National Semiconductor

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LM9022
Vacuum Fluorescent Display Filament Driver

General Description

The LM9022 is a bridged power amplifier capable of delivering typically 2W of continuous average power into a 10Ω filament load when powered by a 5V power supply.

To conserve power in portable applications, the LM9022's micropower shutdown mode (I_Q = 0.6µA, typ) is activated when V_{DD} is applied to the SHUTDOWN pin.

Additional LM9022 features include thermal shutdown protection, unity-gain stability, and external gain set.

Key Specifications

- I_{DD} during shutdown 0.6µA (typ)
- Thermal Shutdown Protection

Features

- No transformers required
- SO or DIP packaging

Applications

- VCR/DVD Displays
- RADIO/TUNER Displays

Typical Application

T_A = 25˚C, V_{DD} = 5V, unless otherwise specified.

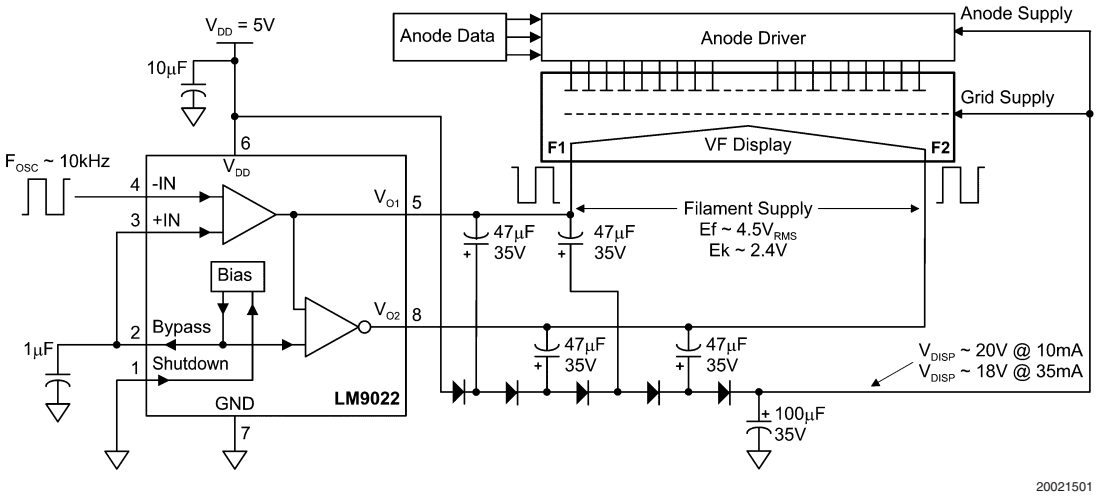
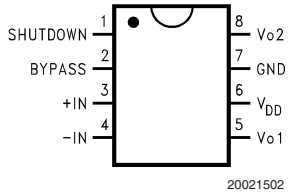


FIGURE 1. Typical Application Circuit

Connection Diagram

MSOP, Small Outline, and DIP Package



Top View
Order Number LM9022M or LM9022N
See NS Package Number M08A or N08E

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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	-0.3V to +6.0V
Supply Temperature	−65˚C to +150˚C
Input Voltage	−0.3V to V_{DD} +0.3V
Power Dissipation (Note 3)	Internally Limited
ESD Susceptibility (Note 4)	5000V
ESD Susceptibility (Note 5)	250V
Junction Temperature	150˚C
Soldering Information	
Small Outline Package	
Vapor Phase (60 sec.)	215˚C
Infrared (15 sec.)	220˚C
θ_{JC} (typ)—M08A	35˚C/W
θ_{JA} (typ)—M08A	140˚C/W
θ_{JC} (typ)—N08E	37˚C/W
θ_{JA} (typ)—N08E	107˚C/W

Operating Ratings

Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	$-40˚C \le T_A \le 85˚C$
Supply Voltage	$2.0V \le V_{DD} \le 5.5V$

Electrical Characteristics (Notes 1, 2)

The following specifications apply for V_{DD} = 5V, $V_{PIN3} = V_{PIN2}$, $V_{SHUTDOWN}$ = 0V, and R_L = 10Ω unless otherwise specified. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM9022			Units
			Min (Note 7)	Typical (Note 6)	Max (Note 7)	
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_o = 0A, $V_{SHUTDOWN}$ = 0V		6.5	10.0	mA
	Power Supply Current during shutdown	$V_{SHUTDOWN} = V_{DD}$ (Note 8)		0.6	2	µA
V_{BP}	Bypass Pin Voltage	V_{IN} = 0V	2.4	2.5	2.6	V
V_{OUT}	Output Voltage Across R_L	R_L = 10Ω	3.6	4.3		V
		R_L = 20Ω	4.2	4.6		V

Note 1: *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not guarantee specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 2: All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 3: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and the ambient temperature T_A. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX}-T_A)/\theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower. For the LM9022, T_{JMAX} = 150˚C. For the θ_{JA}'s for different packages, please see the **Application Information** section or the **Absolute Maximum Ratings** section.

