UNIVERSAL SOURCE DRIVER

■ GENERAL DESCRIPTION

NJM3548 is a bipolar universal high-current highly protected high side driver with transparent input and 2000mA continuous -current source capability. A low-level input activates the output.

The driver is equipped with extensive electrical protection, such as over current protection and thermal protection, which makes the device virtually indestructible.

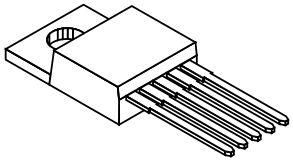
Furthermore it can detect open circuit and short circuit to V_{CC}.

A special feature is the Error indicating output function pin which signals to the host system if the protection or the load check functions is activated.

Typical loads are solenoids, relays or resistive loads.

The NJM3548 and NJM3545 are complementary drivers and have similar data.

■ PACKAGE OUTLINE



NJM3548TA2

■ FEATURES

- 2000mA continuous-output current
- Short circuit to ground protection
- Error signal to host system
- Open circuit detection
- Short circuit to V_{CC} detection
- Thermal protection
- Built-in protection diodes
- Package TO-220 (5-pin)

■ BLOCK DIAGRAM

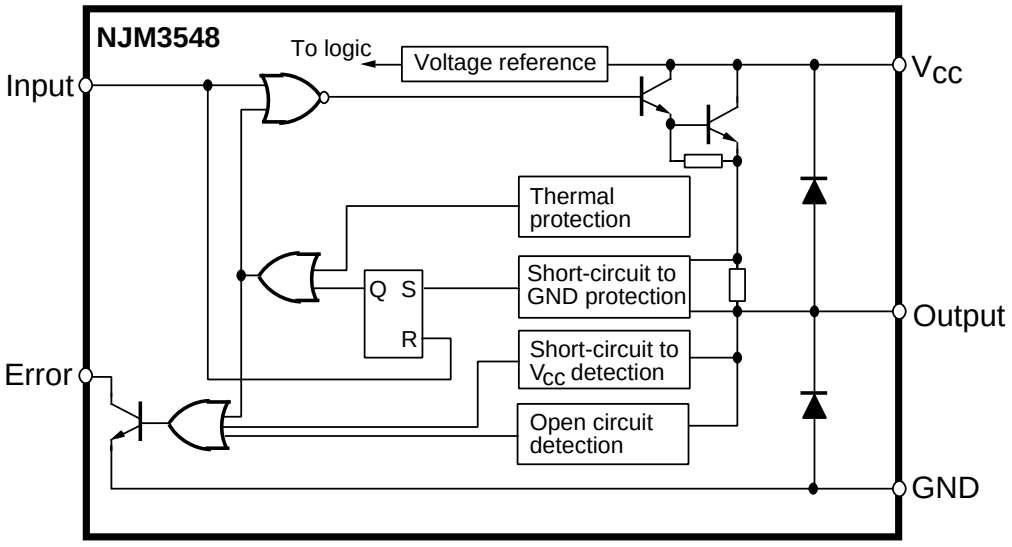


Figure 1. Block Diagram

■ PIN CONFIGURATION

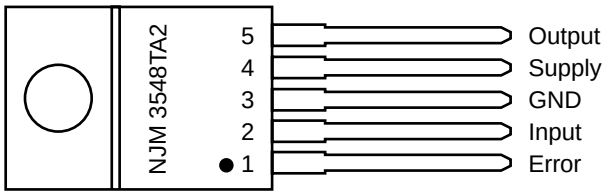


Figure 2. Pin Configuration

■ PIN DESCRIPTION

TO-220	Symbol	Description
1	Error	Error indicating pin. Sinks current to ground if the protection and/or detection circuitry is activated. Note: the current must be externally limited to 8 mA.
2	Input	TTL compatible input. A HIGH input signal turns the output transistor off and a LOW input turns it on. If the input is left open it will be detected as high level.
3	GND	Ground supply.
4	Supply	Supply voltage. Nominally 5 V to 40 V.
5	Output	Output pin. Current flows out from this pin through the load to GND. Nominal current is 8 mA to 2 A.

