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APPLICATION NOTE 5072

Snubber Design for the MAX13256

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Abstract: The MAX13256 features an adjustable overcurrent threshold for short-circuit protection. Unfortunately, this threshold makes it difficult to design a snubber for the device using standard methods. This application note shows how to design a voltage snubber for the MAX13256 while taking the current-limit feature into consideration.

The MAX13256 is an integrated primary-side controller for isolated power-supply circuits. This device features dual push-pull drivers, ST1 and ST2, to drive an external transformer. This drive scheme can result in large transient voltage spikes at the drain of the power switches. The voltage spikes occur because parasitic inductance, together with the parasitic capacitance at the output of the power FETs, forms a resonant circuit. Left unattended, these large voltage spikes can increase the stress on the internal switches and can also increase the electromagnetic interference (EMI) created by the system.

During normal operation, internal diodes clamp the drain voltages to one diode drop above V_{DD} or below ground during switching. However, due to the very fast short-circuit detection and response, large voltage spikes may occur at ST1 and ST2 during a short-circuit event. **Figure 1** shows the typical ST1 and ST2 outputs on a Maxim evaluation board during a short circuit. As can be seen in the figure, voltage spikes as high as 42V can occur (with a supply voltage of 28V), risking damage to the internal FETs and decreasing efficiency. Larger voltage spikes can occur for higher supply voltages.

More detailed image (PDF, 1.5MB)
Figure 1. The MAX13256 ST1 (CH1) and ST2 (CH2) outputs during a short circuit.

A simple RC network (shown in **Figure 2**) added to each drain (ST1 and ST2) can be used to suppress these voltage spikes, but the MAX13256's current-limit feature makes it difficult to design the snubbers using standard methods.

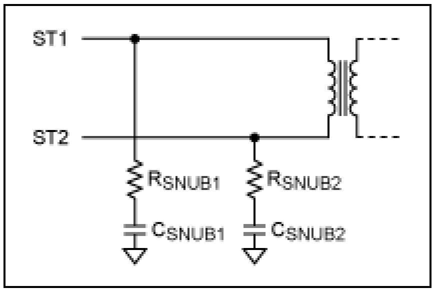

Figure 2. Simple RC snubbers for the MAX13256.

To accommodate for the current limit, we must modify the typical snubber design process slightly:

1. Calculate the current limit of the MAX13256, using the following equation:

   $$I_{LIMIT}\ (mA) = 650(mV)/R_{TH}\ (k\Omega)$$

2. The minimum snubber resistance is set by this current limit. Calculate the snubber resistance, R_{SNUB}, using the following equation:

   $$R_{SNUB} = V_{PEAK}/I_{LIMIT}$$

   where V_{PEAK} is the peak voltage on ST1/ST2 during a short-circuit event. Be sure to use proper probing techniques when measuring V_{PEAK} to ensure an accurate reading by probing the ST1/ST2 voltage as close to the MAX13256 IC as possible, keeping ground leads short, and using a probe with an appropriate bandwidth to avoid erroneous readings.

3. With the resistor in place, add the snubber capacitor. You will need to adjust the value of the snubber capacitance, until the peak voltage on ST1/ST2 is less than 40V. A good starting value is 200pF.

Example:
For this example, the MAX13256 is connected to a 1:1 transformer in the full-wave rectifier configuration on an in-house evaluation board. V_{DD} is 36V.

The maximum measured peak on ST1/ST2 during a short-circuit condition is approximately 49V (**Figure 3**).

More detailed image (PDF, 1.4MB)

Figure 3. The ST1 (CH1) and ST2 (CH2) voltage spike during a short-circuit condition.

Using a current limit resistor of 1kΩ, we can expect a current limit of 650mA (typ) and can calculate R_{SNUB} as follows:

$$R_{SNUB} = 49V/0.65A = 75\Omega$$

Note that this value may need to be adjusted slightly if the actual current limit of the device is less than 650mA. For our circuit, we use a snubber resistance of 91Ω to compensate for a slightly lower actual current limit.

Trial and error show that a 220pF snubber capacitor reduces the peak voltage to 38.4V during a short circuit, a 270pF snubber capacitance further reduces the peak voltage to approximately 38V, and a snubber capacitance of 330pF reduces the peak to 37V.

Although they protect the circuit during short-circuit conditions, the snubber components will have a slightly negative effect on the efficiency of the circuit during normal operation. It is for this reason that smaller component values are generally preferred. We measured the efficiency of the circuit versus the output load for: (1) no snubber; (2) a 91Ω, 220pF snubber; (3) a 91Ω, 270pF snubber; and (4) a 91Ω, 330pF snubber on ST1 and ST2 (**Figure 4**).

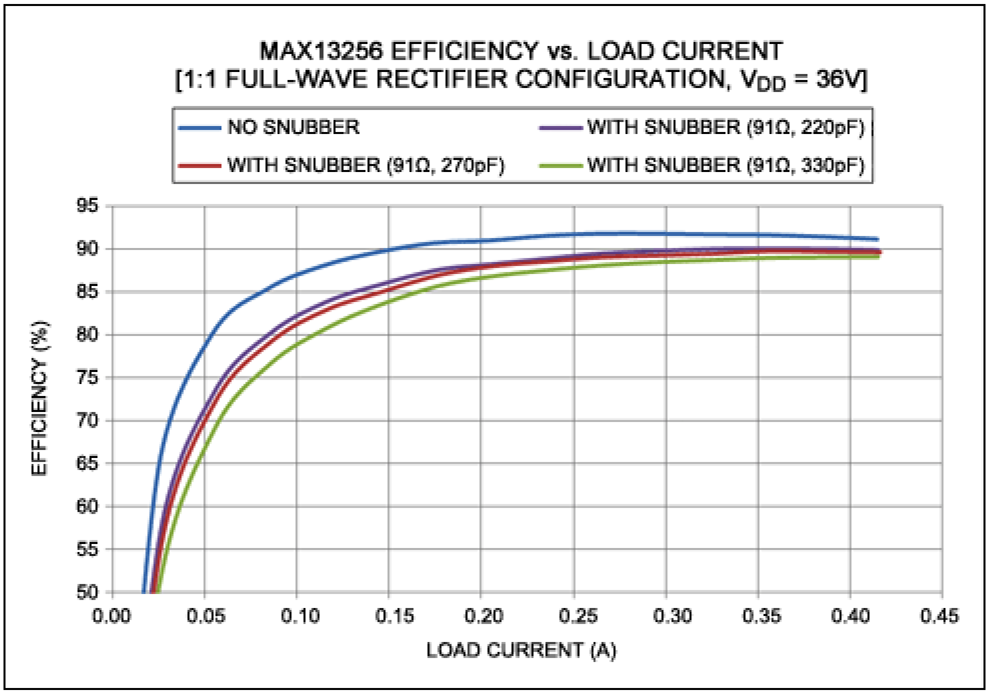

Figure 4. Efficiency vs. load measurements for the MAX13256.

Figure 4 clearly shows that the addition of any snubber reduces the efficiency of the circuit. The actual size of the snubber components (in particular, the snubber capacitance for this example) will depend on the load during normal operation and a trade-off between efficiency and protection. In this case, the efficiency varies more at smaller loads than at large loads for the different snubber-capacitor values.

Related Parts	
MAX13256	36V H-Bridge Transformer Driver for Isolated Supplies

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