

Disk Voice Coil Servo Driver

GENERAL DESCRIPTION

The ML4406 is a voice coil power driver intended for use in Hard Disk servo systems. The ML4406 contains all power and control circuitry necessary to drive the voice coils of most 3.5" drives. In addition, power fail detection and 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 1/24 A/V respectively, using a 1 Ω 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. This allows maximum flexibility and provides for the lowest forward drop.

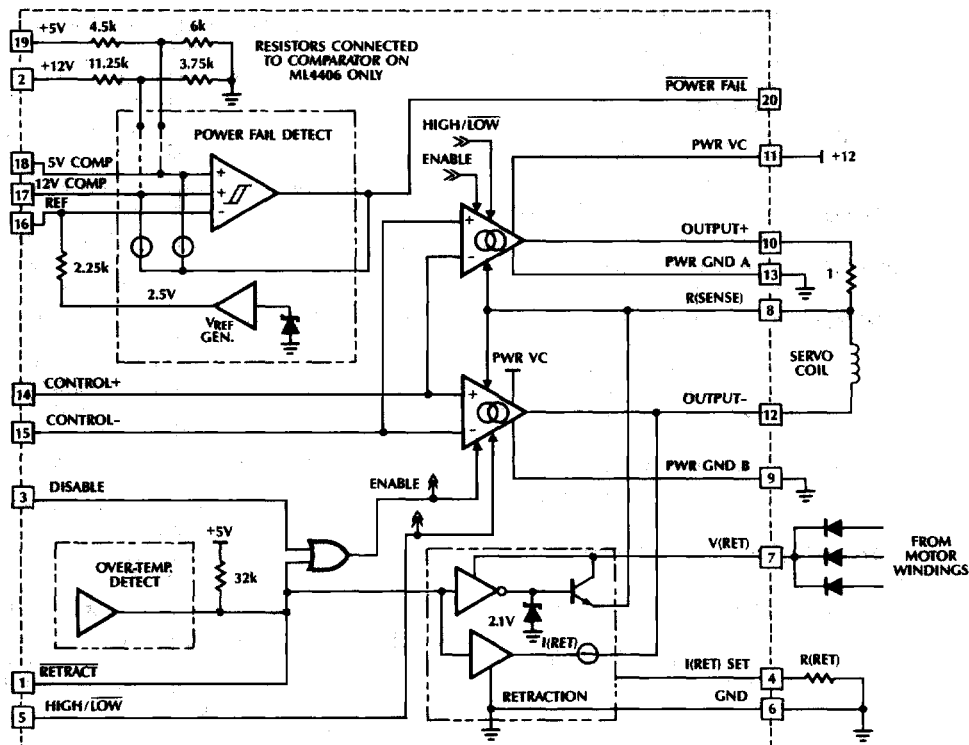
The power fail detection circuit includes a precision 2.5V bandgap reference with the option of either

internally generated power-fail thresholds (ML4406) or open comparator inputs for adjustable thresholds (ML4407).

The ML4406 is implemented using Micro Linear's bipolar array technology. This allows for easy customization of the IC for a user's specific application.

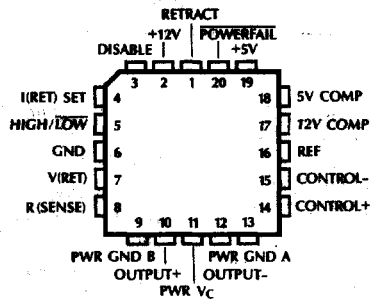
FEATURES

- 500mA power output with 1.5V total forward drop
- Low offsets, cross-over distortion and quiescent current
- Pin-programmable transconductance settings
- Retraction circuitry with programmable retract current, voltage limiting, and separate supply pin
- On-chip precision power fail detect circuitry
- Over-temperature protection with flag output
- Logic input available for disabling outputs



