DATA SHEET

AAT4900

Buffered Power Half Bridge

General Description

The AAT4900 FastSwitch is a member of Skyworks' Application Specific Power MOSFET (ASPM™) product family. It is a buffered power half-bridge, consisting of low on resistance power MOSFETs with integrated control logic. This device operates with inputs ranging from 2.0V to 5.5V, making it ideal for 2.5V, 3V, and 5V systems. The device is protected from shoot-through current with its own control circuitry. The AAT4900 is capable of very fast switching times and is ideal for use in high frequency DC/DC converters. The quiescent supply current is a low 4mA at 1MHz CLK frequency. In shutdown mode, the supply current decreases to less than 1μA max.

The AAT4900 is available in a Pb-free 5-pin SOT23 or 8-pin SC70JW package and is specified over the -40°C to +85°C temperature range.

Features

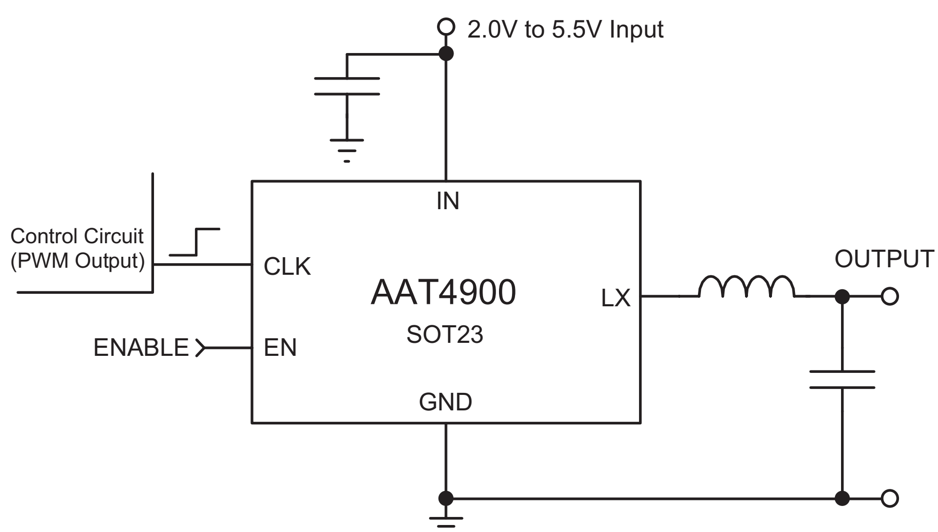
- 2.0V to 5.5V Input Voltage Range
- 105mΩ (typ) Low Side Switch $R_{DS(ON)}$
- 130mΩ (typ) High Side Switch $R_{DS(ON)}$
- Low Quiescent Current:
  - 1μA (max) DC
  - 4mA at 1MHz
- Only 2.5V Needed for Control Signal Input
- Break-Before-Make Shoot-Through Protection
- Temperature Range: -40°C to +85°C
- 5-Pin SOT23 or 8-Pin SC70JW Package

Applications

- DC Motor Drive
- High Frequency DC/DC Converters
- MOSFET Driver

Typical Application

DC/DC Converter Output Stage

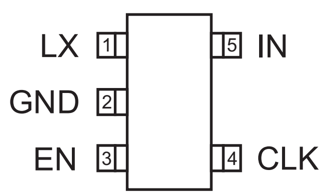


Pin Descriptions

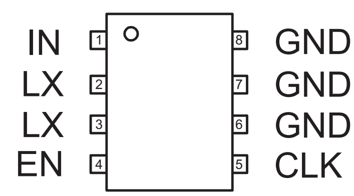
Pin #			
SOT23-5	**SC70JW-8**	**Symbol**	**Function**
1	2, 3	LX	Inductor connection. LX output is controlled by CLK and EN (see Control Logic Table).
2	6, 7, 8	GND	Ground connection.
3	4	EN	Active-high enable input. A logic low signal puts the LX output pin in high impedance mode.
4	5	CLK	Logic input signal determines the state of LX output.
5	1	IN	Supply voltage input. Input voltage range from 2.0V to 5.5V.

Pin Configuration

SOT23-5
(Top View)



SC70JW-8
(Top View)



Control Logic Table

Inputs		Output
CLK	EN	LX
0	0	High Impedance
0	1	V_{IN}
1	0	High Impedance
1	1	Ground

Absolute Maximum Ratings[1]

T_A = 25°C, unless otherwise noted.

