SmartSwitch™

General Description

The AAT4290 and AAT4291 SmartSwitch™ products are members of AATI's Application Specific Power MOSFET™ (ASPM™) product family with 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 Li-Ion batteries. Each switch features a 500ns turn on time. The switch states are controlled by a S²Cwire interface which permits ease of control and efficiency of size. The quiescent supply current is very low, typically 5µA. In shutdown mode, the supply current is reduced to less than 1µA.

The AAT4290 and AAT4291 are offered in an 8 pin SC70JW package specified over -40 to 85°C.

Features

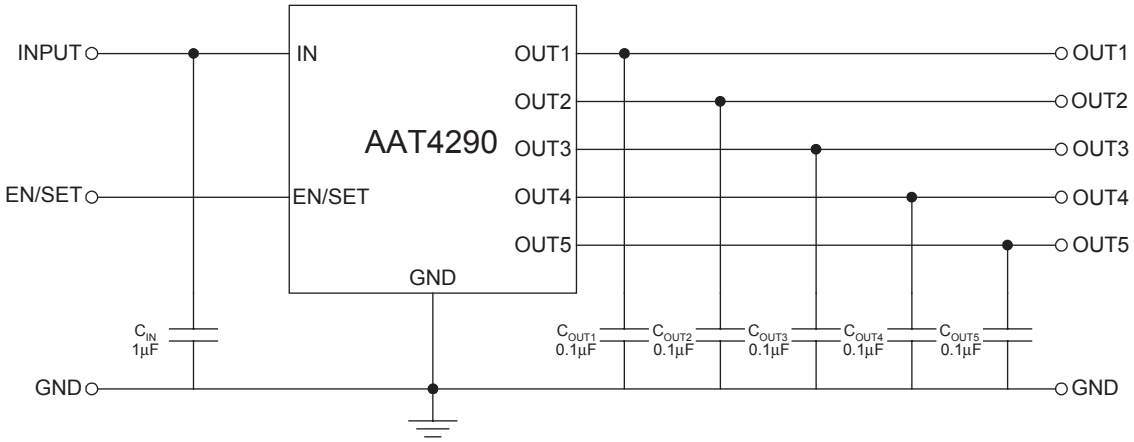
- 1.8V to 5.5V input voltage range
- 5 or 3 Independent Load Switches
- Optional 200µS Slew Rate Control
- Simple Serial Control™ (S²Cwire™) Interface
- 1.1Ω $R_{DS(ON)}$ Per Switch
- Low quiescent current
  - 5µA
  - 0.1µA in shutdown
- -40°C to +85°C Temperature range
- Available in 8-Pin SC70JW package

Applications

- I/O Expansion
- Multiple low power switching
- Cell Phones
- Personal communication devices
- Portable Electronic Devices

Preliminary Information

Typical Application

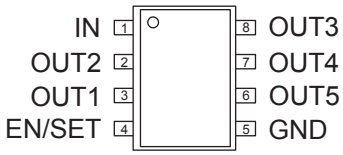


Pin Descriptions

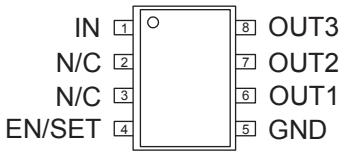
Pin #		Symbol	Function
AAT4290	AAT4291		
1	1	IN	Input power supply is connected to the P-channel MOSFETs sources. Connect a 1µF capacitor from IN to GND.
2	7	OUT2	P-channel MOSFET drain
3	6	OUT1	P-channel MOSFET drain
4	4	EN/SET	Input control pin using S²Cwire serial interface. The device records rising 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

Pin Configuration

AAT4290
(SC70JW-8)



AAT4291
(SC70JW-8)



Absolute Maximum Ratings [1]

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 [2]	4000	V

Notes:
1: Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional conditions 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 100 pF capacitor discharged through a 1.5 KΩ resistor to each pin.

Thermal Characteristics

Symbol	Description	Value	Units
θ_{JA}	Thermal Resistance [3]	225	°C/W
P_D	Maximum Power Dissipation (T_A = 25°C) [4]	440	mW

Note 3: Mounted on the board.
Note 4: Derate 4.4mW/°C above 25°C.