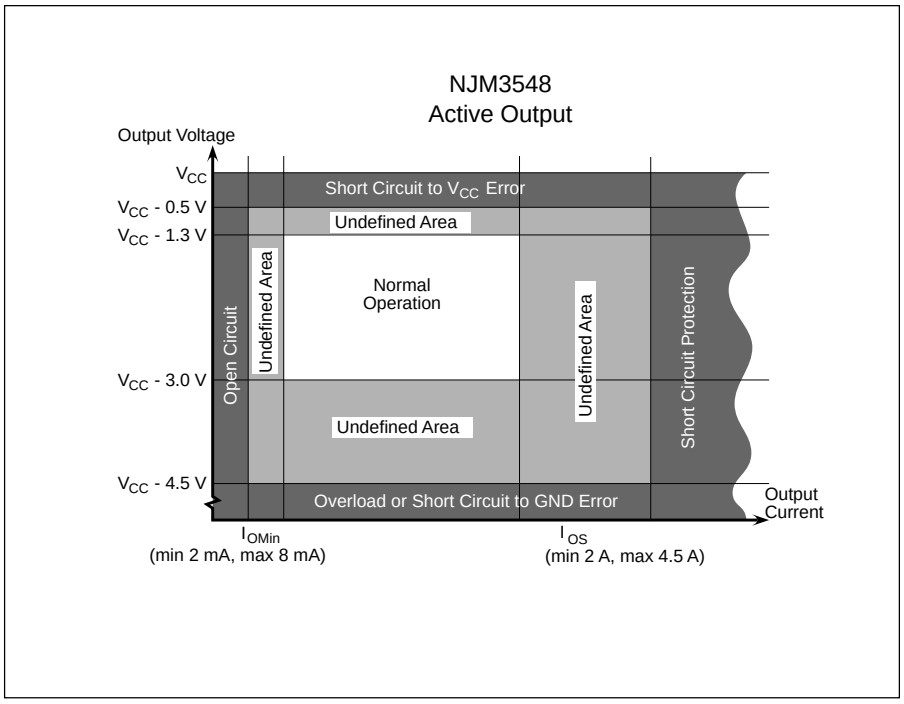


Figure 3. Error state vs. output voltage and output current, active output (0V≤ V_{IN} ≤ 0.8 V, 5 V < V_{CC} < 40 V and -40°C <+T_J>+100°C)

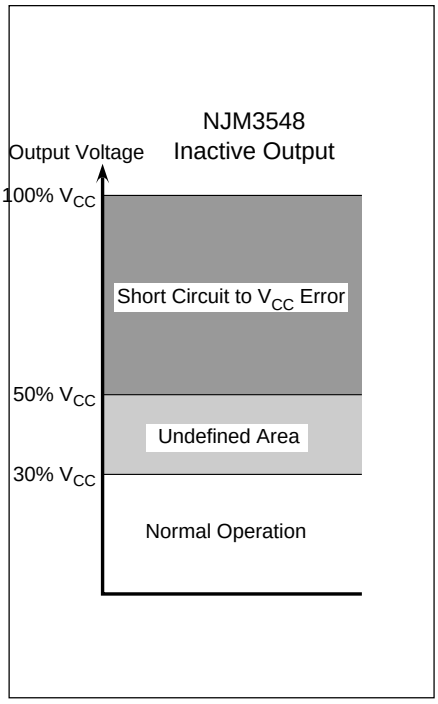


Figure 4. Error state vs. output voltage, inactive output (2.0 V ≤ V_{IN} ≤ V_{CC}, 5 V ≤ V_{CC} ≤ 40 V and -40°C <T_J<+100°C)

■ FUNCTIONAL DESCRIPTION

The circuit NJM3548 is a high side driver capable of driving resistive or inductive loads not exceeding 2 A.

The driver has an error indicating function which generates an Error output signal when a fault condition has occurred.

The circuits NJM3548 and NJM3545 are complementary drivers with equivalent functions and similar data. NJM3548 is a source driver and NJM3545 is a sink driver.

Input stage

The output stage is switched on and off according to the status of the input. LOW level activates the output. If the input is left open, the circuit will accept it as a HIGH level.

Output stage

The output stage contains a power transistor and two clamping diodes. The diodes are used for terminating line transients from inductive loads. If the driver is inactive and the output is shorted to V_{CC} the driver will leak a maximum of 8µA. See figure 18.