Symbol	Description	Value	Units
V_{IN}	IN to GND	-0.3 to 6	V
V_{EN}, V_{CLK}	EN, CLK to GND	-0.3 to 6	V
V_{OUT}	OUT to GND	-0.3 to V_{IN}+0.3	V
I_{MAX}	Maximum Continuous Switch Current	2	A
T_J	Operating Junction Temperature Range	-40 to 150	°C
V_{ESD}	ESD Rating[2] - HBM	4000	V
T_{LEAD}	Maximum Soldering Temperature (at Leads)	300	°C

Thermal Information[3]

Symbol	Description	Value	Units
Θ_{JA}	Thermal Resistance (SOT23-5, SC70JW-8)	190	°C/W
P_D	Power Dissipation (SOT23-5, SC70JW-8)	526	mW

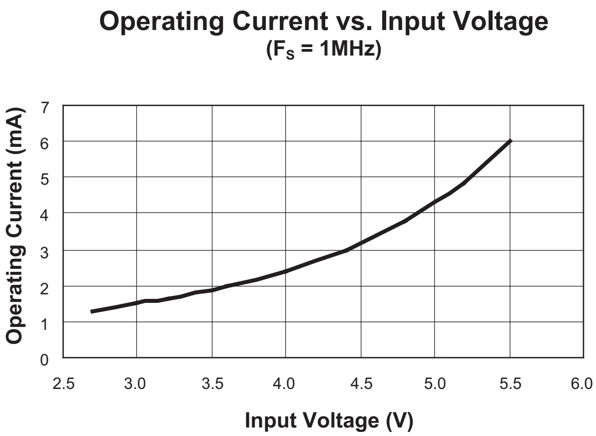
1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum Rating should be applied at any one time.
2. Human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.
3. Mounted on a demo board.

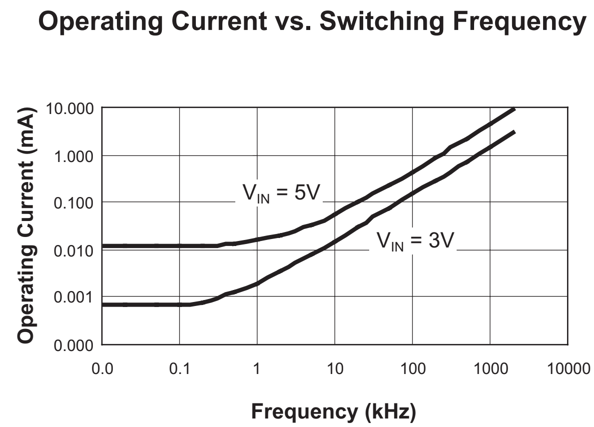
Electrical Characteristics

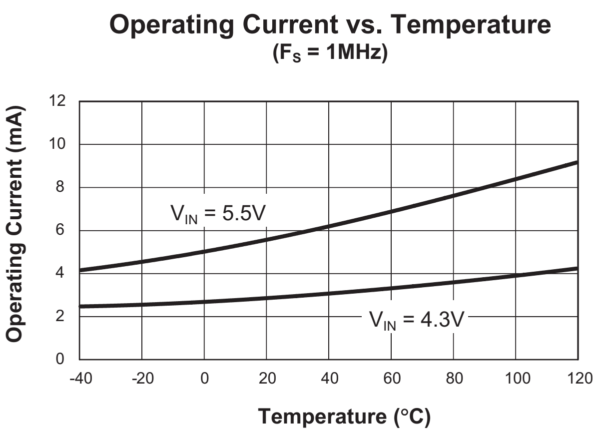
V_{IN} = 5V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = 25°C.

