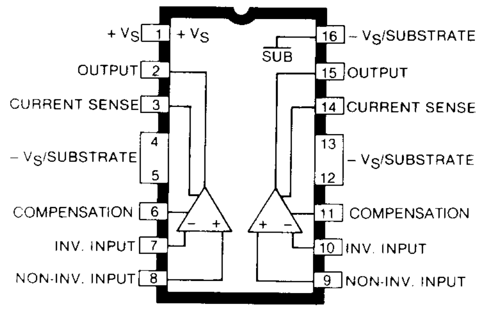
ULN-3753B AND ULN-3753W
DUAL POWER OPERATIONAL AMPLIFIERS

FEATURES

- Operating Supply Range ±3 V to ±20 V
- Output Current to ±3.5 A Peak
- Output-Current Limiting
- Output-Current Sensing
- High Output-Voltage Swing
- Low Crossover Distortion
- Low Input Offset Voltage
- Externally Compensated
- High Open-Loop Gain
- Output Protection Diodes
- Thermal Shutdown Protection
- Excellent Supply and Common-Mode Rejection
- Single or Dual In-Line Power Packages

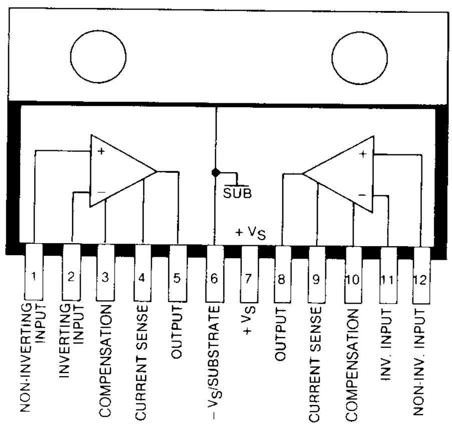


Dwg. No. A-13,636

ULN-3753B

APPLICATIONS

- Dual Half-Bridge and
  Full-Bridge Motor Drivers
  - Linear Servo Motors
  - Voice Coil Motors
  - AC and DC Motors
  - Microstepping Applications
- Power Transconducting Amplifier
- Audio Power Amplifier, Stereo or BTL
- Power Oscillator/Amplifier
- Dual Bipolar Voltage Regulator



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ULN-3753W

High-current linear servo loads, such as voice coil motors used in disc-drive applications, are ideal applications for the ULN-3753B and ULN-3753W dual high-power operational amplifiers. Their building block design concept also makes them ideal for a wide variety of other motor drive applications, audio power amplifiers, power oscillators, and linear voltage regulators. External compensation permits user adjustment of bandwidth and phase margin at any gain level.

The ULN-3753B is furnished in a 16-pin dual in-line package with copper heat-sink contact tabs. For higher power requirements, the ULN-3753W is supplied in a 12-pin single in-line power tab package.

The inputs are designed to allow a wide common mode range from the negative supply, (or ground in single supply applications) to within approximately 2V of the positive supply. Common-mode and power supply rejection are in excess of 60 dB. The amplifiers' wide output swing is complemented by current sensing, which is referenced to the negative supply and allows for feedback as required to produce a transconductance characteristic.

