Transient protection for the NJM3545 and NJM3548

The NJM3545 and NJM3548 general purpose drivers are equipped with a very fast short circuit protection circuitry for reliable SOA (Safe Operating Area) protection of the Darlington output transistor. It is a thyristor-like structure which gives a fast latching turn off of the output transistor. A short circuit at the output creates not only a current spike, but also a voltage transient. This voltage transient activates the fast short circuit protection.

The short circuit protection could also be activated by a voltage transient that is not caused by a short circuit. Strong transients at the V_{cc}, Output or GND terminals may trigger the short circuit protection. Therefore, proper layout and filtering is important in order to avoid false triggering of the short circuit protection.

In some cases this transient protection may be too sensitive, for example when heavy load currents are switched on and off by a mechanical switch or relay located close to the circuit.

Design basics

Power supply and system layout:

Figure 1 shows a decoupling diagram which includes the minimum required decoupling components. In most applications this level of decoupling should be sufficient.

- Keep V_{cc} and GND leads as short and as low resistive possible.
- Use separate ground leads with only one common point at the ground pin of the driver.
- Use separate decoupling capacitors C1 and C2 placed as close as possible to the pins of the circuit. C1 is preferably an 6.8 µF tantalum type capacitor. In a application with a highly stable supply and short leads to the driver a low leakage electrolytic type can be used, which is less expensive. C2 is a ceramic type capacitor to improve high frequency decoupling. Typical value is 0.002 µF to 0.1 µF.

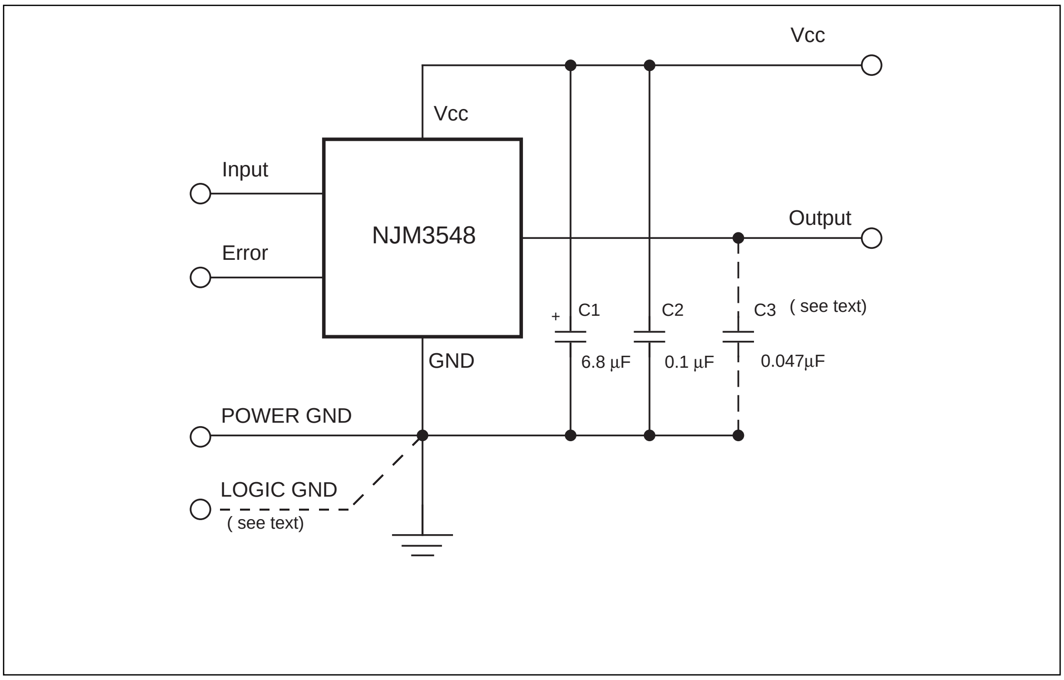

Figure 1. Basic decoupling in a typical application.