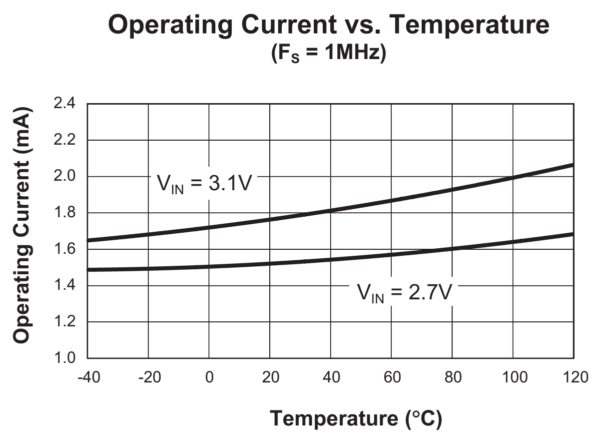
Symbol	Description	Conditions	Min	Typ	Max	Units
V_{IN}	Operation Voltage		2.0		5.5	V
I_{QAC}	AC Quiescent Current	IN = 5V, EN = IN, CLK = 1MHz, I_{LX} = 0		4	9	mA
I_{QDC}	DC Quiescent Current	IN = 5V, EN = IN, CLK = GND, I_{LX} = 0			1	μA
$I_{Q(OFF)}$	Off-Supply Current	EN = CLK = GND, IN = LX = 5.5V			1	μA
$I_{SD(OFF)}$	Off-Switch Current	EN = GND, IN = 5.5V, V_{OUT} = 0 or LX = IN		0.03	1	μA
$R_{DS(ON)H}$	High Side MOSFET On Resistance	IN = 5V, T_A = 25°C		130	165	mΩ
		IN = 3V, T_A = 25°C		165	195	
		IN = 2V, T_A = 25°C		235		
$R_{DS(ON)L}$	Low Side MOSFET On Resistance	IN = 5V, T_A = 25°C		105	145	mΩ
		IN = 3V, T_A = 25°C		135	175	
		IN = 2V, T_A = 25°C		200		
V_{ONL}	CLK, EN Input Low Voltage	IN = 2V to 5.5V			0.4	V
V_{ONH}	CLK, EN Input High Voltage	IN = 2V to 5.5V	1.5			V
I_{SINK}	CLK, EN Input Leakage	CLK, EN = 5.5V		0.01	1	μA
T_{BBM}	Break-Before-Make Time	CLK Rising		5		ns
		CLK Falling		5		
$T_{ON\text{-}DLY}$	CLK to LX Delay	CLK Rising		30		ns
		CLK Falling		40		
T_{HIZ}	EN to OUT HiZ Delay	CLK = GND		40		ns
		CLK = IN		40		

