CIRCUIT CELLAR ONLINE

THE MAGAZINE FOR COMPUTER APPLICATIONS

Circuit Cellar Online offers articles illustrating creative solutions and unique applications through complete projects, practical tutorials, and useful design techniques.

RESOURCE PAGES

RESOURCE LINKS

A Guide to online information about:

Snubbers (dV/dt)

by Bob Paddock

Because I needed to find information on solid-state relays (SSRs) for this months other Resource Page, I decided to do this one on Snubbers, because you generally need to use a Snubber when you use an SSR.

The reason that you need to use a Snubber with most solid-state switches has to do with what is know as dV/dt.

Static dV/dt turn-on is a consequence of the Miller effect and regeneration (see Figure 1). A change in voltage across the junction capacitance induces a current through it. This current is proportional to the rate of voltage change dV/dt. It triggers the device on when it becomes large enough to raise the sum of the NPN and PNP transistor alphas to unity.

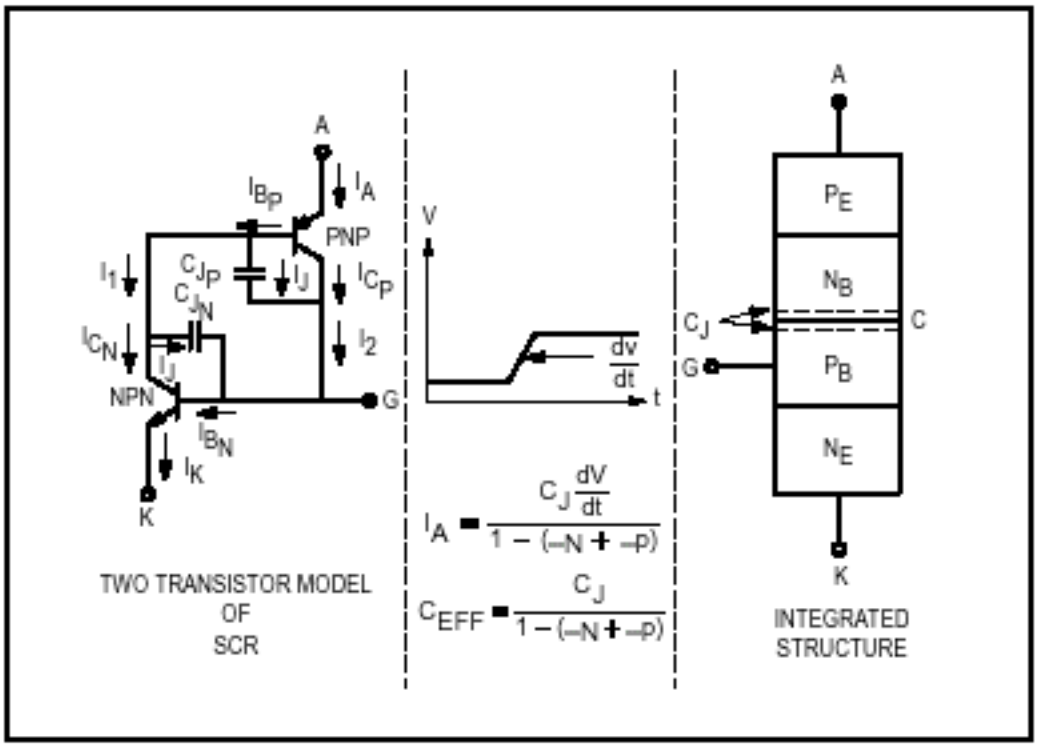


Figure 1

For an in-depth discussion of dV/dt, see "RC Snubber Networks For Thyristor Power Control and Transient Suppression" by George Templeton in Motorola Application Note #1048.

> "RC Snubbers are used to control transients that could falsely turn on a thyristor or triac. But if not used properly they can cause unreliable operation and even damage to the device. This detailed analysis of the problem examines the physics, and provides design examples for many practical applications."

In Dilbert logic, my first job right out of school was one where was I made responsible (i.e., "If it goes wrong, its your fault") for a project that was already designed using Triacs and a RCA 1802 CPU (state of the art back then). I got to experience the real-world effects of dV/dt. The obvious solution was to install Snubbers on all the outputs (alas, third party equipment that I had no control over). I saw these new Snubbers as a low enough impedance to turn on their high impedance inputs.

I swore that I'd never use triacs in anything I would ever design again because of this first real-world experience with them. Fortunately with today's technology, there are IGBT- and MOS-based output devices where dV/dt is less of an issue, but still not one that should be over looked.

