hardware correction is implemented, the PWM output follows the DCY chart as shown in Figure 13 for the PMOS driver polarity. This is demonstrated in Figure 14, as shown by the $PWM_{NMOS\ INVERTED}$. The hardware configuration shown in Figure 16 is the default connection to which the AMC6821 is configured.

4 EVM Software Evaluation Tool Operation

This section covers in detail the operation of the EVM Software Evaluation Tool to guide the user in using this tool to control and monitor cooling fan for thermal management.

4.1 Software Introduction

This software was developed to provide convenience to the user, and easy control and monitor of the AMC6821 EVM via a PC using the USB port. It is a simple graphical user interface that allows the user to configure the AMC6821 device manually or with guidance. Once the device is properly configured, the cooling fan is monitored and controlled as set by the configuration settings made by the user.

The USB-MODEVM is a TAS1020 based platform and is used as the host controller to transfer the data and control from the PC USB port to the AMC6821 EVM. The TAS1020 translates the data into I^2C mode of interface for the AMC6821 device to recognize. The opposite process is initiated when transferring data from the AMC6821EVM to the PC.

4.2 Software Tool Kit Basic Operation

Before starting the software, make sure that the EVM is plugged in to the USB-MODEVM platform as shown in Figure 17. An actual picture is shown in Figure 11 of Section 3.2 in this manual.

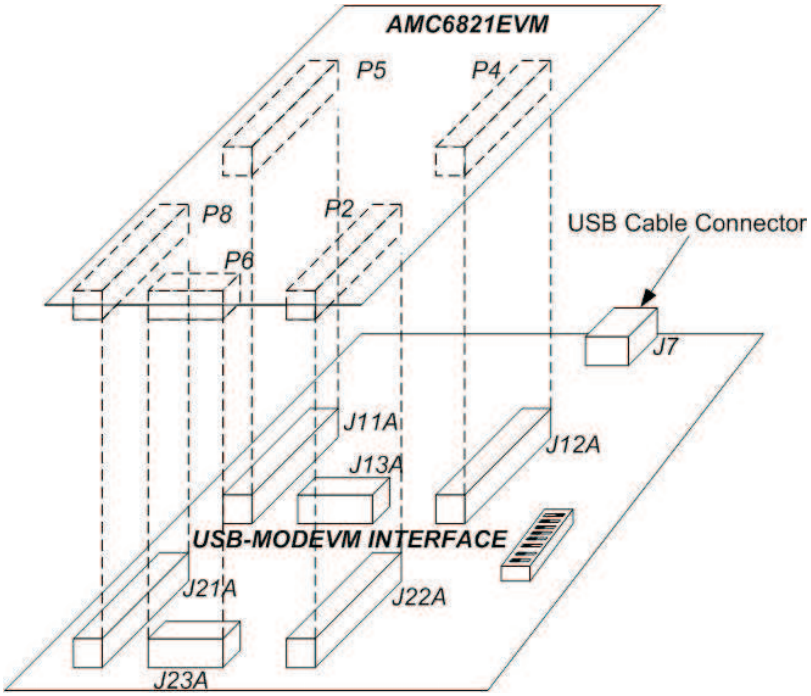


Figure 17. AMC6821EVM and USB-MODEVM Mating Connection

Next is to connect a USB cable to the USB-MODEVM via J7 connector and the PC's USB port. A block diagram of the complete setup is shown in Figure 18.

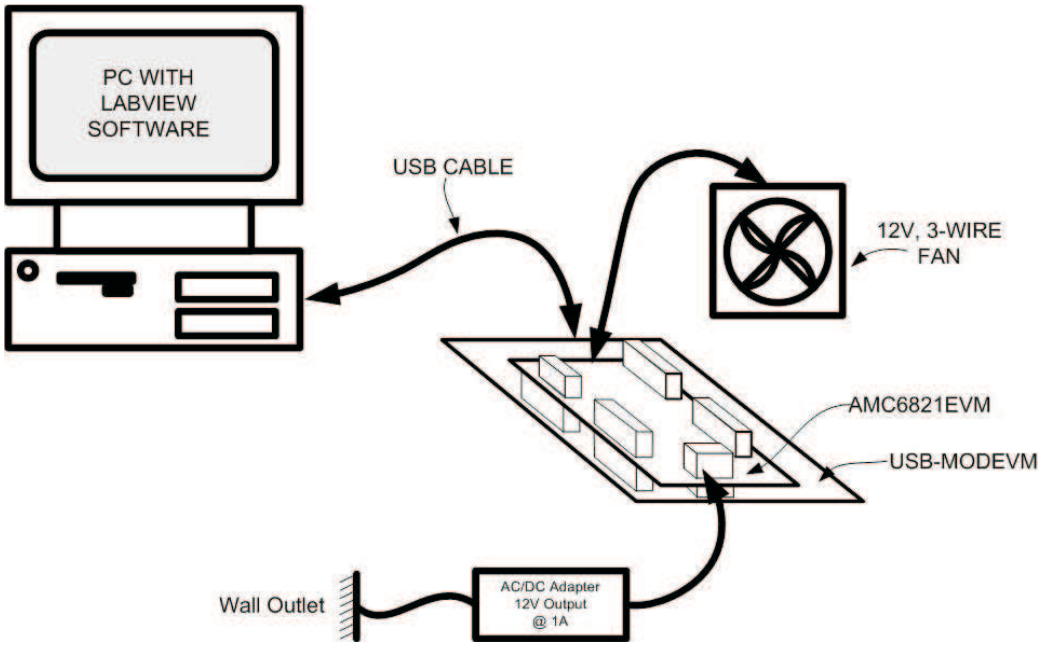
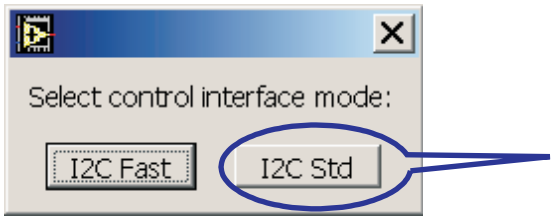


Figure 18. Block Diagram of the AMC6821EVM-PDK Assembly

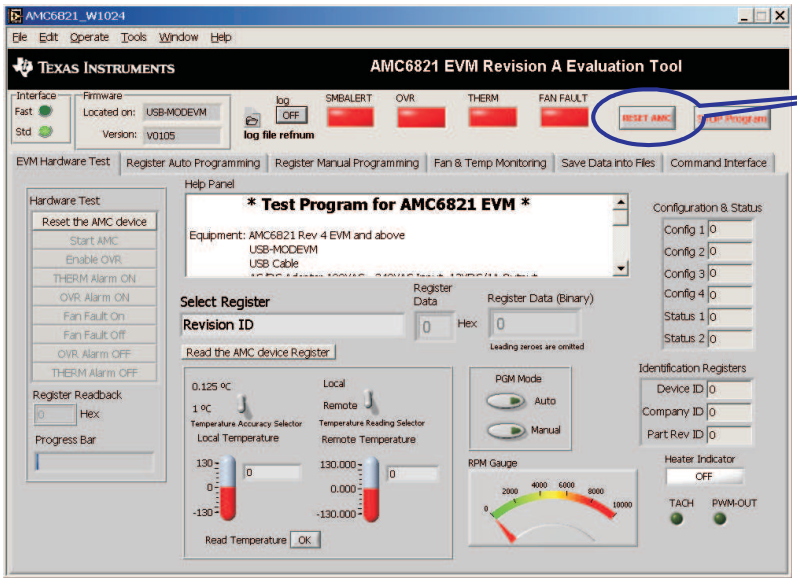
If the software is launched before the communication link, and power to the EVM is established, an error occurs since the initial USB communication link is invalid.

When the software tool is launched, a splash window pops up to choose between I^2C fast or standard protocol as shown below.