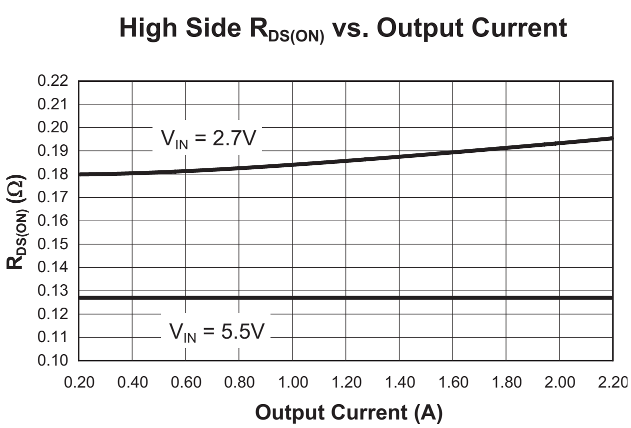
Typical Characteristics

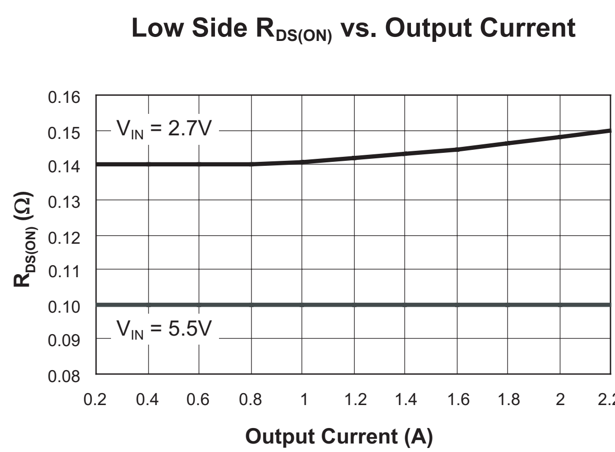




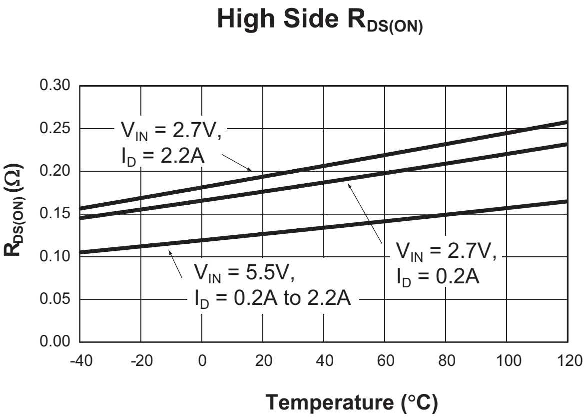


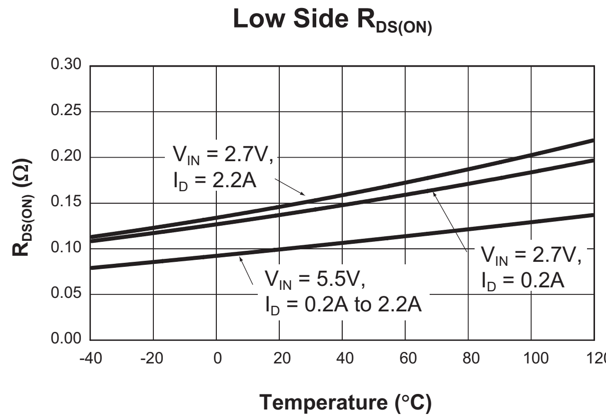


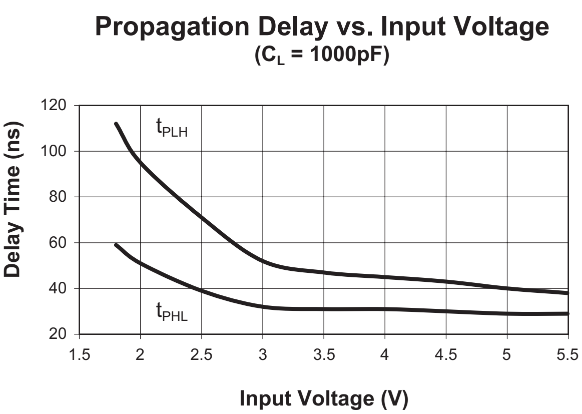


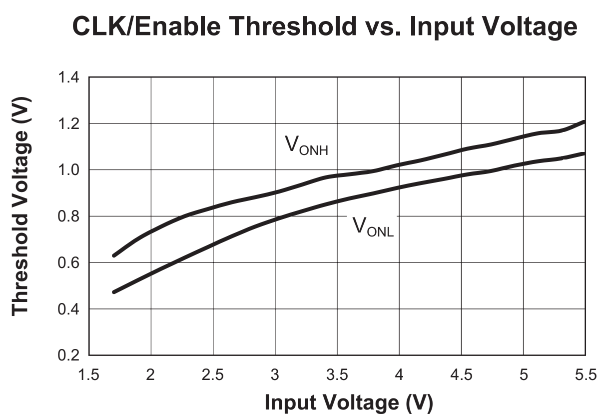


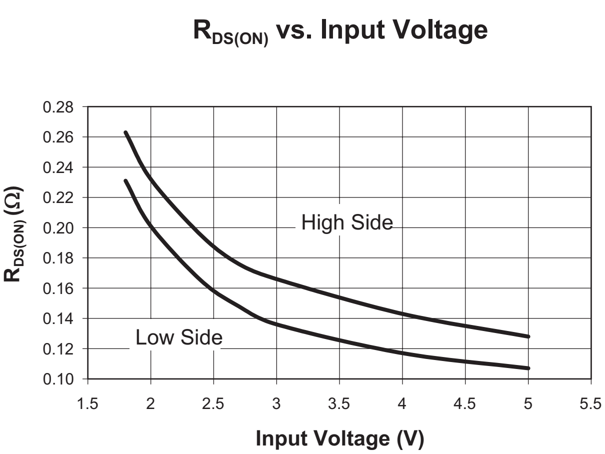
Typical Characteristics











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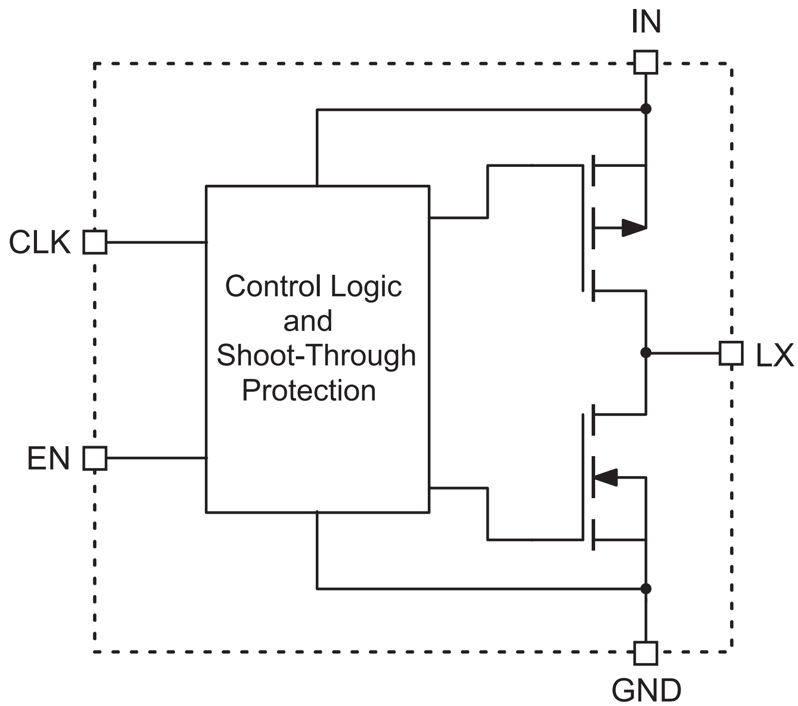
Functional Block Diagram



Typical Applications

DC/DC Converter

The most common AAT4900 applications include a DC/DC converter output power stage and a MOSFET gate drive buffer.