What you want to use in place of triacs are reverse parallel SCRs. In every way, the reverse parallel SCR looks like a triac to your circuit, but it will have a much greater dV/dt rating.

Obviously that would require a lot more space, but Teccor makes their Alternistor family of parts for exactly this application. (I've always wondered if it was at my request, because it was the Teccor triacs that gave me problems as a result of their misapplication.) The Teccor Alternistor has been specifically designed for applications that are required to switch highly inductive loads. To accomplish this, a special chip has been designed that effectively offers the

same performance as two thyristors (SCRs) wired inverse parallel (back-to-back).

Don't overlook your gate drive dV/dt at this point as it may now be the weak dV/dt link. At one point, Siemens made their IL400 optocoupler that had its output made from back-to-back SCRs. I know this particular part was discontinued; it may have been replaced by the IL410, but a quick search at http://www.infineon.com/ didn't find it. http://www.clare.com/ may have also, or may still be, making a similar part, but again a quick search did not find it today.

STMicroelectronics has released their new-and-improved triacs to address the dV/dt problem, see *Improvement In The Triac Commutation.*

They also have an application showing a magnetic snubber, rather than the standard resister/capacitor-based Snubber. See *Magnetic Snubber For 200W PFC With Universal Mains.*

> "In high voltage continuous mode boost converters, a significant part of the power MOSFET switching losses is related to the turn-on edge. In fact, at turn on, the power MOSFET has to sustain both the boost diode reverse recovery and the stray capacitances associated energies. Moreover, the additional peak current due to the recovery of the diode can be significantly high, in particular at high temperature, thus increasing the high frequency noise, the E.M.I. filter requirements and reducing efficiency. The turn on peak current, generating all the above mentioned problems, has been dramatically reduced by using the magnetic snubber we propose at Fig. 1b. The concept of this snubber is to reduce (and control) the turn-on di/dt of the MOSFET to the most convenient value, considering the voltages and switching frequency applied to the system."

Also, there is their *New High Voltage Ultra-Fast Diodes: The Turboswitch A and B Series* of diodes designed for Snubber applications.

> "In today's power converter, the commutation speed of the transistor and the operating frequencies are higher and higher. Fast diodes used for freewheel, snubber, and rectifier functions become one of the main causes of the power losses. In the range of 600V-1200V, SGS THOMSON has developed a new family of ultrafast diodes. Taking into account these new constraints which are different from one application to another, SGS-THOMSON proposes two series: TURBOSWITCH 'A' and TURBOSWITCH 'B'."

National Semiconductor covers Snubber design in their application note "20 Watt Simple Switcher Forward Converter."

> "With the input and output conditions identified, the design procedure begins with the transformer design, followed by the output filter and snubber circuit design."

Lastly, take a look at the extensive application note from Intersil on zero-voltage switching, another way to lessen the requirements on Snubbers, "CA3059 and CA3079 zero-voltage switches are monolithic integrated circuits designed primarily for use as trigger circuits for thyristors in many highly diverse AC power control".

Now let's move on to those Resource Links about Snubbers.

CDE

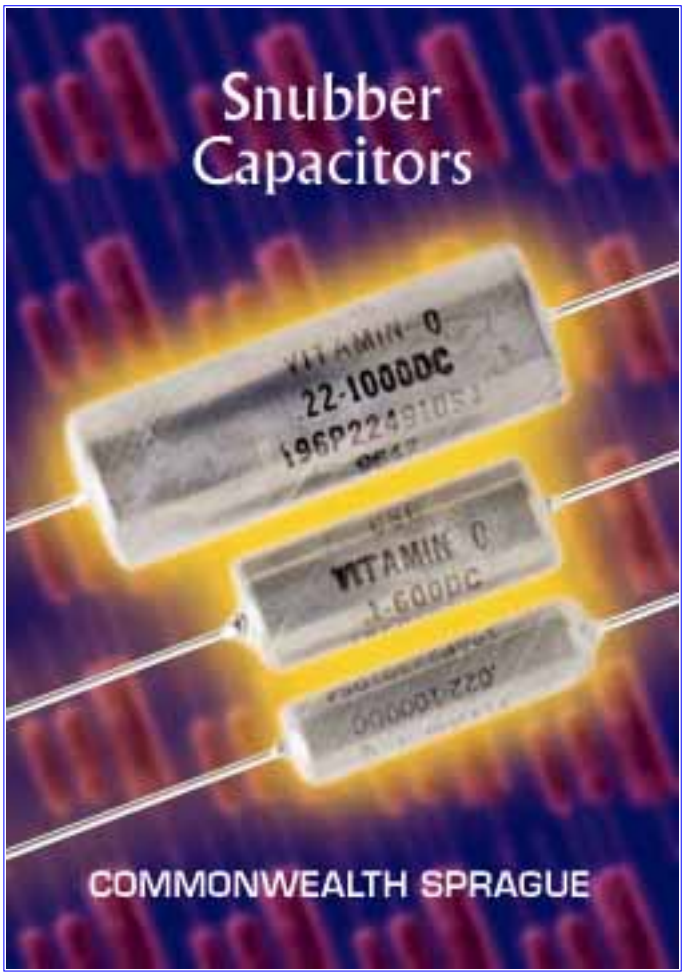
Cornell Dubilier manufactures all type of capacitors, one of them being Snubbers.