Protection circuitry

The circuit contains two protection circuits:

- Overload and Short circuit protection
- Thermal protection

The overload and short circuit protection will be activated at I_{out}= 3.5 A typically at T_J= +25°C, see figure 20.

The output will be turned off immediately and latched to a high-impedance state after an overload or short circuit has been detected.

A logic-level change at the input will reset the internal error latch. If the fault still is present at turn-on, the circuit

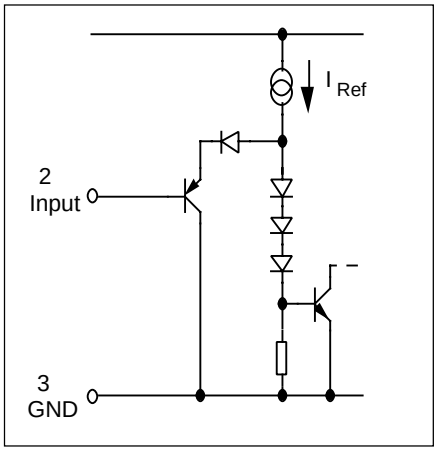


Figure 5. Input stage

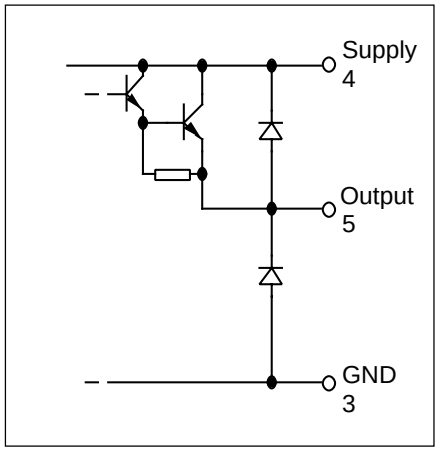


Figure 6. Output stage

Fault condition	Input	Output	Error LOW=ERROR HIGH=Normal	How to resume normal operation
Normal	0 LOW	1 ON	1 HIGH	——
	1 HIGH	0 OFF	1 HIGH	——
V_{OUT} Short to V_{CC}	0 LOW	1 ON	0 LOW	Remove fault condition.
	1 HIGH	0 OFF	0 LOW	Remove fault condition.
V_{OUT} Short to GND	0 LOW	0 OFF	0 LOW	Turn off and on after fault condition is removed.
	1 HIGH	0 OFF	1 HIGH	——
Open load	0 LOW	1 ON	0 LOW	Attach proper load to output or turn off the driver.
	1 HIGH	0 OFF	1 HIGH	——
Over temperature	0 LOW	0 OFF	0 LOW	Temperature is reduced to approx 120°C, or turn off the driver.
T_J=130 °C	1 HIGH	0 OFF	1 HIGH	——

Figure 7. Error table

will once again turn the output off.

Due to a slight delay in the circuit, a high current transient will occur when the output is shorted to GND. This current transient may reach 8 A during 5 μs. Consequently, switching at high frequencies with a shorted output may destroy the circuit. If a short circuit condition is detected, stop switching the input and remove fault condition.

Thermal protection

The output of NJM3548 is equipped with a thermal shut-down function, that turns the outputs off at a chip (junction) tenperature above typically 130°C.

Normal operation is resumed when the temperature has decreased about 20C.

Error functions

The Error indicating signal occurs on a separate pin. The complete error table is shown in figure 7.

The following conditions generate an error signal:

When the driver is activated and at least one of the following conditions has occurred:

- thermal overload
- short circuit to GND
- short circuit to V_{CC}
- open circuit

An output current less than 8 mA might be detected as “open circuit”. Output currents larger than 8 mA and less than 2 A will definitely not generate an error. The normal operational area is shown in figure 3.

Also when the driver is inactivated an Error indication can occur. That is if the output is shorted to V_{CC}. In figure 4 short circuit to V_{CC} Error state versus output voltage is shown.

When the Error-detection function is activated, the Error output is capable of sinking 8 mA, supporting direct connection of an LED. The current has to be externally limited by a series resistor.

Signal diagrams

The signal diagram in figure 8 shows the input signal and the resulting output signals for each error mode. For details, see error table, figure 7.

