PULSE WIDTH MODULATION AMPLIFIERS

FEATURES

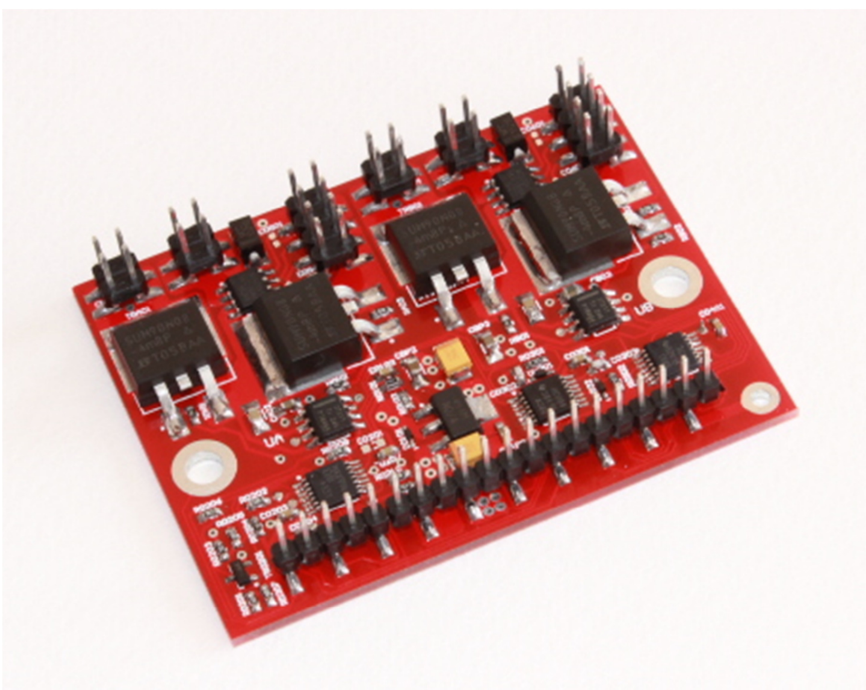
- CONSTRUCTED ON MCPCB(Metal Core PCB)
- LOW THERMAL RESISTANCE
- LOW COST
- HIGH VOLTAGE – 100 VOLTS
- HIGH CURRENT- 50 AMPS CURRENT SENSE
- HIGH EFFICIENCY
- HIGH FREQUENCY – 250KHz
- LOW BRIDGE RESISTANCE-8mohm max
- 5kW OUTPUT CAPABILITY
- DEAD TIME CONTROLLER
- VARIABLE SWITCHING FREQUENCY

APPLICATIONS

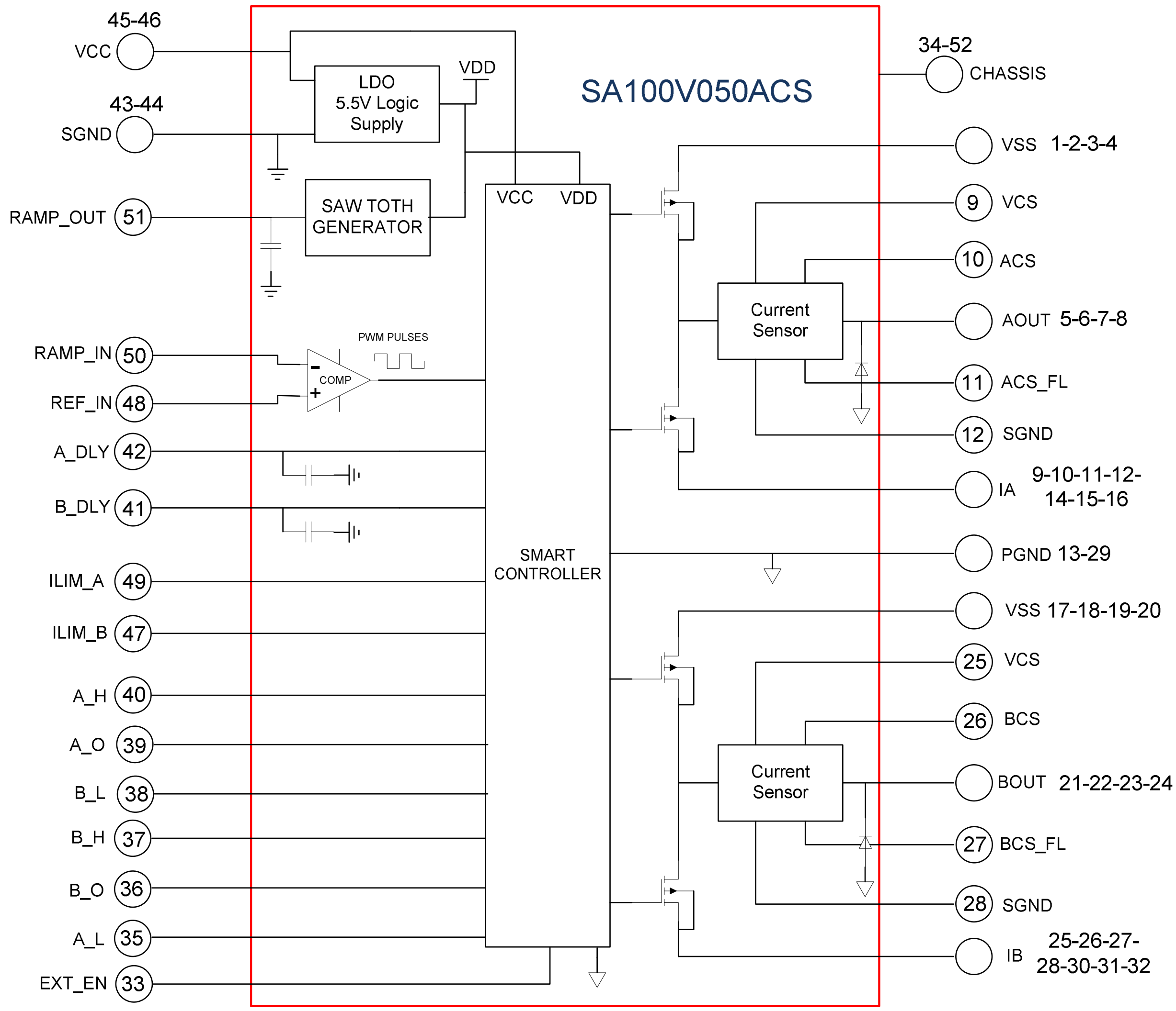
- CLASS D SWITCHING AMPLIFIER
- LASER DIODE DRIVER
- BRUSH MOTOR CONTROL
- MRI
- TEC CONTROL
- MAGNETIC BEARING

