Micro Linear

ML4508

Low Voltage Drop Voice Coil Servo Driver

GENERAL DESCRIPTION

The ML4508 is a voice coil power driver intended for use in High Performance 5V Hard Disk servo systems. The ML4508 contains all control circuitry necessary to drive the voice coils of most small drives. To maximize compliance voltage, the ML4508 includes two 1-Amp (typical) NPN drivers and provides drivers for external PNP transistors. In addition, power fail detection and a low voltage head retraction functions are provided for orderly shut-down of the drive.

The transconductance is programmed by a logic input at 1/4 A/V and 1/24AV respectively, when using a 1Ω sense resistor. This allows for greater DAC resolution in digitally controlled servos during track follow without compromising dynamic range during seek.

The retraction circuit, main drive circuit, and control circuits are each powered from their own supplies. Retract allows the use of an external PNP retraction with as little as 1V of back EMF from the spindle.

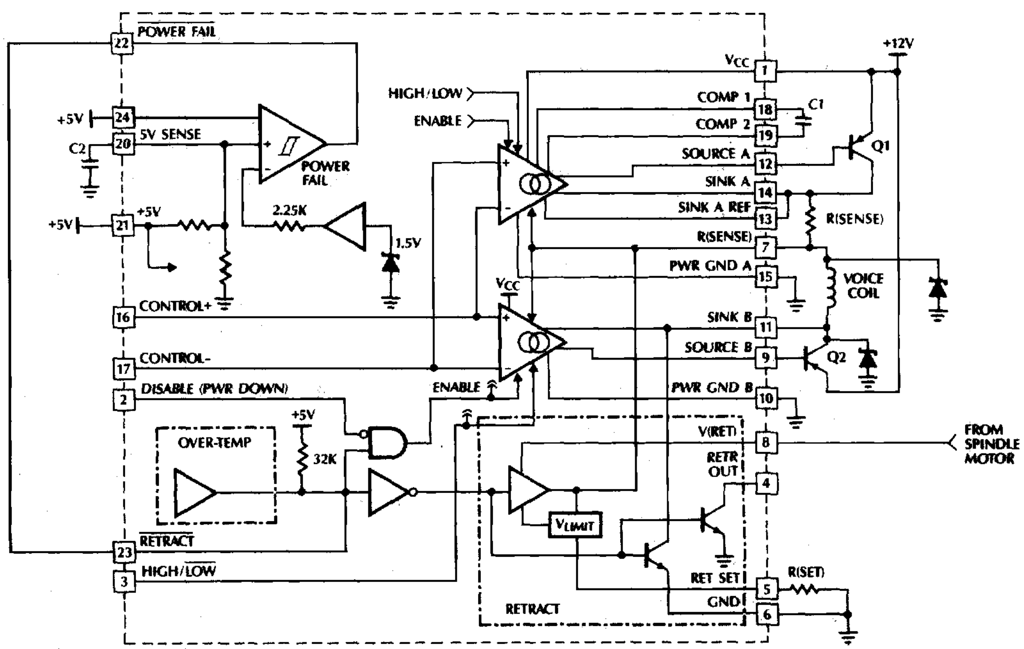
The power fail detection circuit includes a precision 1.5V bandgap reference and a power fail comparator.

The ML4508 is implemented using Micro Linear's bipolar array technology. This allows for customization of the IC for a user's specific application.

FEATURES

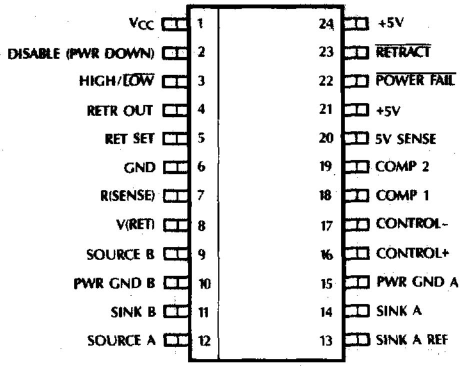
- Low saturation voltage (<1V at 1A typically)
- No cross-over distortion with low quiescent current
- Pin-programmable transconductance settings
- Retraction circuitry with programmable retract voltage and separate power pin
- On-chip precision power fail detect circuitry
- Over-temperature protection with flag output