V_{In} = Input voltage. Active = LOW.

V_{Out} = Output voltage.

I_{Out} = Output current from driver.

V_{Err} = Error output voltage. Error = LOW.

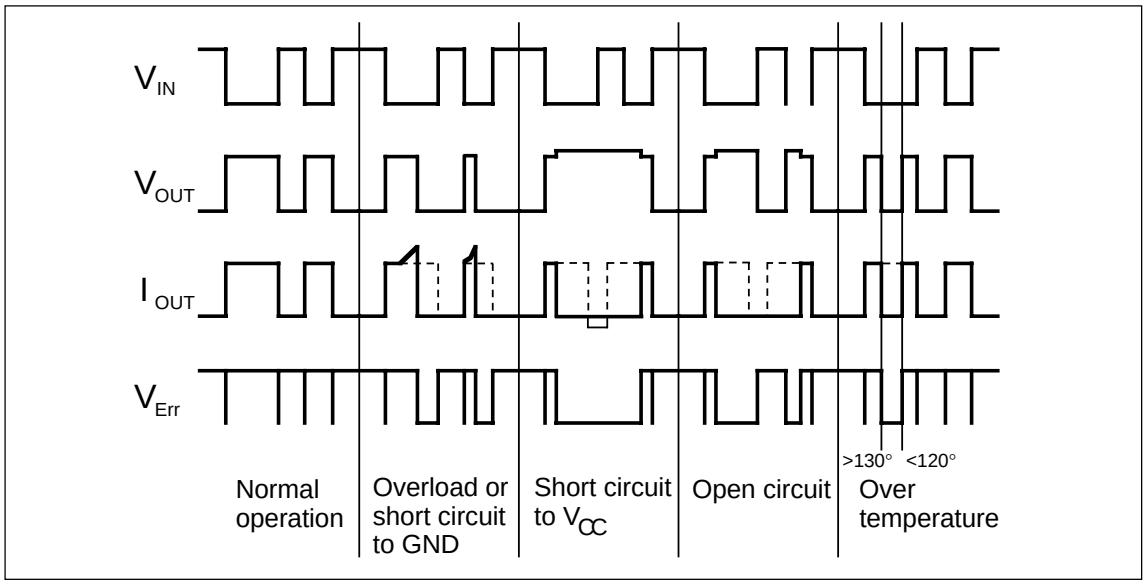


Figure 8. Signal diagram

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Pin no.	Symbol	Min	Max	Unit
Voltage					
Supply voltage	1	V_{CC}	0	45	V
Logic input voltage	5	V_{In}	-0.3	V_{CC}	V
Current					
Logic input current	5	I_{In}	-10	-	mA
Continuous DC Operation output current TO-220	2	I_{Out}	2000	-	mA
Error output current	4	I_{Err}	-	10	mA
Temperature					
Operating junction temperature (internally limited)		T_j	-40	+140	°C
Storage temperature		T_{Stg}	-55	+150	°C
Power Dissipation (Package Data)					
Power dissipation at T_{Case} = 85°C, TO-220 package		P_D	-	11	W
ESD					
ESD tolerance (Note 2)			2000	-	V

■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min	Typ	Max	Unit
Supply voltage	V_{CC}	4.75	-	40	V
Output current, TO-220 package	I_{Out}	-2000	-	-	mA
Operating junction temperature	T_j	-40	-	+100	°C
Error output current	I_{Err}	-	5	8	mA

