Dual Full-Bridge PWM Motor Driver AM6289

The AM6289 motor driver is designed to drive both windings of a bipolar stepper motor or to control bidirectionally two DC motors. Both bridges are capable of sustaining 28V and include internal pulse-width modulation (PWM) control of the output current to 1.5A. The outputs have been optimized for a low output saturation voltage drop (less than 1.8V total source plus sink at 850mA).

For PWM current control, the maximum output current is determined by the user's selection of a reference voltage and sensing resistor. Three-bit nonlinear digital to analog converter allows the motor current to be controlled in full-, half-, quarter-, 1/8th-step (micro stepping mode, see table2). A PHASE input to each bridge determines load current direction.

The bridges include both ground clamp and fly-back diodes for protection against inductive transients. Internally generated delays prevent cross-over currents when switching current direction. Special power-up sequencing is not required. A thermal protection circuitry disables the outputs if the chip temperature exceeds safe operating limits.

The AM6289 is supplied in a 28-lead surface-mountable HSOP. Its batwing construction provides for maximum package power dissipation in the smallest possible construction.

● Applications

Scanner, Printer

● Features

1) 1.5A continuous output current
2) 28V output sustaining voltage
3) Internal clamp diodes
4) Internal PWM current control
5) Low output saturation voltage
6) Internal thermal shutdown circuitry
7) 3-bit nonlinear DAC

● Absolute Maximum Ratings at $T_J \leq 175$℃

Parameter		Symbol	Limits	Unit
Motor supply voltage		V_{BB}	30	V
Output current	Peak	I_{OUT}	1.75	A
	Continuous		1.5	A
Logic supply voltage		V_{CC}	7.0	V
Logic input voltage range		V_{IN}	-0.3 ~ +7.0	V
Output emitter voltage		V_{SENSE}	1.5	V
Operating temperature range		T_A	-20 ~ +85	℃
Storage temperature range		T_S	-55 ~ +150	℃

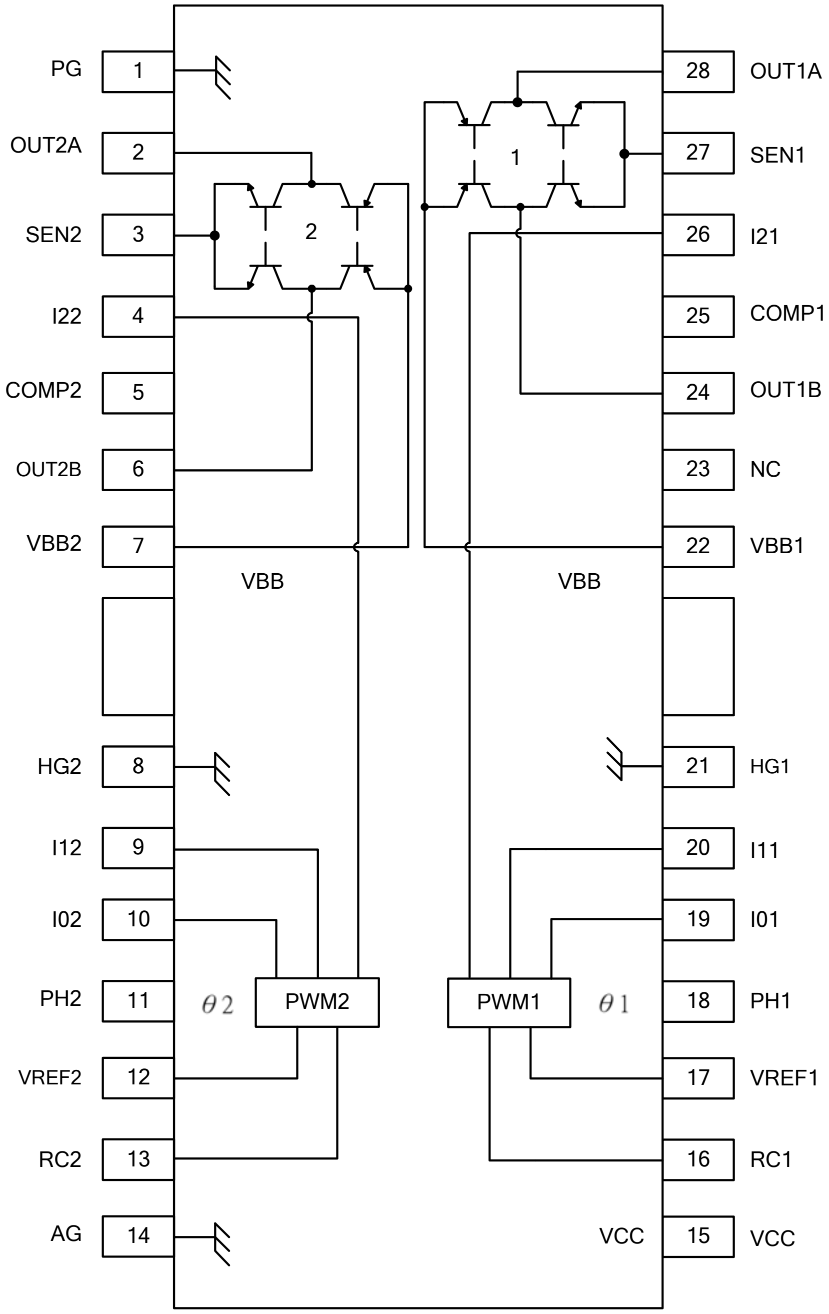
*Output current rating may be limited by duty cycle, ambient temperature, and heat sinking. Under any set of conditions, do not exceed the specified peak current rating or a junction temperature of +175℃.

