MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

TDA1085A

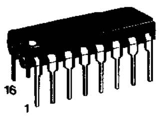
UNIVERSAL MOTOR SPEED CONTROLLER

The TDA1085A has all the necessary functions for the speed control of universal (ac/dc) motors in an open or closed loop configuration. Additionally it has the facility for defining the initial speed/time characteristic. The circuit provides a phase angle varied trigger pulse to the motor control triac.

- Guaranteed Full Wave Triac Drive
- Soft Start from Powerup
- On-Chip Frequency/Voltage Convertor and Ramp Generator
- Current Limiting Incorporated
- Direct Drive from ac Line

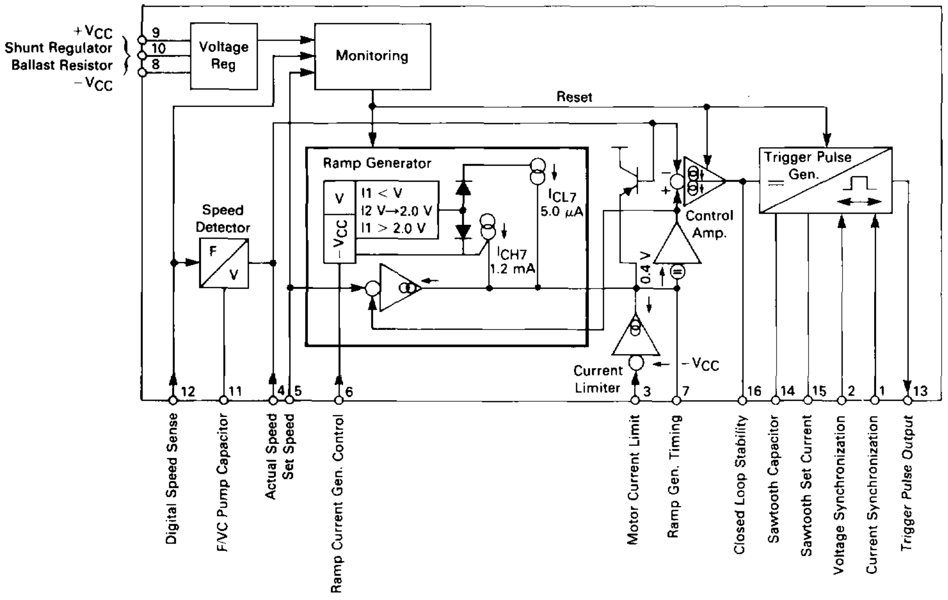
UNIVERSAL MOTOR SPEED CONTROLLER

SILICON MONOLITHIC INTEGRATED CIRCUIT



PLASTIC PACKAGE
CASE 648

FIGURE 1 — BLOCK DIAGRAM AND PIN ASSIGNMENT



MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Power Supply Voltage	$V_{Pin\ 9\text{-}8}$	17	V
Power Supply Current (Pin 10 Open)	$I_{Pin\ 9}$	15	mA
Peak Power Supply Regulation Current	$I_{Pin\ 9} + I_{Pin\ 10}$	35	mA
Peak ac Synchronization Input Current	$I_{Pin\ 1}$ $I_{Pin\ 2}$	±1.0	mA
Peak Output Triggering Current (Pulse Width 300 μs; Duty Cycle ≤ 3%)	$I_{Pin\ 13}$	200	mA
Current Drain per Listed Pin	I_{15} I_3 I_{12}	1.0 −5.0 −3.0, +0.1	mA
Power Dissipation (T_A = 25°C) Derate above 25°C	P_D $1/R_{\theta JA}$	625 6.8	mW mW/°C
Operating Temperature Range	T_A	0 to +70	°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