Figure 1 shows a common configuration when used as a DC/DC converter power stage with synchronous rectification. The enable pin can be used to force the LX output to a high impedance state under light load conditions. This enables the output inductor to operate in discontinuous conduction mode (DCM), improving efficiency under light load conditions. The body diode associated with the low side switching device gives the AAT4900 inductive switching capability, clamping the LX node at a diode drop below GND during the break-before-make time.

Synchronous Buck DC/DC Converter Application

The losses associated with the AAT4900 high side switching MOSFET are due to switching losses and conduction losses. The conduction losses are associated with the $R_{DS(ON)}$ characteristics of the output switching device. At the full load condition, assuming continuous conduction mode (CCM), the on losses can be derived from the following equations.

Eq. 1: $D = \frac{V_O}{V_{IN}}$

D is the duty cycle.

Eq. 2: $\Delta I = \frac{V_O}{L \cdot F_S} \left(1 - \frac{V_O}{V_{IN}}\right)$

ΔI is the *peak-to-peak* inductor ripple current.

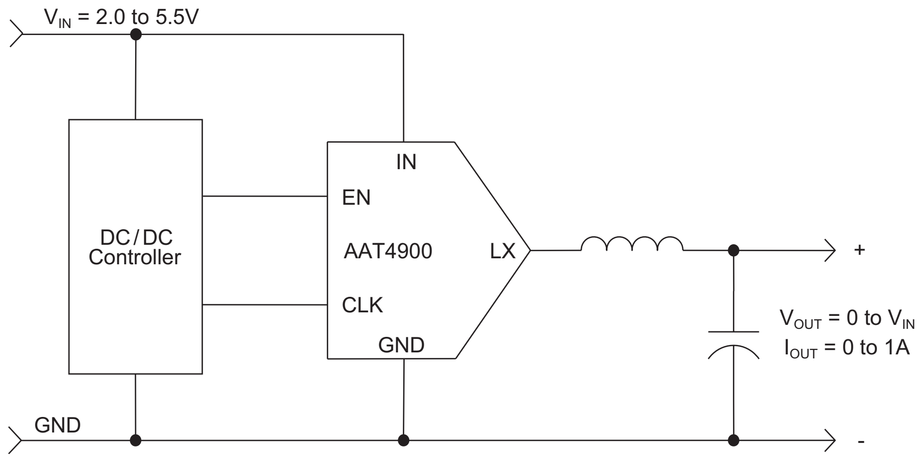


Figure 1: AAT4900 DC/DC Converter Power Stage.

High Side Switch RMS Current

Eq. 3: $I_{RMS(HS)} = \sqrt{\left(I_O^2 + \frac{\Delta I^2}{12}\right) \cdot D}$

Low Side Switch RMS Current

The low side RMS current is estimated by the following equation.

Eq. 4: $I_{RMS(LS)} = \sqrt{\left(I_O^2 + \frac{\Delta I^2}{12}\right) \cdot (1 - D)}$

Total Losses

A simplified form of the above results (where the above descriptions of I_{RMS} has been approximated with I_o) is given by:

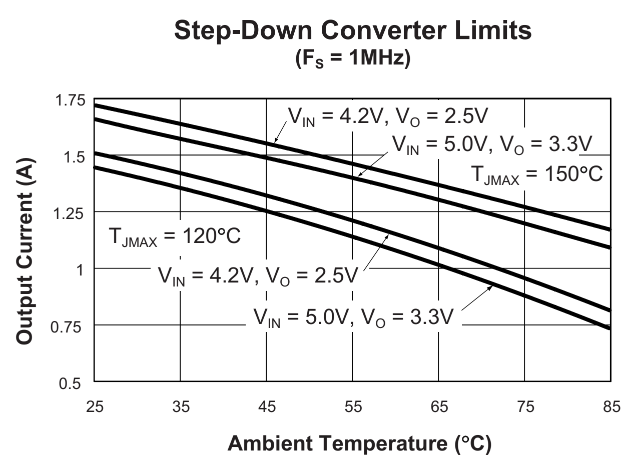
Eq. 5: $P_{LOSS} = \frac{I_O^2 \cdot (R_{DS(ON)H} \cdot V_O + R_{DS(ON)L} \cdot (V_{IN} - V_O))}{V_{IN}}$