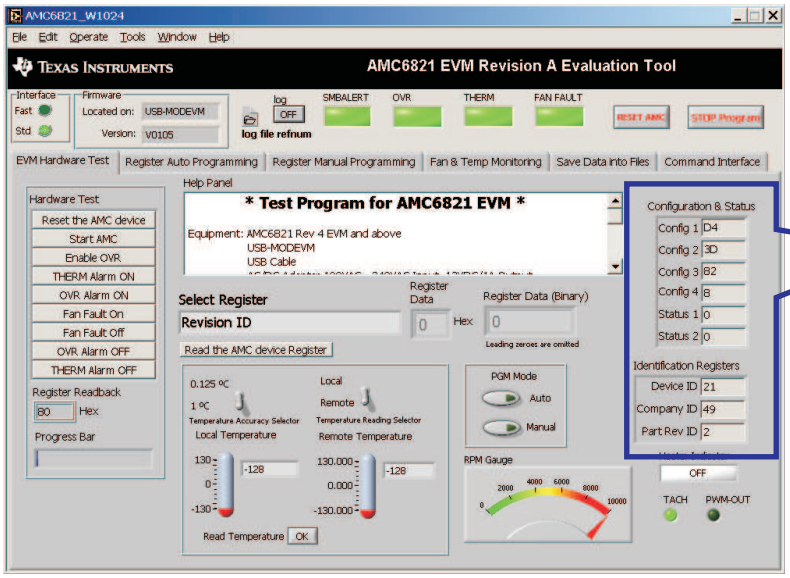
Select the I^2C standard for communication interface

Since the AMC6821 only supports the standard, 100 kHz, mode of operation, choose the standard option. Once the initial communication is established, the first thing that needs to be done is to synchronize the AMC6821 and the software tool by clicking on the reset button as shown below. The reset button may have to be pressed a few times until the alarm indicators (i.e. SMBALERT, OVR, THERM, and FAN FAULT) turn green. This indicates that the software is now synchronized with the EVM.



Press this RESET button to initialize the software.

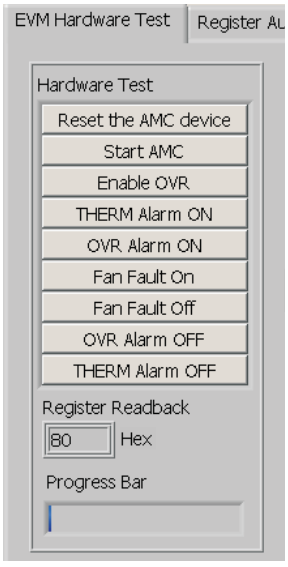
When the software is properly reset, the front panel displays the default values of the AMC6821 device configuration, status, and identification. It also turns the alarm indicators to green. The front panel also shows the values of the local and remote temperatures. The RPM gauge indicator will peg to the highest value (i.e. infinity) because the TACH data register's default value is zero (see the RPM calculation in the data sheet).

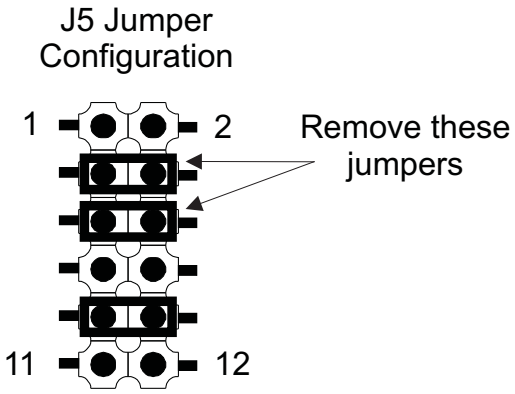


Upon RESET, the default values are loaded into the device registers. The configuration and status, as well as the device identification information are displayed here for quick reference.

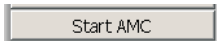
4.3 EVM Hardware Functionality Test

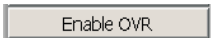
The AMC6821EVM hardware can be tested for functionality from the hardware test box in the front panel as shown below. The test must be performed with the TACH signal disconnected from the fan by removing the appropriate jumper from the J5 header.





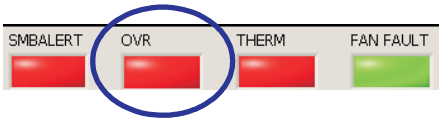
- Reset the EVM by pressing on the button.

- Start the AMC6821 monitoring by pressing on the  button. This sets the AMC6821 start bit (bit 0 of configuration register 1).

- Enable the OVR pin by pressing on the  button.

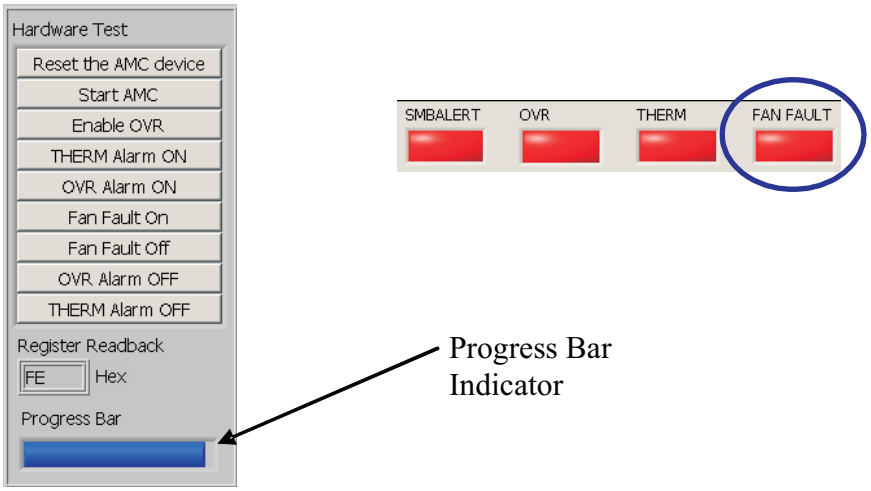
- Turn the THERM alarm on by pressing the button. This programs the Remote-THERM-Limit Register (0x1A), and sets the temperature to 0°C to create an alarm. The SMBALERT and THERM alarm indicators should turn red as shown. The THERM alarm LED indicator, D4, on the EVM should turn on as well.

- Turn the OVR alarm on by pressing the OVR Alarm ON button. This programs the Remote-Critical-Temp Register (0x1D), and sets the critical temperature to 0°C to create an alarm. The OVR alarm indicator should turn red also as shown below. The OVR alarm LED indicator, D2, on the EVM should turn on as well.



- Turn the FAN-FAULT alarm on by pressing the Fan Fault On button. This programs the TACH-Low-Limit Register (0x10 and 0x11), and sets the TACH low limit to a lower value then the TACH Data Register reading. Remember that the TACH signal is no longer being measured during this test, so the TACH data by default is set to 0xFFFF. Since the TACH low limit register defines the minimum speed of the fan, which is now lower then the TACH data register value, a fan spin-up mode is initiated. The fan speed is measured immediately after spin-up and if the fan speed does not return to a normal range after five consecutive spin-up processes, a fan failure occurs and the FAN-FAULT alarm is generated. A delay of approximately 30 seconds is implemented in software to accommodate the spin-up cycle. A splash screen as shown below will be displayed.

Click on the *OK* button and the progress bar should start to show activity. When the progress bar reaches its full range as shown below, the FAN-FAULT alarm should turn red. At this point all alarms should be turned red. The FAN-FAULT alarm LED indicator, D3, on the EVM should turn on as well, but it may turn on earlier than the software indicator.



- Turn the FAN-FAULT alarm off by pressing on the Fan Fault Off button. This programs the TACH-Low-Limit Register (0x10 and 0x11), and sets the TACH low limit to the same value as the

TACH Data Register reading. This takes the fan out of spin-up mode, and return the fan to its normal speed range. The FAN-FAULT alarm indicator should go back to green and the FAN-FAULT alarm LED indicator, D3, should go off.