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

Characteristic	Symbol	Min	Typ	Max	Unit
VOLTAGE REGULATOR					
Regulated Voltage* ($I_9 + I_{10}$ = 10 mA)	V_{CC}	—	15.5	—	V
Monitoring Enable Level*	V_{ME}	—	15.1	—	V
Monitoring Disable Level*	V_{MD}	—	14.5	—	V
Internal Current Consumption (Note 1)	$I_{Pin\ 9}$	—	4.2	—	mA
RAMP GENERATOR					
Reference Input Voltage Range (Note 2)	$V_{Pin\ 5\text{-}8}$	0.08	—	13.5	V
Reference Input Bias Current	$I_{Pin\ 5}$	—	—	−20	μA
Distribute Low Level Voltage Range	$V_{Pin\ 6}$	0	—	2.0	V
Distribute — Low Level (Figure 2)	V_{DL}	—	$V_{Pin\ 6}$	—	V
Distribute — Upper Level* (Figure 2) ($V_{Pin\ 6}$ = 950 mV)	V_{DU}	1.9 V_6	2.0 V_6	2.1 V_6	V
Low-High Acceleration Range (Figure 2)	ΔV_{DA}	—	400	—	mV
High Acceleration Charging Current	I_{CH7}	—	1.2	—	mA
Low Charging Current (Note 3)	I_{CL7}	—	5.0	—	μA

NOTES:

1. Pins 1, 2, 11, 12, 14 and 15 not connected; Pins 4, 5, 6 and 7 grounded to Pin 8: V_{CC} = 15.5 V.
2. When $V_{Pin\ 5}$ is ≤ 80 mV, the internal monitoring circuit interprets it as a true zero, thus minimizing the effects of control amplifier offsets.
3. This value should be accounted for when externally setting the distribute acceleration charging current.

* These figures apply for the application shown in Figure 4.

ELECTRICAL CHARACTERISTICS (Continued)

Characteristic	Symbol	Min	Typ	Max	Unit
CURRENT LIMITER					
Stage Current Gain	$\frac{I_{DL7}}{\Delta I_3}$	—	170	—	—
Output Discharge Current Swing	I_{DL7}	—	35	—	mA
CONTROL AMPLIFIER					
Actual Speed Voltage Range	$V_{Pin\ 4\text{-}8}$	0	—	13.5	V
Actual Speed Input Bias Current	$I_{Pin\ 4}$	—	—	−350	nA
Total Input Offset Voltage (Note 4)	V_{off}	−60	—	20	mV
Transconductance $\left(\frac{\Delta I_{Pin\ 16}}{V_{Pin\ 4} - V_{Pin\ 7}}\right)$	g_m	—	300	—	µA/V
Output Current Swing	$I_{Pin\ 16}$	—	±100	—	µA
FREQUENCY/VOLTAGE CONVERTER					
Input Signal Low Voltage (Note 5)	V_{L12}	−0.1	—	—	V
Input Signal High Voltage	V_{H12}	0.1	—	5.0	V
Polarization Current	$I_{Pin\ 12}$	—	−25	—	µA
Conversion Rate* (Note 6)	K_C	—	15	—	mV/Hz
Linearity* (Figure 3)	K_L	—	±4.0	—	%
TRIGGER PULSE GENERATOR					
Voltage Synchronization Levels	$V_{Pin\ 2}$	—	±50	—	µA
Current Synchronization Levels	$I_{Pin\ 1}$	—	±50	—	µA
Input Voltage Swing (for full angle swing)	V	—	11.7	—	V
Trigger Pulse Width (Note 7)	t_p	—	55	—	µs
Trigger Pulse Repetition Period	t_{prp}	—	215	—	µs
Trigger Pulse High Level ($I_{Pin\ 13}$ = 150 mA)	$V_{Pin\ 13}$	$V_{CC} - 4$	—	—	V
Output Leakage Current ($V_{Pin\ 13}$ = 0 V)	$I_{OPin\ 13}$	—	—	30	µA

4. V_{off} is defined as being the voltage difference between Pin 5 and 4 with no current flow on Pin 16.
5. The negative swing is clamped to −0.3 V.
6. $V_{Pin\ 4} = k \cdot C_{Pin\ 11} \cdot (V_{CC} - V_a) \cdot R_{Pin\ 4} \cdot \left(1 + \frac{180 \times 10^3}{R_{Pin\ 11}}\right)^{-1} \cdot$ freq in.