Thermal Data

Description	Symbol	Value	Unit
Thermal Resistance Junction-case	R_{thjc}	6.7	℃/W
Thermal Resistance Junction-ambient	R_{thja}	56.8	℃/W

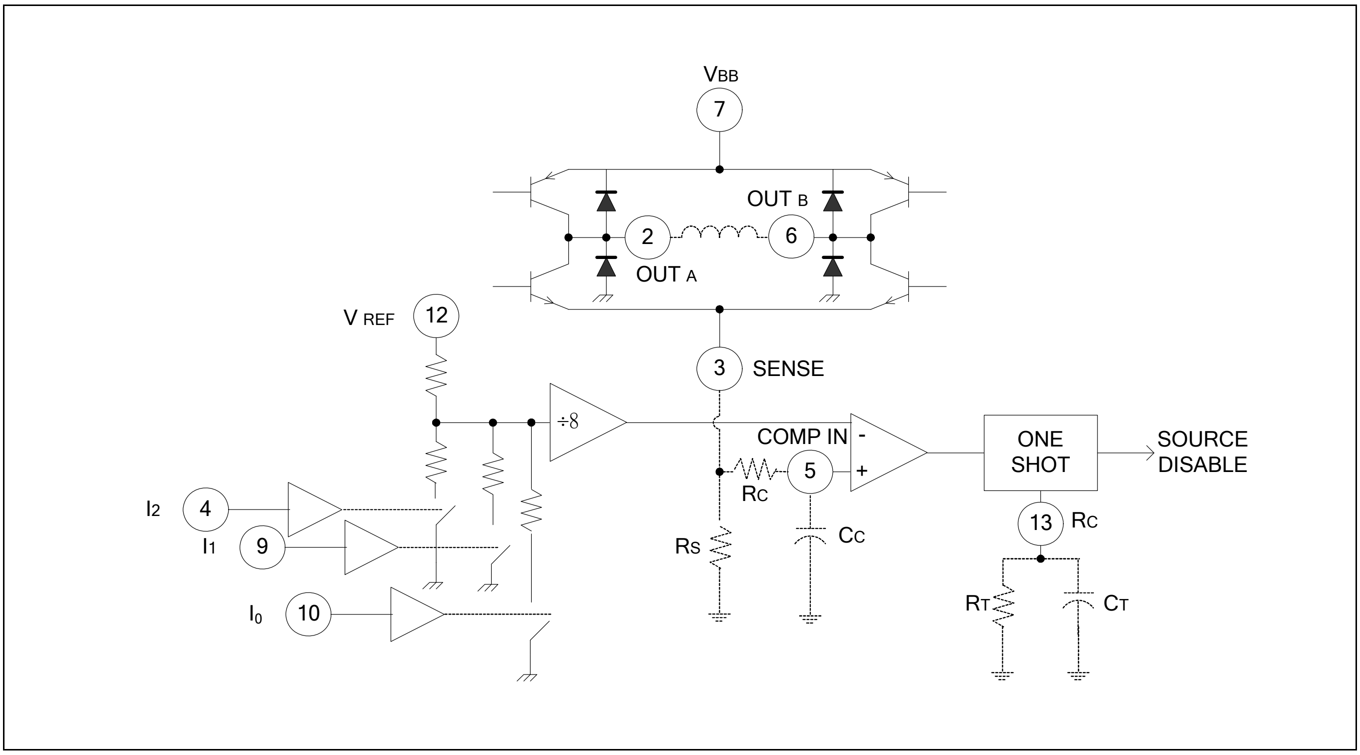
*With minimized copper area.

Block Diagram



PWM Current-Control Circuitry

Channel 1 terminal numbers shown



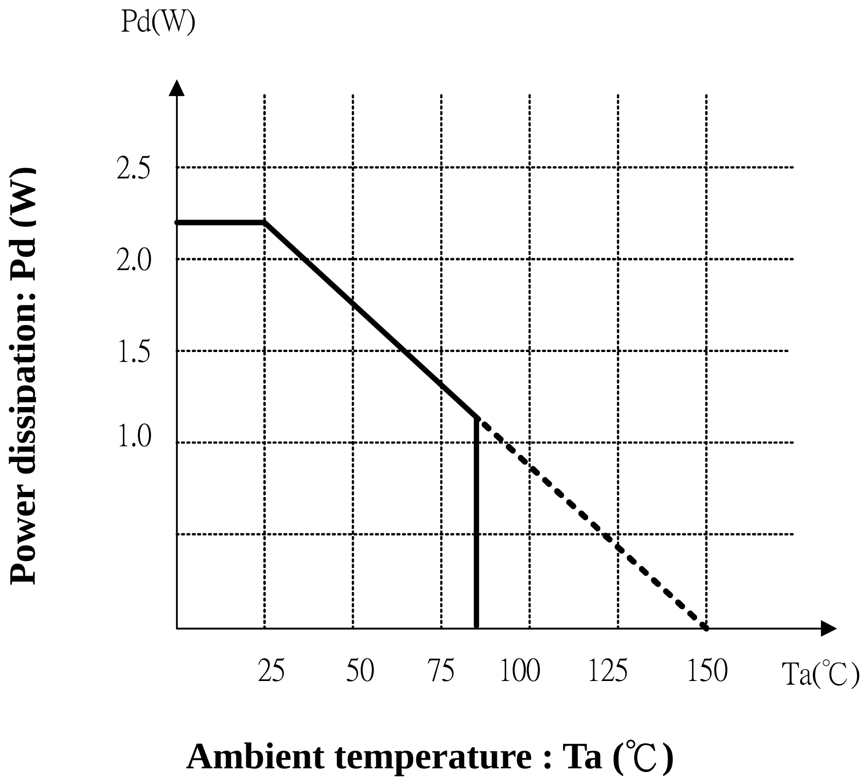
TRUTH TABLE

PHASE	OUT_A	OUT_B
H	H	L
L	L	H

- **Electrical Characteristics (Unless otherwise specified, Ta = 25℃, Tj ≤ 150℃, V_{BB} = 28V, V_{CC} = 4.75V to 5.25V, V_{REF} = 5.0V)**

