

Stepper Motor Drive Circuit

FEATURES

- Half-step and Full-step Capability
- Bipolar Constant Current Motor Drive
- Built-in Fast Recovery Schottky Commutating Diodes
- Wide Range of Current Control 5-1000mA
- Wide Voltage Range 10-45V
- Designed for Unregulated Motor Supply Voltage
- Current Levels can be Selected in Steps or Varied Continuously
- Thermal Overload Protection

DESCRIPTION

The UC3717 has been designed to control and drive the current in one winding of a bipolar stepper motor. The circuit consists of an LS-TTL-compatible logic input, a current sensor, a monostable and an output stage with built-in protection diodes. Two UC3717s and a few external components form a complete control and drive unit for LS-TTL or micro-processor controlled stepper motor systems.

The UC1717 is characterized for operation over the full military temperature range of -55°C to +125°C, the UC2717 is characterized for -25°C to +85°C, and the UC3717 is characterized for 0°C to +70°C.

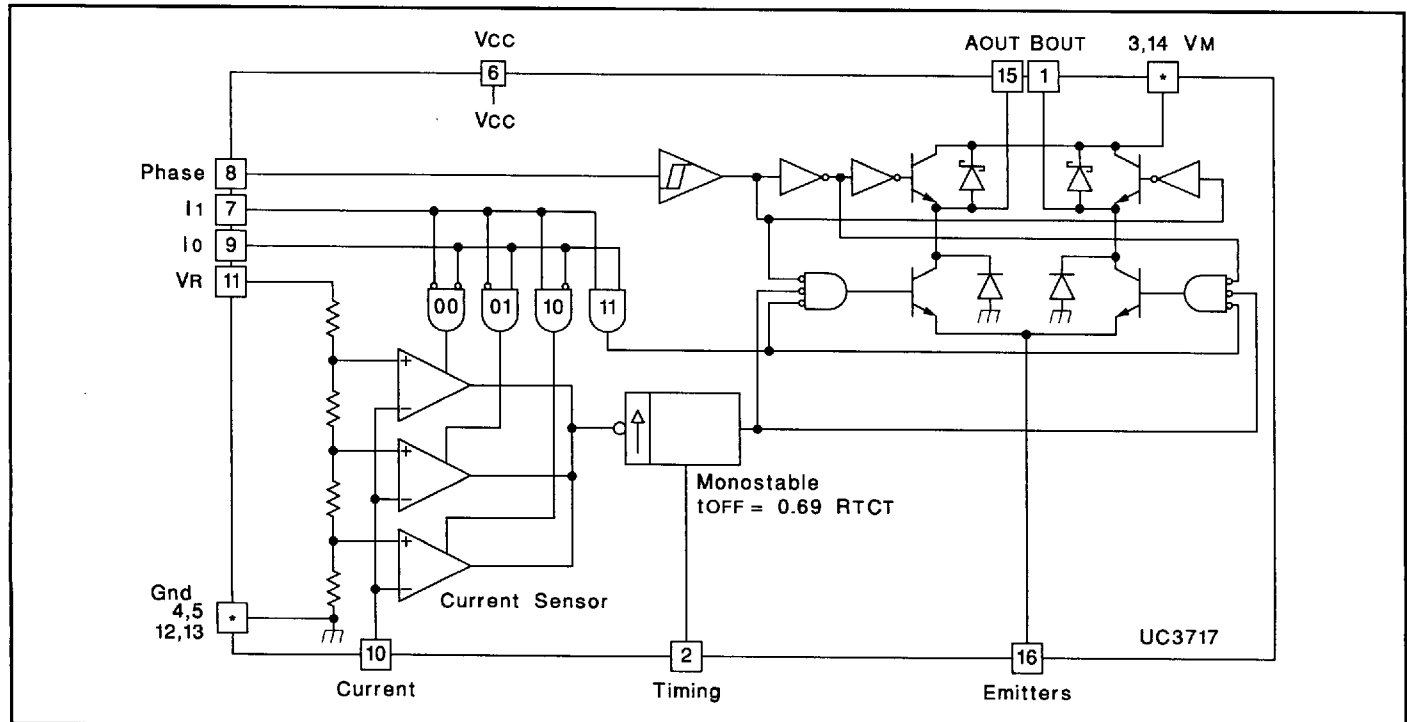
ABSOLUTE MAXIMUM RATINGS (Note 1)

Voltage	
Logic Supply, V _{CC}	7V
Output Supply, V _M	45V
Input Voltage	
Logic Inputs (Pins 7, 8, 9)	6V
Analog Input (Pin 10)	V _{CC}
Reference Input (Pin 11)	15V
Input Current	
Logic Inputs (Pins 7, 8, 9)	-10mA
Analog Inputs (Pins 10, 11)	-10mA
Output Current (Pins 1, 15)	±1A
Junction Temperature, T _J	+150°C
Storage Temperature Range, T _s	-55°C to +150°C

Note 1: All voltages are with respect to ground, Pins 4, 5, 12, 13. Pin numbers refer to DIL-16 package. Currents are positive into, negative out of the specified terminal.