PIN CONFIGURATION

ML4406/ML4407
20-Pin PCC



PIN DESCRIPTION

PIN NO.	NAME	FUNCTION	PIN NO.	NAME	FUNCTION
1	RETRACT	A logic "0" input causes the main outputs to tri-state and the retraction circuit to activate. This input also functions as a flag output and will go low in the event of an over-temperature condition.	11	PWR VC	Power supply for bridge amplifier.
2	+12V	12V power to the circuit and input to the power fail detection circuit.	12	OUTPUT-	Output terminal for bridge amplifier.
3	DISABLE	A logic "1" turns off the main outputs.	13	PWR GND A	Ground Terminal for power amplifier.
4	I(RET) SET	A resistor to ground sets the retract current.	14	CONTROL+	Positive input for current command.
5	HIGH/LOW	A logic "1" sets the transconductance gain to 1/4 while a logic "0" sets the gain to 1/24. Transconductance gain is voltage across $R_{SENSE} \div$ the input voltage.	15	CONTROL-	Negative input for current command.
6	GND	Analog Signal Ground.	16	REF	Reference input to the Power Fail comparator. Leave open to use internal 2.5V reference.
7	V(RET)	Power supply for the retract circuit.	17	12V COMP	Input to the Power Fail Comparator. Connect to an external resistor divider for the ML4407. Internally connected to a resistor divider from 12V in the ML4406.
8	R(SENSE)	Current sensing resistor terminal.	18	5V COMP	Input to the Power Fail Comparator. Connect to an external resistor divider for the ML4407. Internally connected to a resistor divider from 5V in the ML4406.
9	PWR GND B	Ground Terminal for power amplifier.	19	+5V	5V power supply terminal.
10	OUTPUT+	Output terminal for bridge amplifier.	20	POWER FAIL	Open collector output drives low if pin 17 or pin 18 are below pin 16. Normally tied to pin 1.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (Pins 11, 13, 7, 2)	14V
Voltage Pins 19, 18, 17, 16, 1, 3, 5	-3V to +7V
Pins 14, 15	-3 to +V _{CC}
Output Current	±750mA
Retraction Current	80mA
Retract Set Current (Pin 4)	3mA
Junction Temperature	150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering 10 sec.)	260°C
Thermal Resistance (θ _{JA})	60°C/W

OPERATING CONDITIONS

Temperature Range	0°C to 70°C
Supply Voltage (PWR VC, +12V)	12V ± 10%
+5V (Pin 19)	5V ± 10%
V(RET) (Pin 7)	2.5V to 16V
Control + Voltage Range (Pin 15 = 5V)	0V to V _{CC}
Control - Voltage Range	-1V to V _{CC} - 1V

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.

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, T_A = Operating Temperature Range, V_{CC} = 12V, R_{SENSE} = 1Ω, R_{LOAD} = 15Ω, CONTROL- (Pin 15) = 5V, R_{SET} (Pin 4) = 1.2KΩ.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
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			.6	V
	I _{OUT} = 300mA			.8	
	I _{OUT} = 500mA			1.0	
Sourcing Saturation	I _{OUT} = 100mA			1.2	V
	I _{OUT} = 300mA			1.3	
	I _{OUT} = 500mA			1.5	
Retraction Circuit					
I(RET)SET			.75		V
Turn On Time			300		ns
Turn Off Time			2		ms
I(RET) Current	Pin 1 = 0.8V	34	50	65	mA
Power Fail Detection Circuit					
Reference Voltage		2.35	2.50	2.65	V
Reference Source Impedance			2.25		kΩ
Comparator Bias Current	ML4407 only, Pin 20 high		50	250	nA
Hysteresis Current	Pin 20 low, ML4407 only		10		μA
Offset Voltage	ML4407 only			10	mV
12V Threshold Hysteresis	ML4406 only	9.5	10	10.5	V
	ML4406 only		120		mV
5V Threshold Hysteresis	ML4406 only	4.40	4.575	4.75	V
	ML4406 only		30		mV
Logic Inputs					
Voltage High (V _{IH})		2	1.4		V
Voltage Low (V _{IL})			1.4	.8	V
Current High (I _{IH})	V _{IN} = 5V			±10	μA
Current Low (I _{IL})	V _{IN} = 0V	Except Pin 1	-40	-10	μA
		Pin 1 Only	-250	-160	μA

ML4406, ML4407

ELECTRICAL CHARACTERISTICS (Continued)

Unless otherwise specified, T_A = Operating Temperature Range, $V_{CC} = 12V$, $R_{SENSE} = 1\Omega$, $R_{LOAD} = 15\Omega$, CONTROL- (Pin 15) = 5V, R_{SET} (Pin 4) = 1.2k Ω .