Electrical Characteristics

V_{IN}=5.0V, T_A = -40 to 85°C unless otherwise noted. Typical values are at T_A = 25°C.

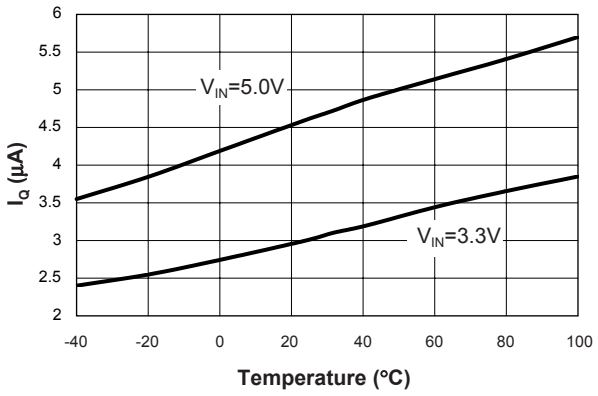
Symbol	Description	Conditions	Min	Typ	Max	Units
V_{IN}	Operation Voltage		1.8		5.5	V
I_Q	Quiescent Current	V_{IN}=5.5V, EN/SET=V_{IN}, I_{OUT}=0, All Switches ON		4.5	8	µA
$I_{Q(OFF)}$	Off Supply Current	EN/SET=0, V_{IN}=5.5V, V_{OUT} Open			1	µA
$I_{SD(OFF)}$	Off Switch Current	EN/SET=0, V_{IN}=5.5V, V_{OUT}n=0		0.1	1	µA
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°C		2.5	3.8	Ω
		V_{IN}=3.0V, T_A = 25°C		1.5	2.2	
		V_{IN}=4.2V, T_A = 25°C		1.2	1.8	
		V_{IN}=5.0V, T_A = 25°C		1.1	1.7	
T_{CRDS}	On-Resistance Temp-Co			2800		ppm°C
AAT4290-1 & AAT4291-1						
$T_{D(ON)}$	Output Turn-On Delay	V_{IN}=5V, R_{LOAD}=500Ω, C_{OUT}=0.1µF		40		ns
T_R	Turn-On Rise Time	V_{IN}=5V, R_{LOAD}=500Ω, C_{OUT}=0.1µF		270		ns
$T_{D(OFF)}$	Turn-Off Delay Time	V_{IN}=5V, R_{LOAD}=500Ω		40		ns
AAT4290-2 & AAT4291-2						
$T_{D(ON)}$	Output Turn-On Delay	V_{IN}=5V, R_{LOAD}=500Ω, C_{OUT}=0.1µF		50		µs
T_R	Turn-On Rise Time	V_{IN}=5V, R_{LOAD}=500Ω, C_{OUT}=0.1µF		200		µs
$T_{D(OFF)}$	Turn-Off Delay Time	V_{IN}=5V, R_{LOAD}=500Ω		40		ns
EN/SET						
$V_{EN(L)}$	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} ≤ 2.5V			500	ns
		V_{IN} > 2.5V			250	
T_O	EN/SET Off Timeout			2.6	4.0	µs
T_{LAT}	EN/SET Latch Timeout			2.6	4.0	µs
I_{SINK}	EN/SET input leakage	$V_{EN/SET}$ = 5.5V		0.01	1	µA

Note 1: The AAT4290 is guaranteed to meet performance specification over the -40°C to 85°C operating temperature range and are assured by design, characterization and correlation with statistical process controls.

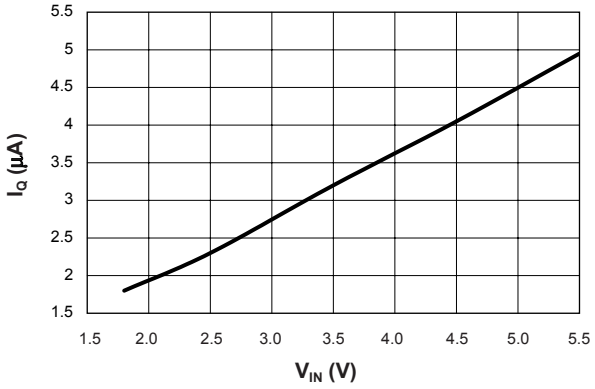
Typical Characteristics

(Unless otherwise noted, V_{IN} = 5V, C_{IN} = 1µF, C_{OUTX} = 0.1µF, T_A = 25°C)