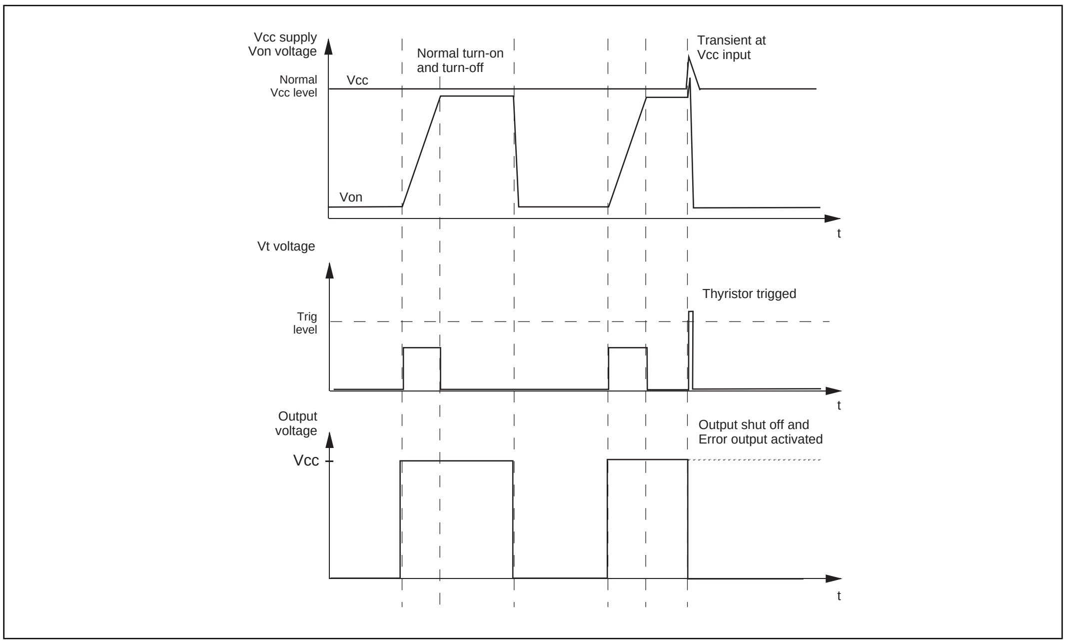

Figure 2. Waveforms at normal operation and at transient turn-off.

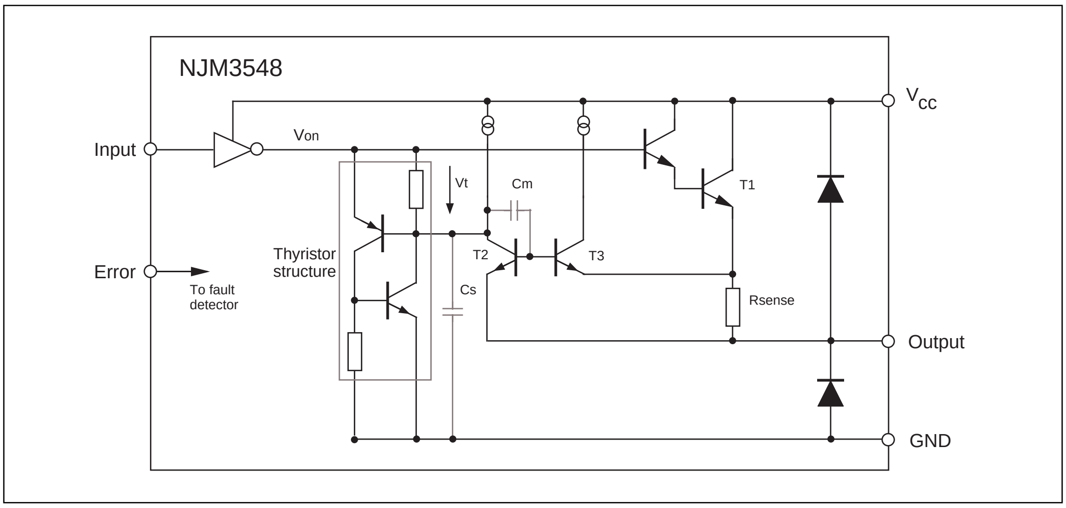

Figure 3. Schematic diagram of the fast short circuit protection.

External components selection guide.

Ext. comp	Purpose	Typ. value
C1	Supply decoupling	6.8 µF tant.
C2	Supply HF decoupling	0.047 µF ceramic
C3	Supply filtering	100 µF
C4	Output filter	0.01 µF
C5	HF LC-filter	0.047 µF
C7	HF RC-filter	0.1 µF
D1	Clamping diode	UF4001, BYV27/100
L1		100 µH
L2		40 µH
R1		56 ohm

NOTE: These are typical values . The final values has to be verified from case to case.

