

**General Description**

The AAT4290 and AAT4291 SmartSwitch™ products are members of Skyworks' Application Specific Power MOSFET (ASPM™) product family. The AAT4290 and AAT4291 are five and three P-channel MOSFETs, respectively, configured for use as a microprocessor I/O expander. Having independent drain outputs and a common source input, they operate with an input voltage ranging from 1.8V to 5.5V, making them ideal for 2.5V, 3.3V, or 5V systems, as well as systems powered by lithium-ion/polymer batteries. Each switch features a 500ns turn-on time. The switch states are controlled by Skyworks' Simple Serial Control (S<sup>2</sup>Cwire™) interface which permits ease of control and efficiency of size. The quiescent supply current is very low, typically 4.5µA. In shutdown mode, the supply current is reduced to less than 1µA.

The AAT4290 and AAT4291 are offered in a Pb-free, 8-pin SC70JW package specified over the -40°C to +85°C temperature range.

A typical application circuit is shown in Figure 1. The pin configurations are shown in Figure 2. A functional block diagram of the AAT4290/4291 is provided in Figure 3.

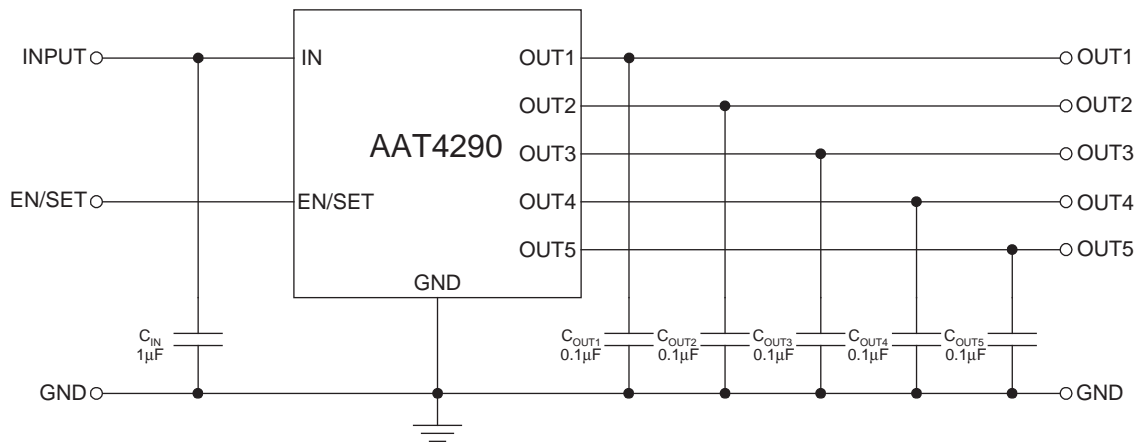
**Features**

- 1.8V to 5.5V Input Voltage Range
- 5 or 3 Independent Load Switches
- S<sup>2</sup>Cwire Interface
- 1.1Ω R<sub>DS(ON)</sub> Per Switch
- Low Quiescent Current
  - 4.5µA Typical
  - 0.1µA in Shutdown
- -40°C to +85°C Temperature Range
- 8-Pin SC70JW Package

**Applications**

- Cell Phones
- I/O Expansion
- Multiple Low Power Switching
- Personal Communication Devices
- Portable Electronic Devices

**Typical Application**



**Figure 1. Typical Application Circuit.**

**AAT4290/4291****I/O Expander Load Switches with Serial Control****Pin Descriptions**

| Pin #   |         | Symbol | Function   |
|---------|---------|--------|--|
| AAT4290 | AAT4291 |        |  |
| 1       | 1       | IN     | Input power supply is connected to the P-channel MOSFET sources. Connect a 1 $\mu$ F capacitor from IN to GND.   |
| 2       | 7       | OUT2   | P-channel MOSFET drain.  |
| 3       | 6       | OUT1   | P-channel MOSFET drain.  |
| 4       | 4       | EN/SET | Input control pin using S <sup>2</sup> Cwire serial interface. The device records rising edges of the clock and decodes them into 32 states (8 states for AAT4291) which controls the ON/OFF states of the MOSFETs. See Table 1 and Table 2 for output settings. |
| 5       | 5       | GND    | Ground connection.   |
| 6       | N/A     | OUT5   | P-channel MOSFET drain.  |
| 7       | N/A     | OUT4   | P-channel MOSFET drain.  |
| 8       | 8       | OUT3   | P-channel MOSFET drain.  |
| N/A     | 2, 3    | N/C    | Not connected.   |

**Pin Configuration**

**Figure 2. AAT4290/4291 Pinout – 8-pin SC70JW (Top View).**

**AAT4290/4291****I/O Expander Load Switches with Serial Control****Absolute Maximum Ratings<sup>1</sup>**

| Symbol        | Description                       | Value                  | Units |
|---------------|-----------------------------------|------------------------|-------|
| $V_{IN}$      | IN to GND                         | -0.3 to 6.0            | V     |
| $V_{OUT}$     | OUT to GND                        | -0.3 to $V_{IN} + 0.3$ | V     |
| $V_{EN/SET}$  | EN/SET to GND                     | -0.3 to 6.0            | V     |
| $I_{MAX}$     | Maximum Continuous Switch Current | 250                    | mA    |
| $T_{STORAGE}$ | Storage Temperature Range         | -65 to 150             | °C    |
| $V_{ESD}$     | ESD Rating - HBM <sup>2</sup>     | 4000                   | V     |

**Thermal Characteristics**

| Symbol        | Description   | Value | Units |
|---------------|---|-------|-------|
| $\theta_{JA}$ | Thermal Resistance <sup>3</sup>                                     | 225   | °C/W  |
| $P_D$         | Maximum Power Dissipation ( $T_A = 25^\circ\text{C}$ ) <sup>4</sup> | 440   | mW    |

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum Rating should be applied at any one time.
2. Human body model is a 100pF capacitor discharged through a 1.5k $\Omega$  resistor to each pin.
3. Mounted on the board.
4. Derate 4.4mW/°C above 25°C.

**AAT4290/4291****I/O Expander Load Switches with Serial Control****Electrical Characteristics**

$V_{IN} = 5.0V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted. Typical values are  $T_A = 25^{\circ}C$ .