Parameter	Symbol	Conditions	Limit Min	Limit Typ	Limit Max	Unit
<Output Drivers (OUT_A or OUT_B)>						
Motor supply range	V_{BB}		10	-	28	V
Output leakage current	I_{CEX}	$V_{OUT} = V_{BB}$	-	< 1.0	50	μA
		$V_{OUT} = 0$	-	< -1.0	-50	μA
Output sustaining voltage	$V_{CE(sus)}$	IOUT = 1.5A, L = 3.0mH	28	-	-	V
Output saturation voltage	$V_{CE(SAT)}$	Sink driver, I_{OUT} = 0.85A	-	0.5	0.6	V
		Sink driver, I_{OUT} = 1.5A	-	1.3	1.5	V
		Source driver, I_{OUT} = -0.85A	-	1.0	1.2	V
		Source driver, I_{OUT} = -1.5A	-	1.3	1.5	V
Clamp diode leakage current	I_R	V_R = 28V	-	< 1.0	50	μA
Clamp diode forward voltage	V_F	I_F = 1.5A	-	1.4	1.7	V
Driver supply current	$I_{BB(ON)}$	Both bridges ON, no load	-	7	10	mA
	$I_{BB(OFF)}$	Both bridges OFF	-	0.5	1	mA
<Control Logic >						
Input voltage	$V_{IN(1)}$	All inputs	2.4	-	-	V
	$V_{IN(0)}$	All inputs	-	-	0.8	V
Input current	$I_{IN(1)}$	V_{IN} = 2.4V	-	< 1.0	20	μA
		V_{IN} = 0.8V	-	-3.0	-200	μA
Reference voltage range	V_{REF}	Operating	1.0	-	7.5	V
Current limit threshold ratio (at trip point)	CLTR	$I_2 = I_1 = I_0$ =0.8	-	0	-	%
		$I_2 = I_1$ = 0.8,I_0=2.4	-	19.5	-	%
		$I_2 = I_0$ = 0.8, I_1=2.4	-	38.2	-	%
		I_2 = 0.8, I_1=I_0=2.4	-	55.5	-	%
		I_2 = 2.4 ,I_1=I_0=0.8	-	70.7	-	%
		$I_2 = I_0$ = 2.4, I_1=0.8	-	83.1	-	%
		$I_2 = I_1$=2.4, I_0=0.8	-	92.4	-	%
		$I_2 = I_1$=I_0=2.4	-	100	-	%
Thermal shutdown temperature	T_J		-	170	-	℃
Total logic supply current	$I_{CC(ON)}$	$I_2 = I_1 = I_0$ =2.4V, No load	-	80	100	mA
	$I_{CC(OFF)}$	$I_2 = I_1 = I_0$ =0.8V, No load	-	24	32	mA

- **Power dissipation curve:**



*70mm×70mm×1.6mm glass epoxy board.

*De-rating is done at 17.6mW/℃ for operating above T_a=25℃

Application Information

PWM Current control

The AM6289 dual bridge is designed to drive both windings of a bipolar stepper motor or to control bidirectionally two DC motors. The output current of each part is sensed and controlled independently in each bridge by external sense resistors (R_S), internal comparator, and monostable multivibrator.

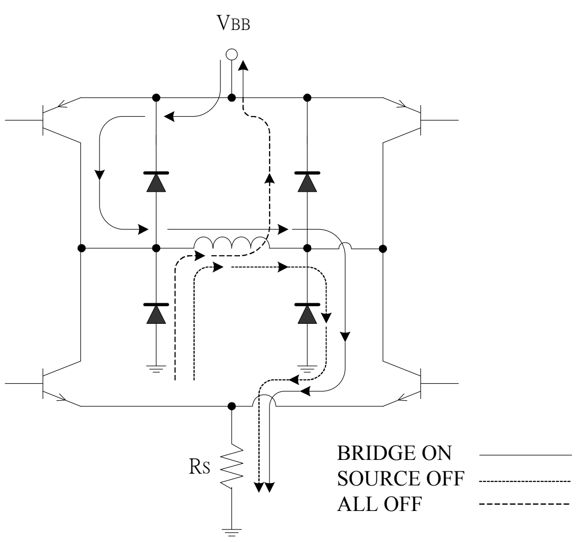
When the bridge is turned ON, current increases in the motor winding and it is sensed by the external sense resistor until the sense voltage (V_{COMPIN}) reaches the level set at the comparator's input:

$$I_{TRIPMAX} = V_{REF} / 8R_S$$

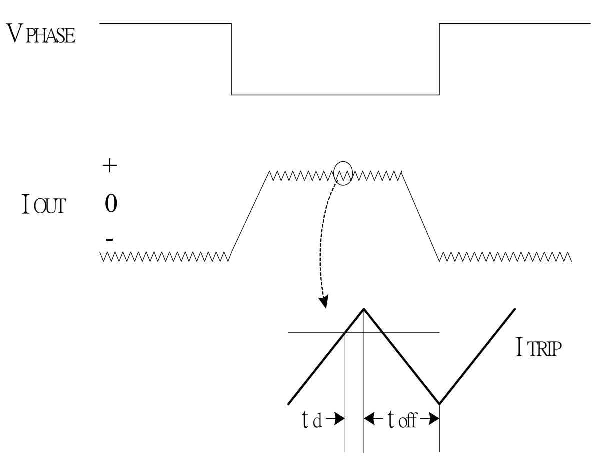
The comparator then triggers the monostabel that turns OFF the source driver of the bridge. The actual load current peak will be slightly higher than the trip point (especially for low-inductance loads) because of the internal logic and switching delays. This delay (t_d) is typically 2 μs. After turn-off, the motor current decays, circulating through the ground-clamp diode and sink transistor. The source driver's OFF time (and therefore the magnitude of the current decrease) is determined by the monostable's external RC timing components, where $t_{off} = R_T C_T$ within the range of 12kΩ to 100kΩ and 470pF to 1500pF.