BLOCK DIAGRAM



PIN CONNECTION

ML4508
24-Pin SOIC



TOP VIEW

PIN DESCRIPTION

PIN#	NAME	FUNCTION
1	V_{CC}	Supply input to power amplifiers.
2	DISABLE (PWR DOWN)	A Logic "1" puts the IC into a low power state and disables the power amplifiers.
3	HIGH/$\overline{\text{LOW}}$	A logic "1" sets the transconductance gain to 1/4 while a logic "0" sets the gain to 1/24. Transconductance gain is the $V_{RSENSE} \div V_{CONTROL}$.
4	RETR OUT	Open collector ouput which pulls low during retract. Used to drive external power transistor to source retract current to the coil and can provide a braking signal to spindle.
5	RET SET	External set resistor to establish a voltage limit for the internal retract driver.
6	GND	Analog signal ground.
7	R(SENSE)	Current sense resistor terminal.
8	V(RET)	Supply pin for retract circuits.
9	SOURCE B	PNP Base drive ouput for inverting power amplifier.
10	PWR GND B	Power return pin for inverting power amplifier. Normally used for current sensing.
11	SINK B	Current sinking ouput for inverting power amplifier. Connects to voice coil (–) terminal.
12	SOURCE A	PNP Base drive output for non-inverting power amplifier.
13	SINK A REF	Kelvin sensing point for power amplifier. Connect to SINK A.
14	SINK A	Current sinking output for non-inverting power amplifier. Connects to voice coil (+) terminal.
15	PWR GND A	Power return pin for non-inverting power amplifier. Normally used for current sensing.
16	CONTROL+	Positive input for current comand.
17	CONTROL–	Negative input for current command.
18	COMP 1	Pin for external compensation capacitor.
19	COMP 2	Pin for external compensation capacitor.
20	5V SENSE	Center node of a resistor divider from +5V.
21	+5V	Input for +5V for power fail detection and logic power supply.
22	$\overline{\text{POWER FAIL}}$	Open Collector output drives low for low voltage conditions.
23	$\overline{\text{RETRACT}}$	A logic "0" initiates retract. Also used as an open-collector over temperature output flag.
24	+5V	For power fail comparator.

ABSOLUTE MAXIMUM RATINGS

Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

Supply Voltage (pins 1,8) 7V
Voltage Pins 2,3,23 .... –0.3V to +7V
Pins 4, 7, 9, 11, 12, 13, 14, 16, 17, 22 ......–0.3 to $+V_{CC}$
Output Sink Current .... ±1A
Retraction Current 80mA
Retract Set current (pin 5) 3mA
Junction Temperature .... 150°C
Storage Temperature Range .... –65°C to +150°C
Lead Temperature (Soldering 10 sec.) .... 150°C
Thermal Resistance (θ_{JA}) .... 60°C/W

OPERATING CONDITIONS

Temperature Range .... 0°C to +70°C
V_{CC} Supply Voltage .... 4.5 to 5.5V
+5V (pin 21) Supply Voltage .... 4.5 to 5.5V
V_{RET} (pin 8) Supply Voltage 2.5V
Control + Voltage Range (pin 15 = 5V) .... 0V to V_{CC}
Control - Voltage Range .... 2V to V_{CC} - 1.5V