DESCRIPTION

The SA100V050ACS is a PWM amplifier that constructed on MCPCB (Metal Core PCB).This provides cost effective, high efficient and low thermal resistance solution in many industrial applications. The SA100V050ACS offers outstanding performance that rivals many much more expensive hybrid components. The SA100V050ACS is a complete PWM amplifier including an frequency adjustable saw tooth generator , comparator, current limit comparators, adjustable dead time control, integrated smart H-Bridge controller, hall effect current sensors at each output and a full H-Bridge output circuit has output impedance as low as 8mohm. These features provide to drive high power loads up to 5kW at 75°C case temperature. The SA100V050ACS can be used for driving weaker load in higher temperature environments. The module has efficiency as high as 97% at full load and has thermal resistance as low as 1.2°C/W. The bottom side of module is component side and upper side of the module is full metal plate to drain heat load from module easily. These superior performances make this module a proper solution for high temperature applications.



EQUIVALENT CIRCUIT DIAGRAM



ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE,VSS	100V
SUPPLY VOLTAGE,VCC	20V
SUPPLY VOLTAGE,VCS	6V
OUTPUT CURRENT, peak	180A, within SOA
POWER DISSIPATION, internal, DC	600W[3]
SIGNAL INPUT VOLTAGES	5.5V
TEMPERATURE, pin solder, 10s	225°C
TEMPERATURE, junction[2]	175°C
TEMPERATURE RANGE, storage	-40°C to 105°C
OPERATING TEMPERATURE, case	-40°C to 85°C

SPECIFICATIONS

PARAMETERS	TEST CONDITIONS[1]	MIN	TYP	MAX	UNITS
SAW TOOTH GENARATOR RAMP_OUT					
HIGH LEVEL VOLTAGE	Full temperature range	3.4	3.5	3.6	V
LOW LEVEL VOLTAGE	Full temperature range	0.3	0.4	0.5	V
FREQUENCY	No cap. on RAMP_OUT	240	250	260	KHz
DEAD TIME CONTROL					
ON Delay upper to lower MOSFETs	No external cap on	150	160	-	ns
OFF Delay upper to lower MOSFETs	A_DLY&B_DLY Pins	150	160	-	ns
OUTPUT					
TOTAL R_{ON}, both MOSFETs[4]	I_O=180A , T_J=85°C	8	9	10	mΩ
CURRENT , continuous				50	A
OUTPUT MOSFET BODY DIODE					
CONTINUOUS CURRENT					
FORWARD VOLTAGE	I= 110A			1.3	V
REVERSE RECOVERY	I_F=110A			60	ns
POWER SUPPLY					
VOLTAGE, VSS		3	60	100	V
VOLTAGE, VCC		8	12	17	V
VOLTAGE, VCS		4.5	5	5.5	V
CURRENT, VSS, quiescent	20kHz Switching		4	28	mA
CURRENT, VCC, quiescent	20kHz Switching			18	mA
CURRENT, VCS, quiescent			20	30	mA
CURRENT, VCC, shutdown				12	mA
THERMAL	Full temperature range				
RESISTANCE, DC, junction to case	Full temperature range			1.2	°C/W
RESISTANCE, junction to air		-40		14	°C/W
TEMPERATURE RANGE, case				85	°C

NOTES:
1. Unless otherwise noted: Tc=25°C, Vcc= 15V, Vs=60V
2. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTBF.
3. Each of the two output transistors on at any one time can dissipate 150W.
4. Maximum specification guaranteed but not tested.