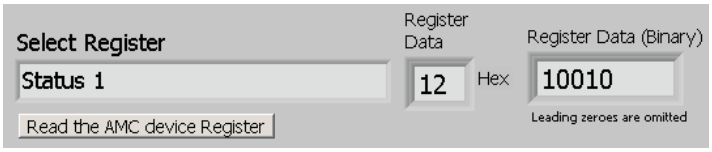
- Turn the OVR alarm off by pressing on the

button. This programs the Remote-Critical-Temp Register (0x1D), and sets the critical temperature to 100°C to clear the alarm. The OVR alarm indicator should turn green and the OVR alarm LED indicator, D2, on the EVM should turn off as well.
- Turn the THERM alarm off by pressing on the

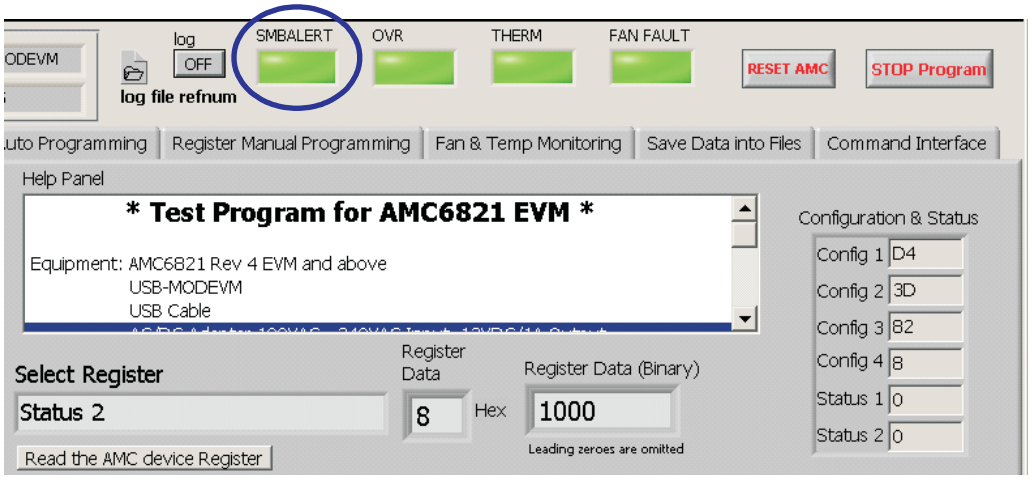
button. This programs the Remote-THERM-Limit Register (0x1A), and sets the temperature to 100°C to clear the alarm. The THERM alarm indicator should turn green and the THERM alarm LED indicator, D4, on the EVM should turn off as well.
- Now, all the alarm indicators are back to normal except for the SMBALERT alarm indicator as shown below.

- To clear the SMBALERT alarm, the status registers 1 and 2 (0x02 and 0x03) must be read. Click on the *Select Register* drop down box and select Status 1 first and click on the

button

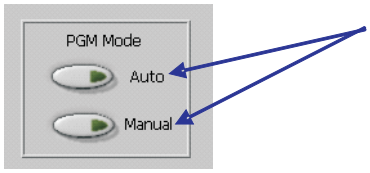


Repeat the same process for Status 2 as performed above. The SMBALERT alarm indicator should now go back to its normal state as shown below.



4.4 AMC6821 Device Register Programming

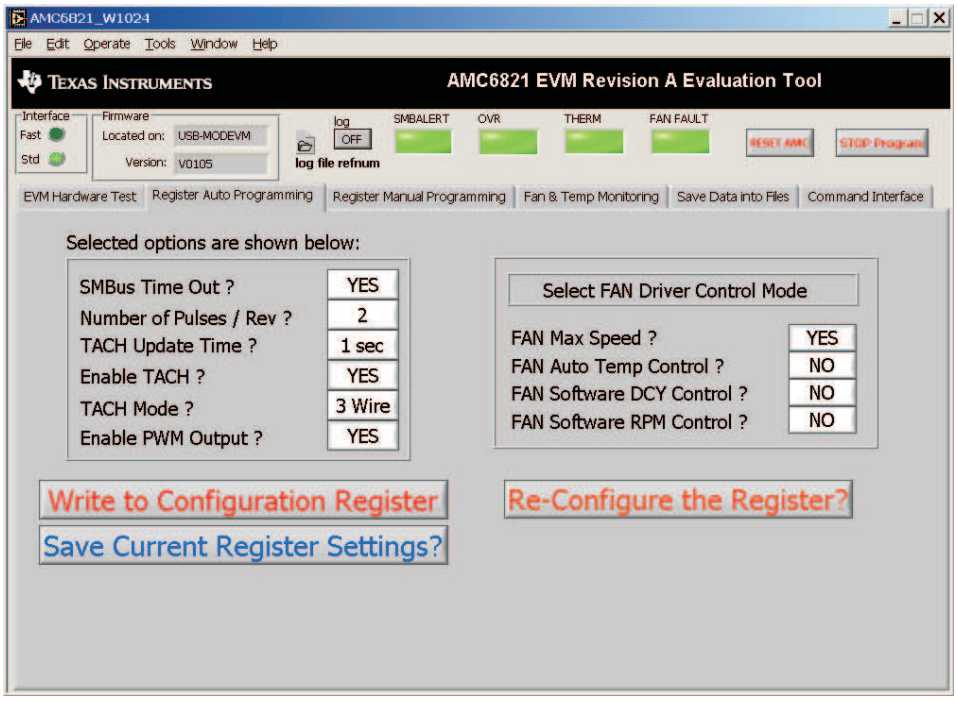
The option to program the device manually or automatically is achieved by choosing the appropriate button in the program mode section of the front panel.



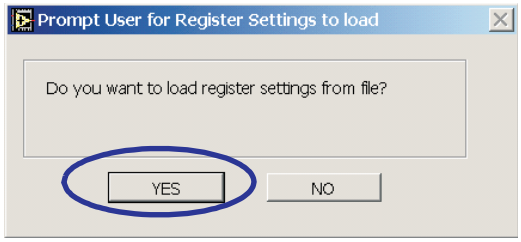
Select the mode of operation of the EVM by clicking on the “Auto” or “Manual” button located in the “PGM Mode” selector box to program the device.

4.4.1 Automatic Programming

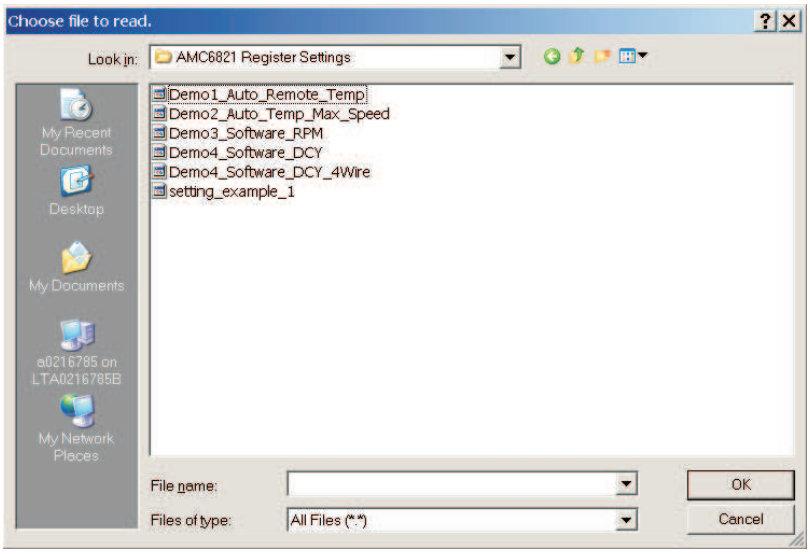
If the *Auto* mode of programming is selected, the user is directed to the *Register Auto Programming* tab or panel as shown below.



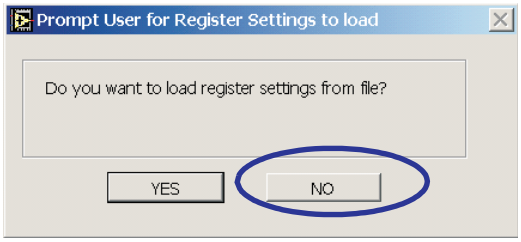
A splash screen appears instantaneously, as shown below, prompting the user to determine if an existing register setting file is to be written or not written to the device.



Clicking on the *YES* button prompts the user to select the register setting file from an existing directory (as shown below) that has previously been used to save the files. From this window, the user can navigate, and select the correct file to write to the device. Confirm the file selected by clicking on the *OK* button. Once the file to be written to the device is selected, the Write to Configuration Register button must be pressed to complete the write command to the AMC6821 device.