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Current Consumption					
Pin 19	$I_{LOAD} = 0$		1	2	mA
Pin 7	$I_{RET} = 0$		1	2	mA
Pin 2 + Pin 11	$I_{LOAD} = 0$		10	15	mA

FUNCTIONAL DESCRIPTION

POWER AMPLIFIER

The ML4406 power amplifier circuit is set up as a Howland current source with a fixed gain of 1/4 or 1/24 (set by driving pin 5 high or low respectively). This architecture yields minimal cross-over 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 2.5 and the V+ input at 4.5V, +500mA would flow through the coil using a 1 Ω sense resistor. Under the same conditions with pin 5 low, the current would be 83mA. 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 (Figure 2) is designed to provide minimal saturation losses and employs a "composite PNP" for the sourcing drive and a saturable NPN to sink current. Sourcing saturation drop is typically .9V while sinking saturation drop is typically < 0.4V.

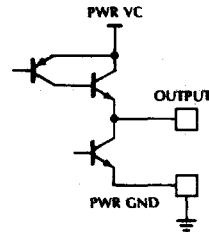


Figure 2. Main Power Output Stage

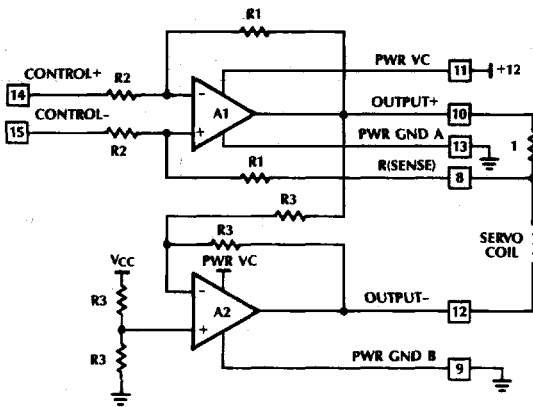


Figure 1. Power Amplifier Topology

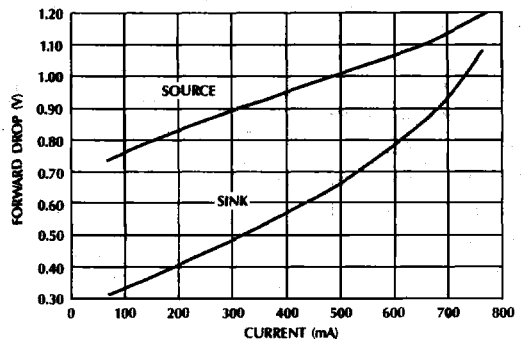


Figure 3. Output Saturation Voltage vs. Output Current (Power $V_C = 12V$)

Power Fail Detect

The ML4406 power fail detection circuit consists of a precision trimmed reference, resistor dividers, and an "or-function" comparator with hysteresis. The 10µA current sink on the comparator input lowers the comparator's positive input by 15mV when the output of the comparator is high. This creates an effective hysteresis of 30mV at the 5V input (on the ML4406). The amount of hysteresis and threshold levels can be programmed by external resistor dividers on the ML4407. The impedance of the external divider sets the amount of hysteresis while the division ratio sets the power fail threshold. The output at pin 20 is open-collector and is normally tied to pin 1 which is internally pulled-up to 5V.

Retract

The retract circuit features a current sink which is programmed via external resistor from pin 4 to ground (R_{RET}). The output of the retract circuit is voltage limited to 1.4V. The current sink provides an acceleration limit during retract while the voltage limited source provides a velocity limit. Pin 1 (Retract Input) also serves as a flag to indicate an over-temperature condition on the die. Pin 1 goes low in the event of over-temperature, which occurs when the die temperature exceeds a safe operating limit (about 160°C).

The retraction current is set by programming R_{RET} (figure 4). The retract circuit works down to 3V on $V_{RETRACT}$ (Pin 7).

Compensation

Figure 6 shows the equivalent AC circuit for the transconductance amplifier.

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

$$C_{OUT} = \frac{25nF}{R_{SENSE}}$$

With no snubber (R_S and C_S) the bandwidth is limited to

$$F_{-3dB} = \frac{1}{2\pi} \sqrt{\frac{2.414}{L(M) C(OUT)}}$$

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. $R(S)$ should not exceed 300Ω.