SPECIFICATIONS CONTINUED

PARAMETERS	TEST CONDITIONS[1]	MIN	TYP	MAX	UNITS
AH_IN,AL_IN,BH_IN,BL_IN ,EXT_EN INPUTS					
VHIT, High Input Voltage Threshold	Full temperature range	1.9	2.3	2.7	V
VLIT, Low Input Voltage Threshold	Full temperature range	1.3	1.6	1.9	V
A_O, B_O OUTPUTS					
VOH, High Level Output Voltage	Full temperature range	5.3	5.35	5.4	V
VOL, Low Level Output Voltage	Full temperature range	0.2	0.3	0.4	V
ILIM_A, ILIM_B INPUTS					
INPUT VOLTAGE LEVEL		-0.3		5.5	V
Current Protect Voltage Threshold		170	180	185	mV
RAMP_IN INPUTS					
INPUT VOLTAGE LEVEL		-0.3	-	5.5	V
ACS, BCS OUTPUTS					
Zero Current Output Voltage	Bidirectional, Ip= 0A	-	VCS/2	-	V
Output Capacitance Load	Out to SGND	-	-	10	nF
Output Resistive Load	Out to SGND	4.7	-	-	kΩ
Output Current Sensitivity	I = -50A to +50A	-	40	-	mV/A
Bandwidth	No cap. on filter pins	-	120	-	kHz

