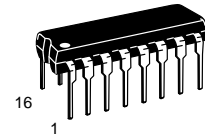# MOTOROLA

SAA1042, A

Advance Information
Stepper Motor Driver

The SAA1042 drives a two–phase stepper motor in the bipolar mode. The device contains three input stages, a logic section and two output stages. The IC is contained in a 16 pin dual–in–line heat tab plastic package for improved heatsinking capability. The center four ground pins are connected to the copper alloy heat tab and improve thermal conduction from the die to the circuit board.
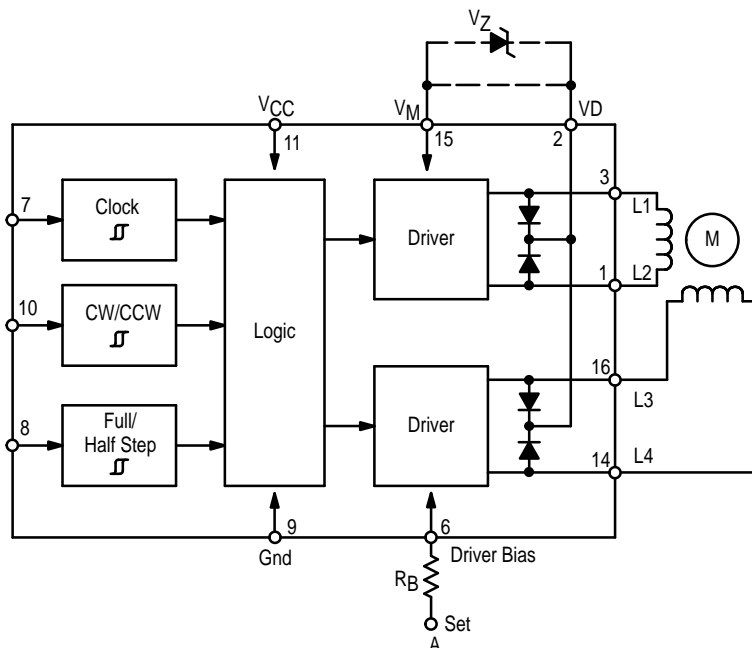
- Drive Stages Designed for Motors: 6.0 V and 12 V: SAA1042V
  24 V: SAA1042AV

- 500 mA/Coil Drive Capability

- Built–In Clamp Diodes for Overvoltage Suppression

- Wide Logic Supply Voltage Range

- Accepts Commands for CW/CCW and Half/Full Step Operation

- Inputs Compatible with Popular Logic Families: MOS, TTL, DTL

- Set Input Defined Output State

- Drive Stage Bias Adaptable to Motor Power Dissipation for Optimum Efficiency
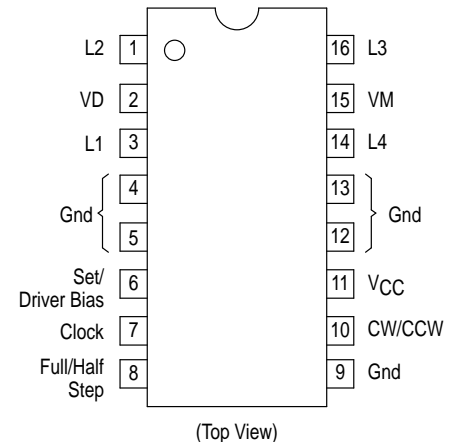
STEPPER MOTOR DRIVER

SEMICONDUCTOR TECHNICAL DATA

V SUFFIX
PLASTIC PACKAGE
CASE 648C

16

1

PIN CONNECTIONS

L2	1	16	L3
VD	2	15	VM
L1	3	14	L4
Gnd {	4	13	} Gnd
	5	12	
Set/ Driver Bias	6	11	VCC
Clock	7	10	CW/CCW
Full/Half Step	8	9	Gnd

(Top View)

Figure 1. Representative Block Diagram

Figure 1. Representative Block Diagram

ORDERING INFORMATION

Device	Operating Temperature Range	Package
SAA1042V	$T_J = -30°$ to +125°C	Plastic DIP
SAA1042AV		Plastic DIP

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MAXIMUM RATINGS (T_A = 25°C, unless otherwise noted.)