When the source driver is re-enabled, the winding current (the sense voltage) is again allowed to rise to the comparator's threshold. This cycle repeats itself, maintaining the average motor winding current at the desired level. Loads with highly distributed capacitances may result in high turn-ON current peaks. This peak (appearing across R_S) will attempt to trip the comparator, resulting in erroneous current control or high-frequency oscillations. An external $R_C C_C$ time delay should be used to further delay the action of the comparator. Depending on load type, many applications will not require these external components (SENSE connected to COMP IN).

Load Current Paths



PWM Output Current Wave Form



・Logic Control Of Output Current

A non-linear DAC is used to digitally control the output current. The output of the DAC is used to set the trip point of. the current sense comparator. The DAC truth table shows the output voltage of each input condition. When I_2 , I_1 and I_0 are all logic Low, all of the power output transistor are turn off.

$$I_{TRIP} = 〔 I_{TRIP}\% 〕 \times I_{TRIPMAX}$$

DAC Truth Table

I_2	I_1	I_0	Output Current (%)	V_{REF}/V_S
L	L	L	All output disable	8
L	L	H	19.5	41.02
L	H	L	38.2	20.94
L	H	H	55.5	14.41
H	L	L	70.7	11.31
H	L	H	83.1	9.62
H	H	L	92.4	8.65
H	H	H	100	8

These logic level inputs greatly enhance the implementation of µP-controlled drive formats.

The logic control inputs can also be used to select a reduced current level (and reduced power dissipation) for 'hold' conditions and/or increased current (and available torque) for start-up conditions.

・General

The PHASE input to each bridge determines the direction of current flow in the motor winding. An internally generated deadtime (approximately 2µs) prevents crossover currents that can occur when switching the PHASE input. All four drivers in the bridge output can be turned OFF between steps ($I_2 = I_1 = I_0 \leq 0.8V$) resulting in a fast current decay through the internal output clamp and flyback diodes. All inputs float high.

Varying the reference voltage (V_{REF}) provides continuous control of the peak load current for microstepping applications and DC motor control.

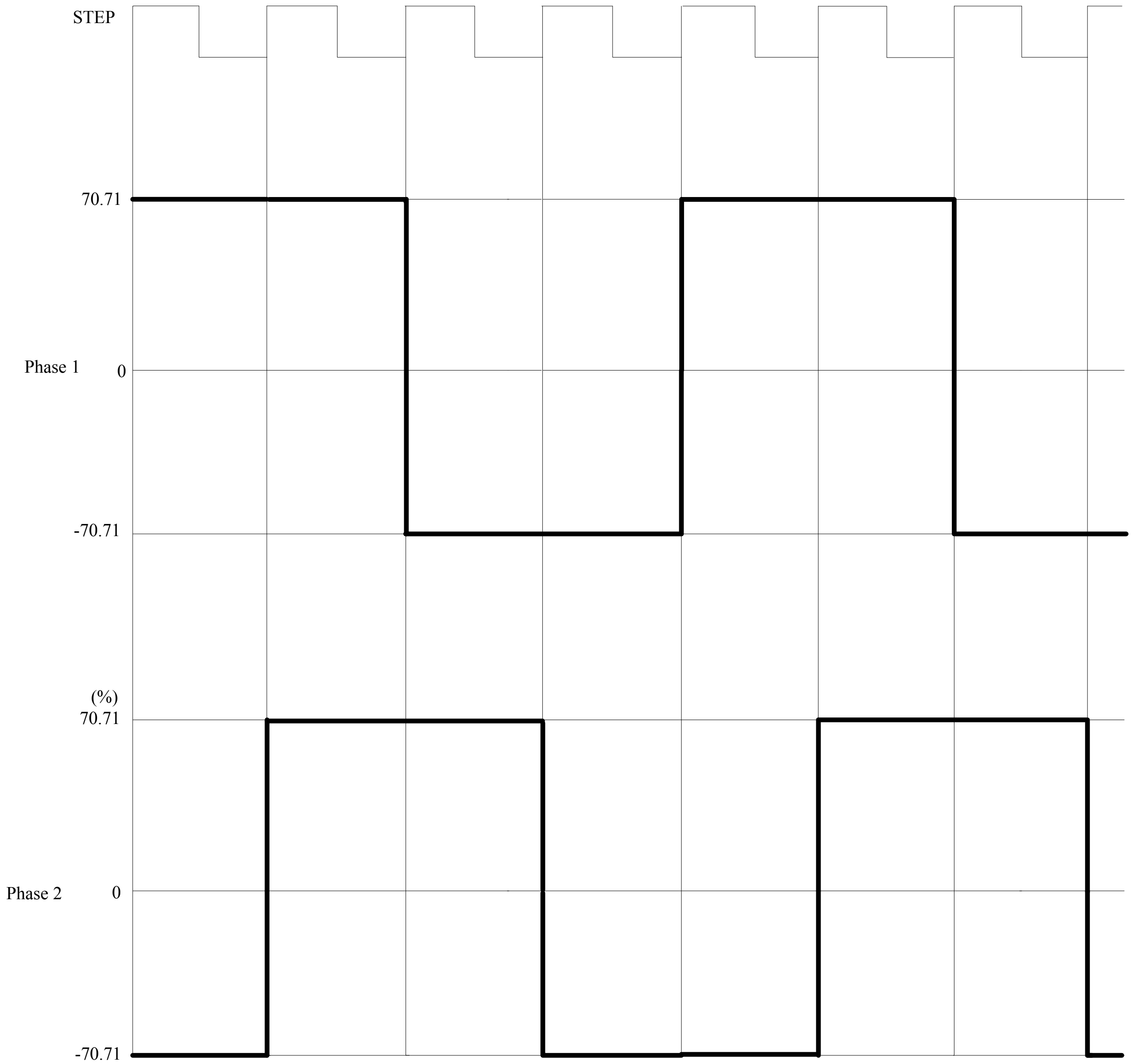
Thermal protection circuitry turns OFF all drivers when the junction temperature reaches +170℃. It is only intended to protect the device from failures due to excessive junction temperature and should not imply that output short circuits are permitted. The output drivers are re-enabled when the junction temperature cools to +145℃.