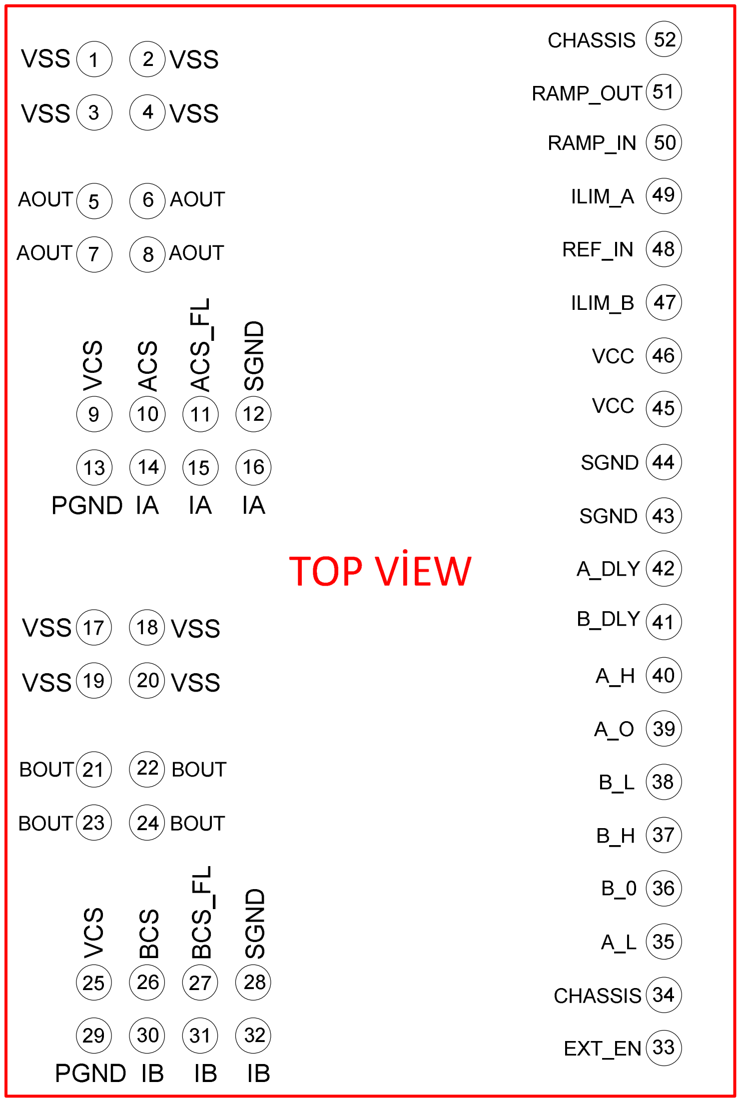


Figure 1 PIN CONFIGURATION

PIN FUNCTIONS

PIN NAME	PIN NO	I/O	DESCRIPTION
VSS	1, 2, 3, 4, 17, 18, 19, 20	-	Load Supply Pin. Decouple this pin to PGND with tantalum or electrolytic capacitor of at least 10µF per output ampere to drive load. In addition place ceramic capacitor 1µF or greater directly at each set of pins for high frequency bypassing. Bypass capacitors to Load Supply terminals VSS must be connected physically close to the pins to prevent local parasitic oscillation and overshoot.
AOUT	5, 6, 7, 8	-	Module Driver Pin, Output of Half Bridge A.
IA	14, 15, 16	-	Return path for Half Bridge A. This pin can be connected directly to PGND or can be connected to current sense resistor for current measuring.
PGND	13, 29	-	Load Supply return Pin.
BOUT	21, 22, 23, 24	-	Module Driver Pin, Output of Half Bridge B.
IB	30, 31, 32	-	Return path for Half Bridge B. This pin can be connected directly to PGND or can be connected to current sense resistor for current measuring.
EXT_EN	33	I	External Enable Input. When logic HIGH all driver outputs AOUT and BOUT are active when logic LOW all driver outputs are high impedance state.
CHASSIS	34, 52	-	These pins are connected to aluminum back plate. To increase EMI ,EMC performance connect these pins to SGND pin via ceramic capacitor bigger than 10µF.
A_L	35	I	Logic control input for low side Mosfet of Half Bridge A
B_O	36	O	Logic control output to drive A_L and B_H control inputs. If H bridge will not be controlled individually for each logic inputs from external H Bridge logic controller, this pin should be connected to A_L and B_H control inputs.
B_H	37	I	Logic control input for high side Mosfet of Half Bridge B
B_L	38	I	Logic control input for low side Mosfet of Half Bridge B
A_O	39	O	Logic control output to drive B_L and A_H control inputs. If H bridge will not be controlled individually for each logic inputs from external H Bridge logic controller, this pin should be connected to B_L and A_H control inputs.
A_H	40	I	Logic control input for high side Mosfet of Half Bridge A
B_DLY	41	O	Dead time adjustment pin between upper and lower MOSFETs of Half Bridge B. If 100ns dead time is enough this pin should be no connection.
A_DLY	42	O	Dead time adjustment pin between upper and lower MOSFETs of Half Bridge A. If 100ns dead time is enough this pin should be no connection
SGND	12, 28, 43, 44	-	Signal ground for low noise analog circuit and logic controller inside module. For proper operation during PCB layout the PGND signal should be connected to this pin via trace, and CHASSIS pin should be connected to this pin via ceramic capacitor bigger than 10µF

PIN MAME	PIN NO	I/O	DESCRIPTION
VCC	45, 46	-	Supply voltage for low noise analog circuits and logic controllers. Decouple this pin to SGND with ceramic capacitor bigger than 10µF. Bypass capacitors to terminal VCC must be connected physically close to the pins to prevent local parasitic oscillation and overshoot.
ILIM_B	47	I	Current sense comparator input for Half Bridge B. If current sense comparator will not be used this pin should be connected to PGND signal.
REF_IN	48	I	
ILIM_A	49	I	Current sense comparator input for Half Bridge A. If current sense comparator will not be used this pin should be connected to PGND signal.
RAMP_IN	50	I	Ramp input of PWM comparator inside module. If the saw tooth generator of comparator will be used the RAMP_OUT pin of module should be connected to this pin.
RAMP_OUT	51	O	Saw tooth generator output pin of the module.
VCS	9, 25	-	Supply voltage for hall effect current sensors. The accuracy of current sensors depends on accuracy of this supply. So this voltage should be supplied from high precision voltage reference. Decouple this pin to SGND with ceramic capacitor bigger than 100nF
ACS	10	O	Current Sensor signal output of Half Bridge A. In case of zero current (I=0A) this signal is half of the supply voltage VCS. For the positive current that flows from AOUT to Load direction, the voltage level of this signal drops 40mV for each ampere of current and vice versa for negative current that flows from Load to AOUT direction.
ACS_FL	11	O	This pin is filter connection for current sensor of Half Bridge A. Normally this pin is internally decoupled to SGND by 1nF capacitor. If lower bandwidth is needed for current sensor, the external capacitor can be connected to this pin in accordance with application notes.
BCS	26	O	Current Sensor output signal of Half Bridge B. In case of zero current (I=0A) this signal is half of the supply voltage VCS. For the positive current that flows from BOUT to Load direction, the voltage level of this signal drops 40mV for each ampere of current and vice versa for negative current that flows from Load to BOUT direction.
BCS_FL	27	O	This pin is filter connection for current sensor of Half Bridge B. Normally this pin is internally decoupled to SGND by 1nF capacitor. If lower bandwidth is needed for current sensor, the external capacitor can be connected to this pin in accordance with application notes.

TYPICAL APPLICATION

With the addition of a few external components the SA100V050ACS becomes a motor torque controller. In the SA100V050ACS each output of Half Bridge circuit is serially connected to Hall Effect current sensors. These high precision current sensors can be used for accurate current controls loops in many applications. Beside this the source terminal of each low side MOSFET driver is brought out for over current protection via RA and RB. A2 is used as an error amplifier for current loop control. A1 is a differential amplifier that amplifies the difference in currents of the two half bridges. This signal is fed into the A2 error amplifier that mixes the current signal and the control signal. The output of A2 is an input signal to the SA100V050ACS that controls the torque on the motor.