Rating	Symbol	SAA1042V	SAA1042AV	Unit
Clamping Voltage (Pins 1, 3, 14, 16)	V_{clamp}	20	30	V
Over Voltage ($V_{OV} = V_{clamp} - V_M$)	V_{OV}	6.0	6.0	V
Supply Voltage	V_{CC}	20	30	V
Switching or Motor Current/Coil	I_M	500	500	mA
Input Voltage (Pins 7, 8, 10)	V_{in} clock V_{in} Full/Half V_{in} CW/ CCW	V_{CC}		V
Power Dissipation (Note 1)	P_D	2.0		W
Thermal Resistance, Junction–to–Air	θJA	80		°C/W
Thermal Resistance, Junction–to–Case	θJC	15		
Operating Junction Temperature Range	T_J	−30 to +125		°C
Storage Temperature Range	T_{stg}	−65 to +150		°C

NOTE: 1. The power dissipation (P_D) of the circuit is given by the supply voltage (V_M and V_{CC}) and the motor current (I_M), and can be determined from Figures 3 and 5. $P_D = P_{drive} - P_{logic}$.

ELECTRICAL CHARACTERISTICS (T_A = 25°C, unless otherwise noted.)

Characteristics	Pin(s)	Symbol	V_{CC}	Min	Typ	Max	Unit
Supply Current	11	I_{CC}	5.0 V	—	—	3.5	mA
			20 V	—	—	8.5	
Motor Supply Current ($I_{Pin\ 6}$ = −400 µA, Pins 1, 3, 14, 16 Open)	15	I_M					mA
V_M = 6.0 V			5.0 V	—	25	—	
V_M = 12 V			5.0 V	—	30	—	
V_M = 24 V			5.0 V	—	40	—	
Input Voltage, High State	7, 8, 10	V_{IH}	5.0 V	2.0	—	—	V
			10 V	7.0	—	—	
			15 V	10	—	—	
			20 V	14	—	—	
Input Voltage, Low State		V_{IL}	5.0 V	—	—	0.8	
			10 V	—	—	1.5	
			15 V	—	—	2.5	
			20 V	—	—	3.5	
Input Reverse Current, High State ($V_{in} = V_{CC}$)	7, 8, 10	I_{IR}	5.0 V	—	—	2.0	µA
			10 V	—	—	2.0	
			15 V	—	—	3.0	
			20 V	—	—	5.0	
Input Forward Current, Low State (V_{in} = Gnd)		I_{IF}	5.0 V	−10	—	—	
			10 V	−25	—	—	
			15 V	−40	—	—	
			20 V	−50	—	—	
Output Voltage, High State (V_M = 12 V) I_{out} = −500 mA	1, 3, 14, 16	V_{OH}	5.0 – 20 V	—	V_M − 2.0	—	V
I_{out} = −50 mA				—	V_M − 1.2	—	
Output Voltage, Low State I_{out} = 500 mA		V_{OL}	5.0 – 20 V	—	0.7	—	
I_{out} = 50 mA				—	0.2	—	
Output Leakage Current, Pin 6 = Open ($V_M = V_D = V_{clamp\ max}$)	1, 3, 14, 16	I_{DR}	5.0 – 20 V	−100	—	—	µA
Clamp Diode Forward Voltage (Drop at I_M = 500 mA)	2	V_F	—	—	2.5	3.5	V
Clock Frequency	7	f_c	5.0 – 20 V	0	—	50	kHz
Clock Pulse Width	7	t_w	5.0 – 20 V	10	—	—	µs
Set Pulse Width	6	t_s	—	10	—	—	µs
Set Control Voltage, High State	6	—	—	V_M	—	—	V
Low State			—	—	—	0.5	

INPUT/OUTPUT FUNCTIONS

Clock — (Pin 7) This input is active on the positive edge of the clock pulse and accepts Logic '1' input levels dependent on the supply voltage and includes hysteresis for noise immunity.