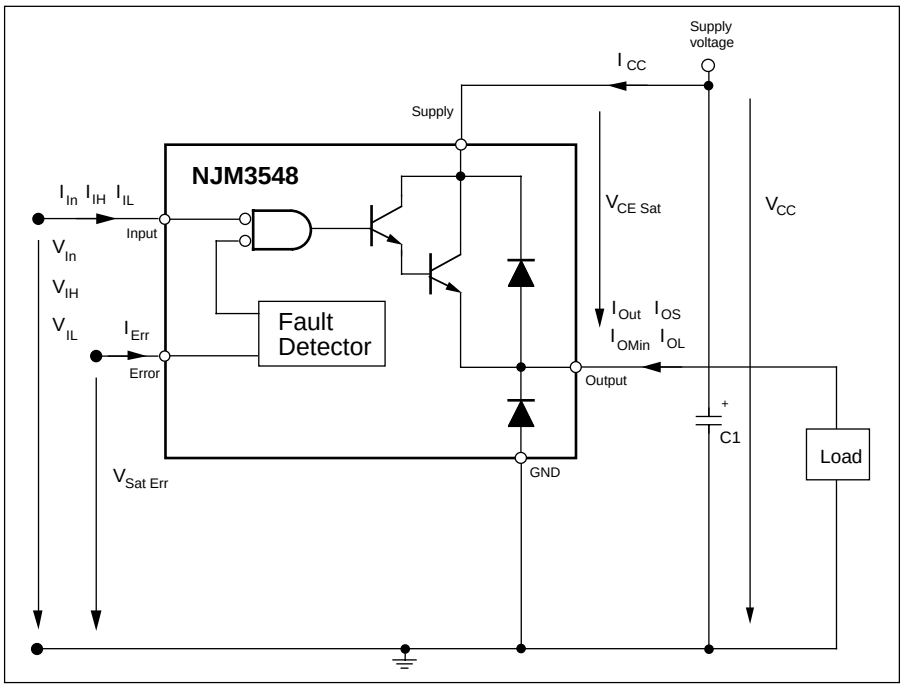


Figure 9. Definition of symbols

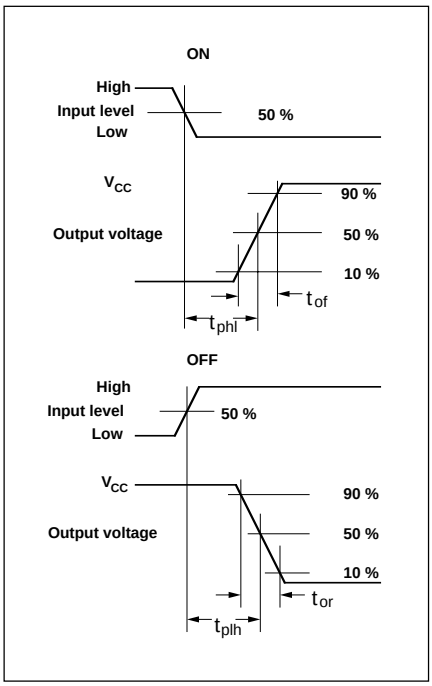


Figure 10. Timing diagram, input vs. output. V_{CC} = 24V

■ ELECTRICAL CHARACTERISTICS

At 5 V ≤ V_{CC} ≤ 40 V, -40°C ≤ T_J ≤ +100°C. Typical values are given at V_{CC} = 24 V, T_J = 25°C.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
General						
Supply currrent	I_{CC}	2.0 ≤ V_{IN} ≤ V_{CC}	1.5	4	7	mA
Thermal shutdown	T_{JS}		-	+130	-	°C
Logic input						
High level input voltage	V_{IH}		2.0	-	V_{CC}	V
Low level input voltage	V_{IL}		-0.3	-	0.8	V
High level input current	I_{IH}	2.0 ≤ V_{IN} ≤ V_{CC}	-	-	20	µA
Low level input current	I_{IH}	0 ≤ V_{IN} ≤ 0.8	-400	-4	-	µA
Outputs						
Error output saturation voltage	$V_{Err\ SAT}$	I_{Err} = 5 mA	-	0.2	1	V
Output saturation voltage	$V_{CE\ SAT}$	I_{OUT} = -2 A	-	1.9	2.4	V
Output current shutdown	I_{OS}	0 ≤ V_{IN} ≤ 0.8 V	-5.0	-3.5	-2.0	A
Output current	I_{OMIN}	0 ≤ V_{IN} ≤ 0.8 V	-8	-3	-1	mA
(not detected as open circuit) Output leakage current	I_{OL}	2.0 ≤ V_{IN} ≤ V_{CC}. Output = V_{CC}	-2	-6	-8	µA
Clamping diode forward voltage		I_F = 2.0 A	-	1.5	1.8	V
Timing						
Propagation time		I_{OUT} = - 2 A				
Output low to high (50%),	t_{plh}		-	0.6	1.0	µs
Output high to low (50%),	t_{phl}		-	0.5	1.0	µs
Rise time (10 to 90%),	t_{or}		-	0.6	1.0	µs
Fall time (90 to 10%),	t_{of}		-	0.2	0.4	µs