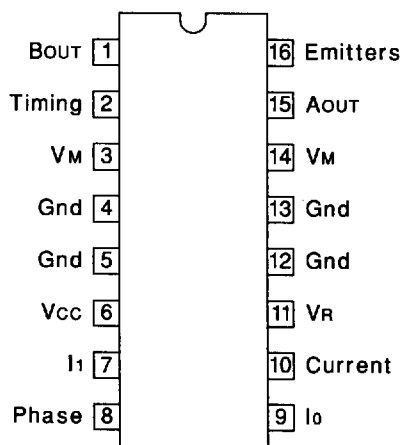
Note 2: Consult Packaging Section of Databook for information on thermal limitations and considerations of package.

BLOCK DIAGRAM

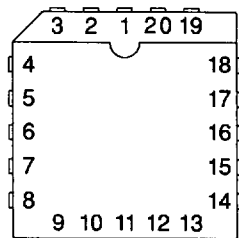


CONNECTION DIAGRAMS

DIL-16 (TOP VIEW)
J or N Package



PLCC-20 (TOP VIEW)
Q Package



PACKAGE PIN FUNCTION	
FUNCTION	PIN
N/C	1
BOUT	2
Timing	3
VM	4
Gnd	5
N/C	6
Gnd	7
Vcc	8
I1	9
Phase	10
N/C	11
Io	12
Current	13
VR	14
Gnd	15
N/C	16
Gnd	17
VM	18
AOUT	19
Emitters	20

RECOMMENDED OPERATING CONDITIONS

PARAMETER	MIN	TYP	MAX	UNITS
Supply Voltage, Vcc	4.75	5	5.25	V
Supply Voltage, VM	10		40	V
Output Current, IM	20		800	mA
Rise Time Logic Inputs, tr			2	μs
Fall Time Logic Inputs, tf			2	μs
Ambient Temperature, TA				
UC1717	-55		125	°C
UC2717	-25		85	°C
UC3717	0		70	°C

ELECTRICAL CHARACTERISTICS Unless otherwise specified, these specifications apply for Vc = 5V, TA = TJ.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current, ICC				25	mA
High-Level Input Voltage, Pins 7, 8, 9		2.0			V
Low-Level Input Voltage, Pins 7, 8, 9				0.8	V
High-Level Input Current, Pins 7, 8, 9	VI = 2.4V			20	μA
Low Level Input Current, Pins 7, 8, 9	VI = 0.4V	-0.4			mA
Comparator Threshold Voltage	Io = 0, I1 = 0, VR = 5.0V	390	420	440	mV
	Io = 1, I1 = 0, VR = 5.0V	230	250	270	mV
	Io = 0, I1 = 1, VR = 5.0V	65	80	90	mV
Comparator Input Current		-20		20	μA
Output Leakage Current	Io = 1, I1 = 1, TA = +25°C			100	μA
Total Saturation Voltage Drop	IM = 500mA			4.0	V
Total Power Dissipation	IM = 500mA, fs = 30kHz		1.4	2.1	W
	IM = 800mA, fs = 30kHz		2.9	3.1	W
Cut Off Time, toFF	VM = 10V, ton ≥ 5μs (See Figure 5 and 6)	25	30	35	μs
Turn Off Delay, td	TA = +25°C; dVc/dt ≥ 50mV/μs (See Figure 5 and 6)		1.6	2.0	μs
Thermal Shutdown Junction Temperature		+160		+180	°C