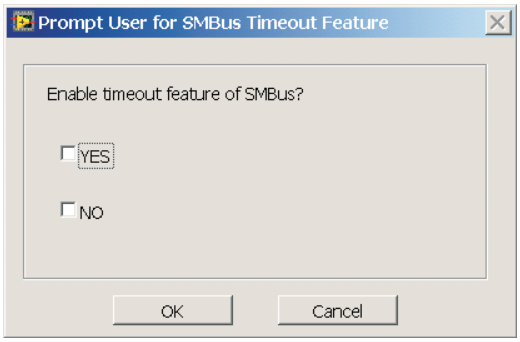


If there is no existing register setting file saved, select the *NO* button of the *Prompt User for Register Settings to load* splash screen as shown below.

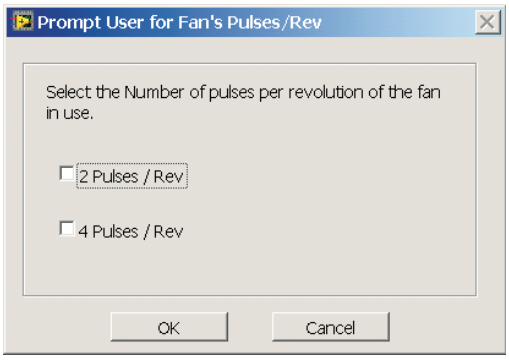


A series of splash screens appear one at a time to prompt the user for inputs as follows:

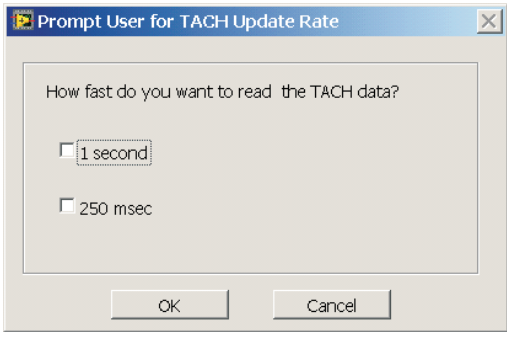
- The first splash screen prompts the user to enable or disable the SMBus timeout feature of the AMC6821 device.



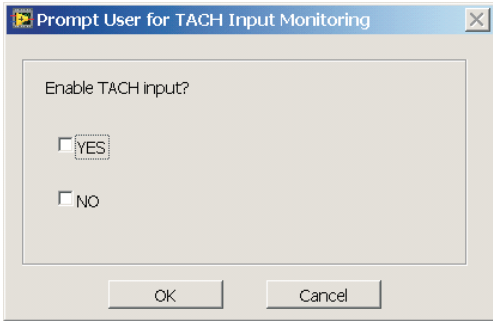
- The second splash screen prompts the user to select for the correct number of pulses per revolution of the fan that is used.



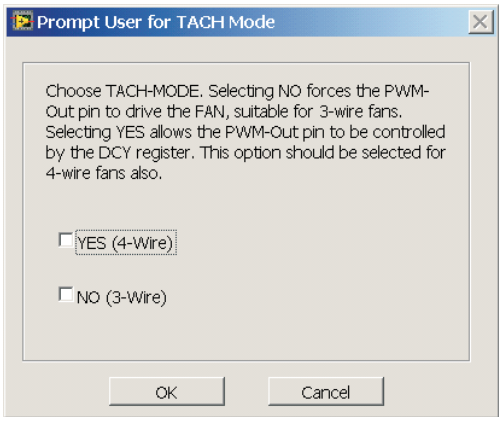
- The third splash screen prompts the user to select for the TACH update rate of 1 second or 250 ms.



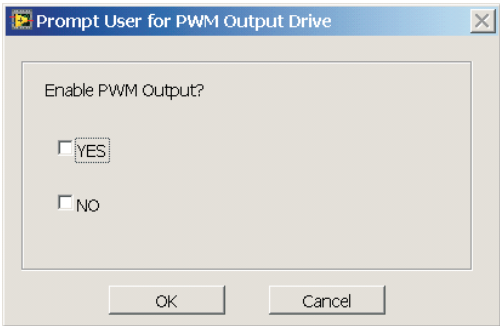
- The fourth splash screen prompts the user to enable or disable the TACH input of the AMC6821 device.



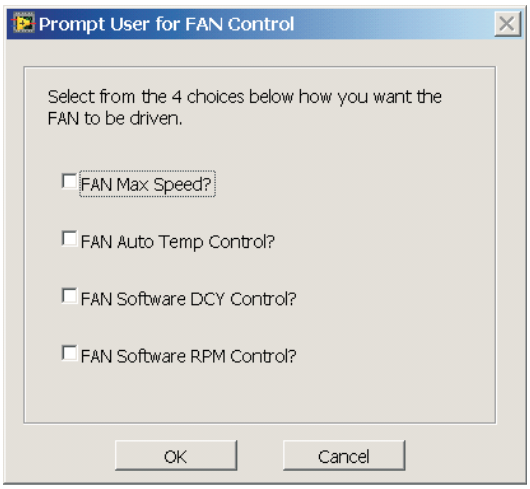
- The fifth splash screen prompts the user to select the correct fan type (i.e. 3-wire or 4-wire) to set the TACH mode function of the AMC6821 device properly.



- The sixth splash screen prompts the user to enable or disable the PWM output of the AMC6821 device.



- The seventh splash screen prompts the user for the desired fan control mode of operation.



The step-by-step dialog as shown in the series of splash screens above is provided to guide the user, and ensure that the correct setup or configuration, based on the fan that is used, is achieved. All other registers that are not touched by the bit settings, as a result of the selections made from the series of splash screens, assume the default values.

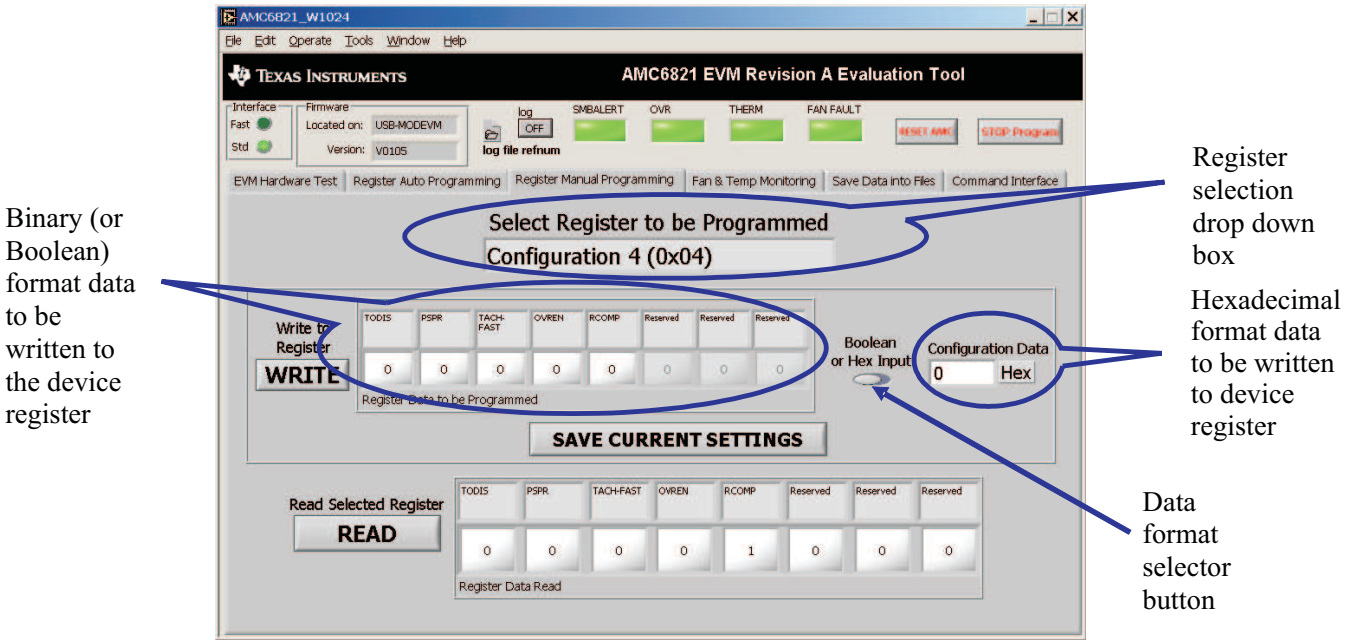
The values that were selected from the series of splash screens can now be written into the device by clicking on the Write to Configuration Register button in the *Register Auto Programming* tab or panel to complete the write command to the AMC6821 device.