Note 4: Human body model, 100pF discharged through a 1.5kΩ resistor.

Note 5: Machine Model, 220pF–240pF discharged through all pins.

Note 6: Typicals are specified at 25˚C and represent the parametric norm.

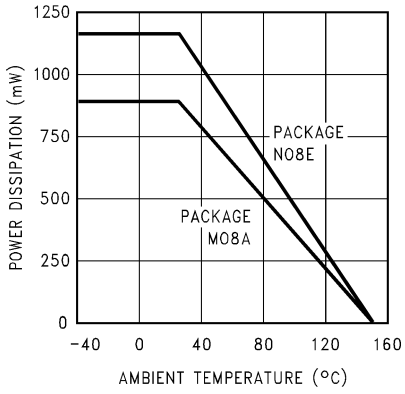
Note 7: Limits are guaranteed to National's AOQL (Average Outgoing Quality Level) by design, test, or statistical analysis.

Note 8: Both outputs are high impedance when in shutdown mode.

Typical Performance Characteristics

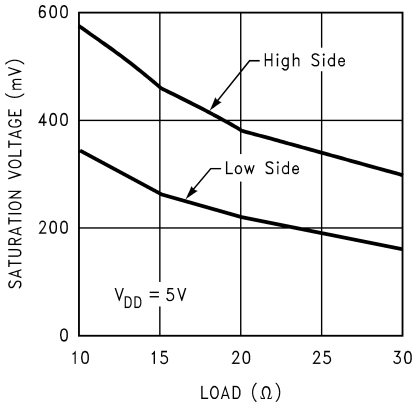
T_A = 25˚C, V_{DD} = 5V, unless otherwise specified.

Power Derating Curve



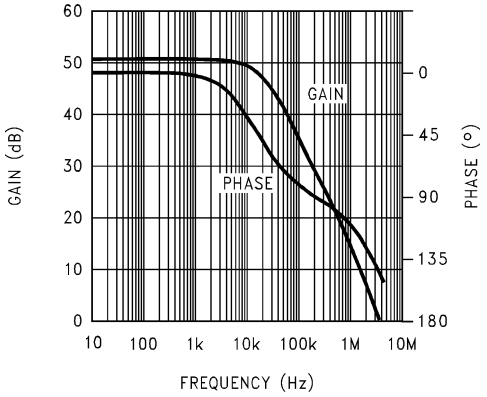
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Output Saturation Voltage vs Load



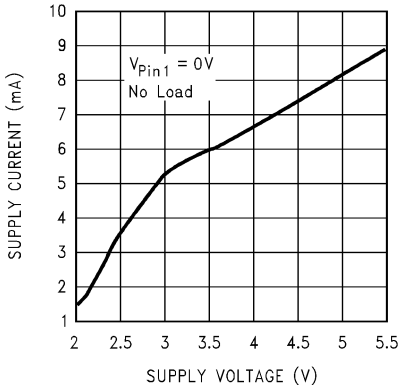
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Open Loop Frequency Response



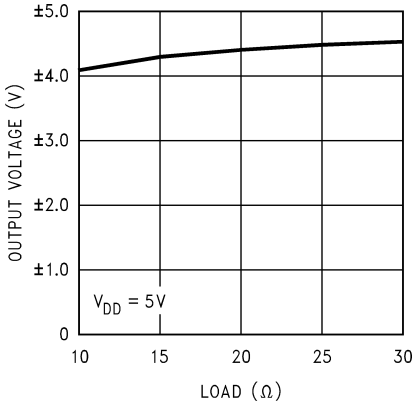
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Supply Current vs Supply Voltage



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Differential Output Voltage vs Load



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Application Information

LM9022 FUNCTIONALITY

Typically a VFD filament requires a low voltage AC power source in order to create a constant brightness across its length. Such a power source is not readily available in a most systems. Existing implementations show different circuits for supplying an AC power for a VFD filament but they require an AC power input, or do not have a standby control, or generate high EMI. The LM9022 can solve all these problems in one compact circuit.