The AM6289 output drivers are optimized for low output saturation voltages – less than 1.8V total (source plus sink) at 850mA. Under normal operating conditions, when combined with the excellent thermal properties of the batwing packing design, this allows continuous operation of both bridges simultaneously at 850mA.

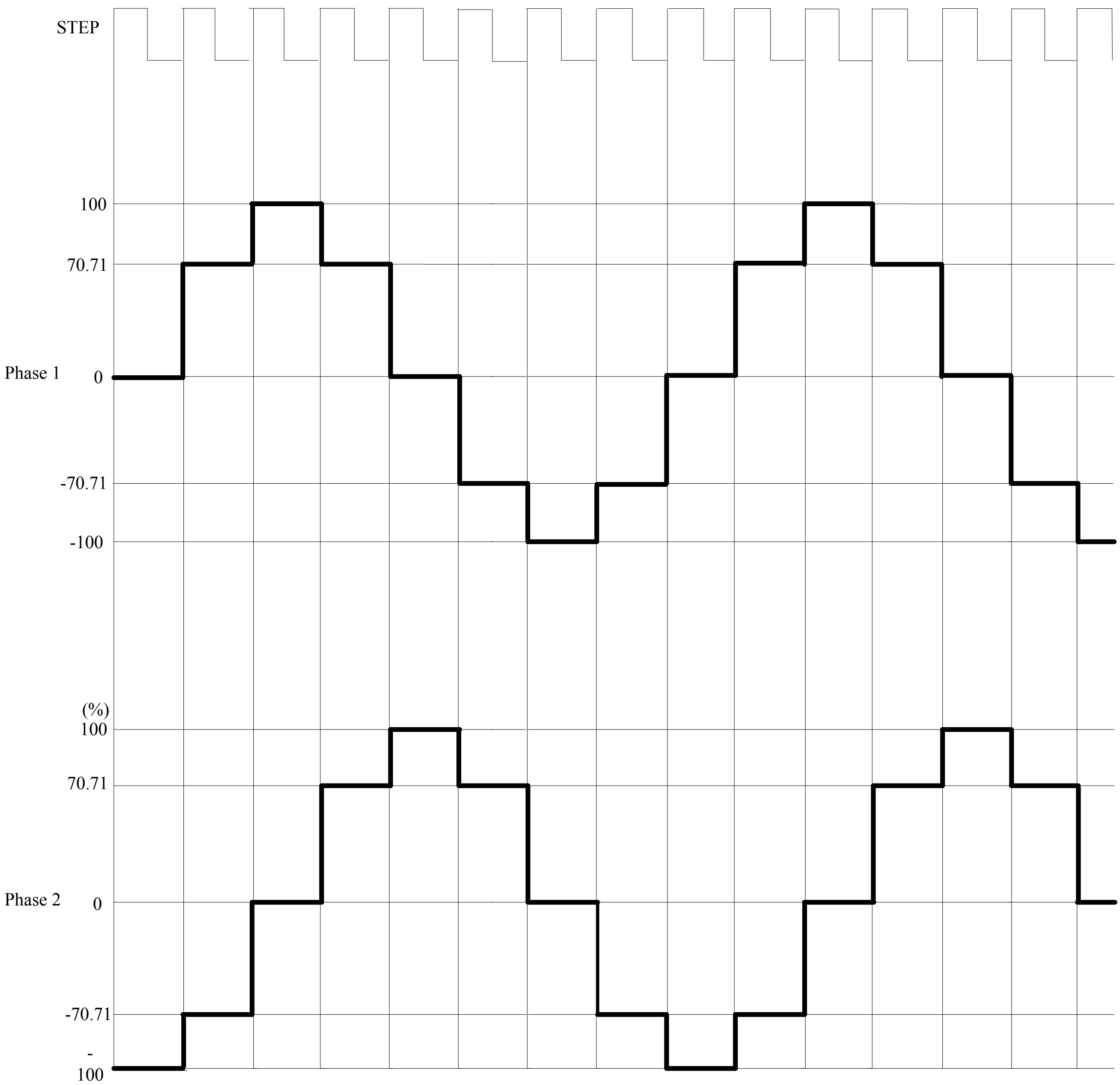
- **Table 2 – Step Sequencing**

Full Step	Half Step	Quarter Step	Eighth Step	Bridge 1					Bridge 2				
				$PHASE_1$	I_{21}	I_{11}	I_{01}	I_{LOAD1}	$PHASE_2$	I_{22}	I_{12}	I_{02}	I_{LOAD2}
1	1	1	1	H	H	L	L	70.7%	H	H	L	L	70.7%
			2	H	L	H	H	55.5%	H	H	L	H	83.1%
		2	3	H	L	H	L	38.2%	H	H	H	L	92.4%
			4	H	L	L	H	19.5%	H	H	H	H	100%
	2	3	5	X	L	L	L	0%	H	H	H	H	100%
			6	L	L	L	H	-19.5%	H	H	H	H	100%
		4	7	L	L	H	L	-38.2%	H	H	H	L	92.4%
			8	L	L	H	H	-55.5%	H	H	L	H	83.1%
2	3	5	9	L	H	L	L	-70.7%	H	H	L	L	70.7%
			10	L	H	L	H	-83.1%	H	L	H	H	55.5%
		6	11	L	H	H	L	-92.4%	H	L	H	L	38.2%
			12	L	H	H	H	-100%	H	L	L	H	19.5%
	4	7	13	L	H	H	H	-100%	X	L	L	L	0%
			14	L	H	H	H	-100%	L	L	L	H	-19.5%
		8	15	L	H	H	L	-92.4%	L	L	H	L	-38.2%
			16	L	H	L	H	-83.1%	L	L	H	H	-55.5%
3	5	9	17	L	H	L	L	-70.7%	L	H	L	L	-70.7%
			18	L	L	H	H	-55.5%	L	H	L	H	-83.1%
		10	19	L	L	H	L	-38.2%	L	H	H	L	-92.4%
			20	L	L	L	H	-19.5%	L	H	H	H	-100%
	6	11	21	X	L	L	L	0%	L	H	H	H	-100%
			22	H	L	L	H	19.5%	L	H	H	H	-100%
		12	23	H	L	H	L	38.2%	L	H	H	L	-92.4%
			24	H	L	H	H	55.5%	L	H	L	H	-83.1%
4	7	13	25	H	H	L	L	70.7%	L	H	L	L	-70.7%
			26	H	H	L	H	83.1%	L	L	H	H	-55.5%
		14	27	H	H	H	L	92.4%	L	L	H	L	-38.2%
			28	H	H	H	H	100%	L	L	L	H	-19.5%
	8	15	29	H	H	H	H	100%	X	L	L	L	0%
			30	H	H	H	H	100%	H	L	L	H	19.5%
		16	31	H	H	H	L	92.4%	H	L	H	L	38.2%
			32	H	H	L	H	83.1%	H	L	H	H	55.5%