CW/CCW — (Pin 10) This input determines the motor's rotational direction. When the input is held low, (OV, see the electrical characteristics) the motor's direction is nominally clockwise (CW). When the input is in the high state, Logic '1', the motor direction is nominally counter clockwise (CCW), depending on the motor connections.

Full/Half Step — (Pin 8) This input determines the angular rotation of the motor for each clock pulse. In the low state, the motor will make a full step for each applied clock pulse, while in the high state, the motor will make half a step.

V_D — (Pin 2) This pin is used to protect the outputs (1, 3,14, 16) where large positive spikes occur due to switching the motor coils. The maximum allowable voltage on these pins is the clamp voltage (V_{clamp}). Motor performance is improved if a zener diode is connected between Pin 2 and 15, as shown in Figure 1.

The following conditions have to be considered when selecting the zener diode:

$$V_{clamp} = V_M + 6.0 \text{ V}$$
$$V_Z = V_{clamp} - V_M - V_F$$

where: V_F = clamp diodes forward voltage drop (see Figure 4)

V_{clamp}: ≤ 20 V for SAA1042V ≤ 30 V for SAA1042AV

Pins 2 and 15 can be linked, in this case $V_Z = 0$ V.

Set/Bias Input — (Pin 6) This input has two functions:
1) The resistor R_B adapts the drivers to the motor current.
2) A pulse via the resistor R_B sets the outputs (1, 3, 14, 16) to a defined state.

The resistor R_B can be determined from the graph of Figure 2 according to the motor current and voltage. Smaller values of R_B will increase the power dissipation of the circuit and larger values of R_B may increase the saturation voltage of the driver transistors.

When the "set" function is not used, terminal A of the resistor R_B must be grounded. When the set function is used, terminal A has to be connected to an open–collector (buffer) circuit. Figure 7 shows this configuration. The buffer circuit (off–state) has to sustain the motor voltage (V_M). When a pulse is applied via the buffer and the bias resistor (R_B), the

motor driver transistors are turned off during the pulse and after the pulse has ended, the outputs will be in defined states. Figure 6 shows the Timing Diagram.

Figure 7 illustrates a typical application in which the SAA1042 drives a 12 V stepper motor with a current consumption of 200 mA/coil. A bias resistor (R_B) of 56 kΩ is chosen according to Figure 2.

The maximum voltage permitted at the output pin is $V_M + 6.0$ V (see Maximum Ratings table), in this application $V_M = 12$ V, therefore the maximum voltage is 18 V. The outputs are protected by the internal diodes and an external zener connected between Pins 2 and 15.

From Figure 4, it can be seen that the voltage drop across the internal diodes is about 1.7 V at 200 mA. This results in a zener voltage between Pins 2 and 15 of:

$$V_Z = 6.0 \text{ V} - 1.7 \text{ V} = 4.3 \text{ V}.$$

To allow for production tolerances and a safety margin, a 3.9 V zener has been chosen for this example.

The clock is derived from the line frequency which is phase–locked by the MC14046B and the MC14024. The voltage on the clock input is normally low (Logic '0'). The motor steps on the positive going transition of the clock pulse.

The Logic '0' applied to the Full/Half input (Pin 8) operates the motor in Full Step mode. A Logic '1' at this input will result in Half Step mode. The logic level state on the CW/CCW input (Pin 10), and the connection of the motor coils to the outputs determines the rotational direction of the motor.

These two inputs should be biased to a Logic '0' or '1' and not left floating. In the event of non–use, they should be tied to ground or the logic supply line, V_{CC}.

The output drivers can be set to a fixed operating point by use of the Set input and a bias resistor, R_B. A positive pulse to this input turns the drivers off and sets the logic state of the outputs.