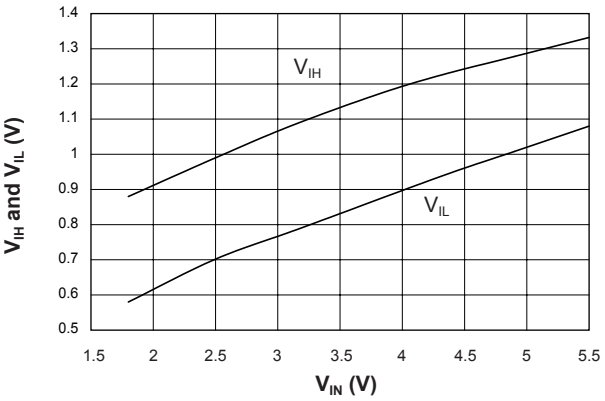
Quiescent Current vs. Temperature



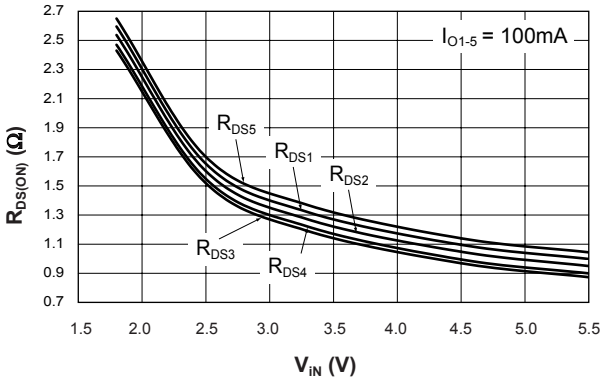
Quiescent Current vs. Input Voltage



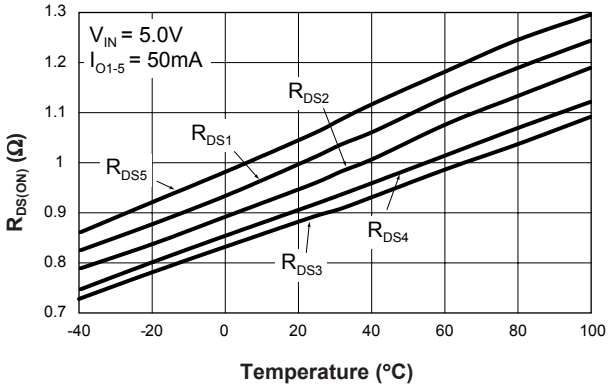
V_{IH} and V_{IL} vs. Input Voltage



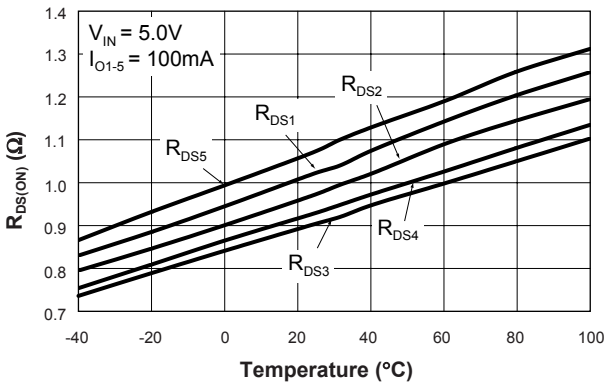
$R_{DS(ON)}$ vs. Input Voltage



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



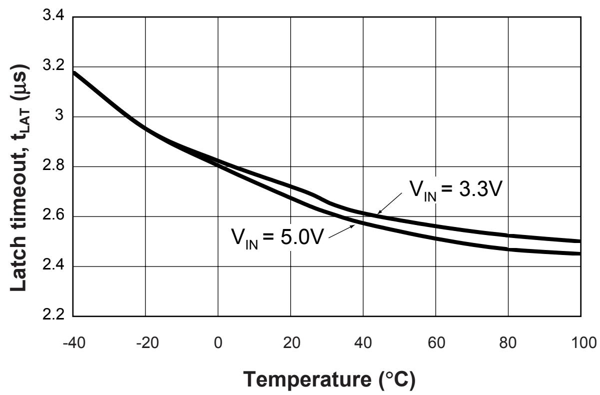
$R_{DS(ON)}$ vs. Temperature



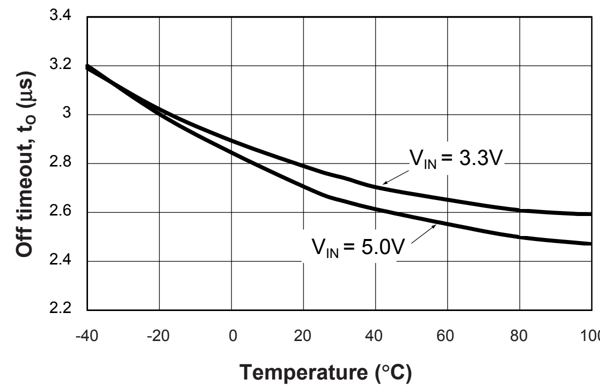