■ THERMAL CHARATERISTICS

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Thermal resistance	Rth_{J-C}	TO-220 package, junction to case	-	5	-	°C/W
	Rth_{J-A}	TO-220 package, junction to ambient	-	60	-	°C/W

Notes:
1. Currents are defined positive if flowing into, and negative if flowing out of a terminal. Voltages are defined between terminal and ground.
2. ESD testing according to Human Body Model (C_{Zap} = 100 pF, R_{Zap} = 1500 Ω)

■ APPLICATIONS INFORMATION

Important application areas are:

- Programmable logic control systems.
- Relay control.
- Hydraulic valves.
- Intelligent interfaces between microprocessors and loads.
- Robot techniques.
- Print head drivers.
- High-current stepper motor drivers.

Transient protection

1. Keep V_{CC} and GND leads as short as possible. Use different supplies if possible.
2. Connect a filter capacitor close to the circuit. Recommended filter capacitor between V_{CC} and GND is 6.8 μF, of tantalum type. A ceramic capacitor in parallel will improve high frequency decoupling. Typical values range from 0.002 μF to 0.1 μF. In an application having a highly stable supply and short power leads to the driver a low leakage electrolytic type can be used, which is less expensive.
3. Connect Input and Error via pull-up resistors to the appropriate logic supply level or V_{CC} to obtain highest noise immunity. See figure 11. The resistor R_1 limits the current into the Error indicating pin. This current must not exceed 8 mA. R_2 is a pull-up resistor which improves noise immunity at the Input. Pull-up current should not exceed the sinking capacity of the controlling device output.
4. If several supply voltages are to be used, prefer a supply having separate ground leads. In this case the logic ground and the power ground should be connected together at only one point, the ground pin of the driver.

Switch mode applications

The internal diodes are normally sufficient for clamping of transients caused by inductive load turn off. External diodes may be necessary in PWM/switch mode applications, and when the terminals are externally accessible and thereby exposed to an electrically noisy environment. Recommended diodes are BYV27/100, BYV98/100, UF4001 or similar types with a $t_{rr} < 100$ ns and $I_F \geq 1$ A.

Error indication signal

When the circuit is switched on/off, a short pulse (t_{Err} <10 μS for resistive loads) is generated at the Error output. This is a correct detection of an incorrect level during the rise and fall times of the output voltage. Consequently the Error output should not be detected when switching on and off. An alternative is to low-pass filter at the Error output at around 100 kHz.

Heat sinking

NJM3548TA2 is packaged in a 5-pin TO 220 power package. The circuit GND is connected to the heat sink tab. External heatsinking is achieved by mounting the package to a heat sink.