A DC power supply is employed to power two power operational amplifiers: POA1 and POA2. The first power operational amplifier (POA1) can utilize an external feedback circuit that will cause it self-oscillate. In a second version, POA1 is driven from an external signal source. The shape of the output wave delivered by POA1 can be square, sinusoidal, triangular, trapezoidal, clipped sinusoidal or any other shape, depending on the feedback circuit or the signal source used. The output of this POA1 is connected externally to one end of the VFD filament, and internally to the input of a second power operational amplifier: POA2. POA2 is internally configured as an inverting unity gain circuit. The output of the POA2 is connected to the second end of the VFD filament. This provides a differential and symmetrical AC signal to the fila

An external standby control signal applied to the Shutdown pin can be used to turn of both power operational amplifiers.

BRIDGE CONFIGURATION EXPLANATION

As shown in *Figure 1*, the LM9022 has two operational amplifiers internally. *Figure 1* shows that the output of amplifier one serves as the input to amplifier two, which results in both amplifiers producing signals identical in magnitude, but 180˚ out of phase.

By driving the load differentially through outputs Vo1 and Vo2, an amplifier configuration commonly referred to as “bridged mode” is established. Bridged mode operation is different from the classical single-ended amplifier configuration where one side of its load is connected to ground.

A bridge amplifier design has a few distinct advantages over the single-ended configuration, as it provides differential drive to the load, thus doubling output swing for a specified supply voltage. Four times the output power is possible as compared to a single-ended amplifier under the same conditions.

POWER DISSIPATION

For the SO package, θ_{JA} = 140˚C/W, for the DIP package, θ_{JA} = 107˚C/W, and for the MSOP package, θ_{JA} = 210˚C/W assuming free air operation. The θ_{JA} can be decreased by using some form of heat sinking. The resultant θ_{JA} will be the summation of the θ_{JC}, θ_{CS}, and θ_{SA}. θ_{JC} is the junction to case of the package, θ_{CS} is the case to heat sink thermal resistance and θ_{SA} is the heat sink to ambient thermal resistance. By adding additional copper area around the LM9022, the θ_{JA} can be reduced from its free air value for the SO package. Depending on the ambient temperature, T_A, and the θ_{JA}, Equation 2 can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation 1 is greater than that of Equation 2, then either the supply voltage must be decreased, the load impedance increased, the θ_{JA} decreased, or the ambient temperature reduced. For the typical application of a 5V power supply, with an 10Ω load, and no additional heatsinking, the maximum ambient temperature possible without violating the maximum junction temperature is approximately 61˚C provided that device operation is around the maximum power dissipation point and assuming surface mount packaging.

POWER SUPPLY PIN

As with any power device, proper supply bypassing is critical for low noise performance. Typical applications will require both a 22µf electrolyte and a 0.1µF ceramic capacitor to bypass the supply pin to ground. These capacitors should be as close to the LM9022 as is physically possible, and are in addition to any capacitors that may be needed for regulator stability.

BYPASS PIN

The internal bias circuit (Fig 1) generates an internal reference voltage that is typically equal to one half of V_{DD}. This voltage is available at the bypass pin and is applied directly to the non-inverting input of the inverting driver. Typical applications will require a bypass capacitor in the range of 0.1µF to 1µF to bypass the supply pin to ground. This capacitor should be as close to the LM9022 as is physically possible.

SHUTDOWN FUNCTION

In order to reduce power consumption while not in use, the LM9022 contains a shutdown pin to externally turn off the amplifier’s bias circuitry. This shutdown feature turns the amplifier off when a logic high is placed on the shutdown pin. The trigger point between a logic low and logic high level is typically half- supply. It is best to switch between ground and supply to provide maximum device performance. By switching the shutdown pin to V_{DD}, the LM9022 supply current draw will be minimized in idle mode. While the device will be disabled with shutdown pin voltages less then V_{DD}, the idle current may be greater than the typical value of 0.6µA. In either case, the shutdown pin should be tied to a definite voltage to avoid unwanted state changes.

Application Information (Continued)