Typical Characteristics

(Unless otherwise noted, V_{IN} = 5V, C_{IN} = 1µF, C_{OUTX} = 0.1µF, T_A = 25°C)

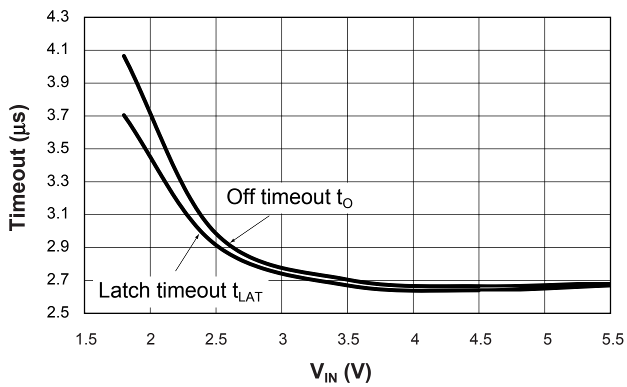
EN/SET Latch Timeout vs. Temperature



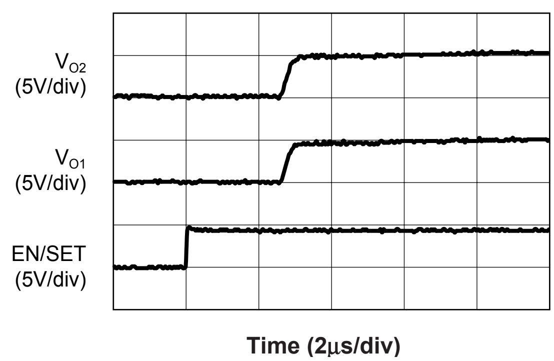
EN/SET Off Timeout vs. Temperature



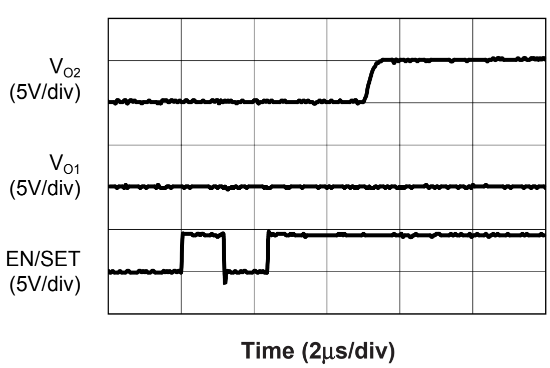
EN/SET Timeout vs. Input Voltage



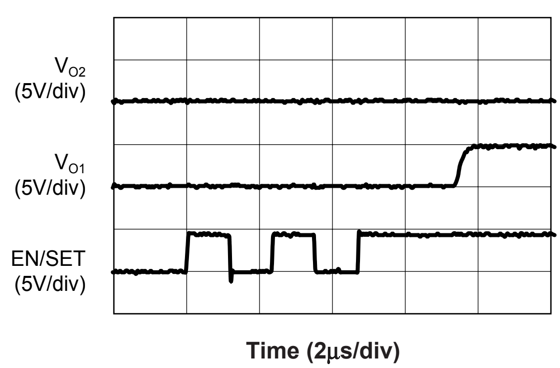
Turn-On Characteristic
V_{IN}=5V, R_{L1}=R_{L2}=50Ω, C_{O1}=C_{O2}=0.1µF