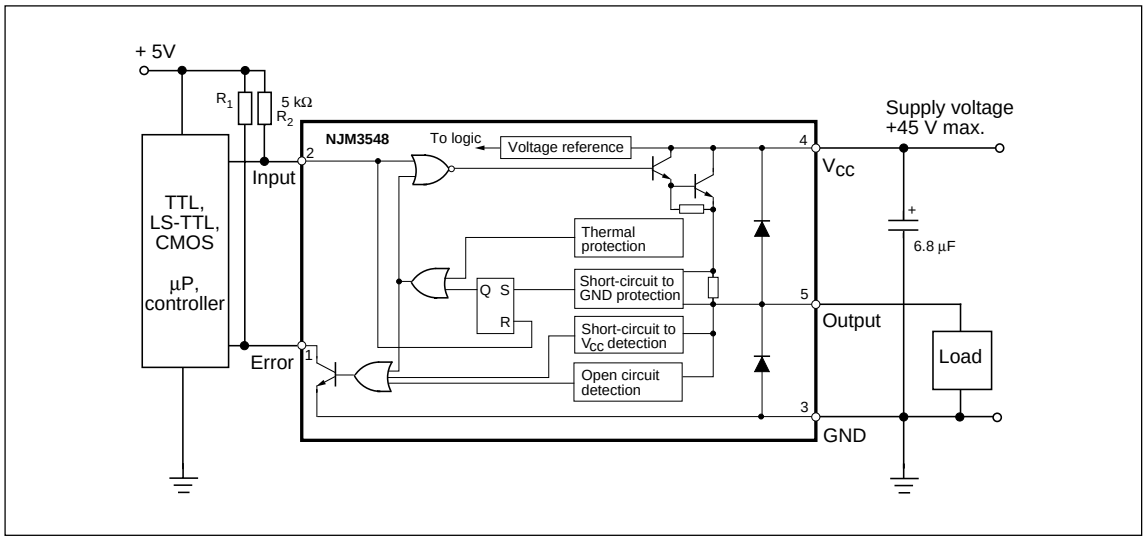


Figure 11. Typical application. Pin numbers refer to TO 220 package

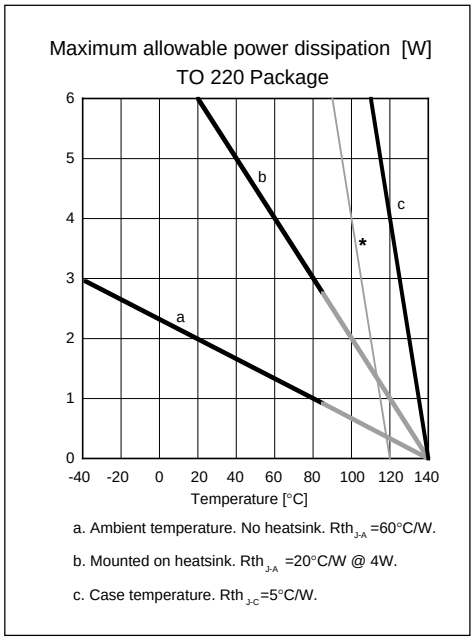


Figure 12. Maximum allowable power dissipation. TO 220 package

■ TYPICAL CHARACTERISTICS

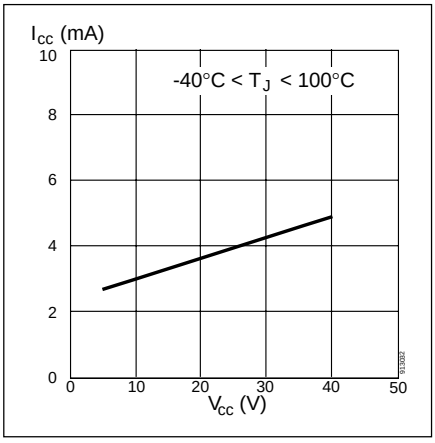


Figure 13. Current consumption vs. supply voltage at 2 V ≤ V_{in} ≤ V_{CC}V (Inactive output)