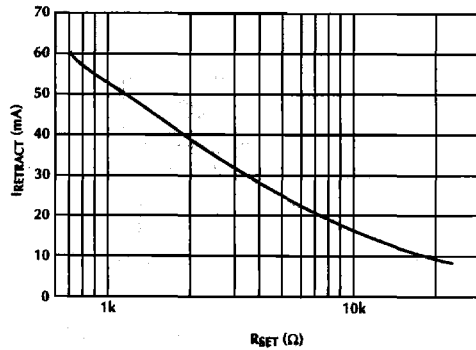


Figure 4. Retract Current vs. R_{RET}

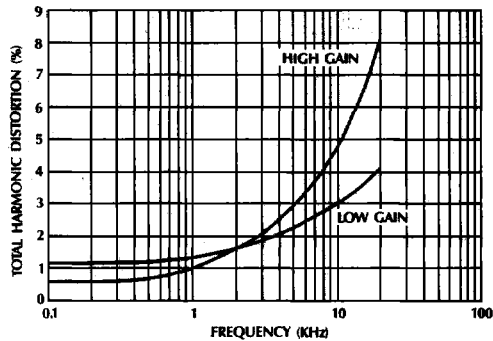


Figure 5. Total Harmonic distortion vs Frequency
 Low Gain Setting ($V_{PIN 5} = 0$), $R_{SENSE} = 1\Omega$, $V_{IN} = 2.4V_{P-P}$
 High Gain Setting ($V_{PIN 5} = 0$), $R_{SENSE} = 1\Omega$, $V_{IN} = 0.4V_{P-P}$

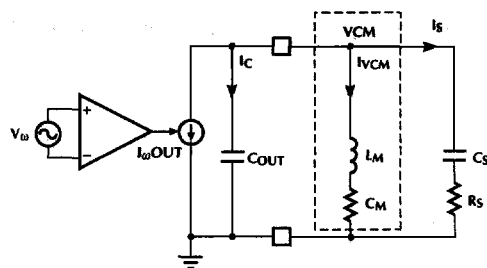


Figure 6. AC Equivalent Circuit for Current Amplifier, Voice Coil Motor (VCM) and Snubber.

$C(S)$ (snubber capacitor) values of between 200nF and 1µF 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.

Tuning the current loop response can be easily done simulating the network in figure 6 with a computer simulator (such as SPICE).

APPLICATIONS

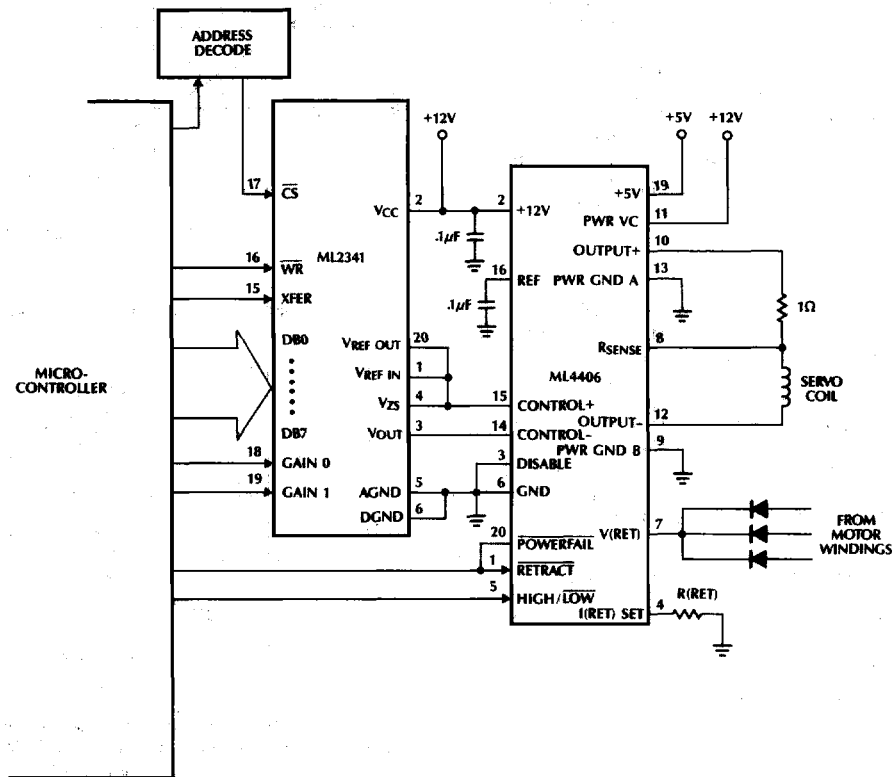


Figure 7. Typical Application: ML4406 used with ML2341 8-bit DAC provides up to 12-bit effective resolution

ORDERING INFORMATION

PART NUMBER	TEMP. RANGE	PACKAGE
ML4406CQ	0°C to +70°C	MOLDED PCC (Q20)
ML4407CQ	0°C to +70°C	MOLDED PCC (Q20)