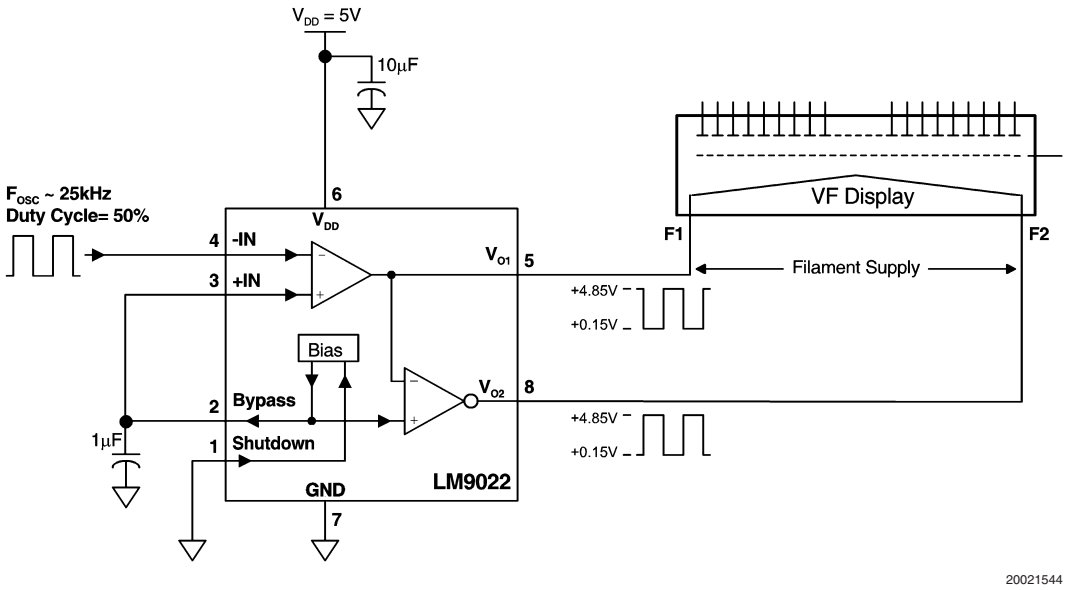


FIGURE 2. Filament Supply using External Oscillator

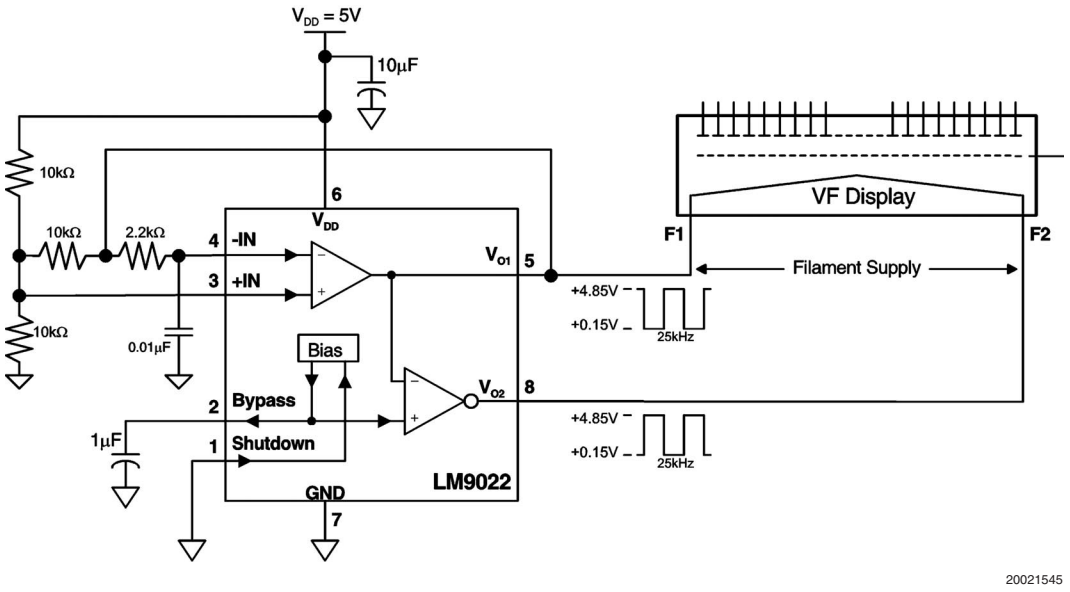
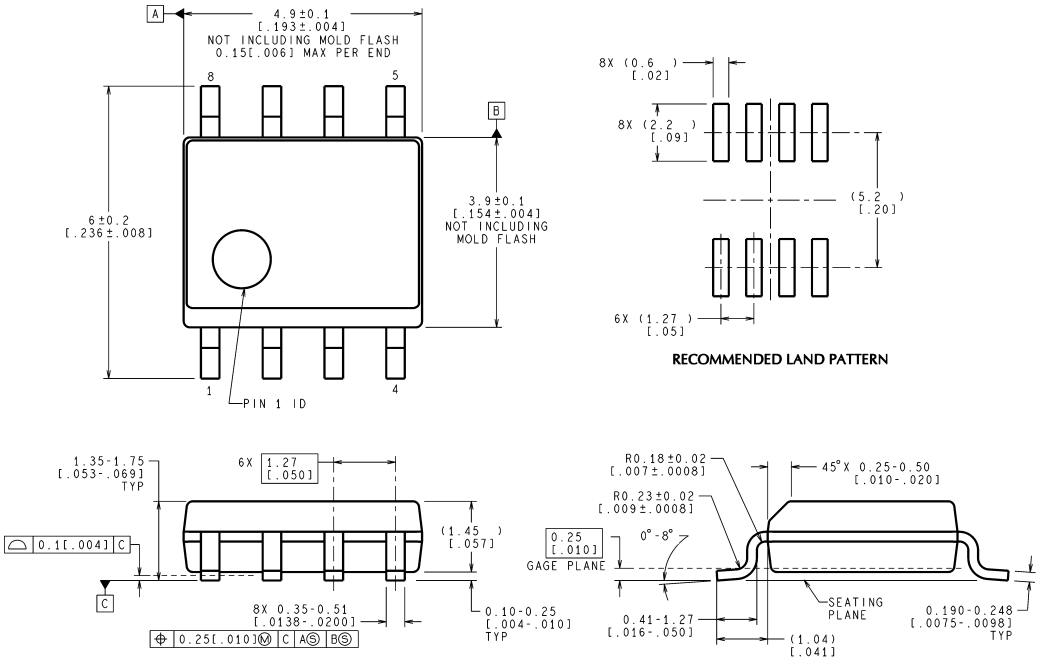