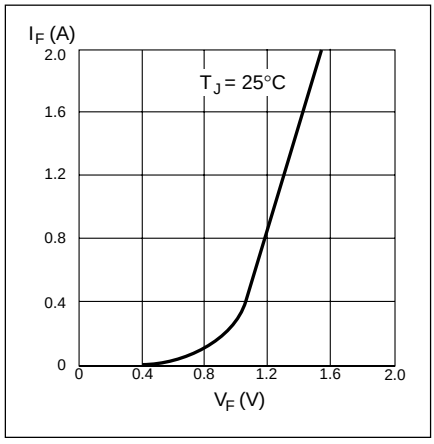


Figure 14. Diode forward voltage drop vs. forward current

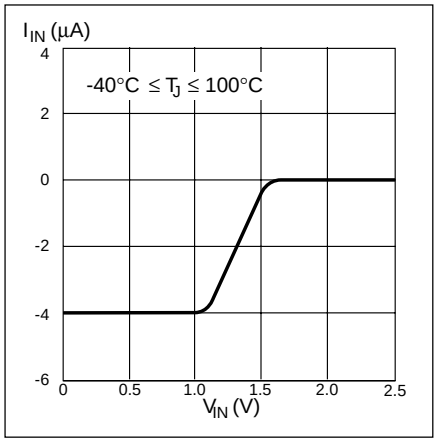


Figure 15. Input current vs. input voltage.5 V ≤ V_{CC} ≤ 40 V

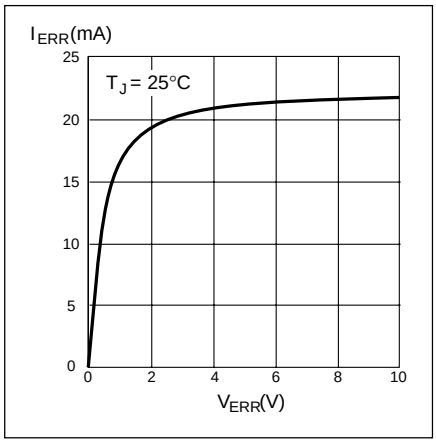


Figure 16. Error output saturation voltage vs. error current. V_{CC} = 24 V

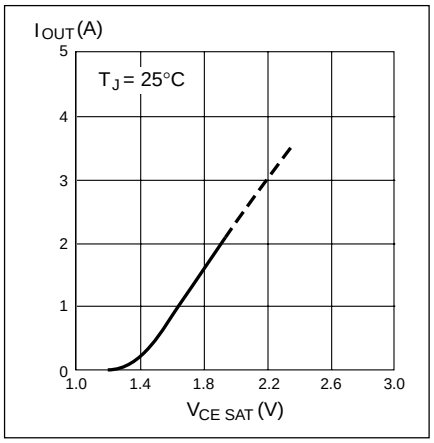


Figure 17. Output saturation voltage vs. output current. 5 V < V_{CC} < 40 V

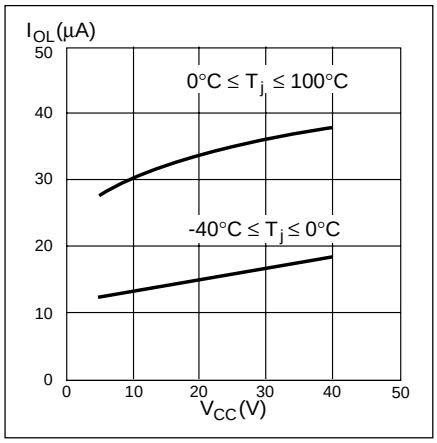


Figure 18. Output leakage current vs. supply voltage. 2.0 V ≤ V_{IN} ≤ V_{CC} Output = V_{CC}

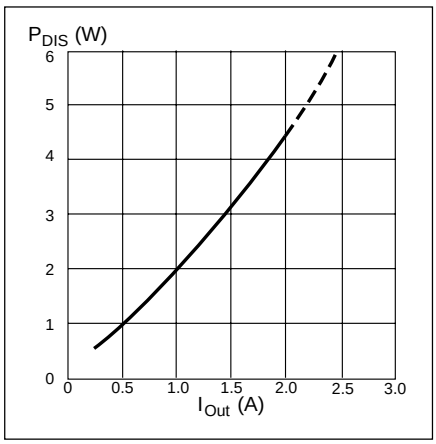


Figure 19. Power dissipation vs. output current.

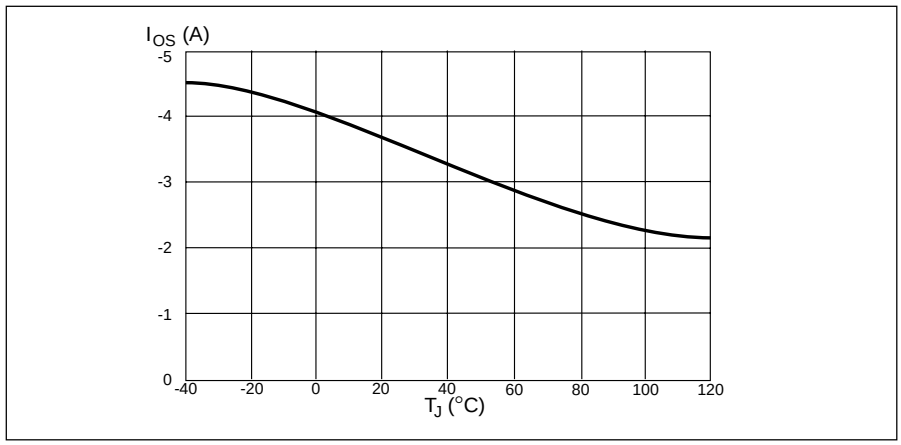


Figure 20. Output current shut-down vs. chip temperature. 5 V ≤ V_{CC} ≤ 40 V

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