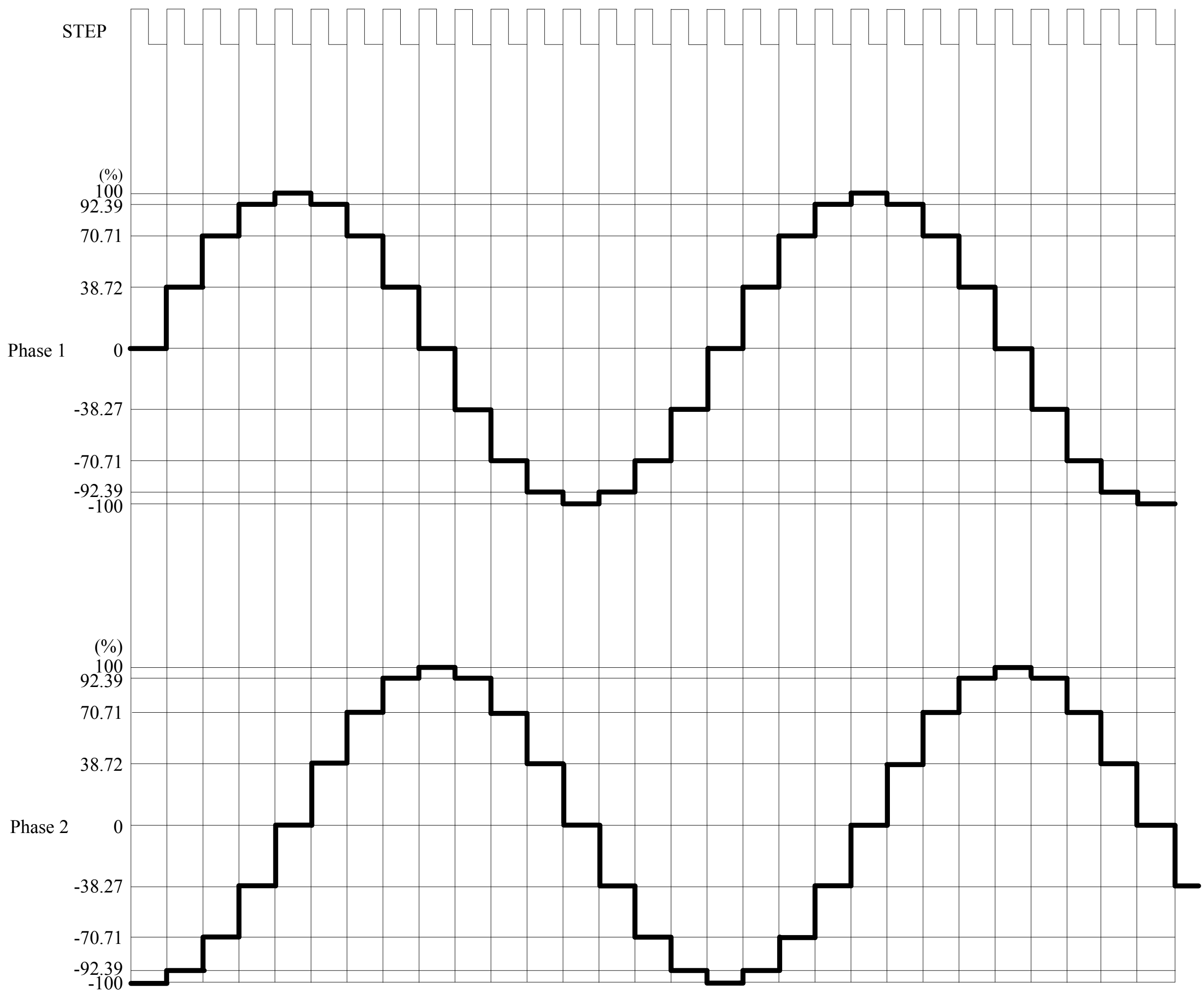
- **Full Step Operation**



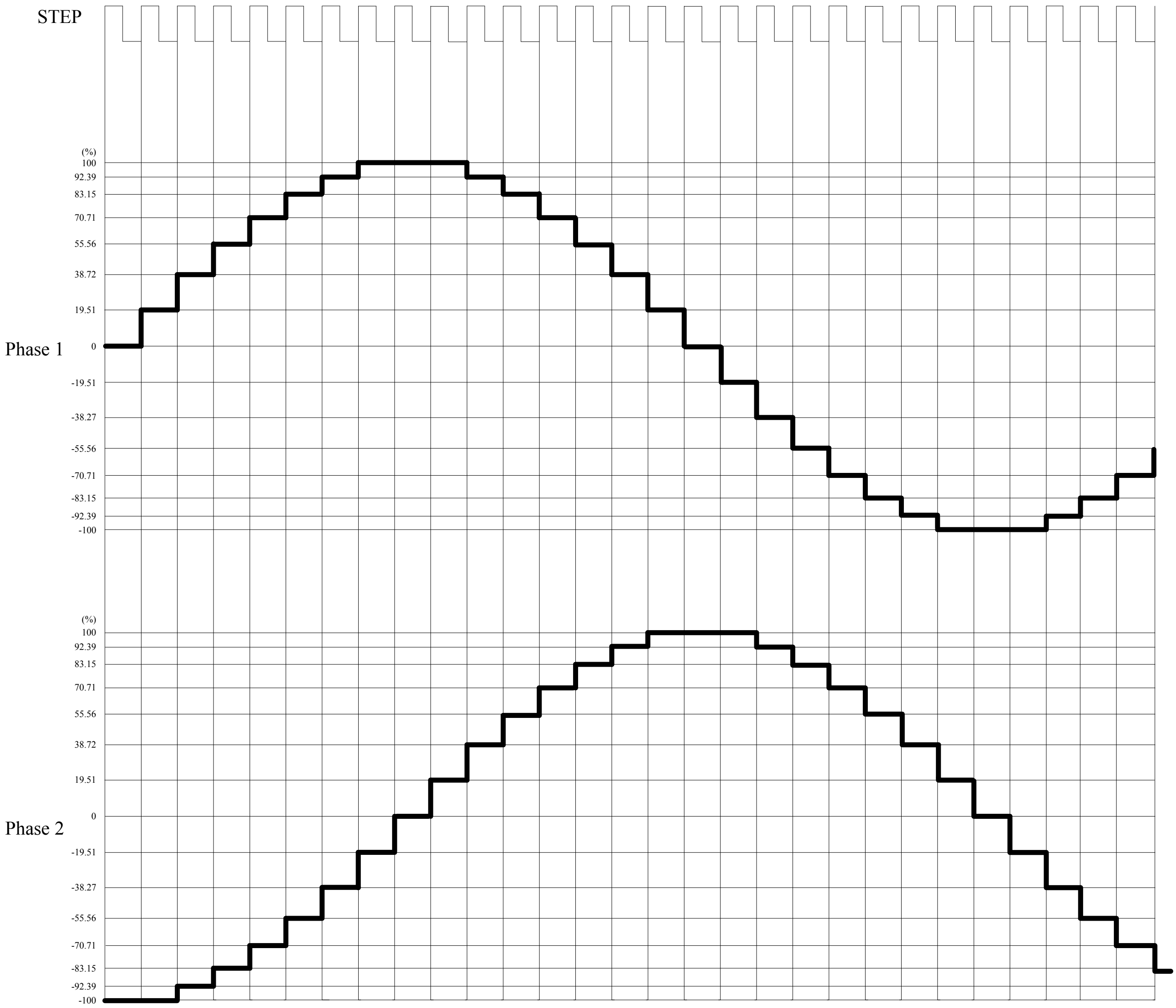
- **Half Step Operation**



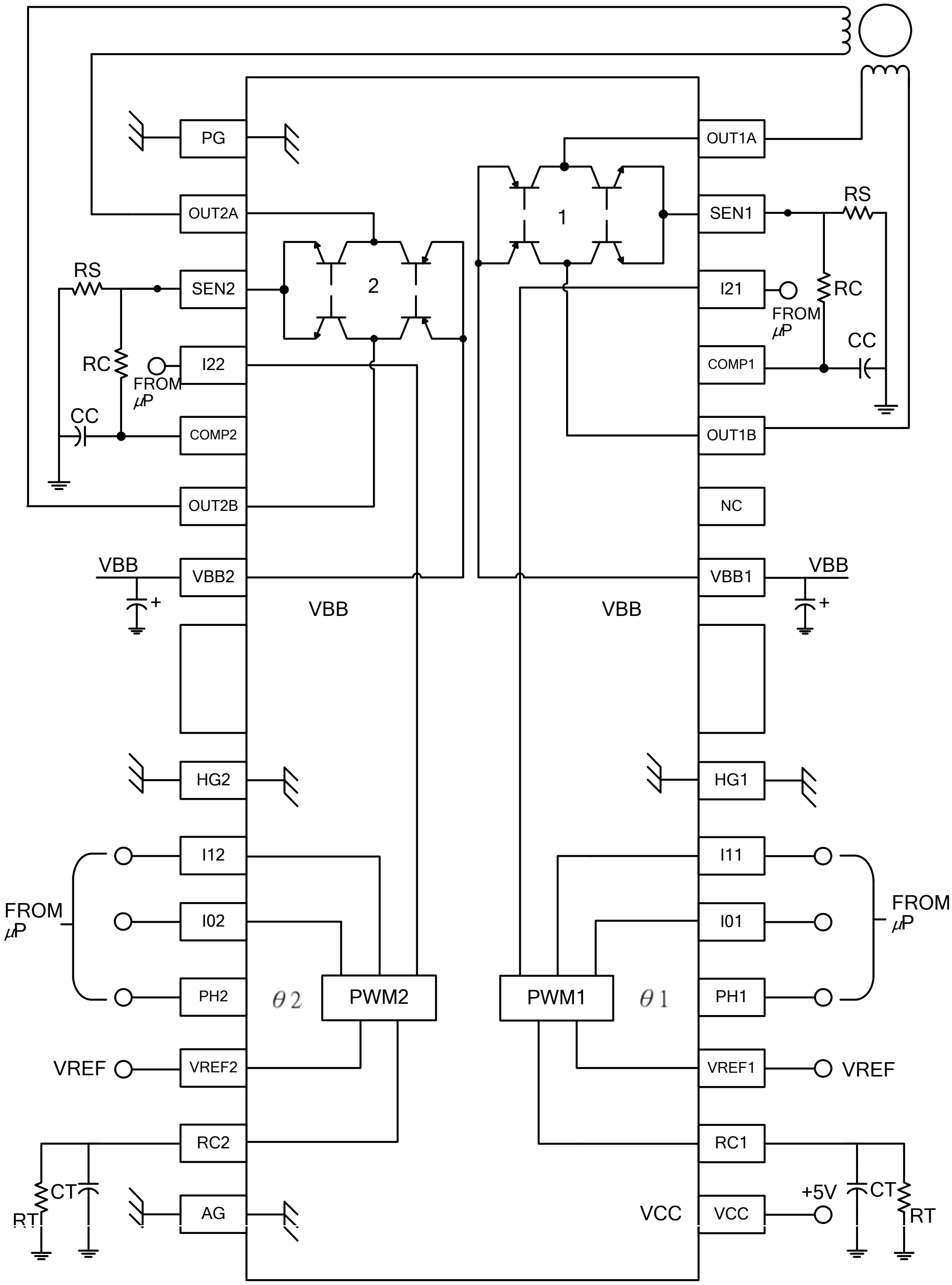
- **4 Microstep /step Operation**



- **8 Microstep /step Operation**

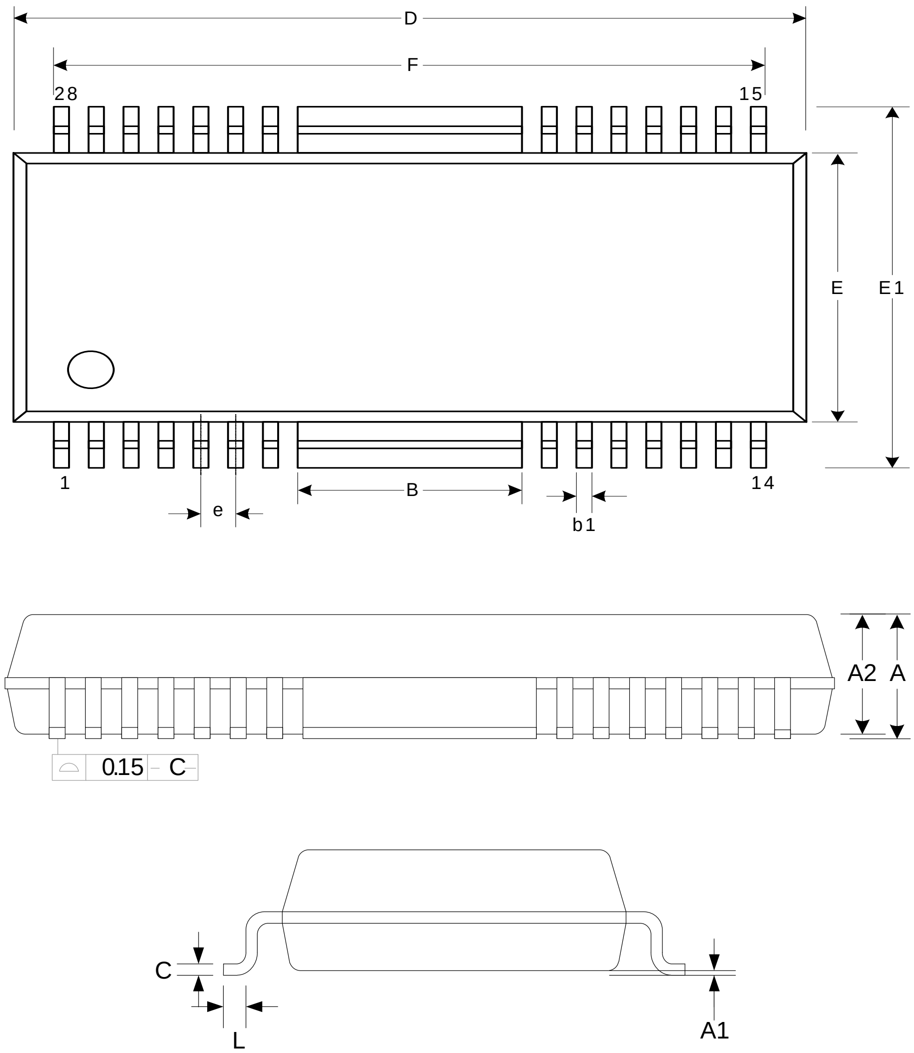