Both auto modes of programming processes above will write the selected configuration settings to the device. The write process also sets the start bit of configuration register 1 (bit 0 of address 0x00), so that fan monitoring and control is started automatically.

Once the configuration setup is written to the device, it can be saved as a text file for future device register programming use. Save the current register setting to a file by clicking on the Save Current Register Settings? button. Saving the register setting file is discussed further in Section 4.4.3. The Re-Configure the Register? button can be used to go through the selection process again as discussed above to write to the device registers.

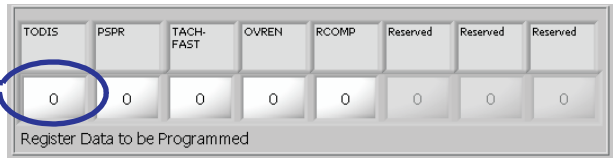
4.4.2 Manual Programming

If the *Manual* mode of programming is selected, the user is directed to the *Register Manual Programming* tab or panel as shown below.



The user can enter the register values either in binary (Boolean) format or hexadecimal format, depending on the position of the *Boolean or Hex Input* selector button (or data format selector button). The appropriate registers to program can be selected by the user via the *Select Register to be Programmed* drop down box. When the Boolean format is selected, the bit settings can then be entered in the appropriate bit position by clicking on their respective bit buttons as shown below. The grayed out boxes are reserved bit positions and cannot be written into.

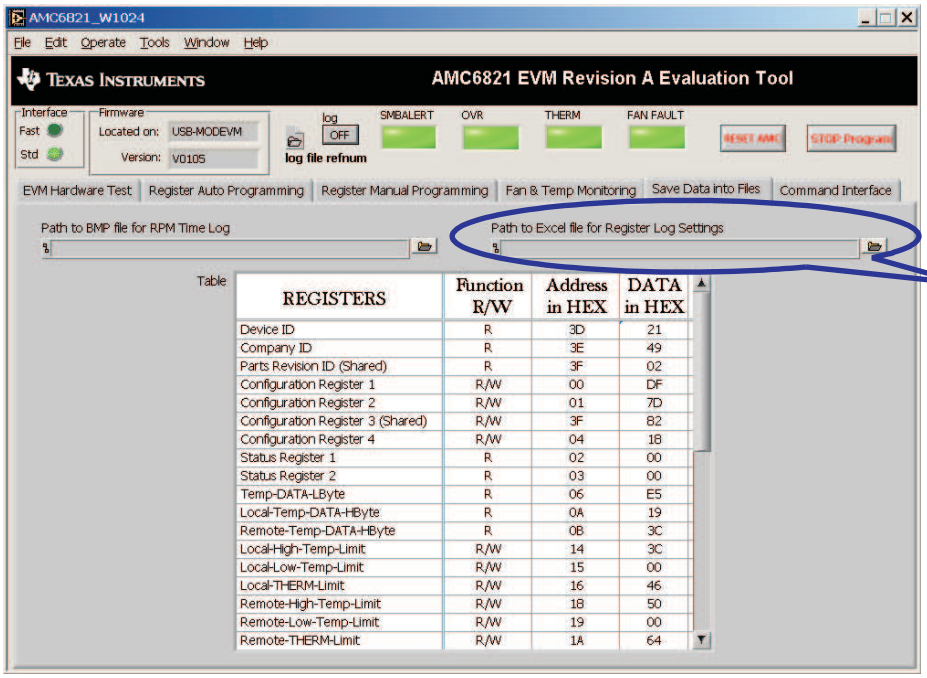
Bit value can be changed to 1 or 0 by simply clicking in the box



When the hexadecimal format is selected, the hex value for the selected register can also be entered in the *Configuration Data* box. The value that was entered can be written to the device registers by clicking on the WRITE button located in the *Register Manual Programming* tab or panel. In addition, the value that was just written into the selected register can be read back by clicking on the READ button located in the *Register Manual Programming* tab or panel to confirm the data that was just written into the device register. The read function can be accessed at any time to read the registers provided the fan monitoring function is stopped.

4.4.3 Saving the Register Setting into a File

The register settings that were written into the device through the *Auto or Manual* mode of programming may be saved as a file for future use or reference. This is done in the *Register Auto Programming*, *Register Manual Programming*, or *Save Data into Files* tab or panel. To do this, click on the Save Current Register Settings? button in the *Register Auto Programming* panel, or click on the SAVE CURRENT SETTINGS button in the *Register Manual Programming* panel. Both actions prompts the user to select the file path and file name of the register settings. It also changes the panel to the *Save Data into Files* panel to show all the current settings of the registers as shown below. To avoid selecting the file path, and selecting or typing in a new file name every time, click on the *Path to Excel file for Register Log Settings* folder icon in the *Save Data into Files* panel as shown below. Select the file path and the file name once, and the register settings is written into the same file over and over once the user saves the file.



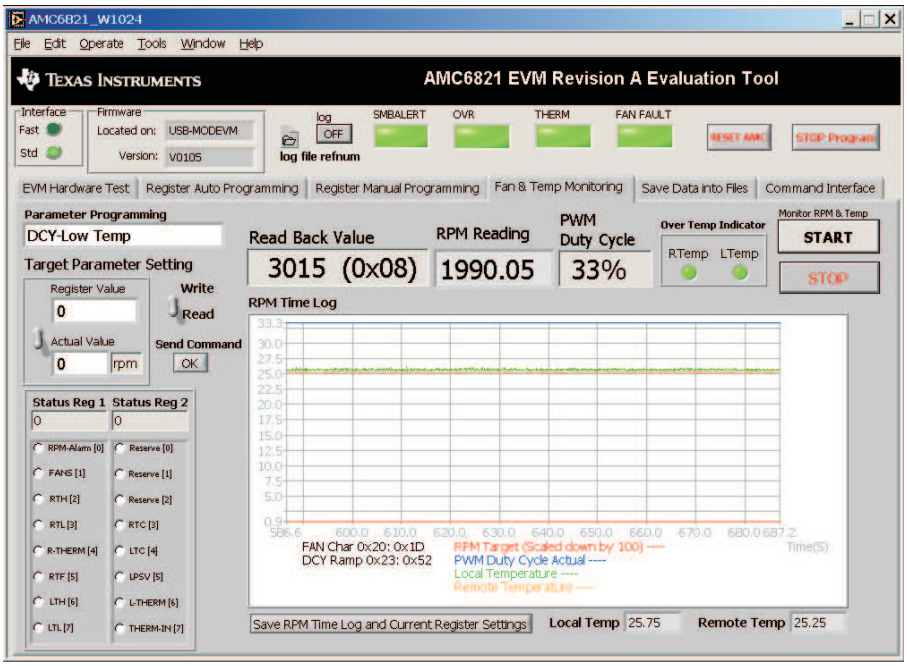
Click on the folder icon to create a file path for the register settings.

Figure 19. Register Settings

The register settings can be viewed in the table as shown in Figure 19. The table can be scrolled down and lists the values of all the registers that the AMC6821 possesses. The table includes the corresponding register address and whether the register is a *read* or a *write* function. The corresponding register data are displayed in hexadecimal format.

4.4.4 Fan Monitoring and Control Panel

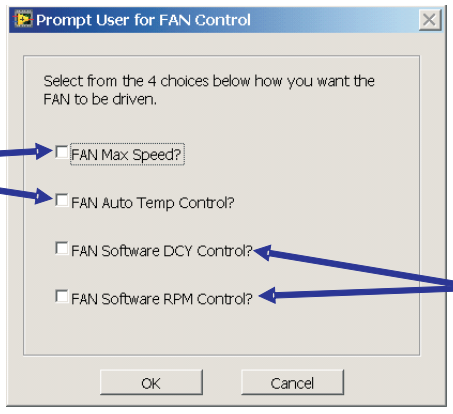
Now that the device registers are properly programmed, the device is now ready to monitor and control the fan. As mentioned earlier, the device starts its monitoring and control function when the start bit (bit 0 of configuration register 1) is set to one. To start monitoring the fan, go to the *Fan and Temp Monitoring* panel by clicking on its tab. From this panel, the user can monitor the fan activities by clicking on the START button. Clicking on the *START* button starts the software to communicate with the AMC6821, and continuously reads back its register contents until the STOP button is pressed. The *Fan and Temp Monitoring* panel is shown below.