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, T_A = Operating Temperature Range, V_{CC} = Operating Range, $R_{SENSE} = 1\Omega$, $R_{COIL} = 15\Omega$, CONTROL– (pin 17) = $V_{CC/2}$, C1 = 30pF, Q1, Q2 = MJE210, $R_{SET} = 3.7k\Omega$ (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
AMPLIFIER					
Offset				±10	mA
Gain	Pin 5 = 2V	238	250	263	mA/V
	Pin 5 = 0.8V	39.6	41.7	43.8	mA/V
Bandwidth			100		KHz
Sinking Saturation	I_{OUT} = 100mA		0.1	0.6	V
	I_{OUT} = 300mA		0.2	0.8	V
	I_{OUT} = 500mA		0.3	1.0	V
Sourcing Saturation	I_{OUT} = 100mA		.1		V
	I_{OUT} = 300mA		.2		V
	I_{OUT} = 500mA		.3		V
Source A/B Base Drive		10		50	mA
Q1/Q2 Standby Current	$V_{PIN\ 16}$ = 5V		4		mA
RETRACTION CIRCUIT V					
I(RET) SET			.75		V
Turn On Time			800		ns
Turn Off Time			8		µs
Source Voltage	$V_{PIN\ 23}$ = 0.8V, $V_{PIN\ 8}$ = 3V, $I_{PIN\ 7}$ = 50mA	0.95	1.2	1.5	V
Sink Current	$V_{PIN\ 23}$ = 0.8V, $V_{PIN\ 8}$ = 1.2V, force 50mA into pin 11	10	37	1000	mV
RETR OUT V_{OL}	$V_{PIN\ 23}$ = 0.8V, $I_{PIN\ 4}$ = 1mA		0.1	0.4	V
POWER FAIL DETECTION CIRCUIT					
5V Threshold		4.40	4.575	4.75	V
Hysteresis — 5V Sense			30		mV

ELECTRICAL CHARACTERISTICS (Continued)

Unless otherwise specified, T_A = Operating Temperature Range, V_{CC} = Operating Range, $R_{SENSE} = 1\Omega$, $R_{COIL} = 15\Omega$, CONTROL– (pin 17) = $V_{CC/2}$, C1 = 30pF, Q1, q2 = MJE210, $R_{SET} = 3.7k\Omega$ (Note 1)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
LOGIC INPUTS AND OUTPUTS					
Voltage High (V_{IH})		2	1.4		V
Voltage Low (V_{IL})			1.4	0.8	V
Current High (I_{IH})	V_{IN} = 5V			±10	μA
Current Low (I_{IL})	V_{IN} = 0V, except pin 23 V_{IN} = 0V, pin 23 only	–40 –250	–10 –160		μA μA
Voltage Low (pins 22, 23)	I_{OL} = 1mA			.4	V
OVER-TEMPERATURE DETECTION					
T_J Threshhold			160		°C
Hysteresis			30		°C
CURRENT CONSUMPTION					
Pin 21	Pin 21 = 5.5V		5	7	mA
Pin 1	V_{CC} = 5.5V, $V_{PIN\ 16} = V_{CC/2}$		5	10	mA
Pin 8	$V_{PIN\ 8}$ = 5.5V, $V_{PIN\ 23}$ = 5V		3.5	5	mA

Note 1: Limits are guaranteed by 100% testing, sampling, or correlation with worst case test conditions.

FUNCTIONAL DESCRIPTION

POWER AMPLIFIER

The ML4508 power amplifier circuit (figure 1) is set up as a Howland Current source with a fixed gain of 1/4 or 1/24 (set by driving pin 3 high or low respectively). This architecture yields minimal crossover distortion while maintaining low output cross conduction currents. The gain figure refers to the ratio of input voltage to the output voltage seen across R_{SENSE}. For example, at a 1/4 gain setting, with V(–) input at 2.5V and the V(+) input at 4.5V, +500mA would flow through the coil using a 1Ω sense resistor. Under the same conditions with pin 3 low, the current would be 83mA. If lower input voltage swings and higher currents are desired, the overall transconductance gain may be increased by using a lower value of sense resistor, however offset current will increase proportionally. The ability to change from low to high gain allows more complete utilization of DAC resolution when in the track follow mode.

The output stage is designed to provide minimal saturation losses and employs an external PNP transistor for the sourcing drive and an internal saturable NPN to sink current. Sinking saturation drop is typically under 0.4V. Sourcing saturation drop depends on the external transistors used.

Care should be taken to avoid drawing substrate currents due to negative excursions on any pin of the ML4508. Schoktty diodes should be included on both sides of the VCM to prevent negative excursions from forward biasing the substrate diodes on the IC.