Turn-On Characteristic
V_{IN}=5V, R_{L1}=R_{L2}=50Ω, C_{O1}=C_{O2}=0.1µF



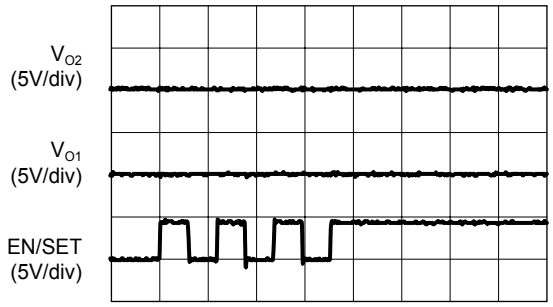
Turn-On Characteristic
V_{IN}=5V, R_{L1}=R_{L2}=50Ω, C_{O1}=C_{O2}=0.1µF



Typical Characteristics

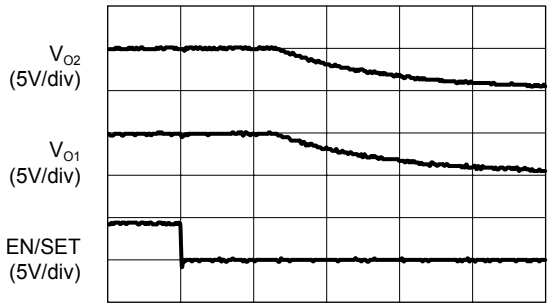
(Unless otherwise noted, V_{IN} = 5V, C_{IN} = 1µF, C_{OUTX} = 0.1µF, T_A = 25°C)

Turn-On Characteristic
V_{IN}=5V, R_{L1}=R_{L2}=50Ω, C_{O1}=C_{O2}=0.1µF



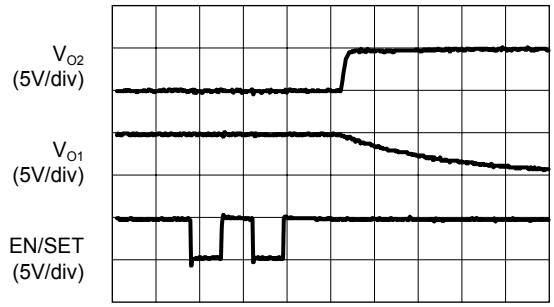
Time (2µs/div)

Turn-Off Characteristic
V_{IN}=5V, R_{L1}=R_{L2}=50Ω, C_{O1}=C_{O2}=0.1µF



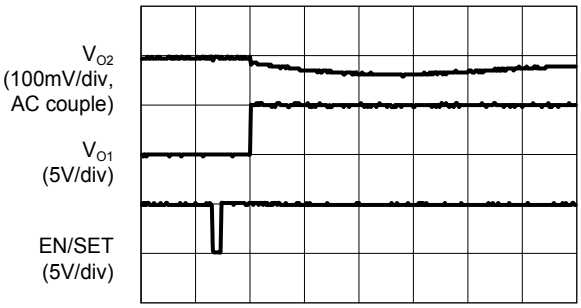
Time (2µs/div)