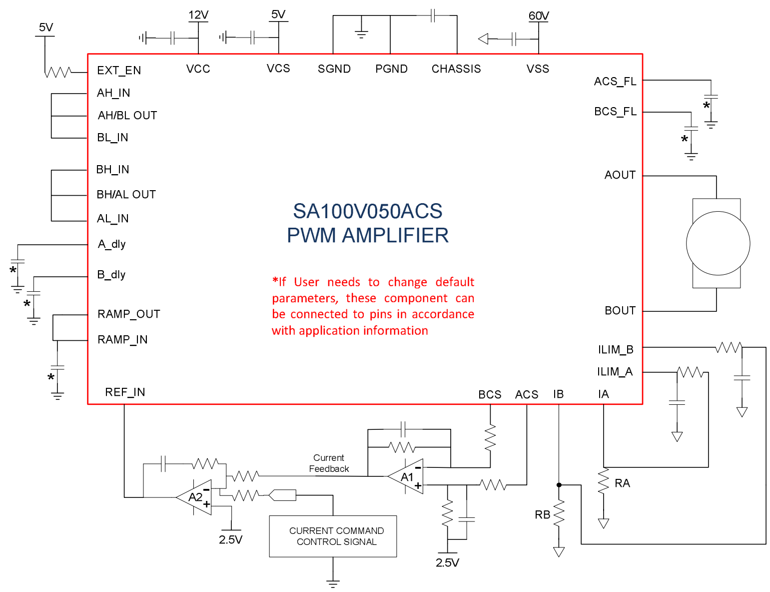


Figure 2 TORQUE MOTOR CONTROL

SAW TOOTH GENERATOR

The SA100V050ACS includes a user frequen programmable saw tooth generator (STG). STG is connected to RAMP_OUT pin of the module. The STG determines the switching frequency of the amplifier. The frequency of the STG can be programed by connecting proper capacitor to RAMP_OUT pin of the amplifier. There is a default internally 1nF capacitor connected to this pin provides maximum 260KHz switching frequency for high frequency PWM application like driving DC load that needs minimum valued output filter component. If user need to lower the frequency, by connecting proper capacitance to RAMP_OUT pin the frequency can be adjusted.

The frequency of PWM amplifier according to external capacitance value is determined by given formula:

Rise time of STG, Tr = 1.17 x 1500 x (1nF+C_{ext})

Fall time of STG, Tf = 2.7 x 1000 x (1nF+C_{ext})

Frequency of STG f = 1/(Tr+Tf)

Also note that to drop frequency will cause to drop peak to peak value of saw tooth waveform. For instance if 100nF external capacitor connected, the frequency will drop to 2.9kHz and saw tooth wave form peaks will be at 3.28V and 0.36V.

The RAMP_IN pin on SA100V050ACS is the saw tooth wave input pin of PWM comparator inside module. In typical application the RAMP_OUT pin should be connected to RAMP_IN pin.

But if user want to use external STG , user can connect external STG to RAMP_IN pin unless the signal specifications are out of the module limits.

SHUTDOWN

The SA100V050ACS output stage can be turned off with shutdown command voltage applied to EXT_EN pin. In case of LOW signal in this pin will disable to module output and output stages will be in high impedance state.

Other way to turn off module is to apply more than 180mV input signal to ILIM_A and ILIM_B pins of the module. These pins are designed to provide over current protection on the module. So in case of EXT_EN signal is LOW or any one of the signals on the ILIM_A or ILIM_B pins are more than 180mV the module will be turned off.

OVER CURRENT SENSING

The low side drive MOSFETs of the SA100V050ACS are brought out for sensing the current in each half bridge. A resistor from each sense line to PGND develops the current sense voltage. Choose R and C such that the time constant is equal to 10 periods of the selected switching frequency. The internal current limit comparators trips at 180mV. Therefore, current limit occurs at I= 0.18V/Rsense for each half bridge. See Figure3. Accurate milliohm power resistors are required for proper operation. Note that for high precision current loop control, user should use Hall Effect Current sensor output for current feedback.

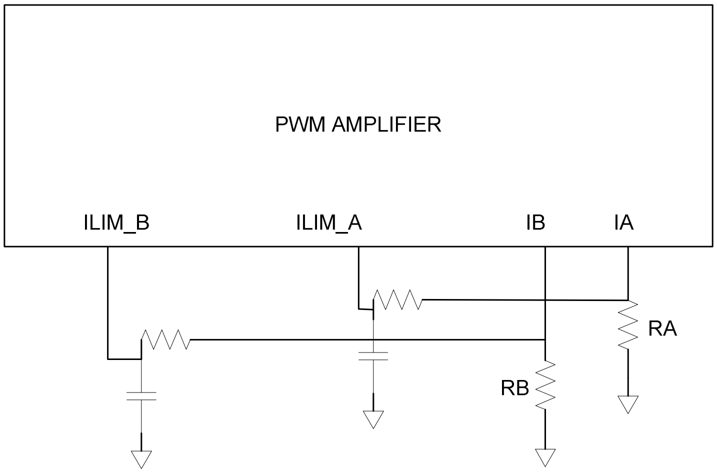


Figure 3 CURRENT SENSING CIRCUIT

POWER SUPPLY BYPASSING

Bypass capacitors to Supply terminals VSS and VCC must be connected physically close to the pins to prevent local parasitic oscillation and overshoot. All VSS pins must be connected together. Place a tantalum or electrolytic capacitor of at least 10µF per output ampere to drive load. In addition place ceramic capacitor 1µF or greater directly at each set of pins for high frequency bypassing.