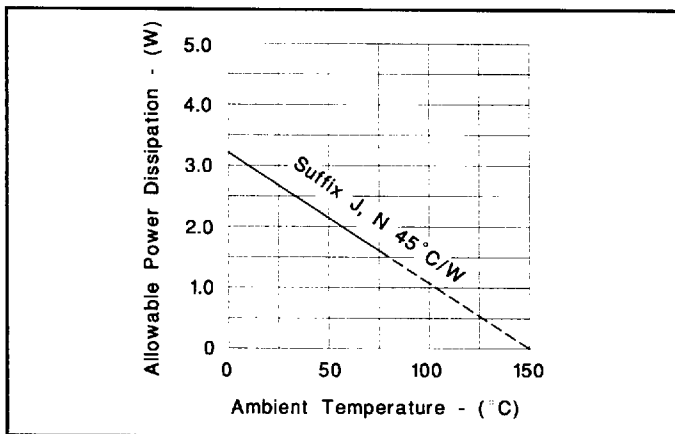


Figure 1

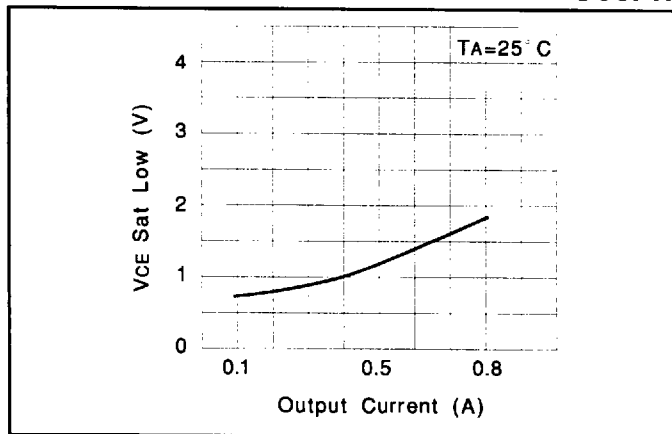


Figure 3: Typical Sink Saturation Voltage vs Output Current

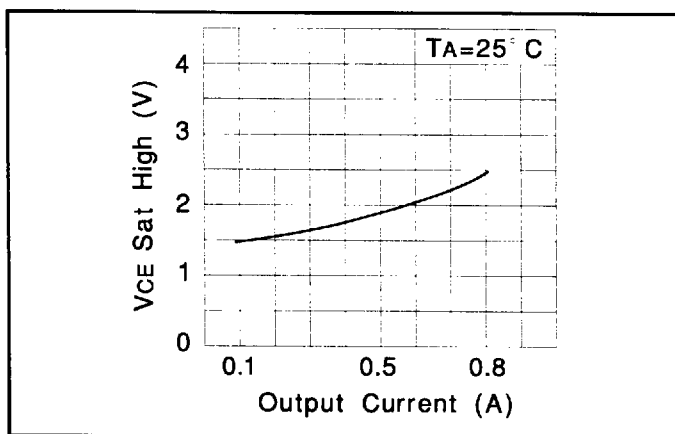


Figure 2: Typical Source Saturation Voltage vs Output Current

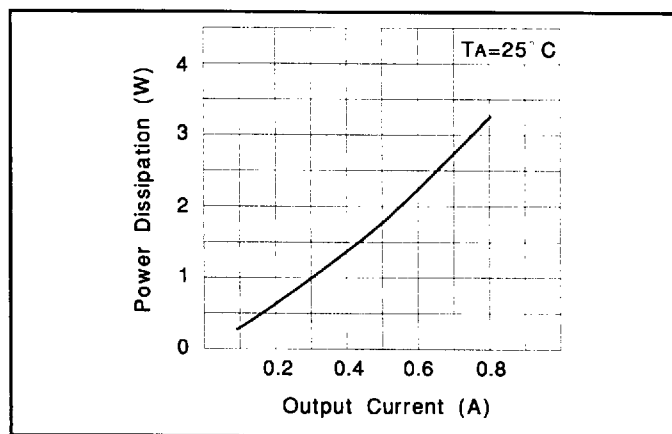


Figure 4: Typical Power Losses vs Output Current

FUNCTIONAL DESCRIPTION

The UC3717 drive circuit shown in the block diagram includes the following functions:

- (1) Phase Logic and H-Bridge Output Stage
- (2) Voltage Divider with three Comparators for current control
- (3) Two Logic inputs for Digital current level select
- (4) Monostable for off time generation

Input Logic: If any of the logic inputs are left open, the circuit will treat it as a high level input.

Phase Input: The phase input terminal, pin 18, controls the direction of the current through the motor winding. The Schmidt-Trigger input coupled with a fixed time delay assures noise immunity and eliminates cross conduction in the output stage during phase changes. A low level on the phase input will turn Q2 on and enable Q3 while a high level will turn Q1 on and enable Q4. (See Figure 7).

Output Stage: The output stage consists of four Darlington transistors and associated diodes connected in an H-Bridge configuration. The diodes are needed to provide a current path when the transistors are being switched. For fast recovery, Schottky diodes are used

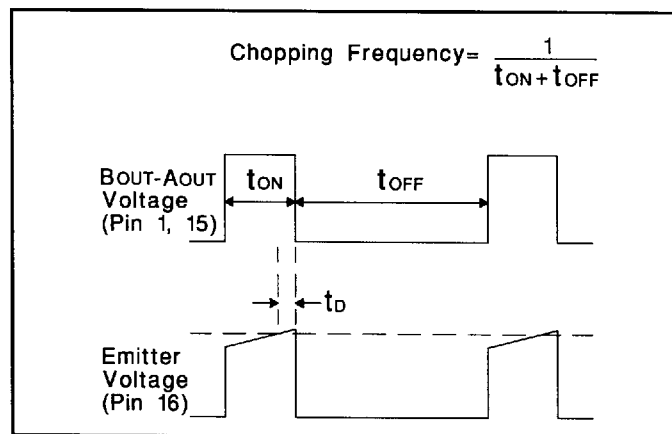


Figure 5: Connections and Component Values as in Figure 6.

across the source transistors. The Schottky diodes allow the current to circulate through the winding while the sink transistors are being switched off. The diodes across the sink transistors in conjunction with the Schottkys provide the path for the decaying current during phase reversal. (See Figure 7).