| Symbol                         | Description                           | Conditions  | Min | Typ  | Max | Units           |
|--------------------------------|---------------------------------------|---|-----|------|-----|-----------------|
| $V_{IN}$                       | Operation Voltage                     |   | 1.8 |      | 5.5 | V               |
| $I_Q$                          | Quiescent Current                     | $V_{IN} = 5.5V$ , $EN/SET = V_{IN}$ , $I_{OUT} = 0$ , All Switches ON |     | 4.5  | 8   | $\mu A$         |
| $I_{Q(OFF)}$                   | Off Supply Current                    | $EN/SET = 0$ , $V_{IN} = 5.5V$ , $V_{OUTn}$ Open                      |     |      | 1   | $\mu A$         |
| $I_{SD(OFF)}$                  | Off Switch Current                    | $EN/SET = 0$ , $V_{IN} = 5.5V$ , $V_{OUTn} = 0$                       |     | 0.1  | 1   | $\mu A$         |
| $V_{UVLO}$                     | Under-Voltage Lockout                 | $V_{IN}$ Falling  |     | 1.2  |     | V               |
| $V_{UVLO(hys)}$                | Under-Voltage Lockout Hysteresis      |   |     | 250  |     | mV              |
| $R_{DS(ON)}$                   | On Resistance                         | $V_{IN} = 1.8V$ , $T_A = 25^{\circ}C$                                 |     | 2.5  | 3.8 | $\Omega$        |
|                                |                                       | $V_{IN} = 3.0V$ , $T_A = 25^{\circ}C$                                 |     | 1.5  | 2.2 |                 |
|                                |                                       | $V_{IN} = 4.2V$ , $T_A = 25^{\circ}C$                                 |     | 1.2  | 1.8 |                 |
|                                |                                       | $V_{IN} = 5.0V$ , $T_A = 25^{\circ}C$                                 |     | 1.1  | 1.7 |                 |
| $T_{CRDS}$                     | On Resistance Temperature Coefficient |   |     | 2800 |     | ppm $^{\circ}C$ |
| <b>AAT4290-1 and AAT4291-1</b> |                                       |   |     |      |     |                 |
| $T_{D(ON)}$                    | Output Turn-On Delay Time             | $V_{IN} = 5V$ , $R_{LOAD} = 500\Omega$ , $C_{OUT} = 0.1\mu F$         |     | 40   |     | ns              |
| $T_R$                          | Turn-On Rise Time                     | $V_{IN} = 5V$ , $R_{LOAD} = 500\Omega$ , $C_{OUT} = 0.1\mu F$         |     | 270  |     | ns              |
| $T_{D(OFF)}$                   | Turn-Off Delay Time                   | $V_{IN} = 5V$ , $R_{LOAD} = 500\Omega$                                |     | 40   |     | ns              |
| <b>EN/SET</b>                  |                                       |   |     |      |     |                 |
| $V_{EN(L)}$                    | Enable Threshold Low                  | $V_{IN} = 1.8V$   |     |      | 0.4 | V               |
| $V_{EN(H)}$                    | Enable Threshold High                 | $V_{IN} = 5.5V$   | 1.6 |      |     | V               |
| $T_{LO}$                       | EN/SET Low Time                       | $V_{EN/SET} < 0.4V$   | 100 |      |     | ns              |
| $T_{HI}$                       | Minimum EN/SET High Time              | $V_{IN} \leq 2.5V$  |     |      | 500 | ns              |
|                                |                                       | $V_{IN} > 2.5V$   |     |      | 250 |                 |
| $T_O$                          | EN/SET Off Timeout                    |   |     | 2.6  | 4.0 | $\mu s$         |
| $T_{LAT}$                      | EN/SET Latch Timeout                  |   |     | 2.6  | 4.0 | $\mu s$         |
| $I_{SINK}$                     | EN/SET Input Leakage                  | $V_{EN/SET} = 5.5V$   |     | 0.01 | 1   | $\mu A$         |

1. The AAT4290/91 is guaranteed to meet performance specifications over the  $-40^{\circ}C$  to  $+85^{\circ}C$  operating temperature range and is assured by design, characterization, and correlation with statistical process controls.

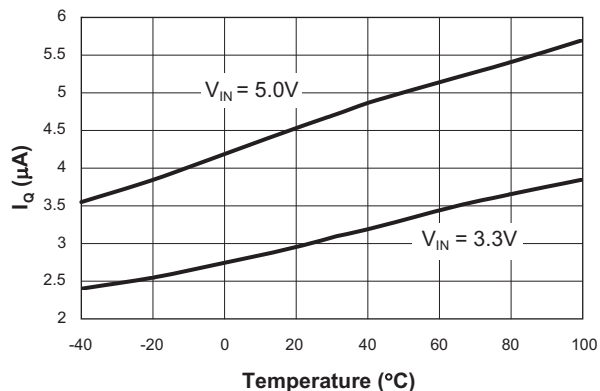
# AAT4290/4291

## I/O Expander Load Switches with Serial Control

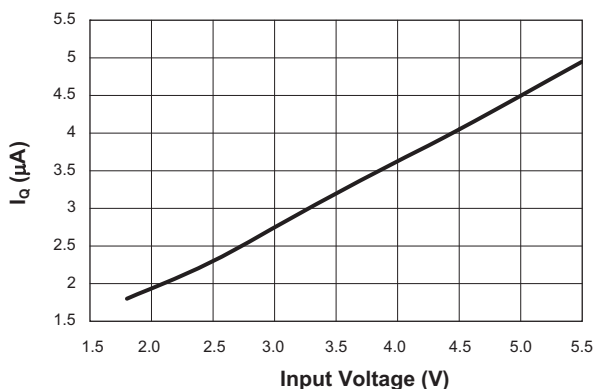
### Typical Characteristics

Unless otherwise noted,  $V_{IN} = 5V$ ,  $C_{IN} = 1\mu F$ ,  $C_{OUTX} = 0.1\mu F$ ,  $T_A = 25^\circ C$ .

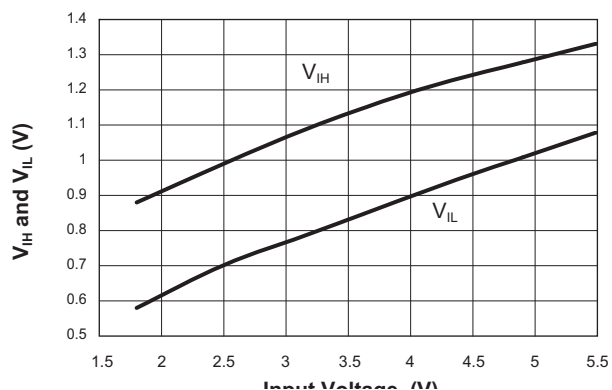
Quiescent Current vs. Temperature



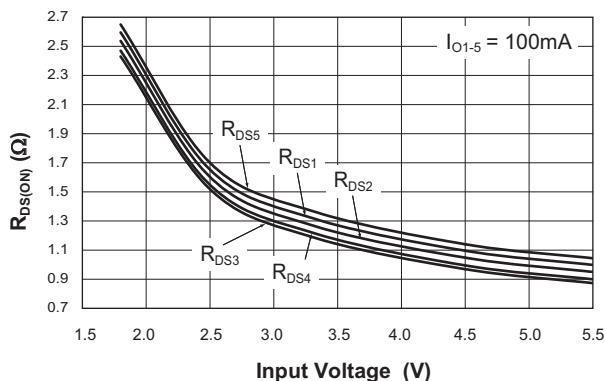
Quiescent Current vs. Input Voltage



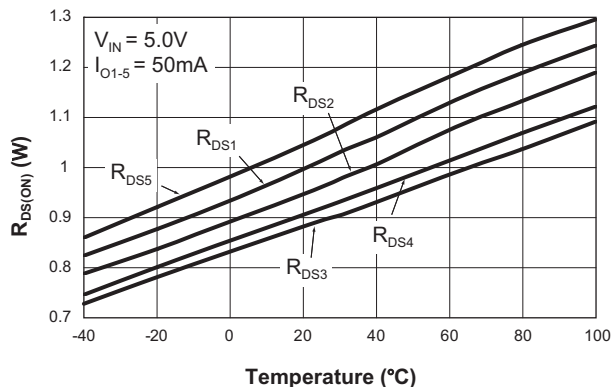
$V_{IH}$  and  $V_{IL}$  vs. Input Voltage