4.4.5 RPM Time Log and Control Functions

The RPM Time Log charts the waveform of the temperatures as well as the fan RPM or PWM depending on the control function selected for the AMC6821 device.

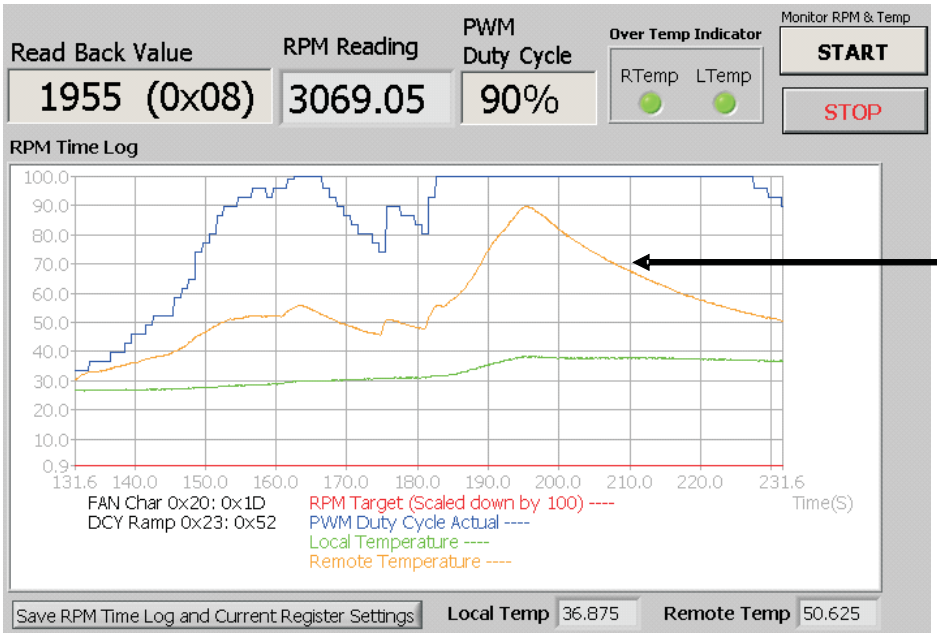
Selecting either of this fan control method plots the actual PWM Duty Cycle that drives the fan in the RPM Time Log chart.



Selecting either of this fan control method plots the measured RPM of the fan in the RPM Time Log chart

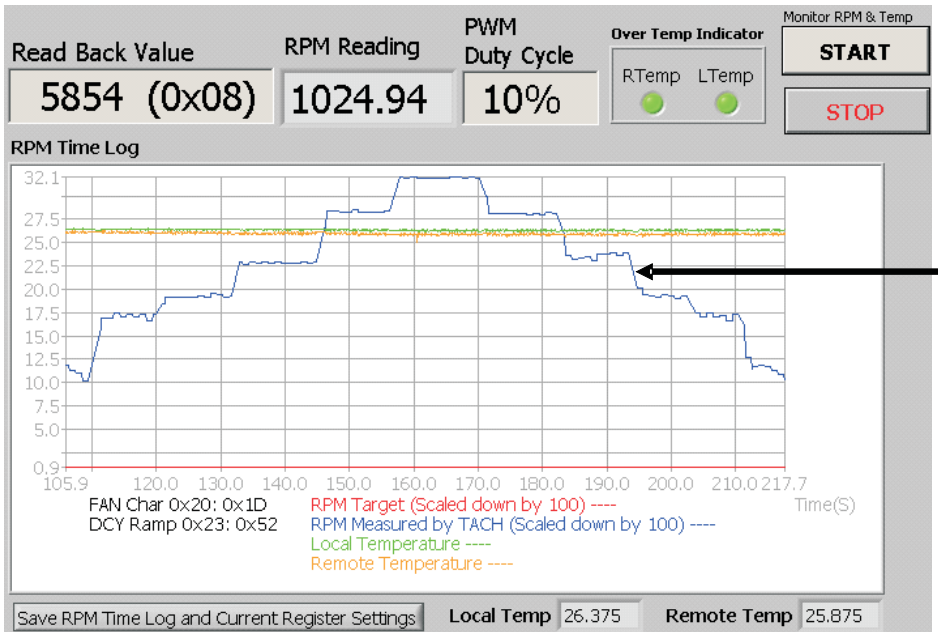
Note: Only one control method should be selected at a time.

When the AMC6821 device is programmed for automatic temperature control, such as *FAN Max Speed* or *FAN Auto Temp Control*, the local and remote temperatures is plotted against the PWM Duty Cycle that is used to drive the fan. For more information regarding the automatic temperature control, see the data sheet.



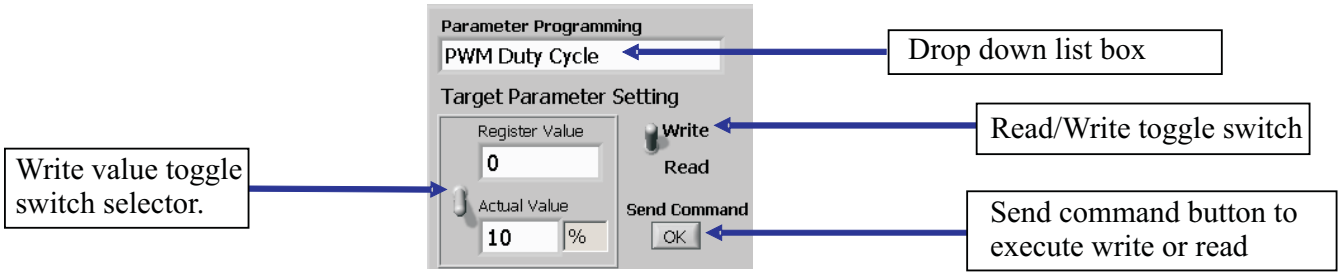
Remote temp controls the PWM duty cycle to drive the fan, as it is the greater temperature between the two temps.

If the fan control method selected is *FAN Software DCY Control*, the measured RPM of the fan that corresponds to the programmed duty cycle is plotted as shown below. The RPM that is plotted on the chart is scaled down by a factor of a hundred to be able to view it as close as possible with the temperature.

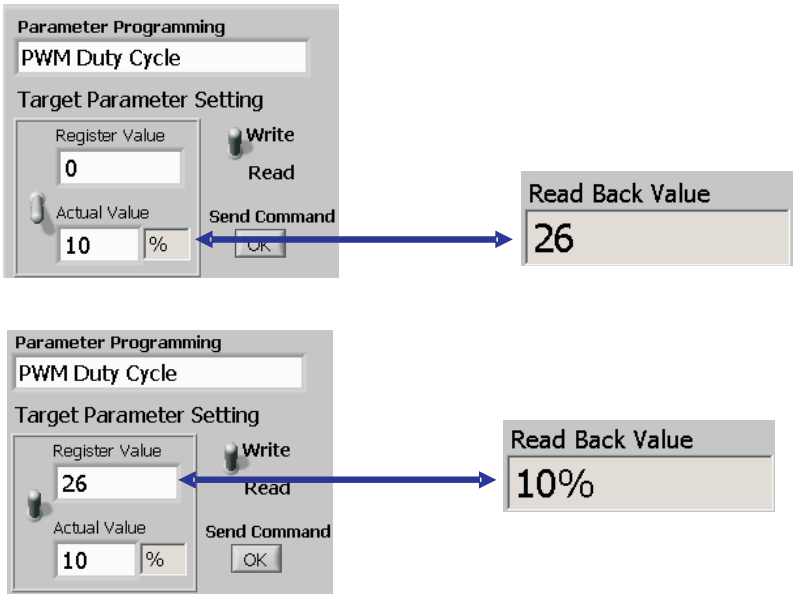


Measured RPM corresponds to the programmed PWM duty cycle.