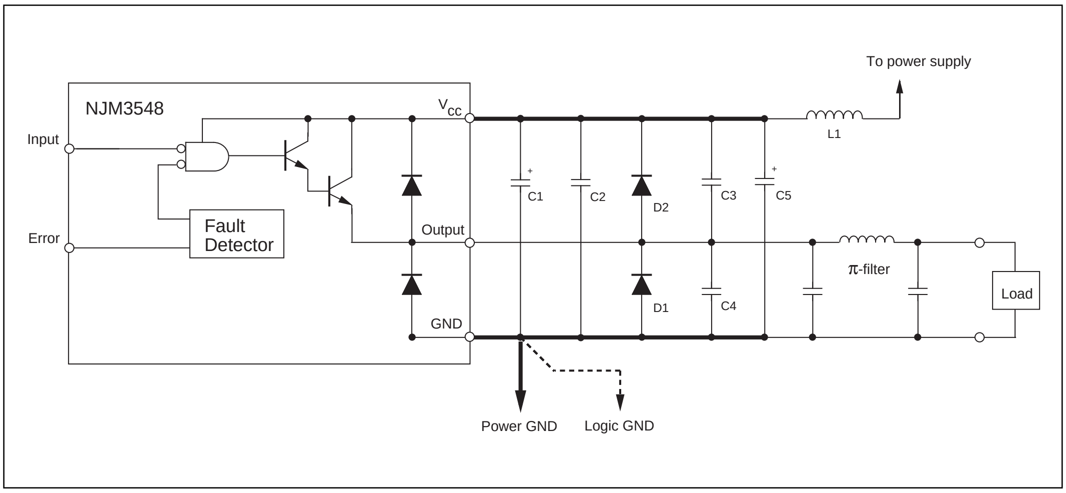

Figure 4. Circuit diagram showing worst case filtering arrangement for suppression of transients.

Filtering:

- An additional capacitor between output and GND may be necessary to reduce incoming transients at the output. The value will depend on the application, but it should be a ceramic type, typically ranging from 0.001 µF to 0.047 µF. Note that a too large total capacitance at the output (i.e. including stray capacitances and load capacitance), will cause the circuit to recognize the charging current at turn-on as a short circuit, and activate the short-circuit protection. Therefore, the value of C3 should be verified in the specific application to prevent this from occuring.

NJM3548 extended Transient protection

The NJM3548 source driver is more sensitive to incoming transients at the output pin than NJM3545 sink driver. This is because 3548/1 has an emitter output and the current sensing resistor, R_{sense}, placed at the emitter. The PBD 3545⁄1 has a collector output and is therefore more tolerant to voltage transients at the output pin. If we look at figures 2 and 3 we can see how strong transients can possibly trigger the sensitive short circuit detection circuitry. A transient at V_{cc} can translate through the output transistor base drive circuit, increase Vt and trigger the thyristor. A transient at the output can translate through T3 and Cm/T2 and triggers the thyristor.

The diagram in figure 4 shows a worst-case filtering arrangement for applications where a high degree of external noise can be expected. All of the components indicated in the figure are usually not required. Start with the basic configuration in figure 1 and apply additional filtering components based on a step by step evaluation in the same order as discussed in the text:

Power supply and system layout:

- Keep V_{cc} and GND leads as short and as low resistive as possible.
- If several supply voltages are to be used, prefer a supply with separate ground leads. In that case the logic ground and the power ground should be connected together at one point, the ground pin of the driver.
- An LC-filter (L1 & C3) at the power supply connection, or at the driver section of the PCB eliminates spikes and noise on the V_{cc} supply line. Several circuits may share a common filter. Typical values range from 10 – 1000 µH and 10 – 1000 µF. Higher values give better transient suppression, but at a higher cost.

Individual decoupling of each circuit:

- Connect a decoupling (filter) capacitor C1 between V_{cc} and GND, as close as possible to the pins of the circuit. A 6.8 µF tantalum or an equivalent low leakage, low impedance type capacitor is recommended .
- Each circuit must have an individual decoupling capacitor (C1). Even if several NJM3548 or NJM3545 are placed on the same PCB, they cannot share decoupling capacitors. However, the value of the capacitors may be decreased, for example to 3.3 µF
- A ceramic capacitor C2 in parallell with C1 improves high frequency decoupling. Typical values range from 0.002 µF to 0.1 µF.

Clamping:

- 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 output terminals are externally accessible and thereby exposed to an electrically noisy environment.
- A diode D1 between GND and Output will clamp negative transients at the Output to ground. The diode must be of switching type with very short recovery time and low forward voltage drop. Recommended type is UF4001, BYV27/100, BYV98/100 or similar types with a recovery time (trr) less than 100 ns and a forward current capability of 1 A or more.

Filtering:

- Filtering of the Output, especially for externally accessible general purpose outputs, reduces transients caused by make and break of inductive loads. (i. e. RFI and EMI)
- A capacitor between Output - GND (C4). Typical values are 0.001 µF to 0.047 µF.
- An LC-filter (L2 and C5) will reduce RFI and ESD efficiently. Typical values range from 1 µH to 100 µH for the inductor and 0.01 µF to 0.1 µF for the capacitor.

  When using the LC-filter, the RC-filter R1 and C6 is needed to reduce oscillations which may occur at switch on and off. The values are chosen depending on the values of L2 and C5.

  If L2 is used, it is possible to drive large capcitive loads (>0.1 µF) and small lamps which have an inrush current.

  With the LC-filter at the output, short circuit will be detected slower than normally. Depending on the supply, voltage, switching frequency and inductor size, the circuit may not detect a short circuit condition at all. In such a case, the temperature shut down function will eventually turn off the circuit.