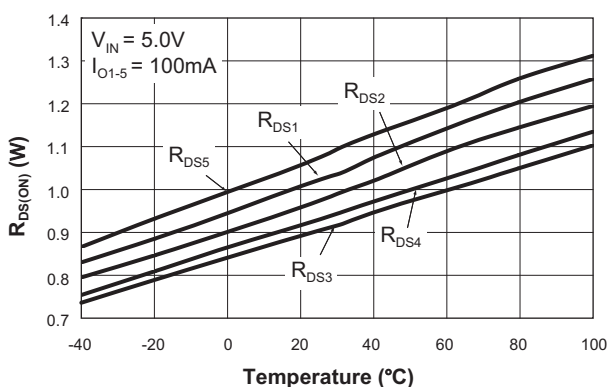
$R_{DS(ON)}$  vs. Input Voltage



$R_{DS(ON)}$  vs. Temperature



$R_{DS(ON)}$  vs. Temperature



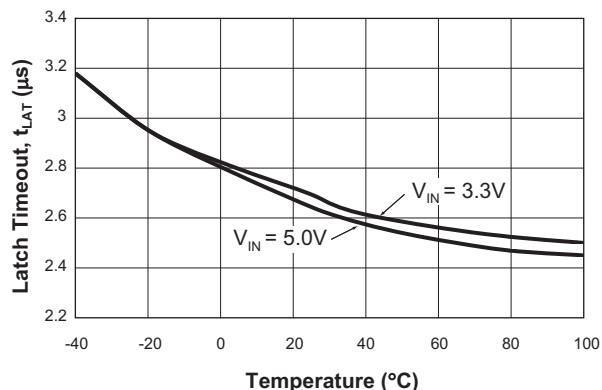
# AAT4290/4291

## I/O Expander Load Switches with Serial Control

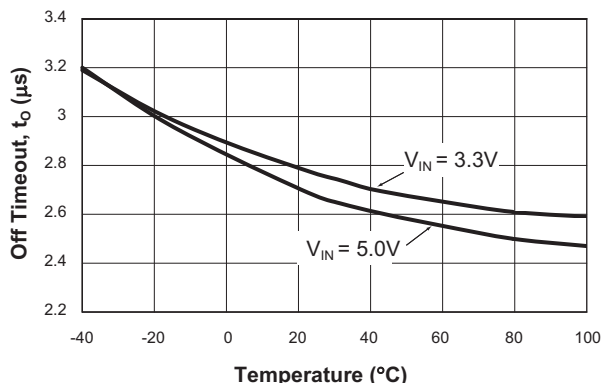
### Typical Characteristics

Unless otherwise noted,  $V_{IN} = 5V$ ,  $C_{IN} = 1\mu F$ ,  $C_{OUTX} = 0.1\mu F$ ,  $T_A = 25^\circ C$ .

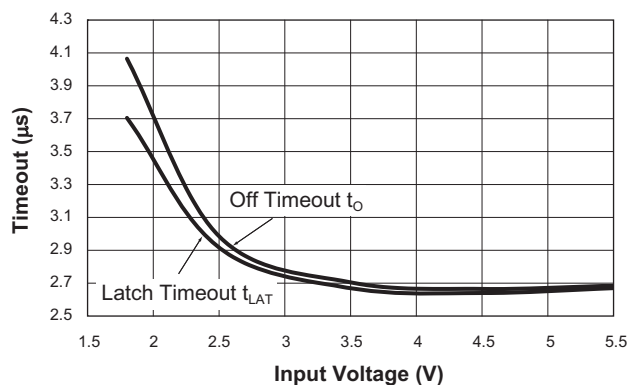
EN/SET Latch Timeout vs. Temperature



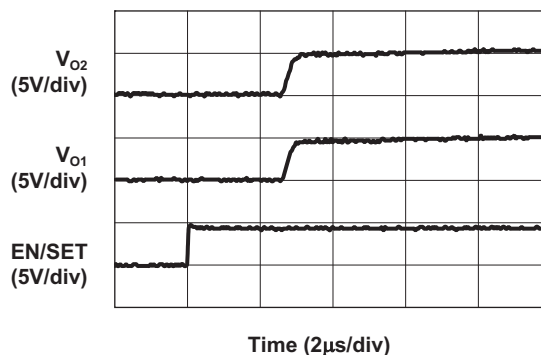
EN/SET Off Timeout vs. Temperature



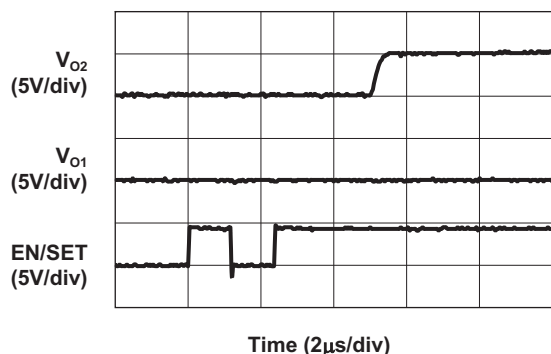
EN/SET Timeout vs. Input Voltage



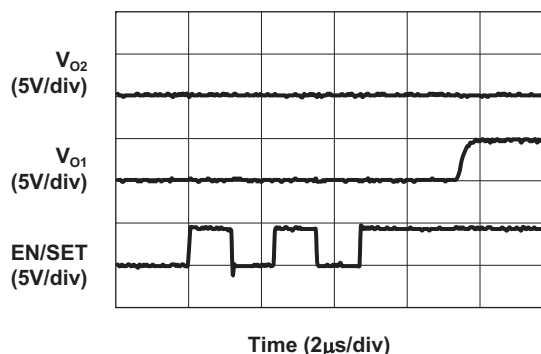
Turn-On Characteristic  
( $V_{IN} = 5V$ ,  $R_{L1} = R_{L2} = 50\Omega$ ;  $C_{O1} = C_{O2} = 0.1\mu F$ )



Turn-On Characteristic  
( $V_{IN} = 5V$ ;  $R_{L1} = R_{L2} = 50\Omega$ ;  $C_{O1} = C_{O2} = 0.1\mu F$ )



Turn-On Characteristic  
( $V_{IN} = 5V$ ;  $R_{L1} = R_{L2} = 50\Omega$ ;  $C_{O1} = C_{O2} = 0.1\mu F$ )



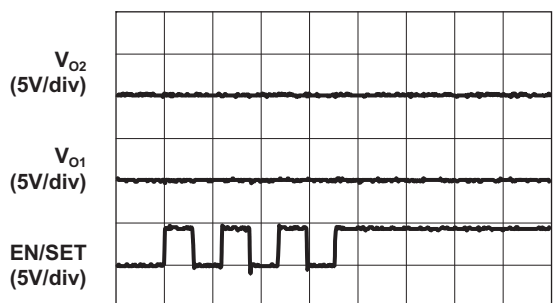
# AAT4290/4291

## I/O Expander Load Switches with Serial Control

### Typical Characteristics

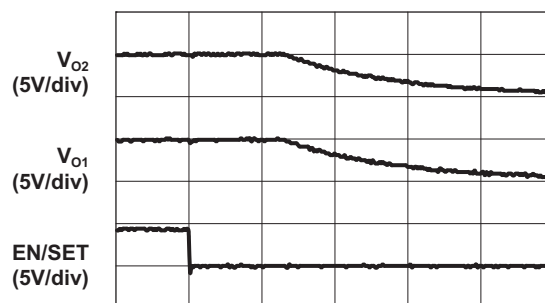
Unless otherwise noted,  $V_{IN} = 5V$ ,  $C_{IN} = 1\mu F$ ,  $C_{OUTX} = 0.1\mu F$ ,  $T_A = 25^\circ C$ .