PHASE INPUT	Q1, Q4	Q2, Q3
Low	Off	On
High	On	Off

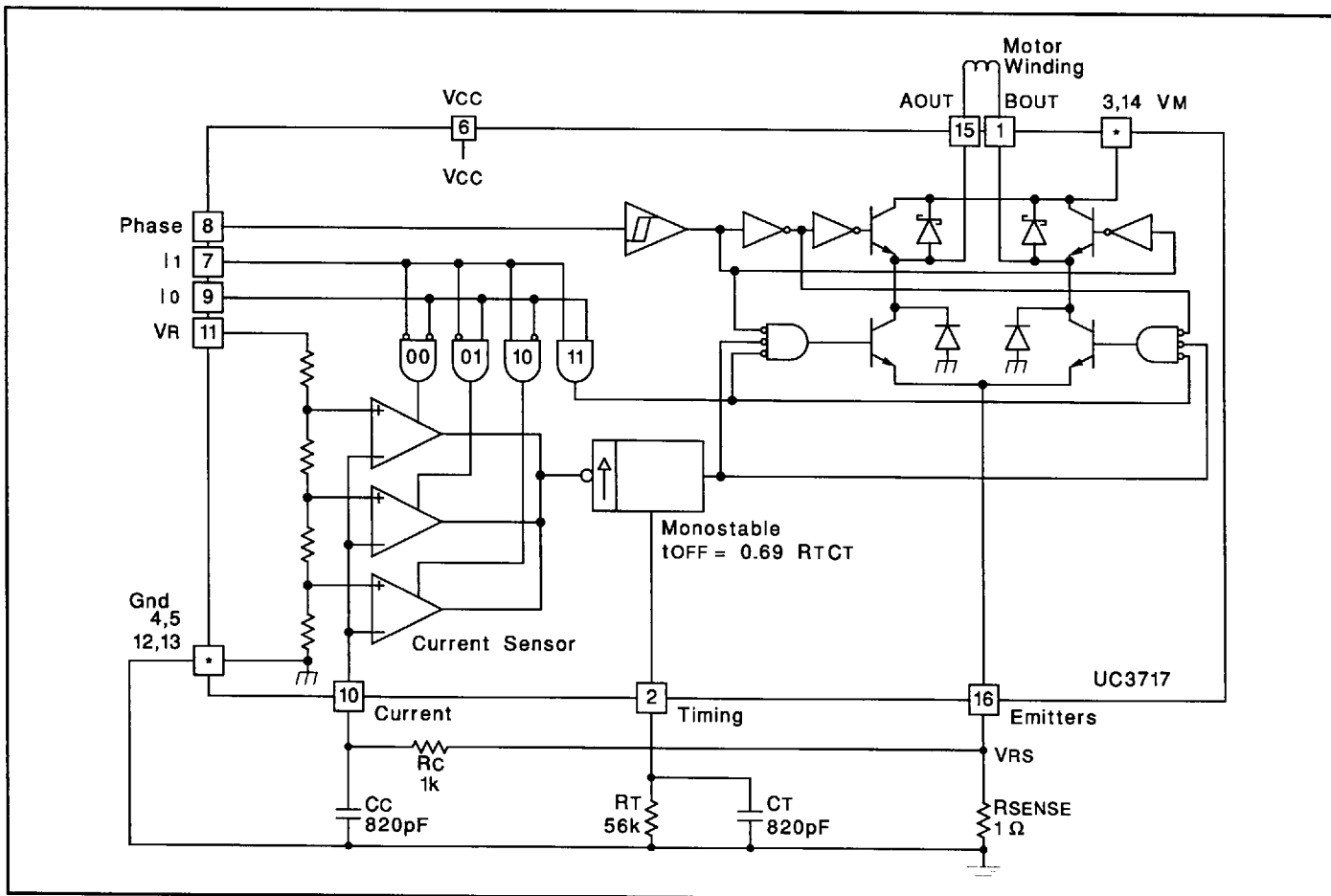


Figure 6

I ₀	I ₁	CURRENT LEVEL
0	0	100%
1	0	60%
0	1	19%
1	1	Current Inhibit

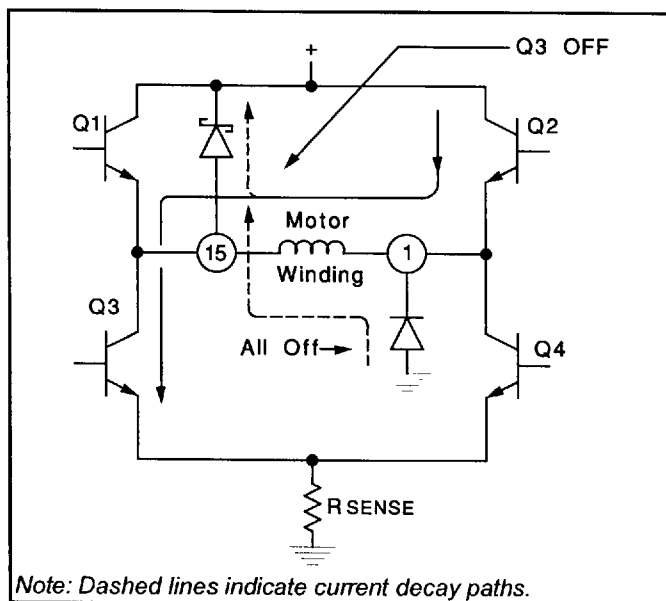
Current Control: The voltage divider, comparators and monostable provide a means for current sensing and control. The two bit input (I₀, I₁) logic selects the desired comparator. The monostable controls the off time and therefore the magnitude of the current decrease. The time duration is determined by RT and CT connected to the timing terminal (pin 2). The reference terminal (pin 11) provides a means of continuously varying the current for situations requiring half-stepping and micro-stepping. The relationship between the logic input signals at pin 7 and 9 in reference to the current level is shown in Table 1. The values of the different current levels are determined by the reference voltage together with the value of the external sense resistor R_S (pin 16).

Single-Pulse Generator: The pulse generator is a monostable triggered on the positive going edge of the comparator. Its output is high during the pulse time and this pulse switches off the power feed to the motor wind-

ing causing the current to decay. The time is determined by the external timing components RT and CT as:

$$T_{OFF} = 0.69 RTCT$$

If a new trigger signal should occur during TOFF, it is ignored.



Note: Dashed lines indicate current decay paths.

Figure 7: Simplified Schematic of Output Stage

FUNCTIONAL DESCRIPTION (cont.)

Overload Protection: The circuit is equipped with a thermal shutdown function, which will limit the junction temperature by reducing the output current. It should be noted however, that a short circuit of the output is not permitted.