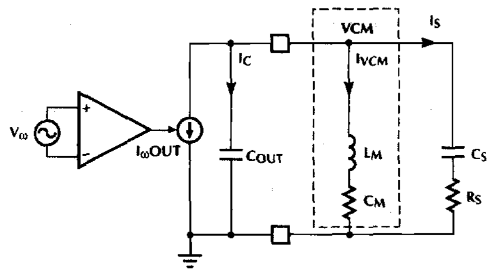


Figure 1. Simplified Power Amplifier Schematic (High Gain Mode)

Two areas should be considered to avoid high frequency oscillation in the output stage:

1. Choose external PNP transistors with a F_T of at least 50MHz.
2. An RC compensation network should be used to cancel the zero presented to the output by the L/R of the voice coil motor as shown in figure 2.

COMPENSATION

Figure 2 shows the equivalent AC circuit for the current amplifier.

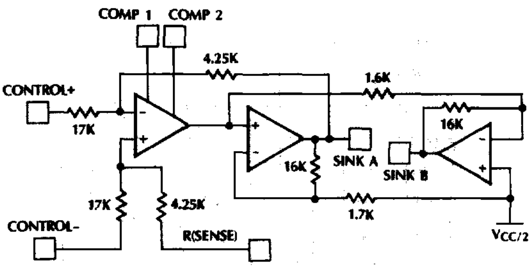


Figure 2. AC Equivalent Circuit for Current Amplifier, Voice Coil Motor (VCM) and Snubber.

The amplifier's current bandwidth is limited by C_{OUT} which varies with the value chosen for R_{SENSE}

$$C_{OUT} \approx \frac{1200 \times (C_{COMP} + 12.8pF)}{R_{SENSE}}$$

Where C_{COMP} is C1 between pins 18 and 19. With no snubber (R_S and C_S) the bandwidth is limited to

$$F_{-3dB} = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

Since this is a second order system with L(M) and C(OUT) *forming a resonant circuit, some damping is desirable to* reduce ringing in the step response. This is accomplished with a resistive snubber. The optimum value of R(S) occurs when the following condition is met:

$$R(S) = \sqrt{\frac{L(VCM)}{C(OUT)}}$$

For a given C(S), setting R(S) to this value will minimize the ringing in the transient response. Larger values of R(S) will result in more ringing and more bandwidth. Smaller values of R(S) will result in more ringing and less bandwidth. C(S) (snubber capacitor) values of between 200nF and 1mF are usually necessary to achieve the desired reduction of ringing in the step response. At the optimum value of R(S) larger values of C(S) further reduce the ringing but do not affect the bandwidth.

Timing the current loop response can be easily done simulating the network in figure 2 with a computer simulator (such as SPICE).

POWER FAIL DETECT CIRCUIT

The ML4508 circuit *consists of a precision trimmed* reference, resistor dividers and an "or function" comparator with hysteresis. The output (open collector) of *this circuit appears on pin 22. When either comparator* input (pins 20 and 24) falls below the 1.5V reference, pin 22 pulls low.

RETRACT CIRCUITS

When pin 23 goes low, pin 4 will pull low. The internal NPN transistor will saturate, pulling SINK B (pin 11) low. This portion of the circuit will function with less than 1V on V(RET). An internal voltage limited pull-up transistor is provided which sources current on pin 7 to the VCM. This circuit will be operated reliably down to a V(RET) voltage of around 2.5V.

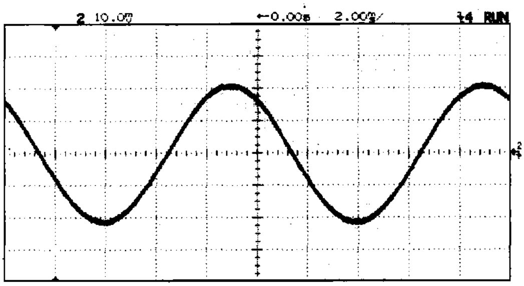


Figure 3. Output Current: V_{IN} = 100 Hz Sine Wave, $1V_{p-p}$ Low Gain Mode ($V_{PIN\ 3} = 0$), $R_{SENSE} = 1\Omega$