$$+ (t_{sw} \cdot F_S \cdot I_O + I_Q) \cdot V_{IN}$$

Substitution of the I_{RMS} equations with I_O results in very little error when the inductor ripple current is 20% to 40% of the full load current. The equation also includes switching and quiescent current losses where t_{SW} is approximated at 18 nsec and I_Q is the no load quiescent current of the AAT4900. Quiescent current losses are associated with the gate drive of the output stage and biasing. Since the gate drive current varies with frequency and voltage, the bias current must be checked at the frequency, voltage, and temperature of operation with no load attached to the LX node. Once the above losses have been determined, the maximum junction temperature can be calculated.

Eq. 6: $T_{J(MAX)} = P_{LOSS} \cdot \Theta_{JC} = T_{AMB}$

Using the above equations, the graph below shows the current capability for some typical applications with maximum junction temperatures of 150°C and 120°C. The increase in $R_{DS(ON)}$ vs. temperature is estimated at 3.75mΩ for a 10°C increase in junction temperature.



Gate Drive

When used as a MOSFET gate driver, the break-before-make shoot-through protection significantly reduces losses associated with the driver at high frequencies. (See Figure 2.)

The low $R_{DS(ON)}$ of the output stage allows for a high peak gate current and fast switching speeds. A small package size facilitates close placement to the power device for optimum switching performance. The logic level inputs (CLK and EN) are high impedance inputs.

Gate Drive Current Ratings
An estimate of the maximum gate drive capability with no external series resistor can be derived from Equation 7. Note that the quiescent current varies with the ambient temperature, frequency of operation, and input voltage. The graphs below display the quiescent current and maximum gate charge drive capability at 85°C ambient vs. frequency for various input voltages.

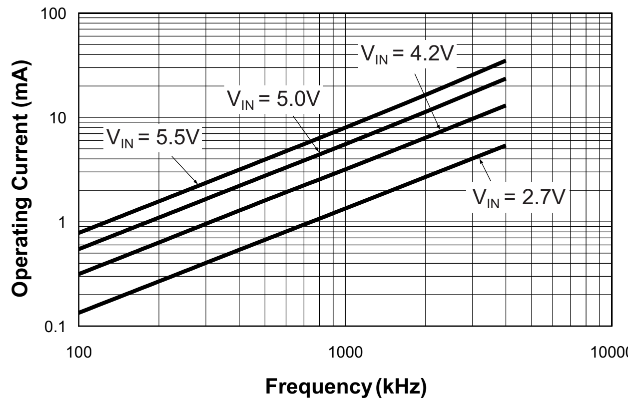
Eq. 7: $$Q_{G(MAX)} = \frac{1}{F_S} \cdot \left(\frac{T_{J(MAX)} - T_{AMB}}{\theta_{JA} \cdot V_{IN(MAX)}} - I_Q\right)$$

$$= \frac{1}{1MHz} \cdot \left(\frac{120°C - 85°C}{190°C/W \cdot 4.2V} - 3.2mA\right)$$

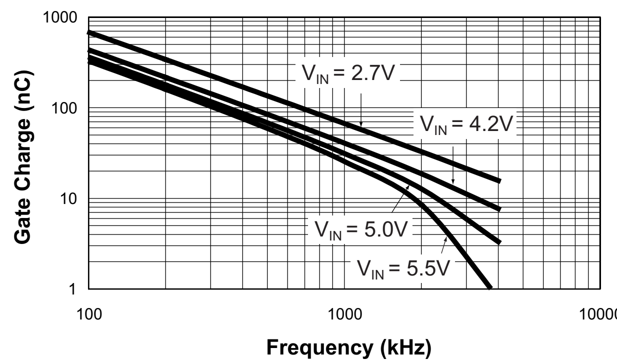
$$= 40nC$$

The quiescent current was first measured over temperature for various input voltages with no load attached. Equation 7 was then used to derive the maximum gate charge capability for the desired maximum junction temperature. Q_G is the gate charge required to raise the gate of the load MOSFET to the input voltage. This value is taken from the MOSFET manufacturer's gate charge curve.