Operation: When the voltage is applied across the motor winding the current rises linearly and appears across the external sense resistor as an analog voltage. This voltage is fed through a low pass filter R_C , C_C to the voltage comparator (pin 10). At the moment the voltage rises beyond the comparator threshold voltage the monostable is triggered and its output turns off the sink transistors. The current then circulates through the source transistor and the appropriate Schottky diode. After the one shot has timed out, the sink transistor is turned on again and the procedure repeated until a current reverse command is given. By reversing the logic level of the phase input (pin 8), both active transistors are being turned off and the opposite pair turned on. When this happens the current must first decay to zero before it can reverse. The current path then provided is through the two diodes and the power-supply. Refer to Figure 7. It should be noted at this time that the slope of the current decay is steeper, and this is due to the higher voltage build up across the winding. For better speed performance of the stepping motor at half step mode, the phase logic level should be changed at the same time the current inhibit is applied. A typical current wave form is shown in Figure 8.

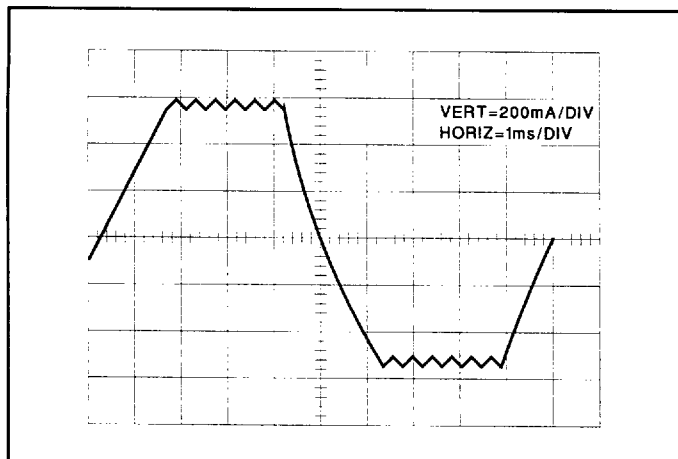


Figure 8

APPLICATIONS

A typical chopper drive for a two phase bipolar permanent magnet or hybrid stepping motor is shown in Figure 9. The input can be controlled by a microprocessor, TTL, LS or CMOS logic.