- **Typical Application**



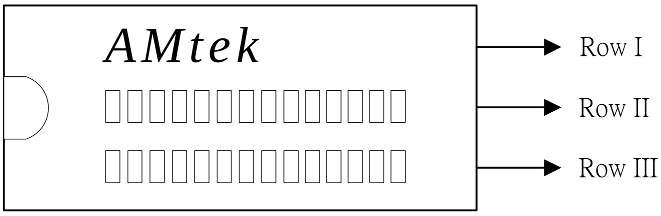
- **Package Outline**

HSOP28



SYMBOL	MILLIMETERS		INCHES	
	Min.	Max.	Min.	Max.
A	-	2.75	-	0.108
A1	-	0.3	-	0.012
A2	-	2.45	-	0.096
B	4.95	5.35	0.195	0.211
b1	0.23	0.47	0.009	0.019
C	0.2	0.36	0.008	0.014
D	17.89	18.8	0.704	0.740
E	7.3	7.9	0.287	0.311
E1	9.6	10.65	0.378	0.419
e	0.8 (TYP)		0.031(TYP)	
F	15.92	16.08	0.627	0.633
L	0.3	1.27	0.012	0.05

- **Marking Identification**



Row I

AMtek

Row II

Part number (Pb)

Part number L/F (Pb free)

Row III

Lot number