Transition of Outputs
V_{IN}=5V, R_{L1}=R_{L2}=50Ω, C_{O1}=C_{O2}=0.1µF



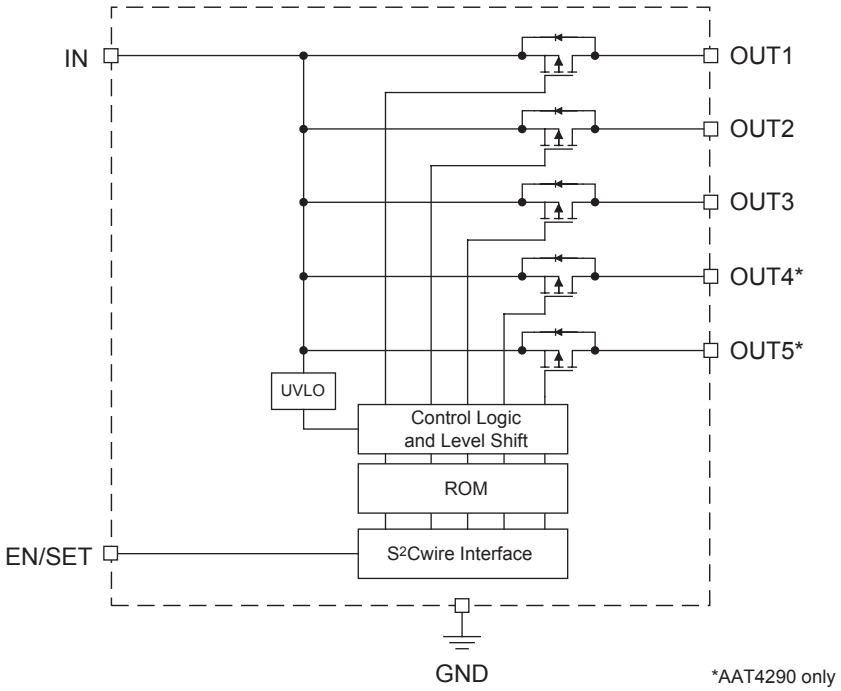
Time (2µs/div)

Turn-On Transient Characteristic
V_{IN}=5V, R_{L1}=R_{L2}=50Ω



Time (5µs/div)

Functional Block Diagram



Functional Description

The AAT4290 consists of 5 P-channel MOSFET power switches designed for I/O expansion applications. The AAT4291 has all of the features offered in the AAT4290, but integrates 3 switches instead of 5. 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 5 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 below). The counter rolls over after 32 clocks and the table repeats. The counter can be clocked at speeds up to 1 MHz, but the count value is not latched until clocking has stopped and the EN/SET pin has remained high for approximately 2.6µs. 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.

Table 1: AAT4290 Output Settings

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

With the exception of 3 channel power switches, the AAT4291 has a similar function to 4290. The ON/OFF state of the 3 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 8 possible states of the MOSFET (see table 2). The counter rolls over after 8 clocks and the table repeats.

Table 2: AAT4291 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

Applications Information

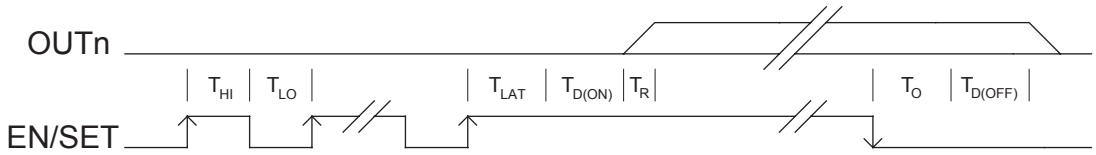
Thermal Considerations

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.

Timing Diagram



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 AAT4290/1 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 the above table, 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.