After the negative going transition of the Set pulse, and until the first positive going transition of the clock, the outputs will be:

L1 = L3 = high and L2 = L4 = low, (see Figure 6).

The Set input can be driven by a MC14007B or a transistor whose collector resistor is R_B. **If the input is not used, the bottom of R_B must be grounded.**

The total power dissipation of the circuit can be determined from Figures 3 and 5:

$$P_D = 0.9 \text{ W} + 0.08 \text{ W} = 0.98 \text{ W}.$$

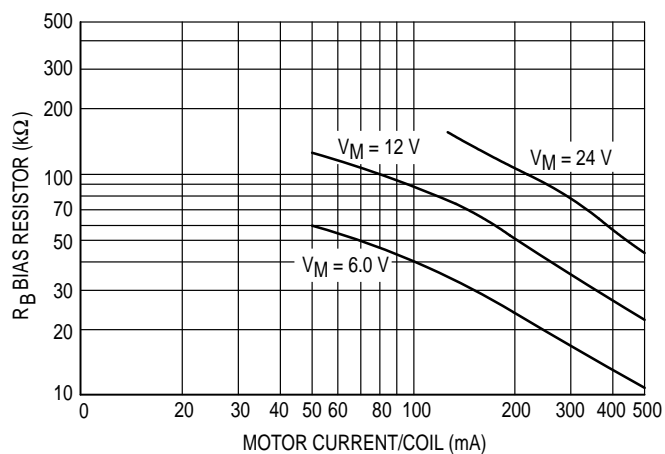The junction temperature can then be computed using Figure 8.

Figure 2. Bias Resistor R$_B$ versus Motor Current

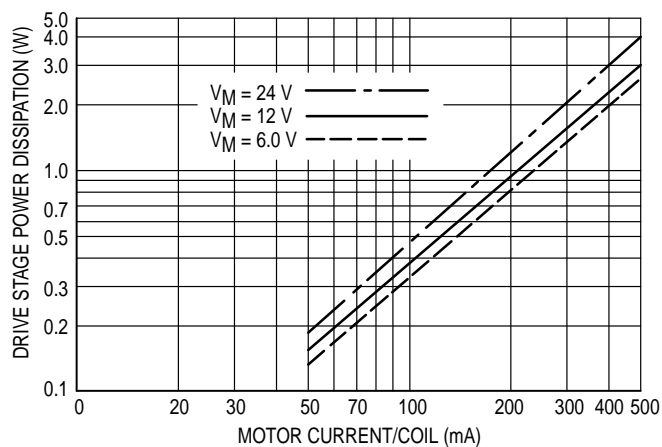**Figure 3. Drive Stage Power Dissipation**

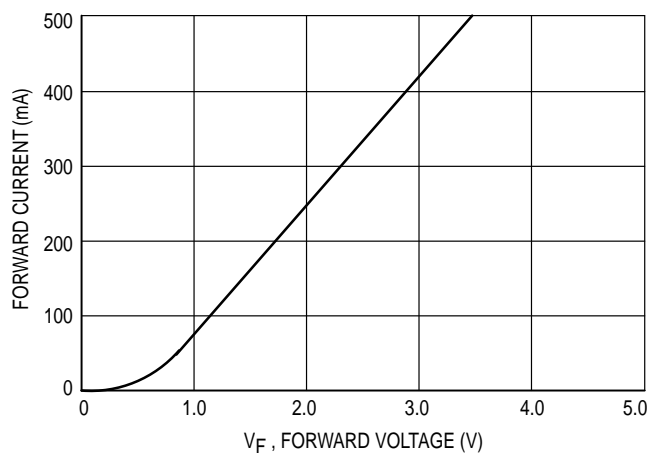**Figure 4. Clamp Diode Forward Current
versus Forward Voltage**
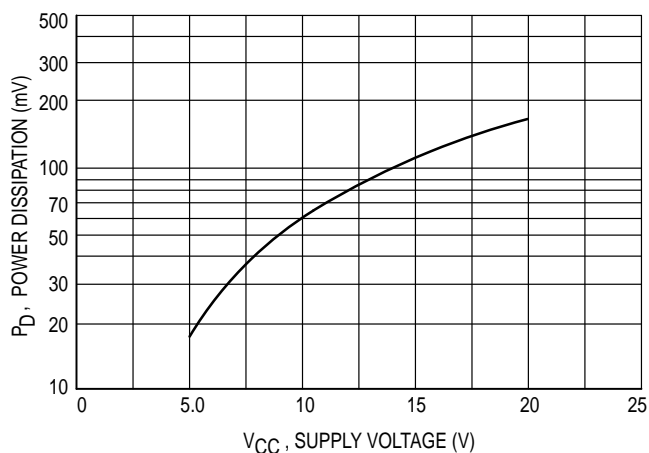