In the software DCY control method, the desired PWM duty cycle value corresponding to the required fan speed can be programmed into the DCY register by selecting the *PWM Duty Cycle* from the drop down list of *Parameter Programming* box. The value to be written can be the actual value or the register value, both in decimal format. The example below shows that 10% PWM duty cycle is suppose to be written into the DCY (address 0x22) register, which is the actual value desired. This value is entered into the *Actual Value* box and the toggle switch is set to select the appropriate value to write into the device DCY register. The equivalent register value of 26 (0x1A) can also be entered into the *Register Value* box, and the toggle switch set to point up so that it is selected. The Read/Write toggle switch should also be set to the *Write* position and the *Send Command* button must be pressed to write the value into the appropriate device register.

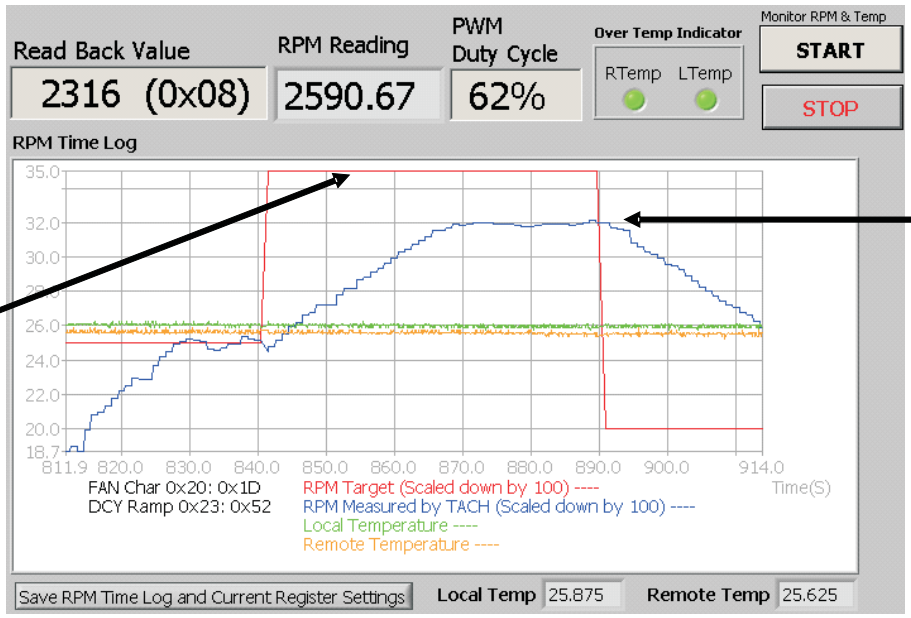


When the write command is accomplished, the *Read Back Value* box displays the equivalent value (depending on which box was selected to do the write function) that was just written into the device DCY register. Both cases are shown as an example below.



If the fan control method selected is *FAN Software RPM Control*, the measured RPM of the fan is plotted against the set target RPM. The RPM that is plotted on the chart is scaled down by a factor of a hundred to be able to view it as close as possible with the temperature. In addition, the target RPM is also plotted in the chart and is also scaled down by a factor of a hundred. The target RPM is the value that is programmed by the user to the device when in software RPM mode of auto temp control.

In the plot shown below, the measured RPM (in blue) does not reach the target RPM (in red) of 3500 rpm. This is because the target RPM is set at a much higher speed than the actual rated speed of the fan that is being monitored and controlled. Therefore, the measured RPM (in blue) that is plotted can only go to the fan's maximum speed of 3200 rpm.



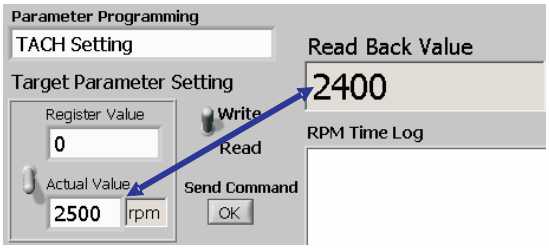
Target RPM is set to 3500 rpm

Fan's maximum RPM is achieved at 3200 rpm

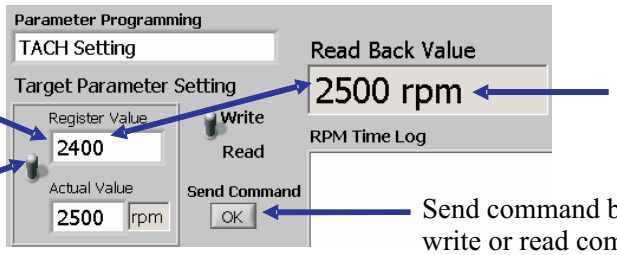
In the software RPM control method, the actual fan speed is measured and stored into the TACH Data Register (addresses 0x08 and 0x09). The value that is stored into the TACH Data Register can then be compared to the value that is stored in the TACH Setting Register (addresses 0x0E and 0x0F), which is written by the user. If there is a difference in value between the two registers, the PWM duty cycle is adjusted, and is used to drive the fan.

The user can write the proper value into the TACH Setting Register that corresponds to the desired fan speed by selecting the *TACH Setting* from the drop down list of *Parameter Programming* box. The value to be written can be the actual value or the register value, both in decimal format.

In the example below, we show that 2500 rpm is suppose to be written into the TACH Setting Register (addresses 0x0E and 0x0F), which is the actual value desired. This value is entered into the *Actual Value* box, and the toggle switch is set to select the appropriate value to write into the selected device register. The equivalent register value of 2400 (0x0960) can also be entered into the *Register Value* box, and the toggle switch set to point up so that it is selected. The Read/Write toggle switch should also be set to the *Write* position and the *Send Command* button must be pressed to write the value into the appropriate device register.



This is the actual register value that is desired to drive the fan.



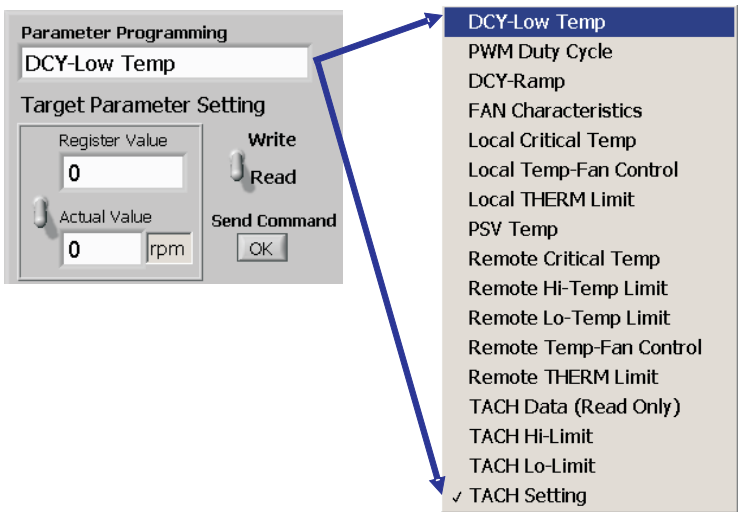
This is the read back value of the TACH Setting Register that is converted into RPM value that is desired to drive the fan.

Toggle switch to select between the register value and the actual value. The current position is in register value.

Send command button to execute write or read command.

In addition, the *Parameter Programming* selector box, as well as the *Target Parameter Setting* box is

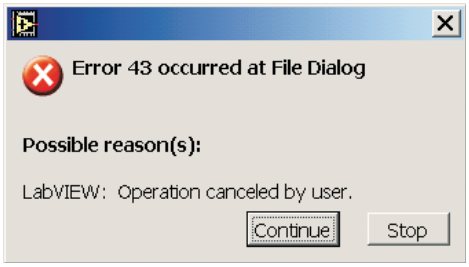
provided to easily program any of the device registers listed below if needed. The parameter programming selector box allows the user to select the appropriate register to be programmed from the drop down menu. The target parameter setting box provides a way for the user to program the register with its hex equivalent decimal value through the *Register Value* box, or with the real-world unit value (i.e., RPM, °C, etc. depending on the selected register) through the *Actual Value* box by switching the toggle switch correctly in their respective position as already discussed in the previous examples above.