**Turn-On Characteristic**  
( $V_{IN} = 5V$ ;  $R_{L1} = R_{L2} = 50\Omega$ ;  $C_{O1} = C_{O2} = 0.1\mu F$ )



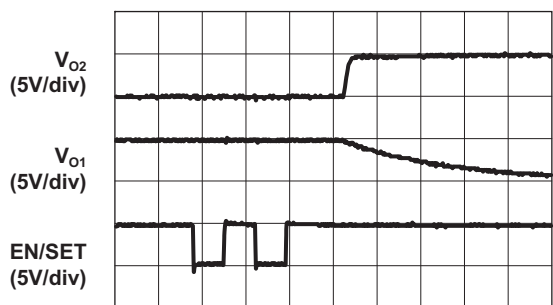
Time (2 $\mu s$ /div)

**Turn-Off Characteristic**  
( $V_{IN} = 5V$ ;  $R_{L1} = R_{L2} = 50\Omega$ ;  $C_{O1} = C_{O2} = 0.1\mu F$ )



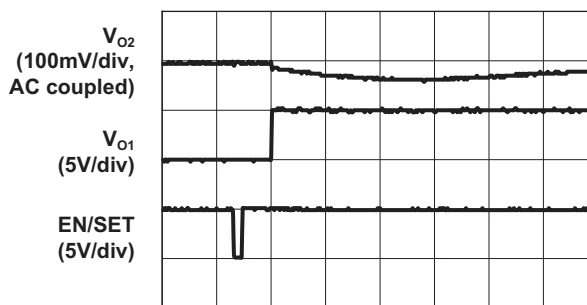
Time (2 $\mu s$ /div)

**Transition of Outputs**  
( $V_{IN} = 5V$ ;  $R_{L1} = R_{L2} = 50\Omega$ ;  $C_{O1} = C_{O2} = 0.1\mu F$ )



Time (2 $\mu s$ /div)

**Turn-On Transient Characteristic**  
( $V_{IN} = 5V$ ;  $R_{L1} = R_{L2} = 50\Omega$ )



Time (5 $\mu s$ /div)

# AAT4290/4291

## I/O Expander Load Switches with Serial Control

### Functional Block Diagram

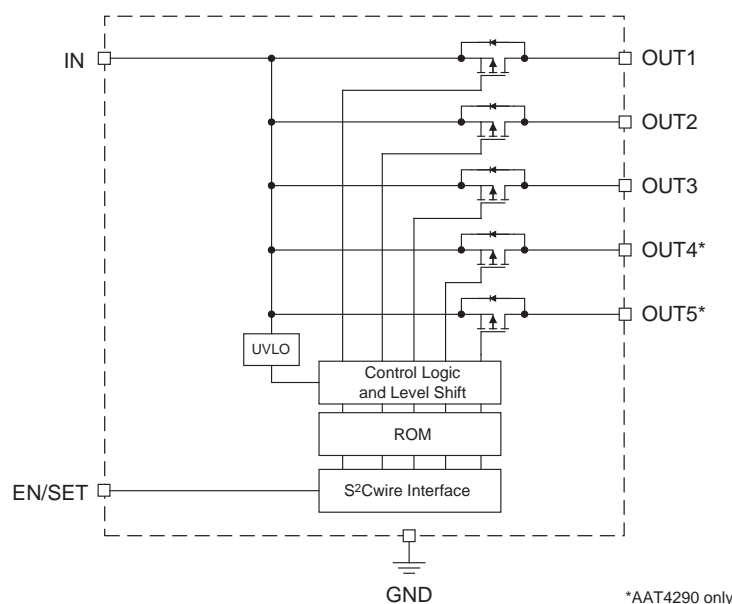


Figure 3. AAT4290/4291 Functional Block Diagram.

### Functional Description

The AAT4290 consists of five P-channel MOSFET power switches designed for I/O expansion applications. The AAT4291 has all of the features offered in the AAT4290, but integrates three switches instead of five. It operates with input voltages ranging from 1.8V to 5.5V which, along with its extremely low operating current, makes it ideal for battery-powered applications. In cases where the input voltage drops below 1.8V, the AAT4290 MOSFETs are protected from entering the linear region of operation by automatically shutting down. In addition, the TTL-compatible EN/SET pin makes the AAT4290 an ideal level-shifted load switch. An optional slew rate controlling feature eliminates in-rush current when a MOSFET is turned on, allowing the AAT4290 to be implemented with a small input capacitor or no capacitor at all, while maintaining isolation between channels. During slewing, the current ramps linearly until it reaches the level required for the output load condition. The proprietary control method works by careful control and monitoring of the MOSFET gate voltage. When the device is switched ON, the gate voltage is quickly increased to the threshold level of the MOSFET. Once at this level, the current begins to slew as the gate voltage is slowly increased until the MOSFET becomes fully enhanced. Once it has reached this point, the gate is quickly increased to the full input voltage and  $R_{DS(ON)}$  is minimized.

The ON/OFF state of the five MOSFET switches are controlled by the EN/SET serial data input. An internal control counter is clocked on the rising edge of the EN/SET pin and is decoded into the 32 possible states of the MOSFET (see Table 1). The counter rolls over after 32 clocks and the table repeats. The counter can be clocked at speeds up to 1MHz, but the count value is not latched until clocking has stopped and the EN/SET pin has remained high for approximately 2.6 $\mu$ s. The first rising edge of EN/SET enables the AAT4290 and is counted as the first clock. To change states, additional low going clock pulses may be asserted on the EN/SET pin with the resulting change taking effect after the EN/SET pin has remained in a high state for  $T_{LAT}$ . The AAT4290 is disabled after the EN/SET pin has transitioned and remained in a logic low state for  $T_O$ .

With the exception of three channel power switches, the AAT4291 has a similar function to the AAT4290. The ON/OFF state of the three MOSFET switches are controlled by the EN/SET serial data input. An internal control counter is clocked on the rising edge of the EN/SET pin and is decoded into the eight possible states of the MOSFET (see Table 2). The counter rolls over after eight clocks and the table repeats.

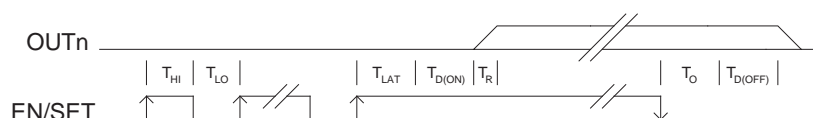
Figure 4 shows the timing diagram.



# AAT4290/4291

## I/O Expander Load Switches with Serial Control

### Timing Diagram

**Figure 4. Timing Diagram.**

| Clock | OUT5 | OUT4 | OUT3 | OUT2 | OUT1 |
|-------|------|------|------|------|------|
| 1     | on   | on   | on   | on   | on   |
| 2     | on   | on   | on   | on   | off  |
| 3     | on   | on   | on   | off  | on   |
| 4     | on   | on   | on   | off  | off  |
| 5     | on   | on   | off  | on   | on   |
| 6     | on   | on   | off  | on   | off  |
| 7     | on   | on   | off  | off  | on   |
| 8     | on   | on   | off  | off  | off  |
| 9     | on   | off  | on   | on   | on   |
| 10    | on   | off  | on   | on   | off  |
| 11    | on   | off  | on   | off  | on   |
| 12    | on   | off  | on   | off  | off  |
| 13    | on   | off  | off  | on   | on   |
| 14    | on   | off  | off  | on   | off  |
| 15    | on   | off  | off  | off  | on   |
| 16    | on   | off  | off  | off  | off  |
| 17    | off  | on   | on   | on   | on   |
| 18    | off  | on   | on   | on   | off  |
| 19    | off  | on   | on   | off  | on   |
| 20    | off  | on   | on   | off  | off  |
| 21    | off  | on   | off  | on   | on   |
| 22    | off  | on   | off  | on   | off  |
| 23    | off  | on   | off  | off  | on   |
| 24    | off  | on   | off  | off  | off  |
| 25    | off  | off  | on   | on   | on   |
| 26    | off  | off  | on   | on   | off  |
| 27    | off  | off  | on   | off  | on   |
| 28    | off  | off  | on   | off  | off  |
| 29    | off  | off  | off  | on   | on   |
| 30    | off  | off  | off  | on   | off  |
| 31    | off  | off  | off  | off  | on   |
| 32    | off  | off  | off  | off  | off  |