   Where: $9 < K < 13$ & $V_a \div 1.3$ V.
7. The timing given is when $C_{Pin\ 14}$ = 47 nF.

* These figures apply for the application shown in Figure 4.

INPUT/OUTPUT FUNCTIONS

VOLTAGE REGULATOR — (Pins 8, 9, 10). This is a parallel type voltage regulator able to sink a large amount of current while offering good regulation characteristics.

A resistor between Pins 9 and 10 reduces the internal power dissipation. Under minimal current sink conditions (min. current from the unregulated supply, max. consumption by the circuitry), at least 1.0 mA should flow through this resistor. Under max. sink conditions (max. current from the unregulated supply, min. consumption by the circuitry), the maximum resistor value is chosen so that the voltage at Pin 10 falls towards 3.0 V, but not lower. The above, fixed dynamic range of the regulator must not be exceeded within one line cycle.

A power supply failure causes shutdown.

For operation from an externally regulated voltage, Pin 10 is not connected.

SPEED SENSING — (Pins 4, 11, 12). Speed sensing can be achieved either digitally (tachogenerator frequency) or analogically (tachogenerator amplitude).

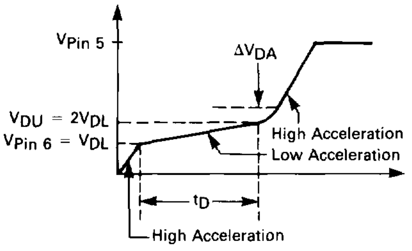
For digital sensing, a bipolar signal with respect to ground is applied to Pin 12. During positive excursions $C_{Pin\ 11}$ is charged. An internal mirror delivers ten times the charge on $C_{Pin\ 11}$ via Pin 4. However, due to internal circuitry, the charge on Pin 4 can vary in the region of 9 to 13 times the charge on $C_{Pin\ 11}$. For that reason it is necessary to calibrate the Frequency/Voltage Convertor (F/VC) with a variable resistor on Pin 4. Thus the relationship between speed and $V_{Pin\ 4}$ is defined by $R_{Pin\ 4}$ and $C_{Pin\ 11}$.

To maintain linearity in the high speed ranges it is important that $C_{Pin\ 11}$ is fully charged across an equivalent resistor of about 180 kΩ. It should be borne in mind that the impedance on Pin 11 should be kept as low as possible as $C_{Pin\ 11}$ has a large influence on the temperature coefficient of the FV/C. The time constant on Pin 4 should also be kept as low as possible.

Pin 12 is also an impedance monitoring input; at high impedances $V_{Pin\ 12}$ increases. Should $V_{Pin\ 12}$ exceed 5.0 V the triac trigger pulses are inhibited and the circuit resets.

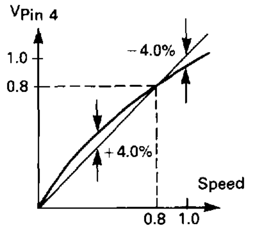
A 470 kΩ resistor from Pin 11 to $+V_{CC}$ significantly reduces the leakage current and reduces the device temperature coefficient to almost zero.

FIGURE 2 — RAMP GENERATOR TRANSFER CHARACTERISTIC



The shape of the curve is determined by $CR_{Pin\ 7}$; where $C_{Pin\ 7}$ defines the high acceleration slope and $R_{Pin\ 7}$ defines that of the low acceleration.

FIGURE 3 — FREQUENCY/VOLTAGE CONVERTER OUTPUT CHARACTERISTIC



INPUT/OUTPUT FUNCTIONS (continued)

For analog sensing input 12 should be grounded and a positive signal, with respect to ground, Pin 8, applied to Pin 4.

RAMP GENERATOR — (Pins 5, 6, 7) (refer to Figure 2). A preset voltage applied to Pin 5 will initiate the generation of a ramp whose final value is determined by the voltage applied to Pin 5. The voltage applied to Pin 6 will determine how much of the full ramp, shown in Figure 2, is used. The charging current passing through Pin 7 to the ramp generator timing capacitor determines the ramp slope.