GROUNDING AND PCB LAYOUT

Switching amplifiers combine millivolt level analog signals and large amplitude switching voltages and currents with fast rise times. As such grounding is crucial. Use a single point ground at SGND (pins 43 and 44). Connect PGND signal to SGND terminal. Connect Chassis signal to SGND pin via ceramic capacitor bigger than 10µ. Connect the ground terminal of the VCC supply directly to SGND as well. Make sure no current from the load return to PGND flows in the analog signal ground. Make sure that the power portion of the PCB layout does not pass over low level analog signal traces on the opposite side of the PCB. Capacitive coupling through the PCB may inject switching voltages into analog signal path. Further, make sure that the power side of the PCB layout does not come close to the analog signal side. Fast rising output signal can couple through the trace-to-trace capacitance on the same side of the PCB.

DEAD TIME ADJUSTMENT

The SA100V050ACS has already dead time controller inside the module. These dead time controller circuits provide approximately 160ns dead time duration between upper and lower MOSFETs of each Half Bridge. If user needs to increase the dead time duration, the capacitive load connection pins of the dead time controller circuits of the module brought out via A_DLY and B_DLY pins. By connecting extra capacitor to these pins will increase the dead time duration. To increase dead time duration for each 10 Nano second, one Pico farad capacitor should be connected to these pins. If 160ns dead time is enough these pins should have no connection.

DETERMINING THE OUTPUT STATE

The input signal is applied to REF_IN (Pin 28) and varies from 0.3 to 3.5 volts, zero to full scale. As REF_IN varies from 0.3 to 2 volts the B output "high" duty cycle (relative to ground) is greater than the A output "high" duty cycle. The reverse occurs as the input signal varies from 2 to 3.5 volts. When REF_IN = 2 volts the duty cycles of both A and B outputs are 50%. Consequently when the input voltage is 3.5V the A output is close to 100% duty cycle and the B output is close to 0% duty cycle. The reverse occurs with an input voltage of 0.3V. The output duty cycle extremes vary somewhat with switching frequency.

If REF_IN signals exceeds the lower and upper limits of the saw tooth signals the output of the PWM amplifier enters "lock out" state. Because 100% and 0% duty cycle is not supported from any high power H Bridge topologies. The charge pump circuits of high side MOSFET driver circuits needs toggling control signal inputs to be able to work properly. So to prevent PWM amplifier from lock out state simple input signal limiter circuit can be implemented by few components. The input limiter circuit shown in Figure 4 can be used.

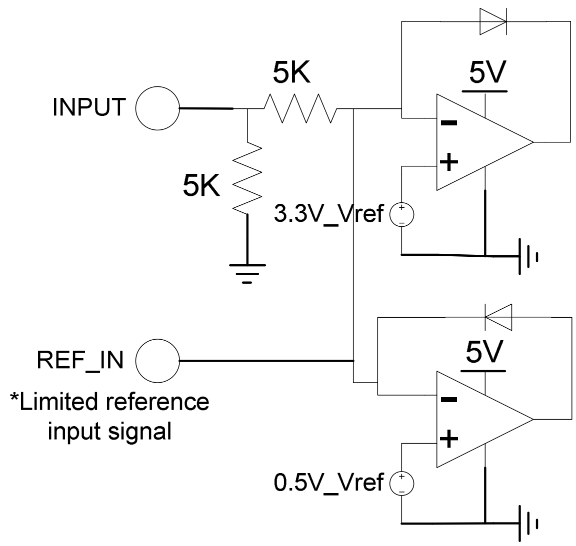


Figure 4 VOLTAGE LIMITTER CIRCUIT

PRECISION CURRENT SENSOR

SA100V050ACS include Hall Effect Current sensor at each output of the Half Bridge driver circuit. These high precision current sensors are placed serial to driver output and provide accurate current sensing for current control.

Supply voltage VCS for Hall Effect current sensors should be selected carefully. The accuracy of current sensors depends on accuracy of this supply. So it is strongly recommended that VCS should be supplied from high precision voltage reference. This pin internally decoupled to SGND via 100nF bypass capacitor, if user wants extra decoupling capacitor, extra ceramic capacitor can be connected to VCS pin.