**Table 1: AAT4290 Output Settings.**

| Clock | OUT3 | OUT2 | OUT1 |
|-------|------|------|------|
| 1     | on   | on   | on   |
| 2     | on   | on   | off  |
| 3     | on   | off  | on   |
| 4     | on   | off  | off  |
| 5     | off  | on   | on   |
| 6     | off  | on   | off  |
| 7     | off  | off  | on   |
| 8     | off  | off  | off  |

**Table 2: AAT4291 Output Settings.**

### Applications Information

#### Thermal Considerations

The AAT4290 is designed to deliver continuous output load currents. Due to its high level of integration, care must be taken in designing for higher load conditions. If greater loads are required, outputs can be tied together to deliver higher power to a given load.

At 25°C ambient, the AAT4290 is capable of dissipating 440mW of power, or 1.14A at 5.0V, for an average current of 228mA per output.

At 85°C ambient, the AAT4290 is capable of dissipating 178mW of power, or 0.72A at 5.0V, for an average current of 145mA per output.

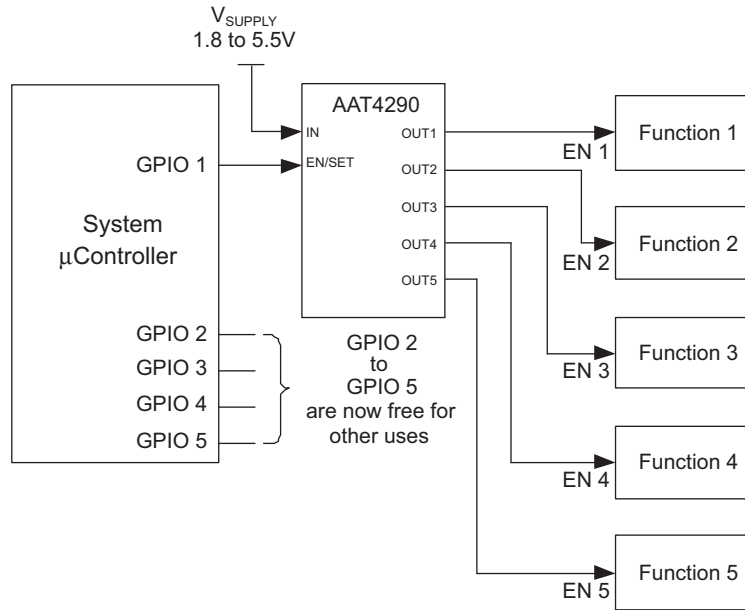
#### Output Sequencing

If output sequencing is not necessary, then all of the outputs will be switched on simultaneously on the first rising edge of the EN/SET pin. However, if output sequencing is desired, then a series of pulses on the EN/SET pin will accomplish this. Each time a new group of pulses is asserted on EN/SET, the AAT4290/91 internal control is reset. For example, to sequence the outputs in order from OUT5 to OUT1, five clocks bursts are input on the EN/SET pin. From Table 1, the first burst of 16 clocks turns on OUT5. A following burst of 8 clocks (as the counter resets) will add OUT4, followed by 4 clocks to add OUT3, 2 clocks to add OUT2, and 1 clock to add OUT1. Likewise, the outputs can be turned off in any order by adding more clock bursts.

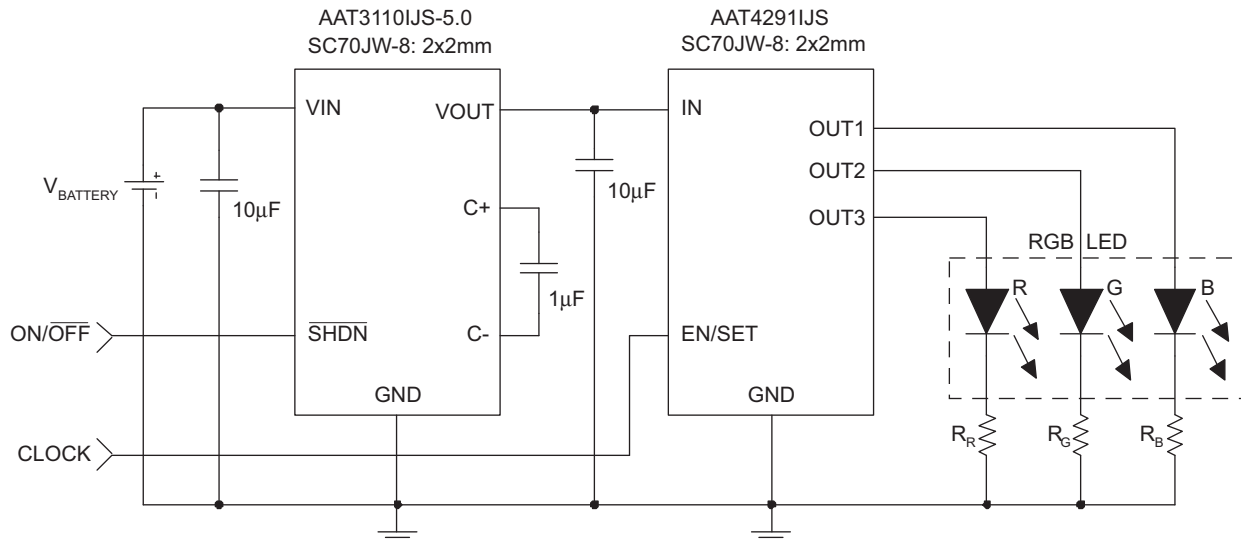
# AAT4290/4291

## I/O Expander Load Switches with Serial Control

### Applications Circuits



**Figure 5: GPIO I/O Expander**  
(condense five GPIO control lines to one).



**Figure 6: RGB LED Control**  
(eliminate three discrete MOSFET switches).

# AAT4290/4291

## I/O Expander Load Switches with Serial Control

### Evaluation Board Description

#### AAT4290 Evaluation Board

The AAT4290IJS-1-DB3 Evaluation Board is used to test the performance of the AAT4290. This section describes

the evaluation board and its accompanying user interface. In addition, a brief Getting Started section is included to help the user begin operating the evaluation board. A schematic of the complete circuit is shown in Figure 7.