When Pin 6 is held at $-V_{CC}$ a charging current of 1.2 mA is delivered to Pin 7, regardless of the voltage of Pin 5. This represents the high acceleration period shown in Figure 2.

If the preset voltage applied to Pin 5 is equal to or less than the voltage on Pin 6 the charging current will be 1.2 mA, or high acceleration.

If the preset voltage applied to Pin 5 is between $V_{Pin\ 6}$ and 2 $V_{Pin\ 6}$ the charging current is 1.2 mA (high acceleration) until the voltage at the reference input of the control amplifier equals $V_{Pin\ 6}$. At this point the charging current will switch to 5.0 μA; i.e. low acceleration.

If the preset voltage applied to Pin 5 is greater than 2 $V_{Pin\ 6}$ the charging current will be 1.2 mA (high acceleration) until the control amplifier's reference input reaches $V_{Pin\ 6}$ when it will switch to 5.0 μA (low acceleration) until 2 $V_{Pin\ 6}$ is reached. At this point the charging current will revert to 1.2 mA, high acceleration, until the final value of $V_{Pin\ 5}$ is reached.

Should the preset voltage at Pin 5 fall below 80 mV, the triac trigger pulses are inhibited and the circuit resets. This fact should be borne in mind when switching from one preset value to another.

As long as the voltages applied at Pins 5 and 6 are derived from the internal voltage regulator, they and the voltage on Pin 4 are ratioed and thus independent of the voltage regulator spread and temperature coefficient.

CURRENT LIMITER — (Pin 3). Safe operation of the motor and triac under all conditions is ensured by reducing the motor speed if a preset current limit is exceeded.

This is achieved as follows: The motor current will set up an alternating current, consisting of positive and negative peaks through the shunt resistor (0.05 Ω in Figure 4).

The negative peaks of this current are fed through a resistor to Pin 3 where they are compared with a preset current defined by a resistor between Pin 3 and $+V_{CC}$. An excessive shunt current will try to pull Pin 3 below $-V_{CC}$, but the current limiter becomes active at this point and reduces the charge on $C_{Pin\ 7}$, consequently reducing the motor speed.

Thus the value of the shunt and the ratio of the two resistors to Pin 3 fix the level at which the limiter becomes active, while the parallel equivalent of the two resistors determines the magnitude of the discharge current and thus how rapidly the circuit responds to an overcurrent condition.

CONTROL AMPLIFIER — (Pin 16). Connected to this pin is a network which compensates electrically for the mechanical characteristics of the motor and its load to give the circuit optimum closed loop stability and transient response.

The component values are best determined empirically by connecting R and C substitution boxes and looking for the best results.

TRIGGER PULSE GENERATOR — (Pins 1, 2, 13, 14, 15). This circuit performs four functions:

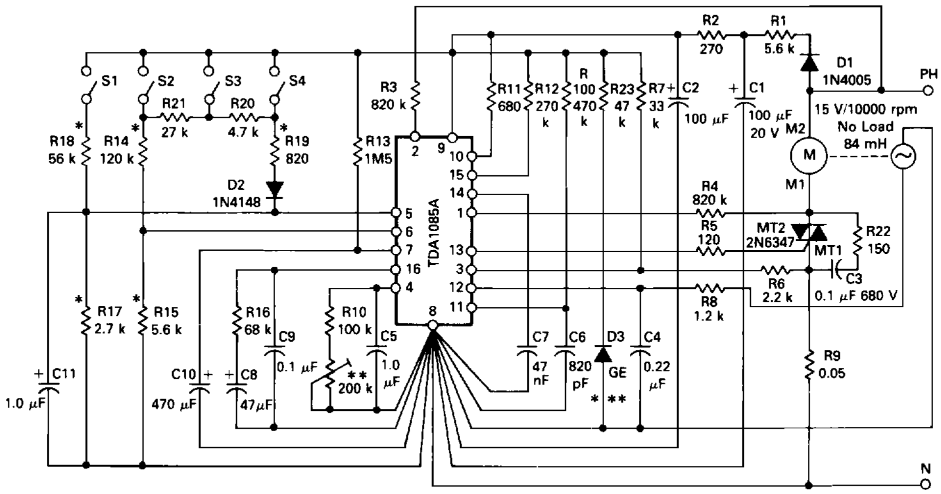
1. The conversion of the control amplifier's dc output level to a proportional firing angle positioned to within half a line cycle.
2. The calibration of the pulse width.
3. The repetition of the firing pulse if the triac fails to latch, or if the current is interrupted by brush bounce.
4. To delay the firing pulse until the current crosses zero at wide firing angles.