**Figure 5. Power Dissipation versus
Logic Supply Voltage**

Figure 6. Timing Diagram
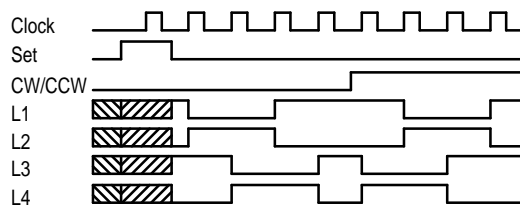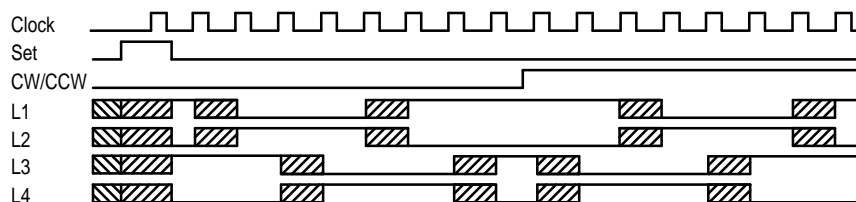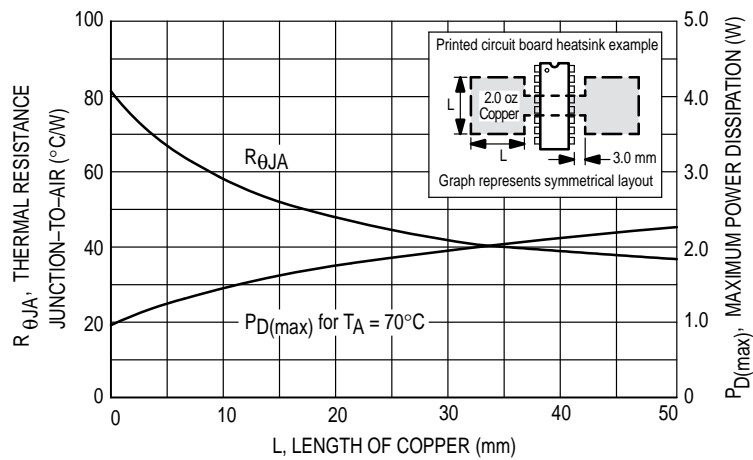
SAA1042, A