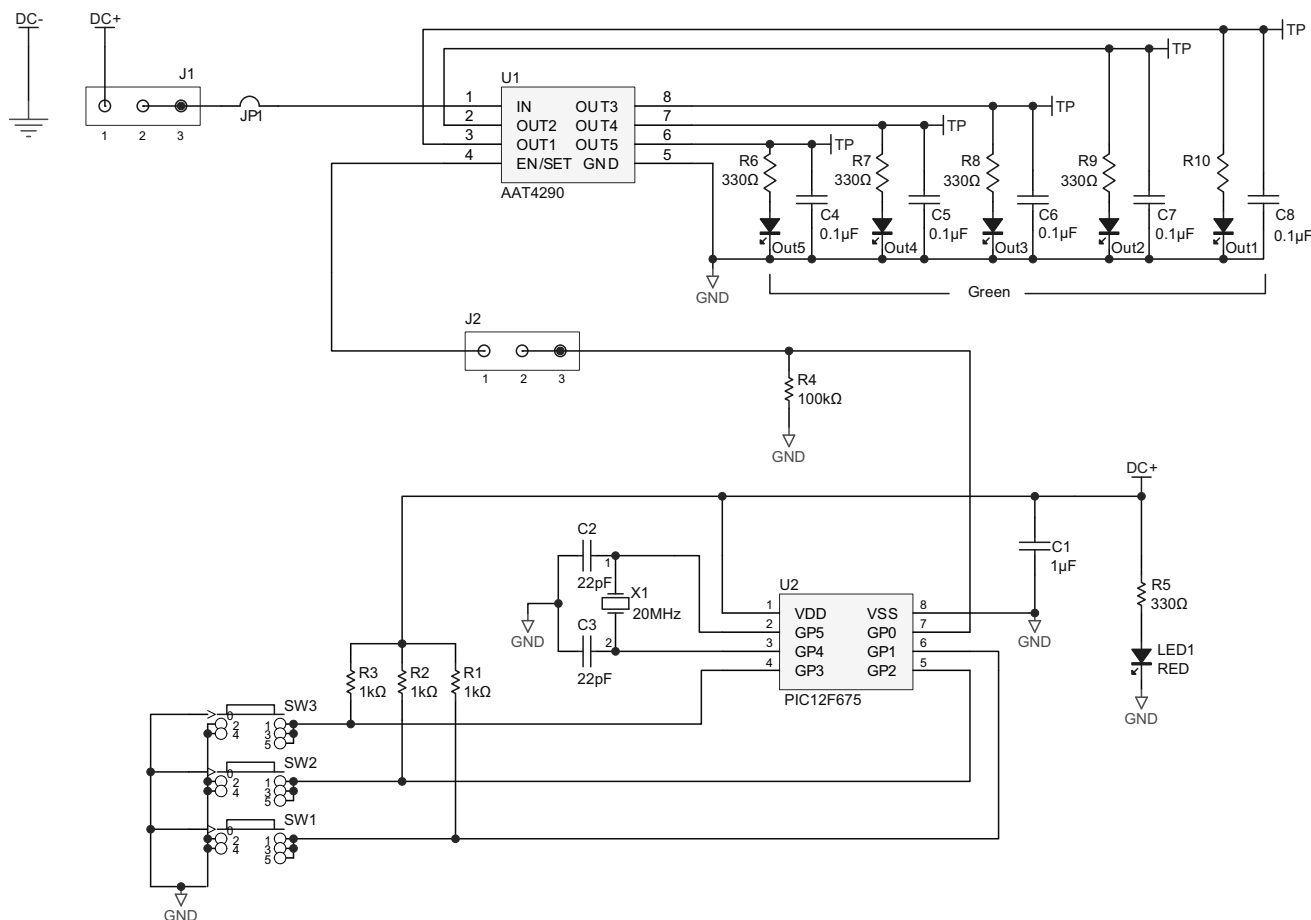


Figure 7: AAT4290IJS-1-DB3 Evaluation Board Schematic.

#### Getting Started

The AAT4290IJS-1-DB3 evaluation board is typically mounted on a battery pack. The battery pack holds three AAA size, conventional alkaline batteries. A jumper is inline with the battery supply for connecting/disconnecting power. There is an additional jumper labeled ON SRL OFF, which provides access to EN/SET. Ensure that the jumper is in the ON SRL position for normal operation. To apply power to the board, ensure the jumper is at the ON MCU position. The red LED1 should illuminate indicating that power has been connected.

The AAT4290 may be operated from an external power source. The batteries should be removed from the battery pack. External power may be applied to the DC+ and DC- points on the board. The external power source should be set from 1.8V to 5.5V before the AAT4290 is turned on by moving the jumper on J1 to the "ON MCU" position.

There are three buttons on the board (SW1, SW2, and SW3) that enable and disable the ON and OFF state for the five output channels. Once a button (or a combination of buttons) is toggled, the corresponding LED for

# AAT4290/4291

## I/O Expander Load Switches with Serial Control

OUT1 to OUT5 will turn ON or OFF accordingly, depending on the previous state. This indicates that the selected state has been submitted through the EN/SET line to the AAT4290. Detailed operations are listed in Table 3. Toggling SW1 and SW3 at once, activates the auto-cycling state through the Table 1 "AAT4290 Output Settings". In other words, the microcontroller will submit a burst of edges, pause, and submit another burst of edges and so on. It will start by submitting 31 edges, next submit 30 edges, etc.; next, submit 1 edge and

then start over. All LEDs should blink five times before the sequence of autocycling. By toggling all three buttons together, all LEDs should turn off.

The AAT4290 outputs can be probed via the test points near the output capacitors (C4 to C8).

The evaluation board layer detail is provided in Figures 8 and 9. Table 4 provides the component list for the AAT4290 evaluation board.

| Button(s) Pushed | Description   |
|------------------|---|
| SW1              | Toggle on/off of output Channel 1.  |
| SW2              | Toggle on/off of output Channel 2.  |
| SW3              | Toggle on/off of output Channel 3.  |
| SW1 + SW2        | Toggle on/off of output Channel 4.  |
| SW2 + SW3        | Toggle on/off of output Channel 5.  |
| SW1 + SW3        | Auto cycling. All outputs blinks (on and off) five times and enter binary-increment mode. Auto cycling repeats three times. |
| SW1 + SW2 + SW3  | Reset. All outputs turn off.  |

Table 3: User Interface Functionality.

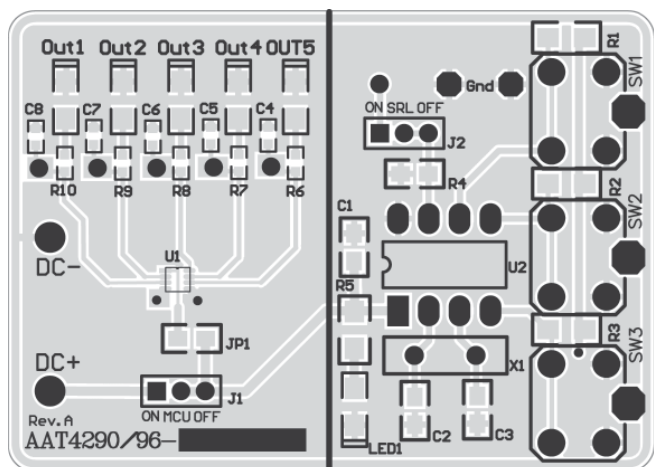


Figure 8: Top Layer (not to scale).

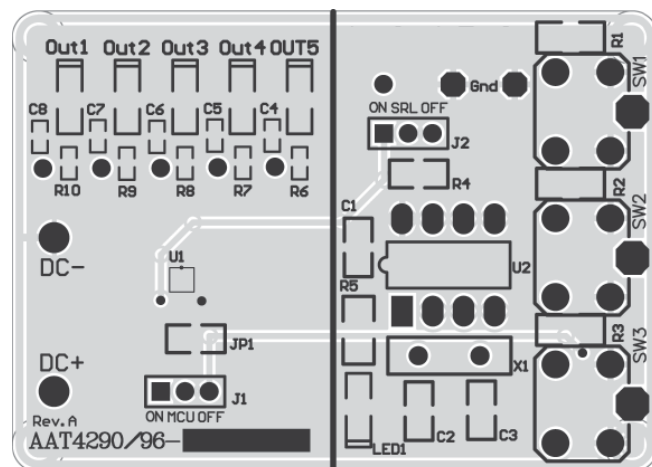


Figure 9: Bottom Layer (not to scale).