No Load Operating Current at 85°C Ambient



Maximum Gate Charge Load @ 85°C
(Ambient $T_{J(MAX)}$ = 120°C)



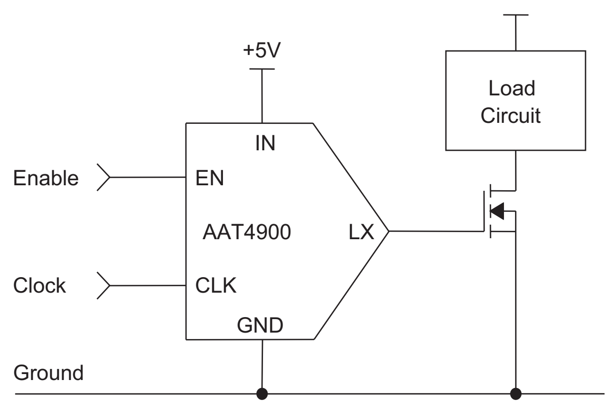


Figure 2: AAT4900 Gate Drive Configuration.

Motor Drive

The AAT4900 is also ideally suited for use as an efficient output driver for DC brushless motor control. The inductive load switching capability of the AAT4900 eliminates the need for external diodes. A typical motor control circuit is illustrated in Figure 3.

Recommended Decoupling Layout Pattern

Because of the extremely fast switching speed and the high switching currents, optimum placement of the input capacitor is critical. It is recommended that a 0.1μF to 10μF 0805 or 1206 ceramic capacitor be placed as close as possible to the IC, as shown in Figure 4. This helps to decouple the switching transients from the stray inductance present in the PC board.

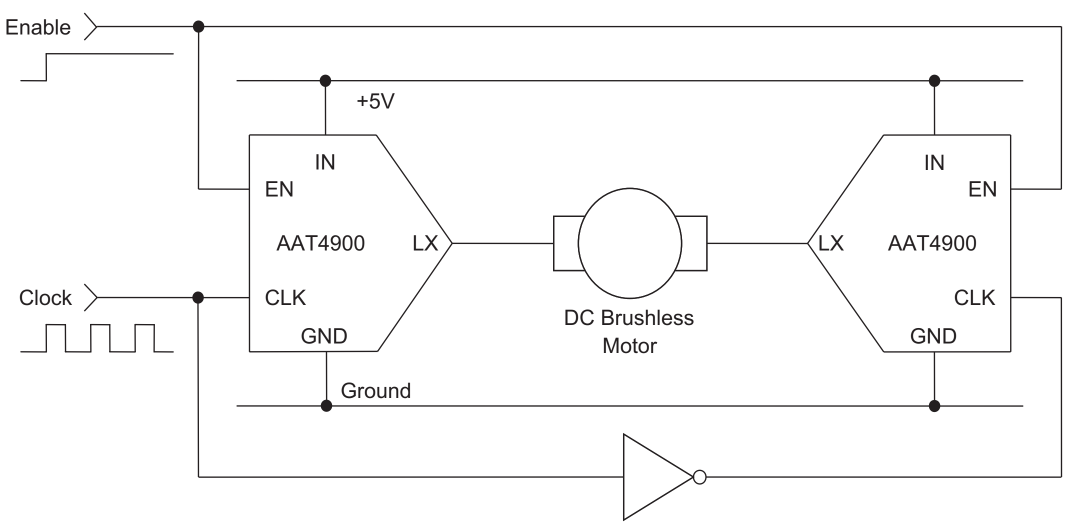


Figure 3: Typical Motor Control Block Diagram.

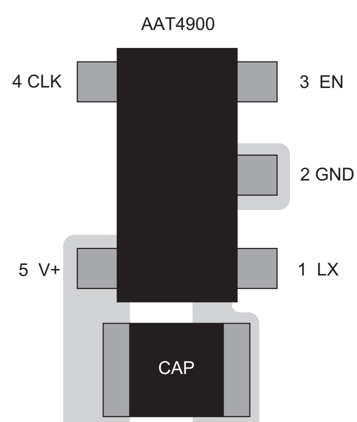


Figure 4: Recommended Decoupling Layout Pattern.

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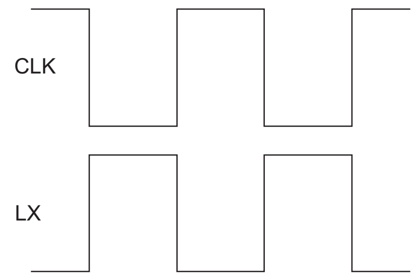


Figure 5: Timing Diagram.

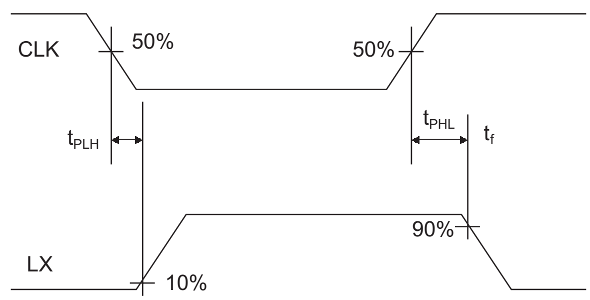


Figure 6: Switching Time Waveforms.