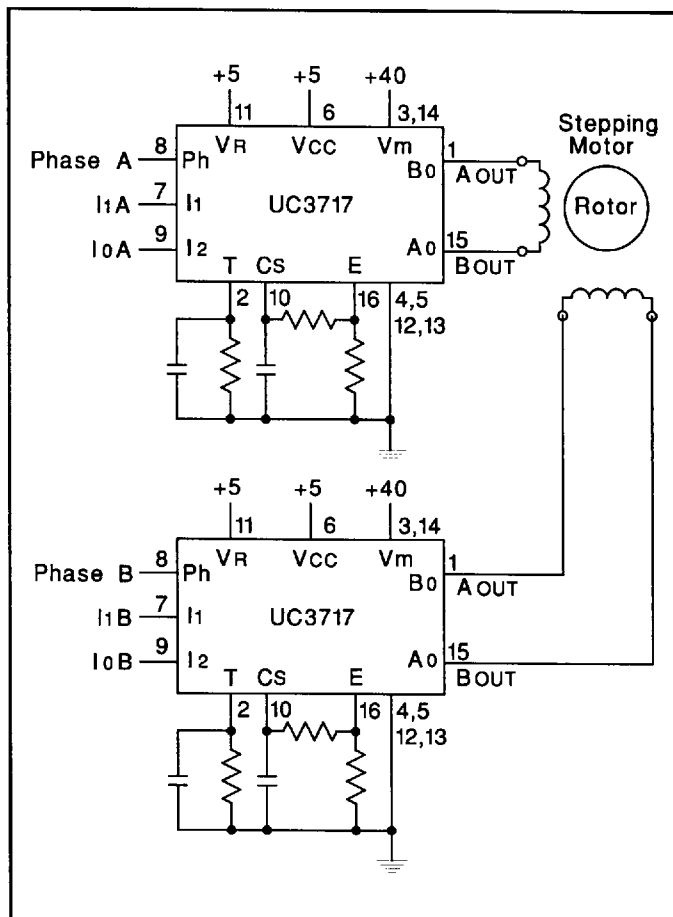


Figure 9

The timing diagram in Figure 10 shows the required signal input for a two phase, full step, stepping sequence. Figure 11 shows a one phase, full step, stepping sequence, commonly referred to as wave drive. Figure 12 shows the required input signal for a one phase-two phase stepping sequence called half-stepping.

The circuit of Figure 13 provides the signal shown in Figure 10, and in conjunction with the circuit shown in Figure 9, will implement a pulse-to-step two phase, full step, bidirectional motor drive.

The schematic of Figure 14 shows a pulse to half step circuit generating the signal shown in Figure 12. Care has been taken to change the phase signal the same time the current inhibit is applied. This will allow the current to decay faster and therefore enhance the motor performance at higher step rates.

Using the UC3717 to drive the L298 provides a uniquely packaged state-of-the-art high power stepper motor control and drive. See Figure 15.

FUNCTIONAL DESCRIPTION (cont.)

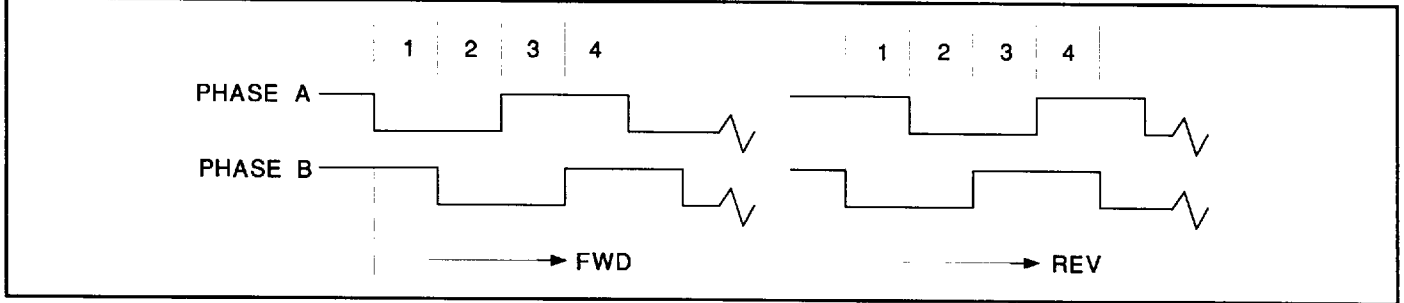


Figure 10: Phase Input Signal for Two Phase Full Step Drive (4 Step Sequence)