# AAT4290/4291

## I/O Expander Load Switches with Serial Control

| Component        | Part#              | Description  | Manufacturer           |
|------------------|--------------------|--|------------------------|
| U1               | AAT4290            | I/O Expander Load Switch with Serial Control; SC70JW-8 package | Skyworks               |
| U2               | PIC12F675          | 8-bit CMOS, FLASH-based $\mu$ C; 8-Pin PDIP package            | Microchip              |
| SW1 – SW3        | PTS645TL50         | Switch Tact, SPST, 5mm   | ITT Industries         |
| R1 – R3          | Chip Resistor      | 1K, 5%, 1/4W; 1206   | Vishay                 |
| R4               | Chip Resistor      | 100K, 5%, 1/4W; 0805   | Vishay                 |
| R5               | Chip Resistor      | 330K, 5%, 1/4W; 1206   | Vishay                 |
| R6-R10           | Chip Resistor      | 330K, 5%, 1/4W; 0603   | Vishay                 |
| JP1              | Chip Resistor      | 0 $\Omega$ , 5%; 0805  | Vishay                 |
| C1               | ECJ-2YB1A105K      | 1 $\mu$ F, 10V, X5R, 10%; 0805                                 | Panasonic-ECG          |
| C2, C3           | VJ0805A220KXAA     | 22pF, 50V, NPO, 10%; 0805                                      | Vishay                 |
| C4-C8 (optional) | GRM188R71C104KA01D | 0.1 $\mu$ F, 16V, 10%; 0603                                    | Murata                 |
| J1, J2           | PRPN401PAEN        | Con. Header, 2mm zip   | Sullins Electronics    |
| X1               | X439-ND            | Quartz crystal 20MHz HC-49US                                   | ECS Inc                |
| LED1             | CMD15-21SRC/TR8    | Red LED; 1206  | Chicago Miniature Lamp |
| OUT1-OUT5        | CMD15-21UGC/TR8    | Green LED; 1206  | Chicago Miniature Lamp |

**Table 4: AAT4290 Evaluation Board Component Listing.**

### AAT4291 Evaluation Board

This section discusses the AAT4291 evaluation board and the application of the AAT4291 as an RGB LED driver. Advanced RGB LED control is realized without having to use multiple discrete MOSFET switches controlled by multiple I/O pins from the system processor. Only one digital I/O pin is needed for complete, independent brightness control of each of the R, G, and B LEDs.

Using RGB LEDs to generate various colors presents unique challenges. Among them is a requirement to pulse width modulate (PWM) three independent LED currents to accurately control the brightness for each LED color. The AAT4291 is well suited for this. Using only one GPIO pin from the system processor, a high PWM rate can be achieved with complete brightness control for each LED.

A schematic of the complete circuit is shown in Figure 10.

### Getting Started

The evaluation board comes with a battery pack attached. In this configuration, VIN is supplied from three standard "AAA" alkaline batteries. Under new conditions for the batteries, the input voltage is generally 4.7V ~ 4.8V and falls off depending on the degree of discharge and load conditions. If desired, the batteries can be removed and an independent, DC supply can be used.

There are five buttons on the board. Their functions are as follows:

- SW1: Increments through the eight Output Setting states (Table 2).
- SW2: Increments B\_LED duty cycle.
- SW3: Increments G\_LED duty cycle.
- SW4: Increments R\_LED duty cycle.
- SW5: Brings EN/SET low (shuts down the AAT4291 device).

Notes:

1. Buttons 1 through 4 will automatically increment if held down.
2. Buttons 2 through 4 are set up so that a user can independently control the corresponding R, G, or B LED brightness. This is done by incrementing the PWM duty cycle through the following states: 0%, 25%, 50%, 75%, 100%, 0%, ...

The PIC microcontroller toggles the EN/SET line high and low at 500kHz. The rise and fall times of the EN/SET signal are small relative to the period, so  $T_{HI}$  and  $T_{LO}$  are roughly 1 $\mu$ s (see Figure 10).  $T_{HI}$  and  $T_{LO}$  depend on the  $\mu$ C's internal RC oscillator, so the 1 $\mu$ s reference is an approximate figure and subject to the precision of the RC oscillator.

Figure 11 shows the typical EN/SET signal.

The evaluation board layer detail is provided in Figures 12 through 14. Table 5 provides the component list for the AAT4290 evaluation board.

# AAT4290/4291

## I/O Expander Load Switches with Serial Control

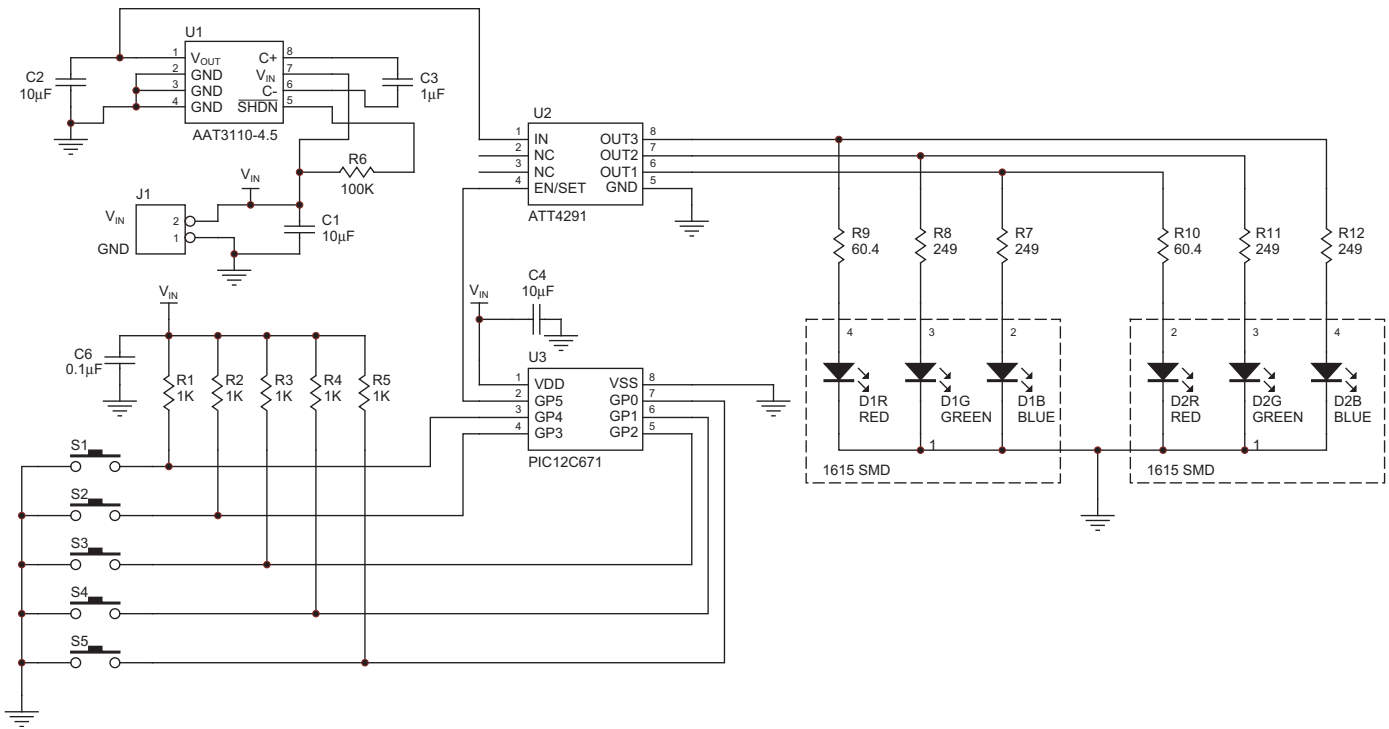


Figure 10: AAT4291IJS-1 Evaluation Board Schematic.