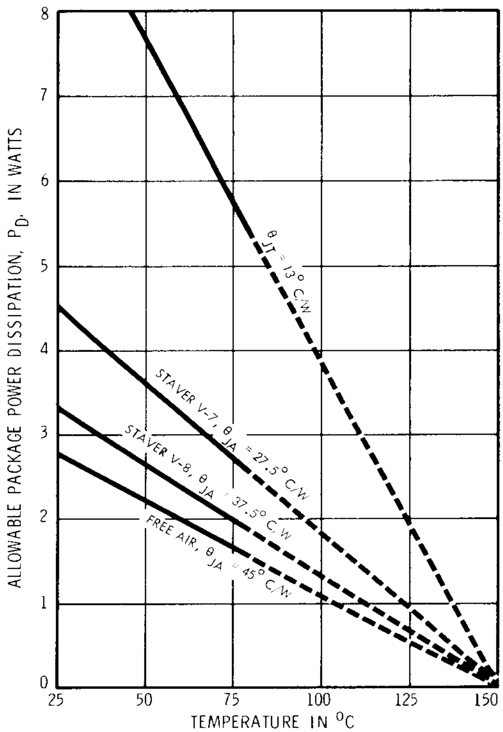
The ULN-3753B (batwing DIP) can typically dissipate 6 W at a tab temperature of 70°C. The lead configuration enables easy attachment of a heat sink while fitting a standard socket or printed wiring board layout. The ULN-3753W (SIP) can safely dissipate significantly higher power levels with appropriate heat sinking. With either package configuration, the heat sink is at the negative supply, or at ground in a single-ended application.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage Differential ($+V_S$ to $-V_S$)	40 V
Peak Supply Voltage (50 ms)	45 V
Continuous Output Current, I_{OUT} ($V_S = \pm 15$ V)	±2.0 A
($V_S = \pm 6$ V)	±2.5 A
Peak Output Current, I_{OUT} (50 ms)	±3.5 A
Package Power Dissipation, P_D	See Graphs
Operating Temperature Range, T_A	−20°C to +85°C
Storage Temperature Range, T_S	−55°C to +125°C

ALLOWABLE AVERAGE PACKAGE POWER DISSIPATION AS A FUNCTION OF TEMPERATURE

ULN-3753B



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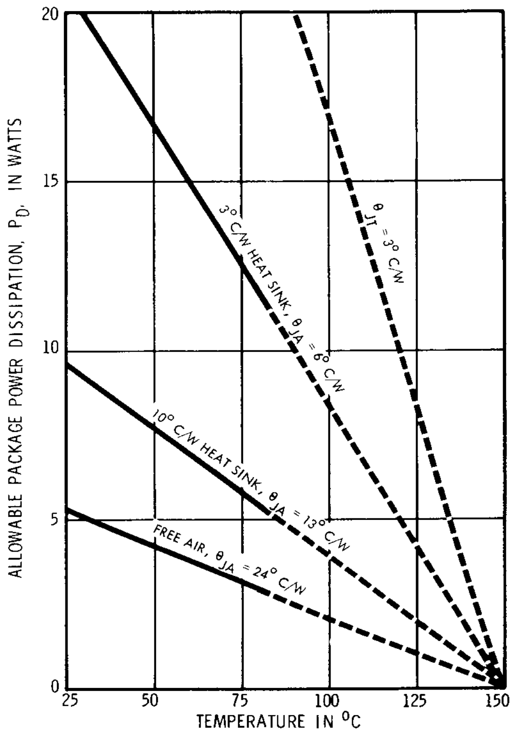
ULN-3753W



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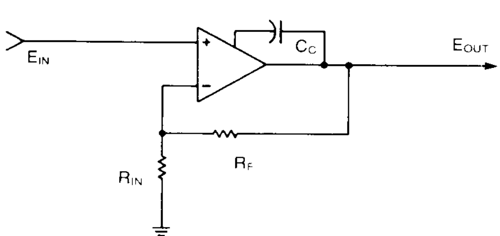
ELECTRICAL CHARACTERISTICS at $T_A = +25°C$, $T_{TAB} \leq +70°C$, $V_S = \pm 6\,V$, $C_C = 0$, each amplifier tested separately (unless otherwise specified)