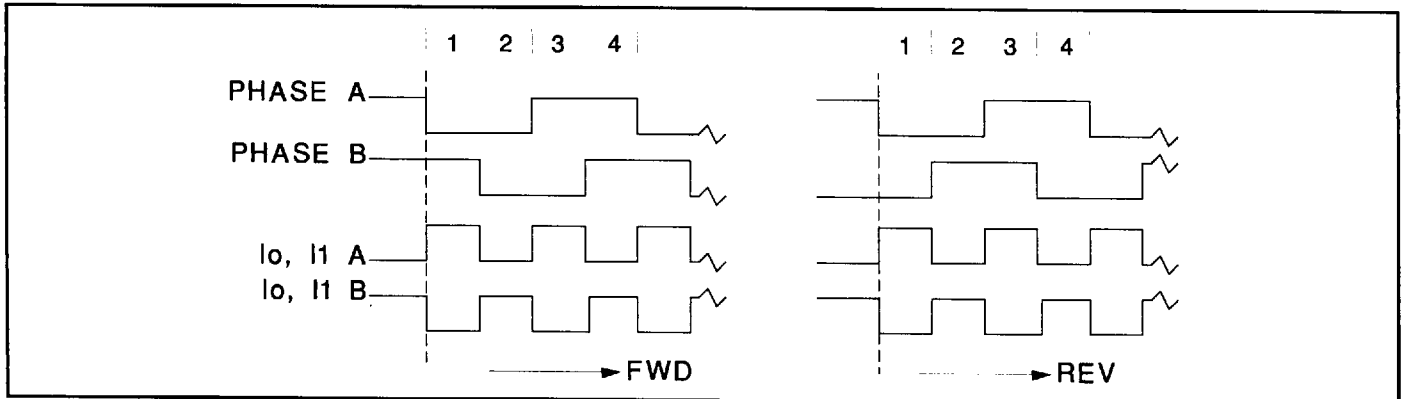


Figure 11: Phase and Current-Inhibit Signal for Wave Drive (4 Step Sequence)

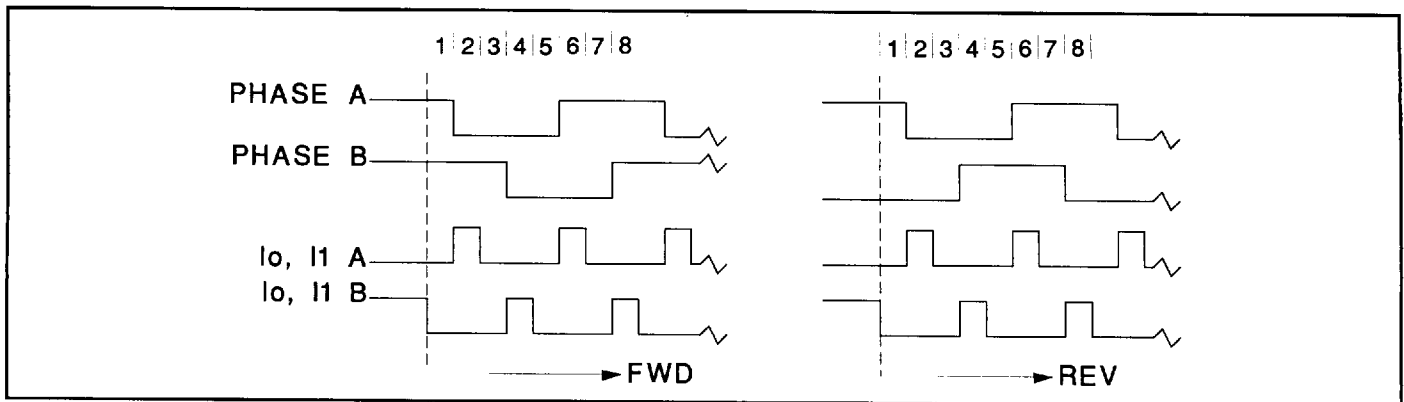


Figure 12: Phase and Current-Inhibit Signal for Half Stepping (8 Step Sequence)