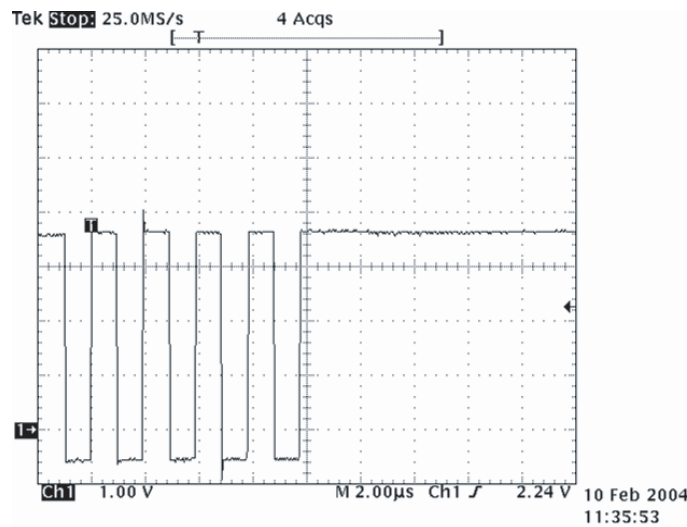


Figure 11: Typical EN/SET Signal.

# AAT4290/4291

## I/O Expander Load Switches with Serial Control

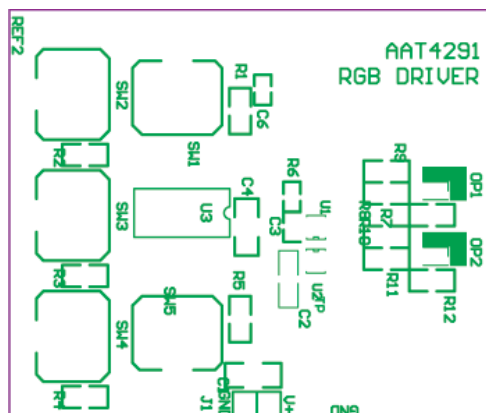


Figure 12: Top Layer Silkscreen (not to scale).

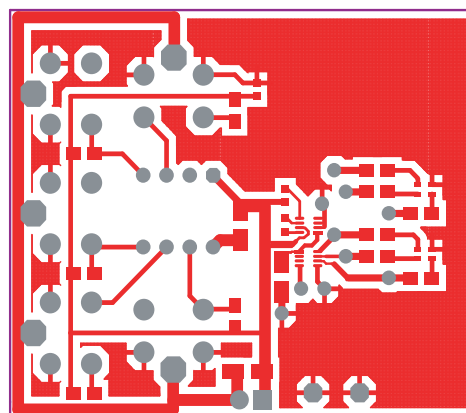


Figure 13: Top Layer (not to scale).

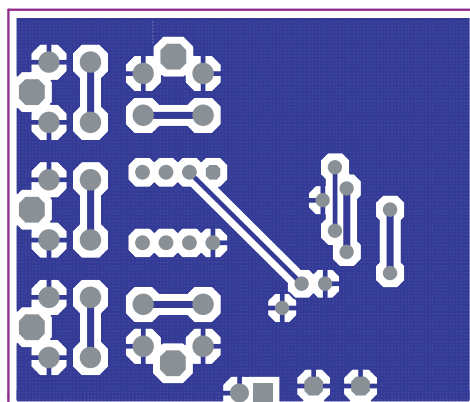


Figure 14: Bottom Layer (not to scale).

| Component  | Part#              | Description                                  | Manufacturer   |
|------------|--------------------|--|----------------|
| U1         | AAT3110            | µPower regulated 4.5V CP; SC70JW-8 package   | Skyworks       |
| U2         | AAT4291            | I/O Expander load switches; SC70JW-8 package | Skyworks       |
| U3         | PIC12C671          | 8-bit CMOSµC; 8-pin PDIP package             | Microchip      |
| OP1, OP2   | CSLRGB1-1505       | RGB LED, common-cathode; 1505 package        | CSENG          |
| C1, C2, C4 | GRM31CR70J106KA01L | 10µF, 6.3V, X7R, 10%; 1206                   | Murata         |
| C3         | ECJ-1VB1A105K      | 1µF, 10V, X5R, 10%; 0603                     | Panasonic-ECG  |
| C6         | ECJ-1VB1C104K      | 0.1µF, 16V, X7R, 10%; 0603                   | Panasonic-ECG  |
| R1 – R5    | Chip Resistor      | 1K, 5%, 1/8W; 0805                           | Vishay         |
| R6         | Chip Resistor      | 100K, 5%, 1/10W; 0603                        | Vishay         |
| R7, R12    | Chip Resistor      | 249, 1%, 1/10W; 0805                         | Vishay         |
| R8, R11    | Chip Resistor      | 249, 1%, 1/10W; 0805                         | Vishay         |
| R9, R10    | Chip Resistor      | 60.4, 1%, 1/10W; 0805                        | Vishay         |
| SW1 – SW5  | PTS645TL50         | Switch Tact, SPST, 5mm                       | ITT Industries |

Table 5: AAT4291 Evaluation Board Component Listing.

# AAT4290/4291

## I/O Expander Load Switches with Serial Control

### Ordering Information

| Package  | Marking <sup>1</sup> | Part Number (Tape and Reel) <sup>2</sup> |
|----------|----------------------|--|
| SC70JW-8 | HSXY                 | <b>AAT4290IJS-1-T1</b>                   |
| SC70JW-8 | HCTX                 | <b>AAT4291IJS-1-T1</b>                   |



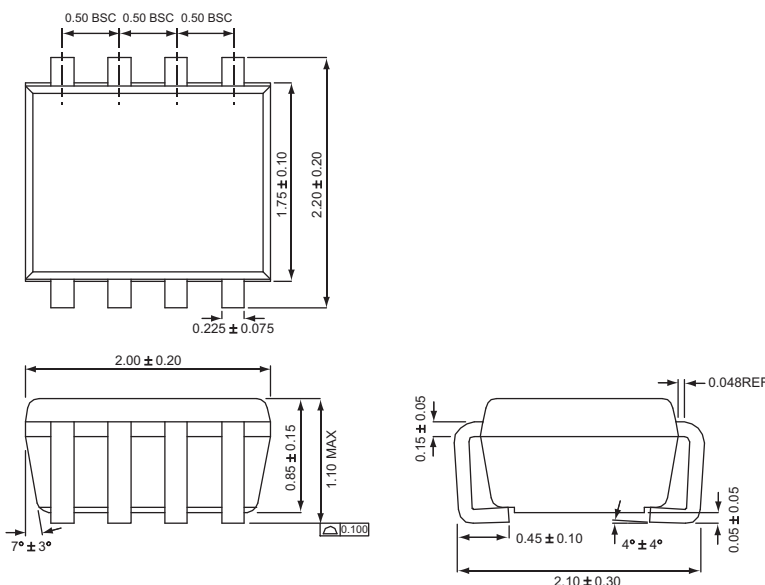
Skyworks Green™ products are compliant with all applicable legislation and are halogen-free.



For additional information, refer to *Skyworks Definition of Green™*, document number SQ04-0074.

### Package Information

#### SC70JW-8



All dimensions in millimeters.

1. XYY = assembly and date code.
2. Sample stock is generally held on part numbers listed in **BOLD**.

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