ACS and BCS are current Sensor signal output of each Half Bridge A. In case of zero current (I=0A) this signal is half of the supply voltage VCS. For the positive current that flows from module driver pin to Load direction, the voltage level of this signal drops 40mV for each ampere of current and vice versa for negative current that flows from Load to module driver direction.

ACS_FL and BCS_FL pins of the current sensors are filter pins. These pins are internally decoupled to SGND via 1nF capacitor. This provides noise reduction at current sense output signal while keeping 120 kHz bandwidth at output stage.

If user needs the lower bandwidth for current sensor, the external capacitor should be connected to this pin. After external capacitor connected to this pin new bandwidth of sensor is calculated by below formula;

$$Fbandwidth = 120kHz \times \left[\frac{1nF}{(1nF + Cext)}\right]$$

APPLICATION WITH MCU

This module is designed to be used with MCU (Micro Controller Unit). If user wants to use this module with MCU instead of analog controlled loop, this module can be adapted easily to digital platform. Figure 5 shows typical application of SA100V050ACS that used with MCU.

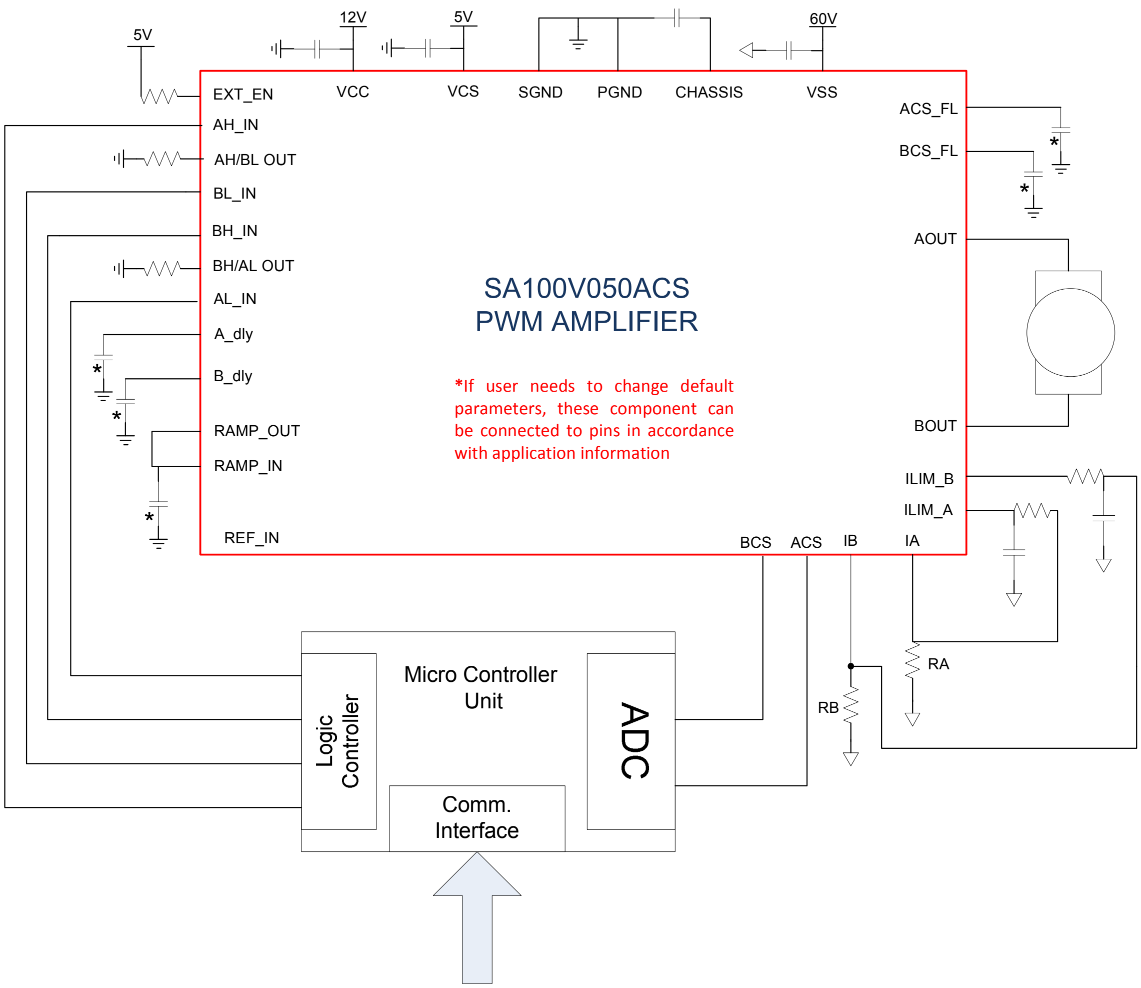


Figure 5 MCU APPLICATIONS WITH SA100V050CS

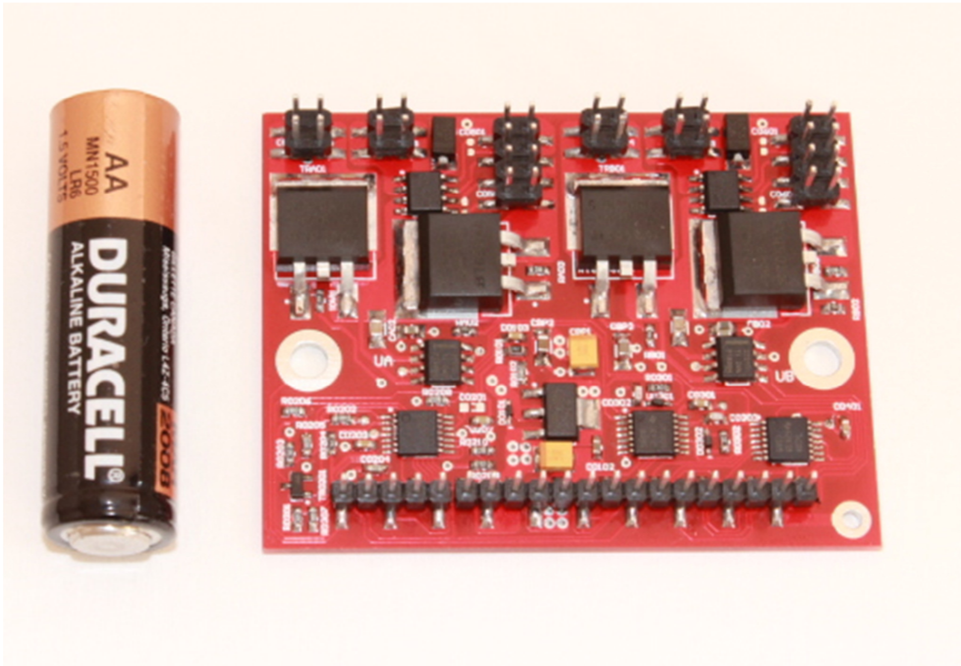
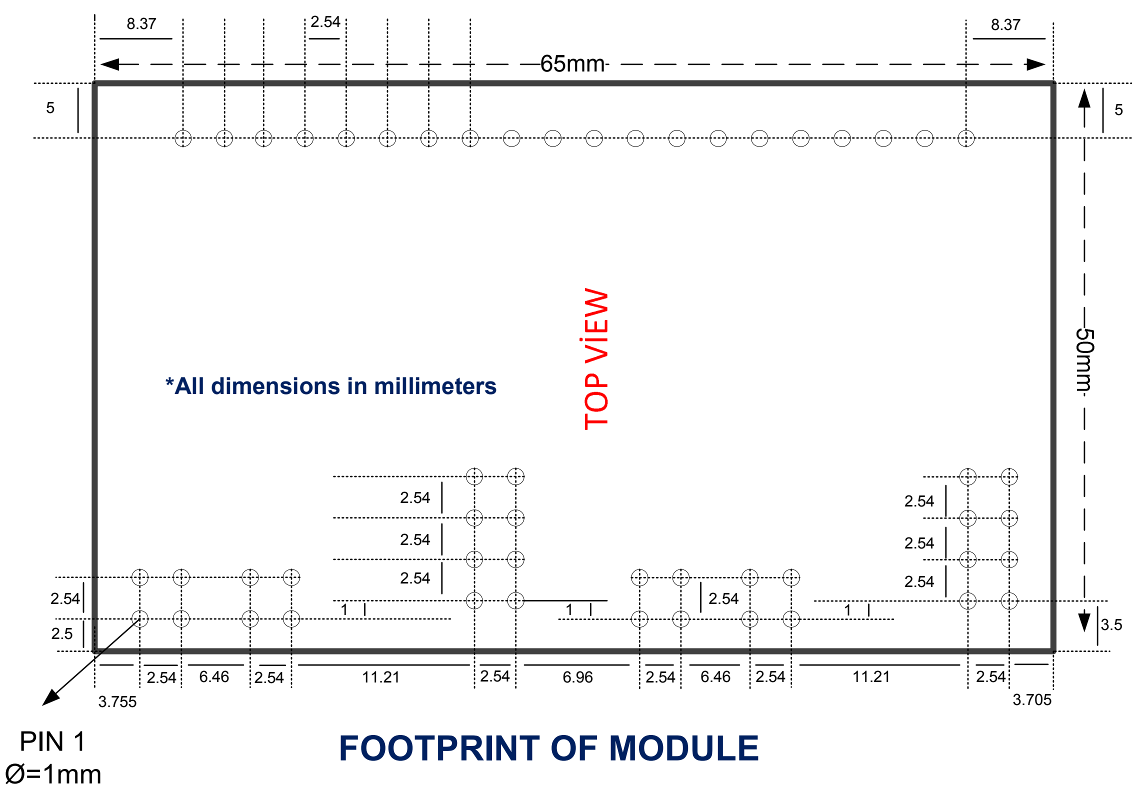


Figure 6 BOTTOM VIEW OF SA100V050ACS



FOOTPRINT OF MODULE