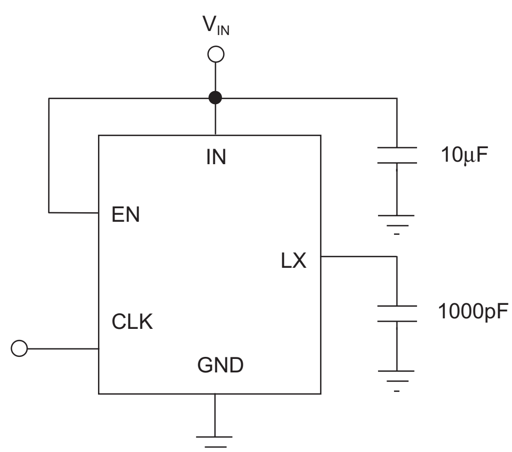


Figure 7: Propagation Delay Test Circuit.

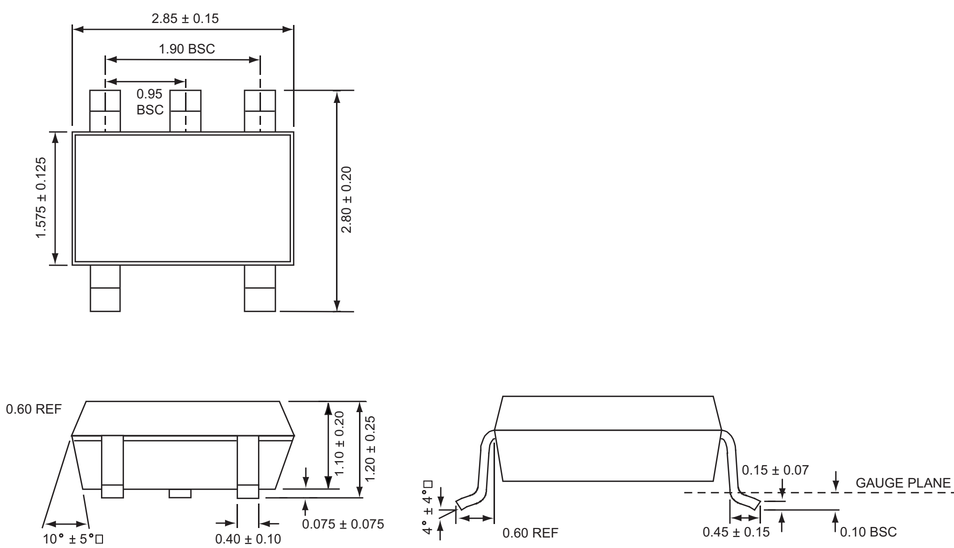
Ordering Information

Package	Marking[1]	Part Number (Tape and Reel)[2]
SOT23-5	ABXYY	**AAT4900IGV-T1**
SC70JW-8	ABXYY	**AAT4900IJS-T1**

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

SOT23-5



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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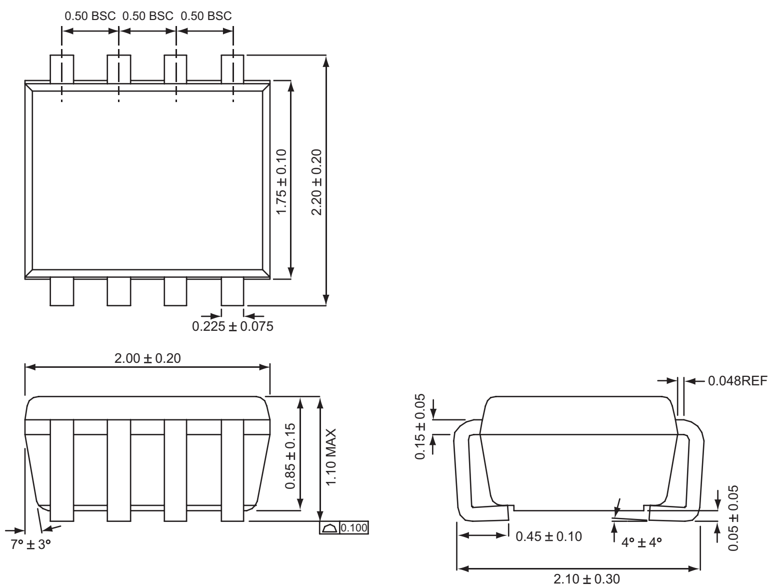
SC70JW-8



All dimensions in millimeters.

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