Applications Circuits

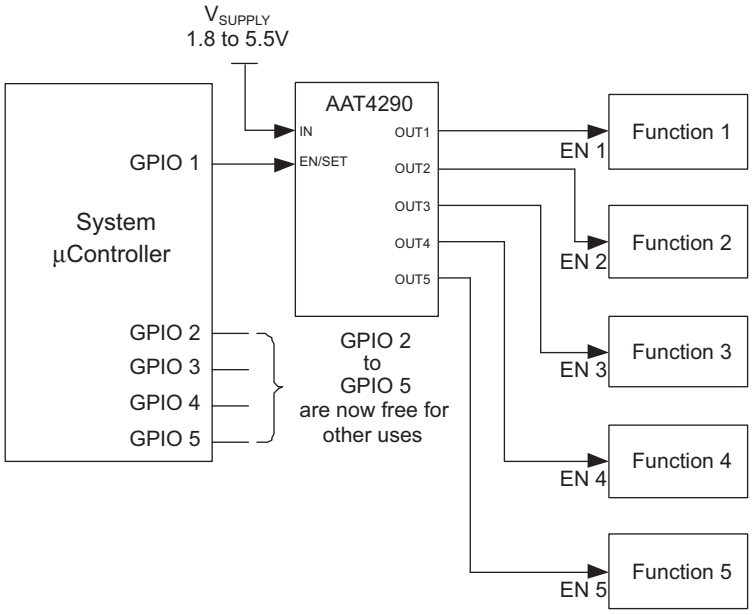


Figure 1: GPIO I/O Expander
Condense 5 GPIO Control Lines to 1

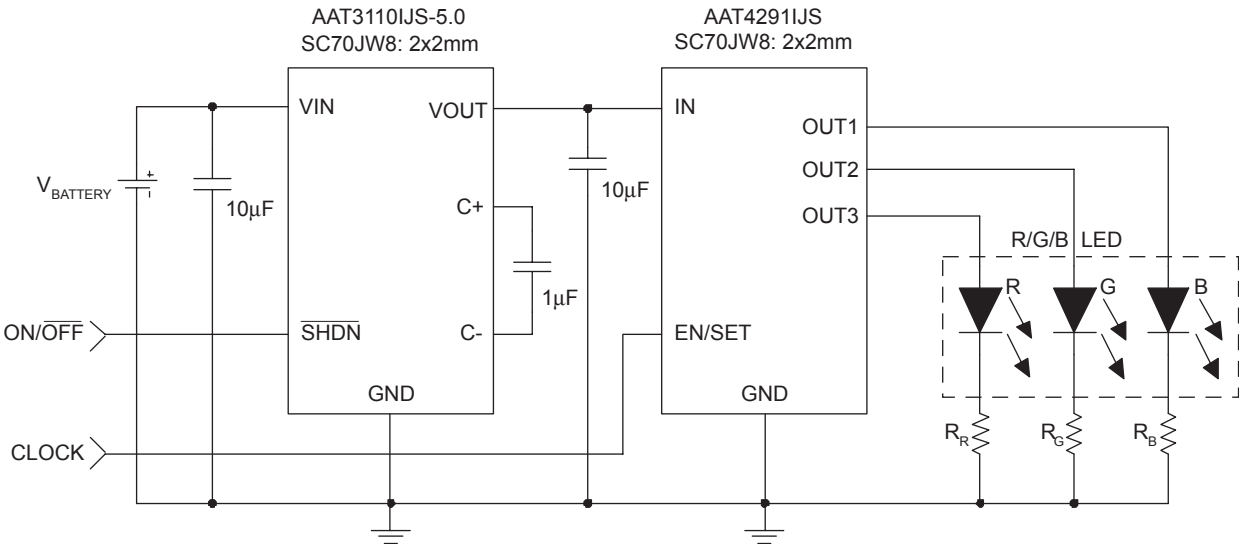


Figure 2:RGB LED Control
Eliminates 3 Discrete MOSFET Switches

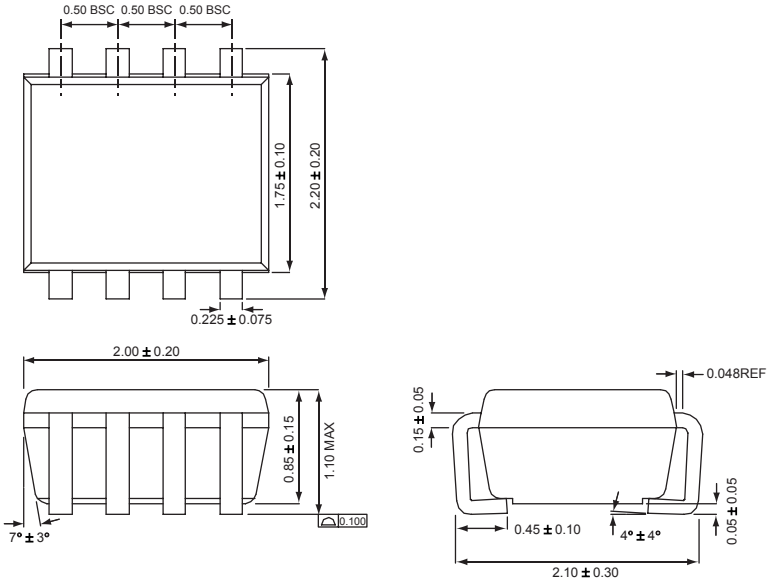
Ordering Information

Package	Marking[1]	Part Number (Tape and Reel)
SC70JW-8	HSXYY	AAT4290IJS-1-T1
SC70JW-8	HCXYY	AAT4291IJS-1-T1

Note 1: XYY = assembly and date code.

Package Information

SC70JW-8



All dimensions in millimeters.

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