Characteristic	Test Conditions	Limits			Units
		Min.	Typ.	Max.	
Functional Supply Voltage Range	$+V_S$ to $-V_S$	6.0	—	40	V
Quiescent Supply Current		—	90	150	mA
Input Bias Current	$V_{OUT} = 0$	—	−80	−1000	nA
Input Offset Voltage	$V_{OUT} = 0$, $I_{OUT} = 0$	—	±1.0	+10	mV
Input Offset Volt. TC†	Over Op. Temp. Range	—	−15	—	μV/°C
Input Offset Current	$V_{OUT} = 0$, $I_{OUT} = 0$	—	10	100	nA
Input Noise Voltage†	BW = 40 Hz to 15 kHz	—	4.0	—	μV
Input Noise Current†	BW = 40 Hz to 15 kHz	—	60	—	pA
Crossover Distortion†	$P_{OUT} = 50\,mW$, $R_L = 4\Omega$	—	0.2	—	%
Common Mode Rejection	$V_{CM} = 3\,V$	60	85	—	dB
Input Common Mode Range*	$V_S = +6\,V$	−6.3	—	+4.0	V
	$V_S = +15\,V$	−15.3	—	+13	V
Open Loop Voltage Gain	f = 0	80	100	—	dB
Slew Rate	$V_{IN} = V_{OUT} = 6\,Vpp$	5.0	10	—	V/μs
Gain-Bandwidth Product†	$A_V = 40\,dB$	—	3.0	—	MHz
Channel Separation†	$I_{OUT} = 100\,mA$, f = 1 kHz	—	60	—	dB
Output Voltage Swing	$I_{OUT} = 1\,A$	9.0	9.5	—	Vpp
Supply Voltage Rejection	$+V_S$, $\Delta V = 1\,V$	60	85	—	dB
	$-V_S$, $\Delta V = 1\,V$	60	80	—	dB
Thermal Resistance, Θ_{JT}	ULN-3753B	—	—	15	°C/W
	ULN-3753W	—	—	3.0	°C/W
Thermal Shutdown Temp.†		—	165	—	°C

*This parameter is tested to a lot sample plan only.

†Typical values given for circuit design information only.