FIGURE 3. Filament Supply using Self Oscillation

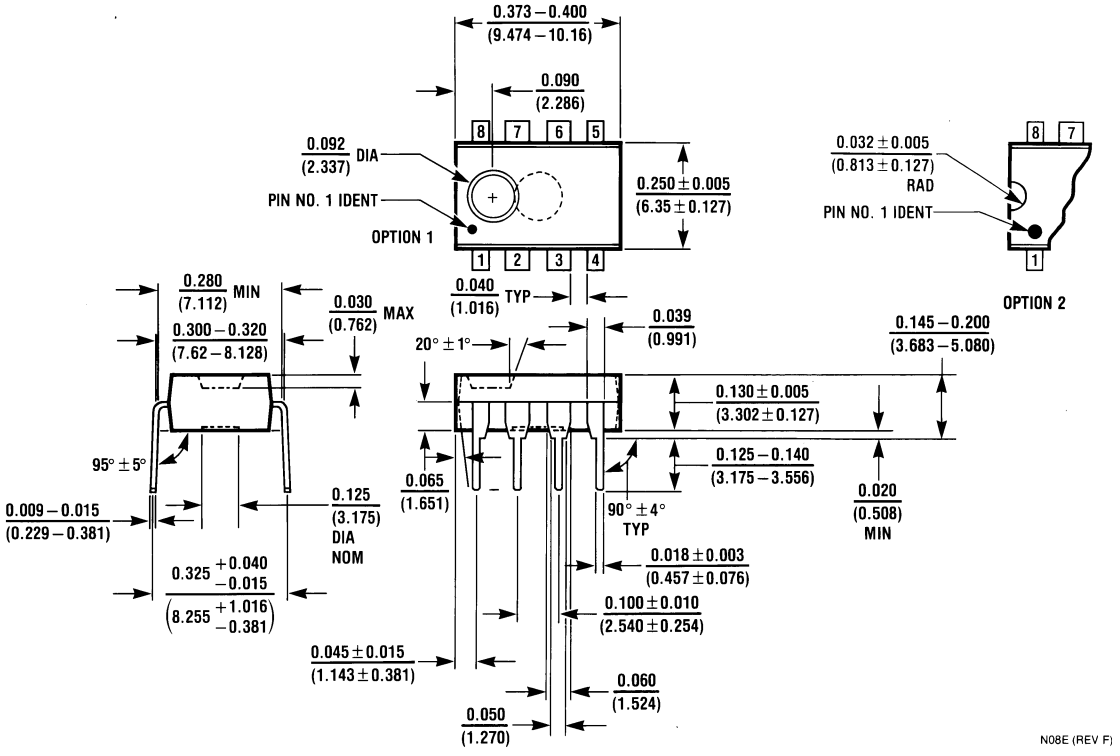
Physical Dimensions inches (millimeters) unless otherwise noted



CONTROLLING DIMENSION IS MILLIMETER
VALUES IN [ ] ARE INCHES
DIMENSIONS IN ( ) FOR REFERENCE ONLY

M08A (Rev K)

Order Number LM9022M
NS Package Number M08A



N08E (REV F)

Order Number LM9022N
NS Package Number N08E

Notes

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