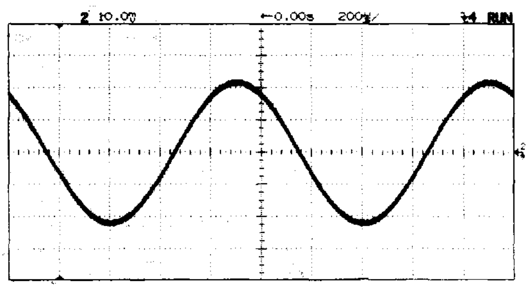


Figure 4. Output Current: V_{IN} = 1KHz Sine Wave, $1V_{P-P}$ Low Gain Mode ($V_{PIN\ 3} = 0$), $R_{SENSE} = 1\Omega$

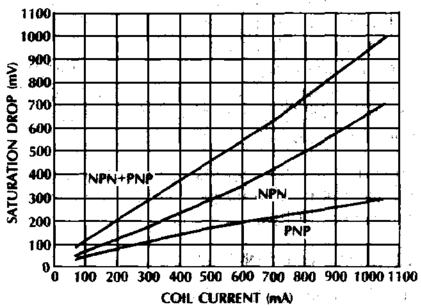


Figure 5. Output Saturation Voltage vs Output Current ($Q_1 = Q_2 =$ MJE210)

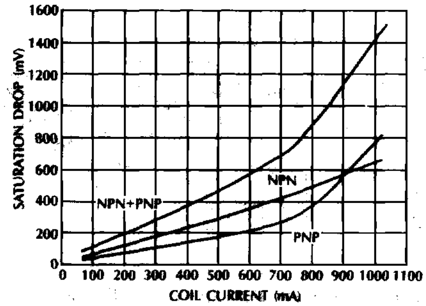


Figure 6. Output Saturation Voltage vs Output Current with BSR31 ($Q_1 = Q_2 =$ BSR31)

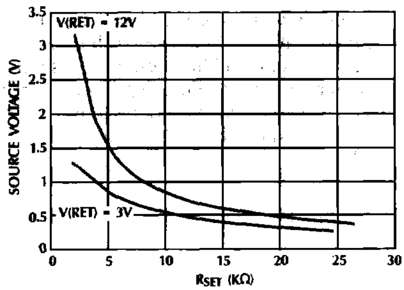


Figure 7. Retract Source Voltage Limit

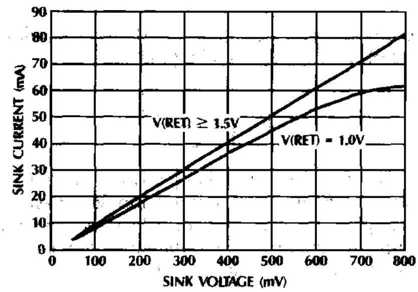


Figure 8. Retract Sink Voltage vs Current

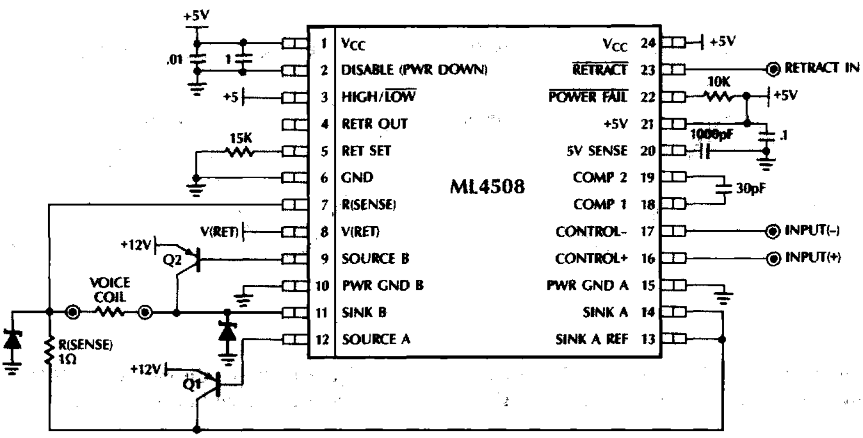


Figure 9. Typical 12V Application

ORDERING INFORMATION

PART NUMBER	TEMPERATURE RANGE	PACKAGE
ML4508CS	0°C to +70°C	S20W

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