NON-INVERTING AMPLIFIER

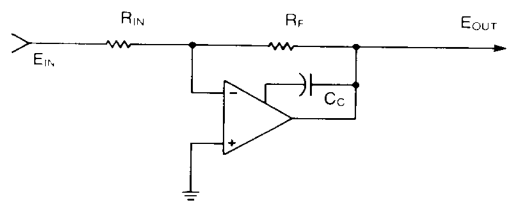


$$\frac{E_{OUT}}{E_{IN}} = 1 + \frac{R_F}{R_{IN}}$$

IF $R_F = 0$ or $R_{IN} = \infty$, $E_{OUT} = E_{IN}$

Dwg. No. W-155

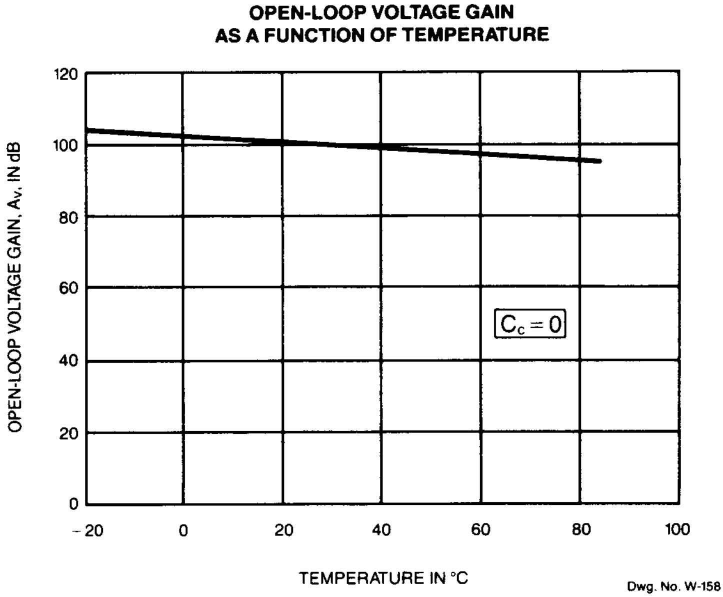
INVERTING AMPLIFIER

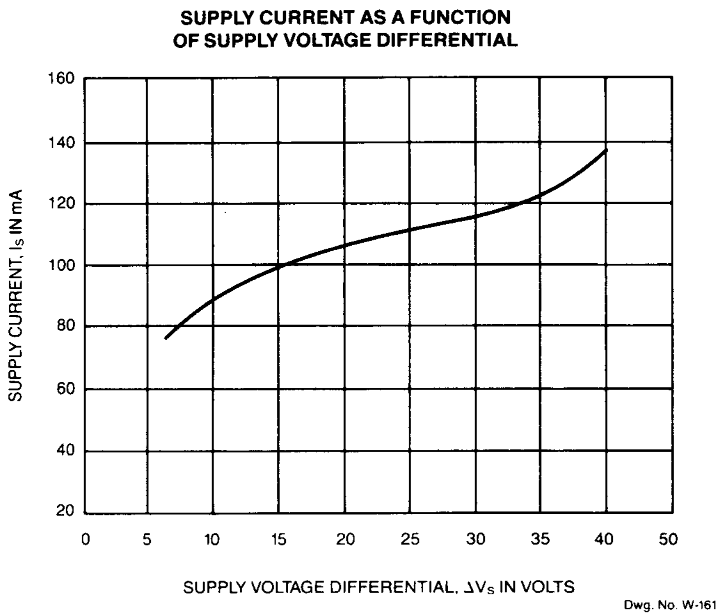


$$\frac{E_{OUT}}{E_{IN}} = -\frac{R_F}{R_{IN}}$$

Dwg. No. W-156

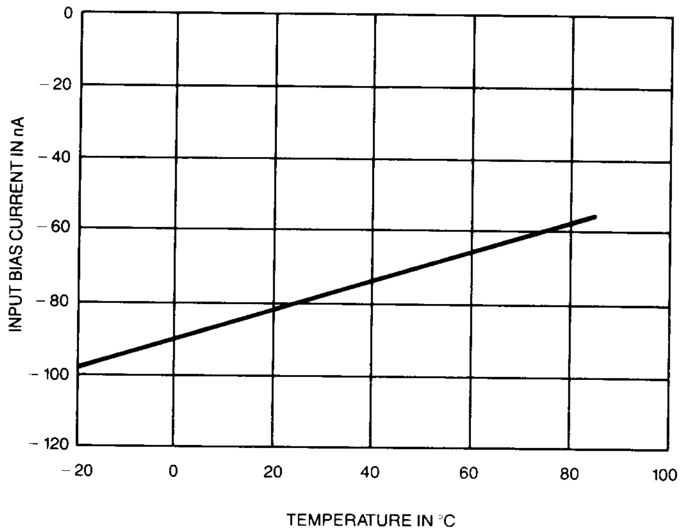
TYPICAL CHARACTERISTICS





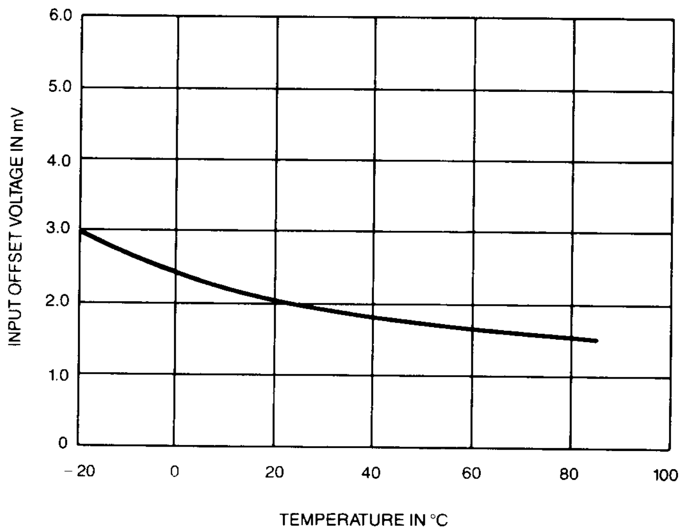
TYPICAL CHARACTERISTICS

INPUT BIAS CURRENT AS A FUNCTION OF TEMPERATURE



Dwg. No. W-159

INPUT OFFSET VOLTAGE AS A FUNCTION OF TEMPERATURE



Dwg. No. W-160

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APPLICATIONS

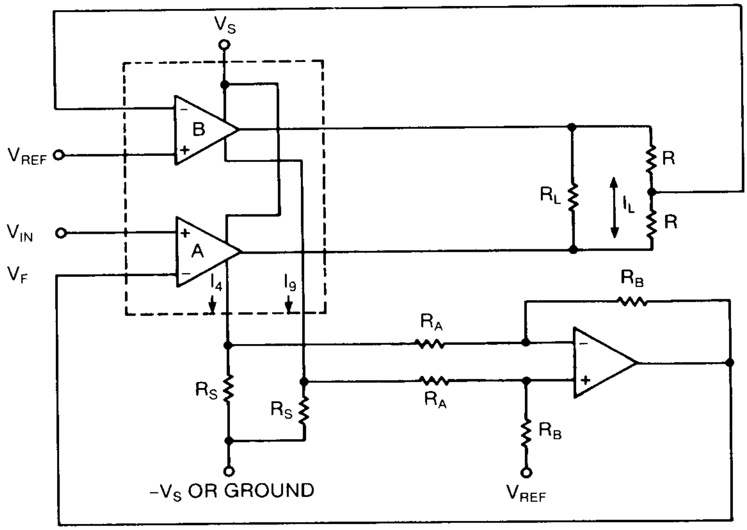

FIGURE 1

Dwg. No. W-162

CURRENT-SENSE TRANSCONDUCTANCE AMPLIFIER

The ULN-3753B/W current-sense terminals can be used to obtain a transconductance function. This characteristic is commonly used in motor control applications such as voice coil servo or micro-stepping positioning systems found in many computer disk drives.

Figure 1 shows a ULN-3753W dual amplifier connected as a transconductance amplifer. In this example, amplifier B is used as a slave to amplifier A. Feedback from the current-sensing resistors (R_S) in the emitters of the output current-sinking transistors, is applied to the summing network and scaled to the inverting input of amplifier A where it is compared to the input voltage. The current-sensing feedback imparts a transconductance characteristic to the amplifier's transfer function. That is, the voltage developed across the sensing resistors is directly proportional to the output current. Using this voltage as a feedback source allows expressing the gain of the circuit as output current in amperes vs. input voltage in volts. The gain assumes the dimensions of a transconductance function, expressed in mhos.

The negative-feedback forces the amplifier to adjust the output current to attain a value such that the feedback voltage equals the applied input voltage. The transfer function of the transconductance amplifier is approximately:

$$I_L/(V_{IN} - V_{REF}) = R_A/R_BR_S$$

In the figure, resistors R_A, R_B, and R_S define the transconductance gain. To avoid limiting the transconductance amplifier's output compliance (swing capability), low-value current-sensing resistors (R_S) should be used.