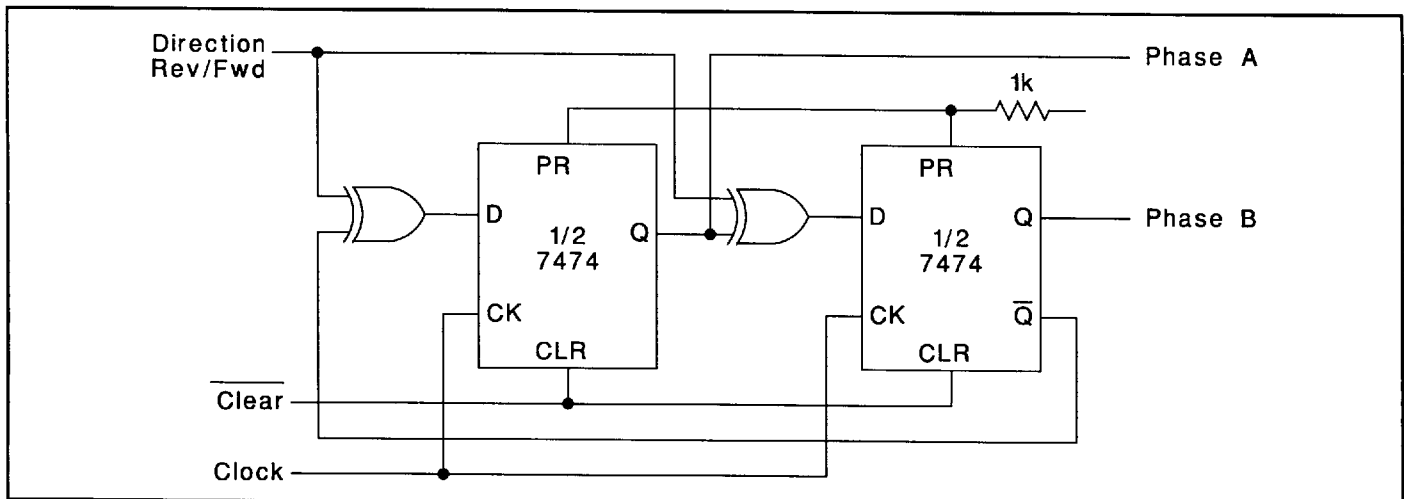


Figure 13: Full Step Bidirectional Two Phase Drive Logic

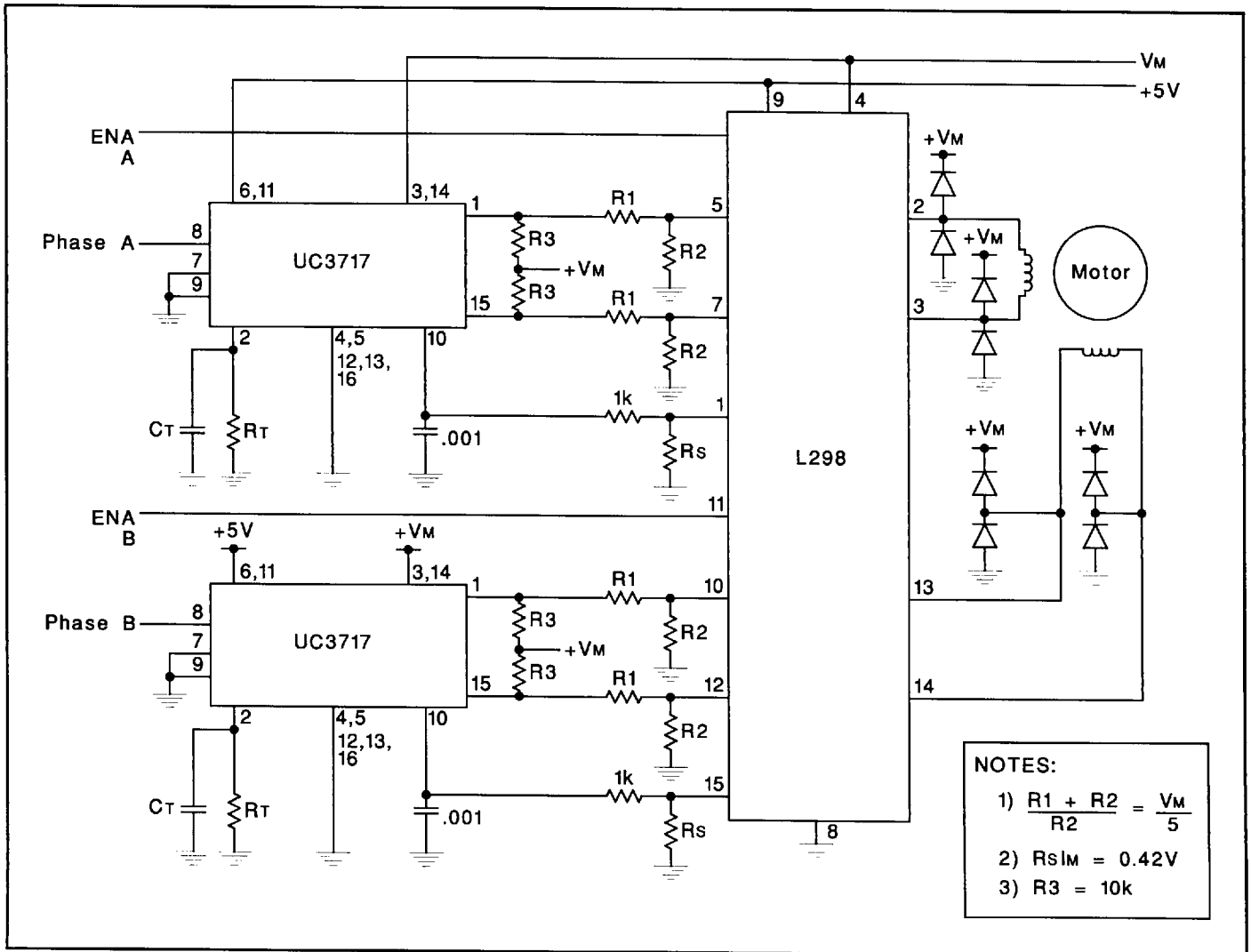


Figure 15: UC3717 with L298 Power Amplifier