Figure 7. Typical Application
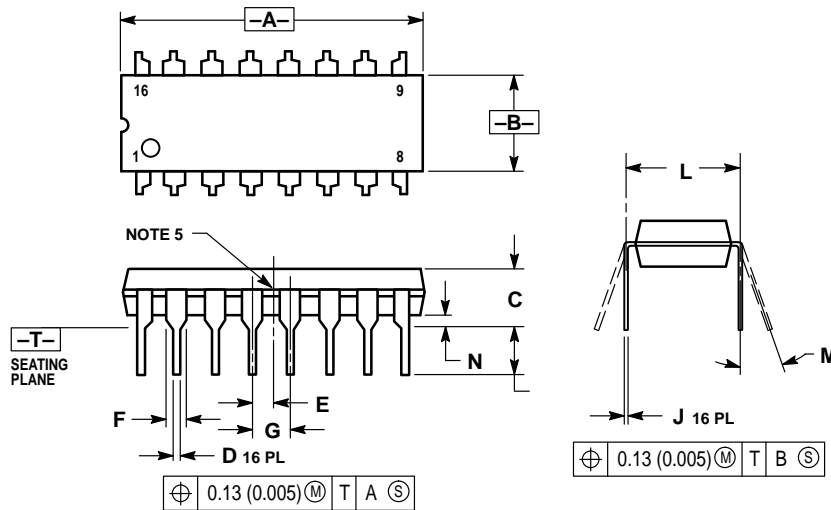**Selectable Step Rates with the Time Base Derived from the Line Frequency**
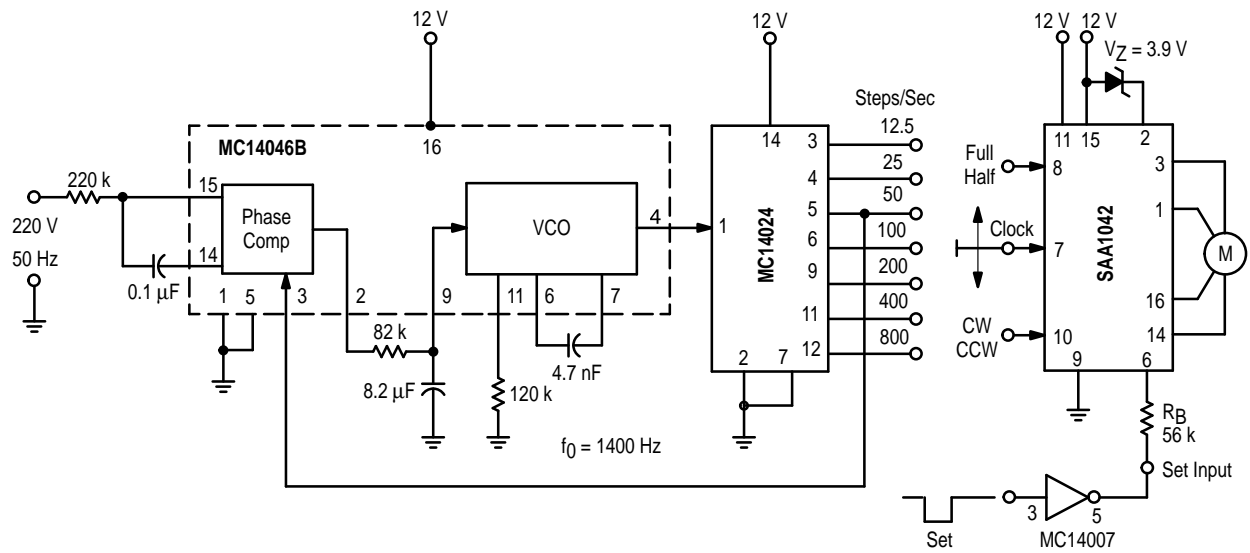
Figure 8. Thermal Resistance and Maximum Power
Dissipation versus P.C.B. Copper Length

OUTLINE DIMENSIONS

V SUFFIX
PLASTIC PACKAGE
CASE 648C–03
ISSUE C

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
5. INTERNAL LEAD CONNECTION BETWEEN 4 AND 5, 12 AND 13.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.740	0.840	18.80	21.34
B	0.240	0.260	6.10	6.60
C	0.145	0.185	3.69	4.69
D	0.015	0.021	0.38	0.53
E	0.050 BSC		1.27 BSC	
F	0.040	0.70	1.02	1.78
G	0.100 BSC		2.54 BSC	
J	0.008	0.015	0.20	0.38
K	0.115	0.135	2.92	3.43
L	0.300 BSC		7.62 BSC	
M	0°	10°	0°	10°
N	0.015	0.040	0.39	1.01

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