$R_{Pin\ 15}$ and $C_{Pin\ 14}$ fix the sawtooth while $C_{Pin\ 14}$ also determines the pulse width.

Pin 13 is the trigger pulse output. A current limiting resistor is essential on this pin. This configuration will drive two thyristors controlling a bridge if the supply for the speed controller is isolated.

TYPICAL APPLICATIONS

FIGURE 4 — CLOSED LOOP, FULLY PROGRAMMED, MULTI-SPEED SYSTEM WITH CURRENT LIMITING



* Chosen to suit the speeds required
** Adjust for the highest speed
*** Required only with 'A' suffix device

Speed Control Resistor Network Equations

R17	=	given
R18	=	$R17\left(\frac{15.5\ V}{V_W} - 1\right)$
R19	=	$R17\left(\frac{14.8\ V}{V_{spin\ 2}} - 1\right)$
R20	=	$R17\left(\frac{14.8\ V}{V_{spin\ 1}} - 1\right) - R19$
R21	=	$R17\left(\frac{14.8\ V}{k.V_W} - 1\right) - R19 - R20$
R15	=	$R21\left(\frac{K.V_W}{15.5\ V\ (2-K)}\right)$
R14	=	$R15\left(\frac{15.5\ V}{V_W} - 1\right)$

The ratio distribute speed to wash speed can be chosen as:

$$\frac{V_{DIST}}{V_{WASH}} \leq 2 = K$$

	S1	S2	S3	S4	$V_{Pin\ 5}$	$V_{Pin\ 6}$
Wash	sc	oc	oc	oc	V_W	0
Distribute	oc	sc	oc	oc	KV_W	V_W
Spin 1	oc	oc	sc	oc	$>KV_W$	$\frac{K}{2}V_W$
Spin 2	oc	oc	oc	sc	$>>KV_W$	$\approx\frac{K}{2}V_W$

sc = switch closed
oc = switch open

Note:
When changing from one speed to another $V_{Pin\ 5}$ must not be allowed to fall below 80 mV — otherwise the circuit will reset and restart from zero.

The component values given in Figure 4 correspond to:

V_W = 0.7 V
V_D = 1.13 V
$V_{spin\ 1}$ = 5.0 V
$V_{spin\ 2}$ = 11 V
K = 1.6

FIGURE 5 — OPEN LOOP, SOFT START — WITH PROGRAMMED TIME TO MAX. SPEED
$(t = C_{Pin\ 7} \cdot 65 \times 10^5)$

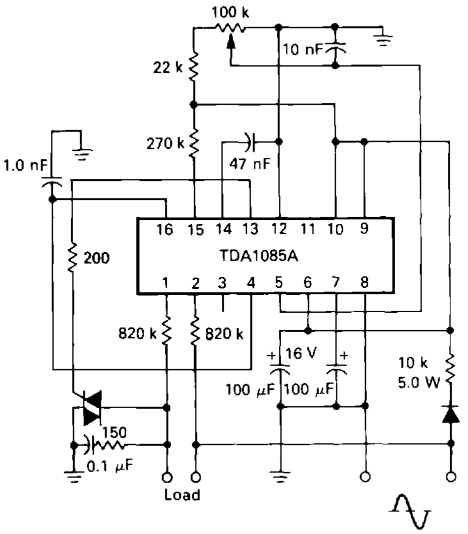


FIGURE 6 — OPEN LOOP, SOFT-START/SOFT-STOP, LIGHTING/INDUCTIVE LOAD CONTROLLER