APPLICATIONS

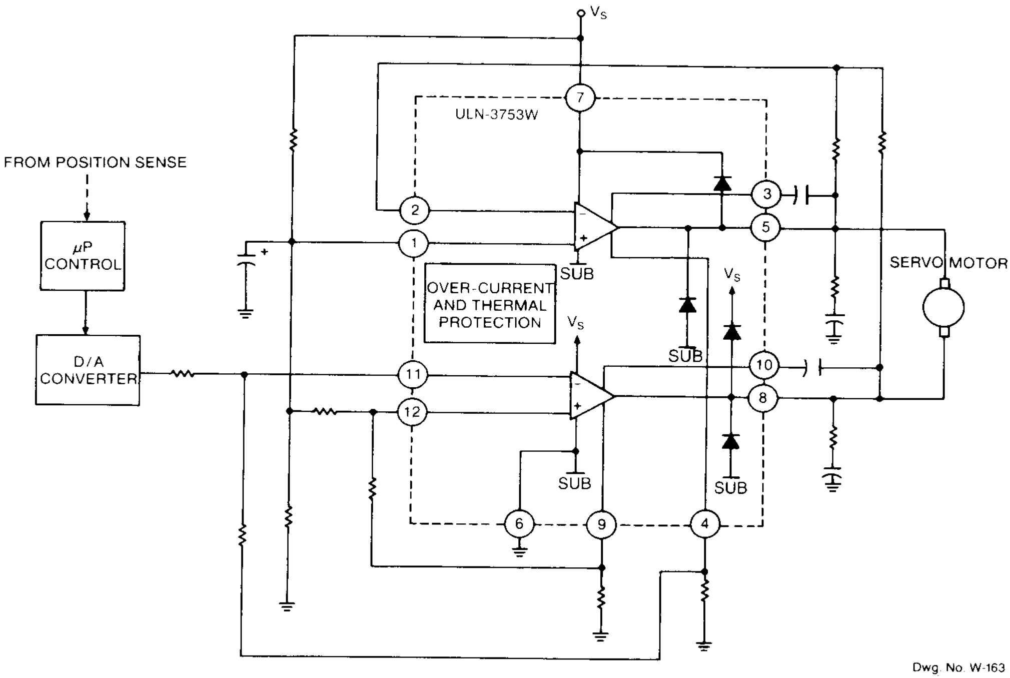

FIGURE 2

DIGITALLY CONTROLLED POSITION SERVO

In a position-control application, a microprocessor is often used to control a servomotor's shaft angle or to control position as in a disk drive application. The circuit requires small-signal input op amps, drivers, and power output stages. The circuit derives its input from the D/A converter whose output is determined by a code from the controlling microprocessor and related digital control circuitry. The sensed position signal normally undergoes processing and comparison with the desired position, through the microprocessor system that produces an error signal to control the servo amplifier's output.

The circuit includes thermal and short-circuit protection, matching and thermal tracking inherent to monolithic construction. The configuration shown in Figure 2 uses a ULN-3753W dual power operational amplifier whose two independent outputs are connected in a push-pull, H-bridge arrangement. The IC's outputs also include clamping diodes with current-handling capacity equal to that of the output drivers.

The current-sense pins (4 and 9) provide access to the emitters of the H-bridge current sinks, thereby providing convenient output current sensing, while allowing separate low-current signal ground returns.

APPLICATIONS

TWO-PHASE 60 Hz AC MOTOR DRIVER

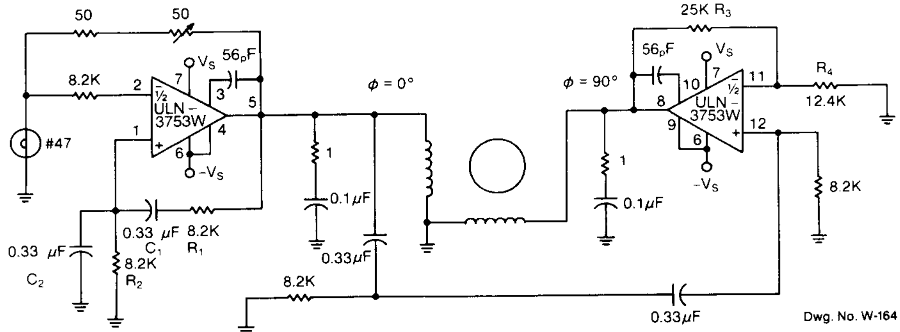

FIGURE 3

THREE-PHASE 400 Hz AC MOTOR DRIVER

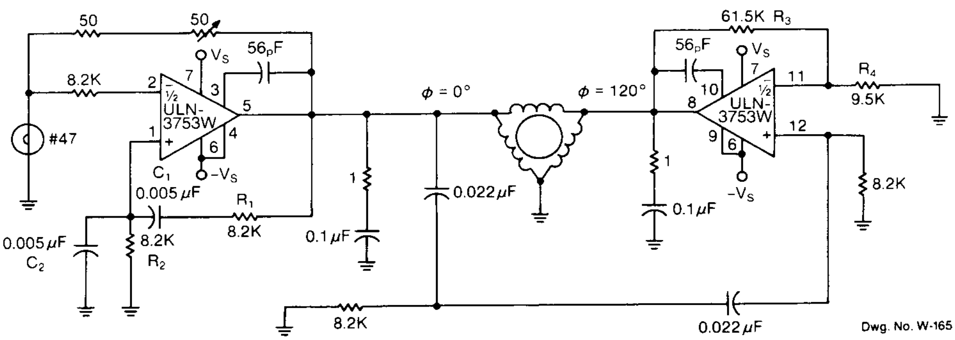

FIGURE 4

N-PHASE MOTOR DRIVE

Because of its high amplification factor and built-in power-output stage, an integrated power operational amplifier makes a convenient driver for ac motors. One op amp can be configured as an oscillator to generate the required ac signal. The power-output stage, of course, supplies the high-current drive to the motor.