To program the register to change its parameters, the monitoring process must be stopped first by clicking on the *STOP* button, right below the *START* button. After stopping the monitoring process, the user can now program the desired values into the appropriate registers by entering the values into the *Register Value* box or the *Actual Value* box. Make sure the toggle switch is properly positioned to select the correct entry box to ensure that the correct value is written to the selected device register. Switch the Read/Write toggle switch to the *Write* position and press the *Send Command* button to complete the write process. The value that is written to the selected register is automatically read back in the *Register Read Back Value* box. Depending on the register that is programmed, the reading that is displayed in the *Register Read Back Value* box is the actual data written into the register in decimal format.

The *RPM Time Log* plot can be saved as a bitmap file (BMP) also for future reference. This process can be accomplished by clicking on the *Save RPM Time Log and Current Register Settings* (

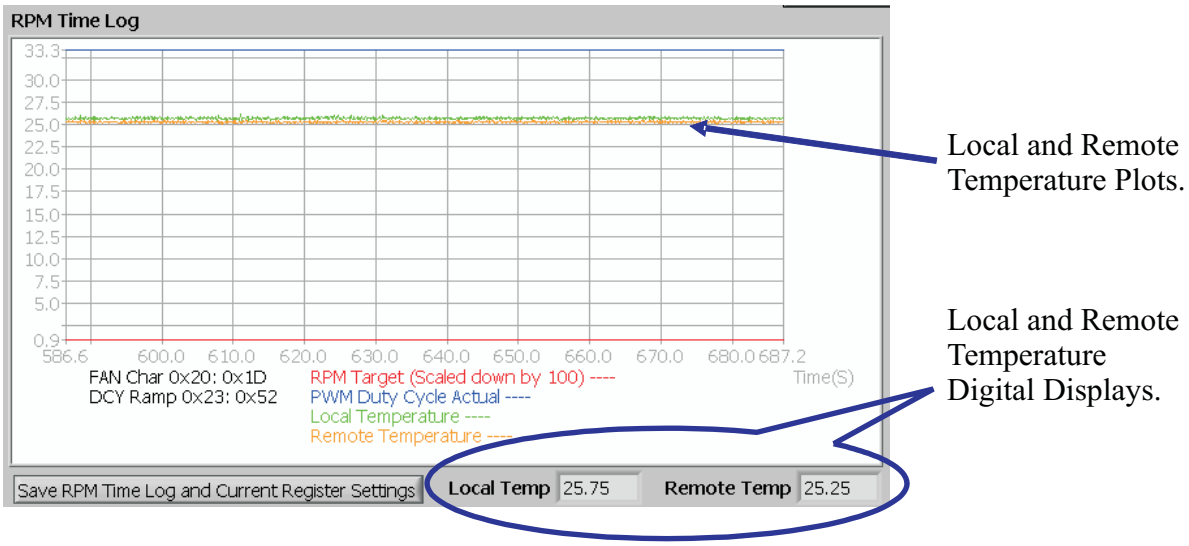
) button right below the RPM Time Log chart. This prompts the user to save the *RPM Time Log* into a file as the first step. If the user chooses to save the RPM Time Log, a file path window appears, and the user must choose the appropriate file path and file name. When the *OK* button is clicked, the next prompt for the register file settings appears. Choose the appropriate file path and file name to save the register settings. This process is done to ensure the user saves the register setting along with the RPM Time Log; therefore, the user can use the current RPM Time Log performance against the register setting for further test and analysis. If the RPM Time Log is chosen to not be saved, the next prompt for the register file settings appears, and if the user chooses not to save the register settings either, an error dialogue appears as shown below. Click on the continue button to continue with the program.



4.4.6 Local and Remote Temperature

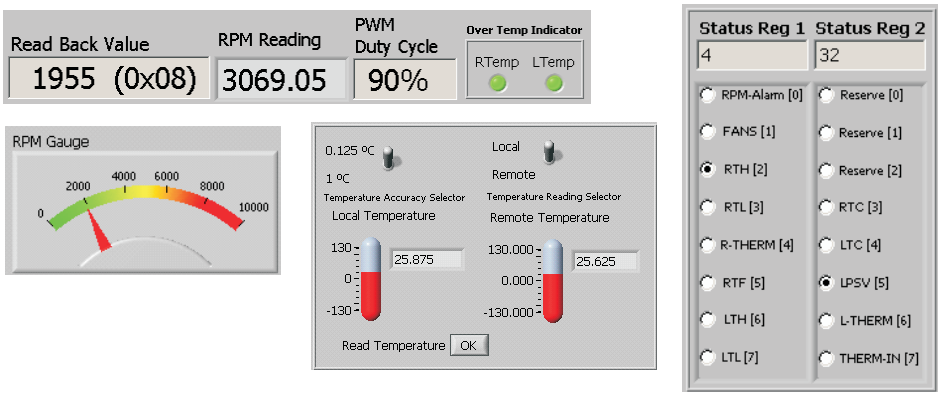
The local and remote temperatures are also displayed in their digital representation for easy monitoring. The digital displays for these temperatures are located right below the RPM Time Log Chart, to the right of the *Save RPM Time Log and Current Register Settings* (Save RPM Time Log and Current Register Settings) button. Since the remote temperature sensor of the AMC6821 is specifically designed to measure the external CPU temperature, such as the Pentium-IV with a built-in substrate transistor sensor with an ideality factor of 1.0021, a slight difference in temperature reading by approximately 0.5°C between the remote and local temperatures is observed. This is because a remote-diode connected transistor (i.e., 2N3904) that has an ideality factor of 1.004 is used to sense the external temperature. The difference in ideality factor between the transistor sensor and the AMC6821 remote temperature sensor circuitry which is trimmed for (1.0021) produces the error in temperature measurement.

The local and remote temperature measurements are plotted in the *RPM Time Log* chart as shown below.



4.4.7 Additional Indicators

The software includes a few additional indicators such as: register readback indicator, RPM reading indicator, PWM duty cycle indicator, overtemp indicator, status register indicator (as well as bit status indicators), RPM gauge, and analog temperature display as well as its corresponding digital display for user interface.



All the digital displays that are mentioned are shown in their decimal format except for the status bits where they are either dotted or not, and the overtemp indicators where they are either green or red. The status bit indicators are in Boolean display where a dot represents a 1 and no dot represents a 0. The overtemp indicator on the other hand is green when it is false (no overtemp condition) or red when it is true (overtemp condition).

4.5 Related Documentation From Texas Instruments

To obtain a copy of any of the following TI documents, call the Texas Instruments Literature Response Center at (800) 477 – 8924 or the Product Information Center (PIC) at (972) 644 – 5580. When ordering, identify this manual by its title and literature number. Updated documents can also be obtained through our website at www.ti.com.

Data Sheets:	Literature Number:
AMC6821	SLAS435
TPS79333	SLVS348
SN74LVC2G14	SCES200

4.6 Questions about this or other Data Converter EVM's?

If you have questions about this or other Texas Instruments Data Converter evaluation modules, feel free to e-mail the Data Converter Application Team at dataconvapps@list.ti.com. Include in the subject heading the product you have questions or concerns with.

5 Schematic

The AMC6821EVM schematic appears on the following page.

Revision History		
REV	ECN Number	Approved

Note: FAN1 leads connect to J1 header, pins 1, 2 & 3

FAN TERMINAL

Use Samtec connector P/N: SS-101-T-1C (2 pcs.) for RS1 & RS2 as resistor sockets

Serial I2C Header (Top)

Customer Specific Header

Serial I2C Header (Bottom)

Do Not Populate

Engineer: J. PARGUIAN	
Drawn By:	
FILE: AMC6821_Rev_A.Sch	

TEXAS INSTRUMENTS

12500 TI Boulevard. Dallas, Texas 75243

Title: AMC6821 EVM			
DOCUMENTCONTROL # 6468327			REV: A
DATE: 12-Mar-2009	SIZE:	SHEET: 1	OF: 1

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