As shown in the motor-drive circuits in Figure 3 and 4, the controlling op amp is configured as a Weinbridge oscillator. The R_1C_1, R_2C_2 feedback networks determine the oscillation frequency, according to the following expression:

$$f_o = 1/(2\pi R_1R_2C_1C_2)$$

By varying either R_1 or R_2, the oscillator frequency can be adjusted over a narrow range.

The R_3/R_4 ratio sets the second amplifier's gain to compensate for signal attenuation occurring in the phase shifters.

The circuits can be driven from an external source, such as a pulse or square wave, setting the gain of the left-hand amplifier to a level less than that required for oscillation. The RC feedback networks then function as an active filter causing the outputs to be sinusoidal.

APPLICATIONS

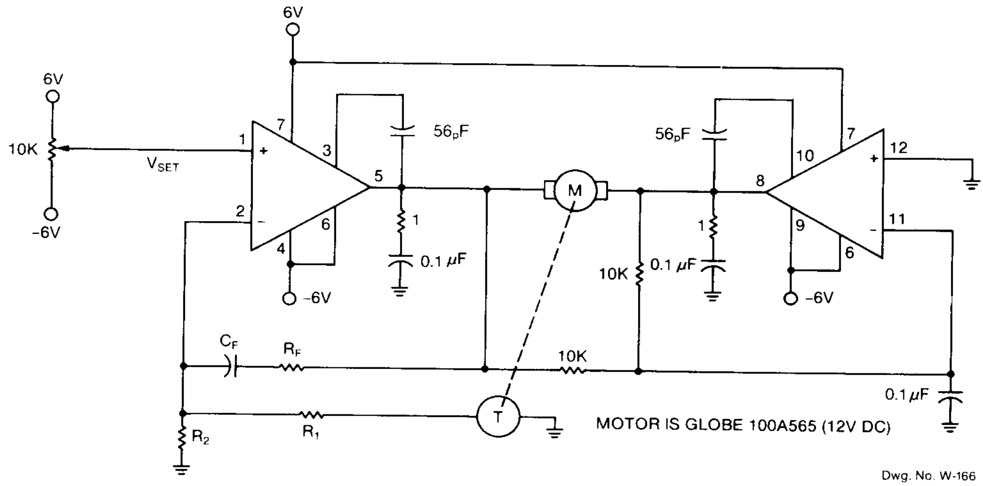

FIGURE 5

DC MOTOR SPEED CONTROL

In addition to the synchronous ac motor drives described above, the ULN-3753B/W can be used to provide accurate speed control of dc motors. Figure 5 shows a closed-loop system for controlling the speed of a 12 V dc motor. The circuit provides bidirectional speed control. The amplifiers' push-pull configuration ensures a full rail-to-rail voltage swing (minus the output stages' saturation drops) across the motor in either direction.

The circuit uses a mechanically-coupled tachometer to provide speed-stabilizing feedback to the first amplifier section. The motor's speed and direction of rotation is set by adjusting the 10 kΩ potentiometer at the amplifier's noninverting input. The motor speed, in rpm, is given by the following expression:

$$S = V_{SET}(R_1 + R_2)/.0027\,R_2$$

The R_FC_F feedback network prevents oscillation by compensating for the inherent dynamic mechanical lag of the motor. The R_FC_F time constant is selected to match the particular motor's response or dynamic time constant. This should yield a good starting point for stabilizing the system with optimum response achieved by varying the compensating capacitor.