If you need to use a Snubber, then *Design of Snubbers for Power Circuits* is "must read" material. Other Cornell-Dubiler application notes can be found here.

Commonwealth Sprague

http://www.comsprague.com

Commonwealth Sprague is a manufacturer of motor run, snubber, and commutation capacitors, power factor correction assemblies, and harmonic filters.



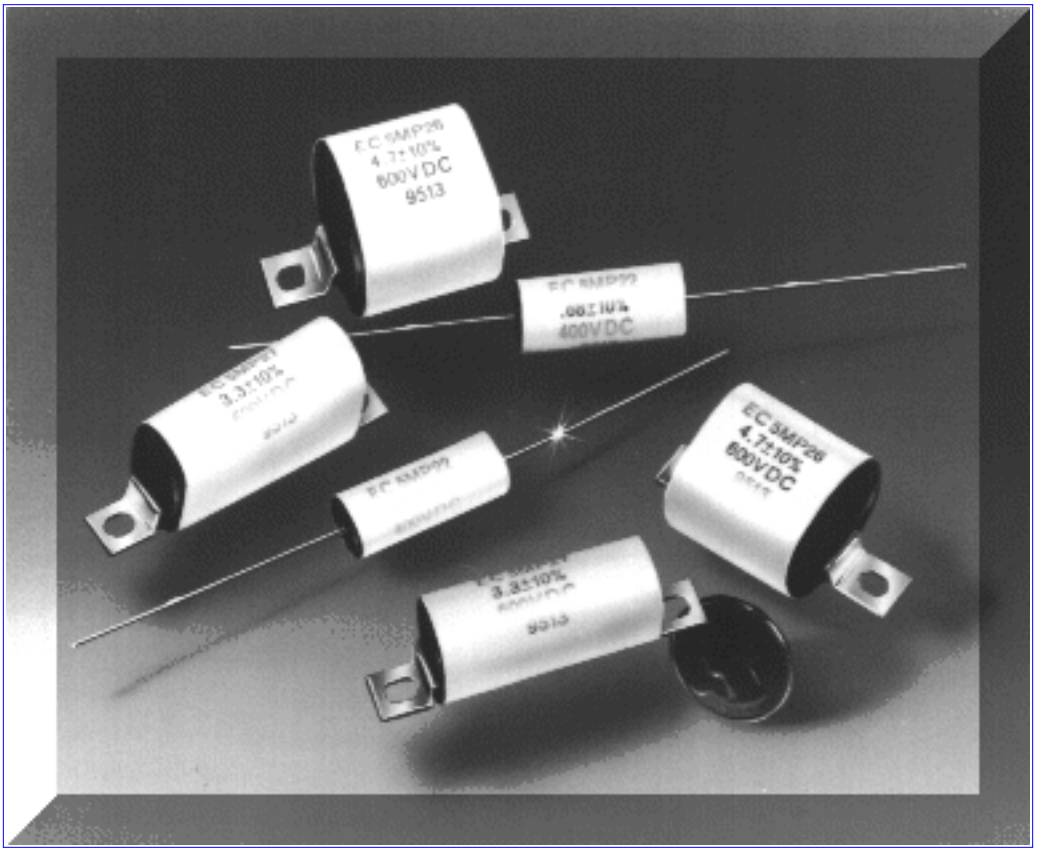
ELECTRONIC FILM CAPACITORS

EFC

EFC Series M1206 are polypropylene capacitors with double-sided metallized plates. This series offers the advantages of a self-healing metallized dielectric and the high current/pulsing capabilities (see dv/dt Table) of a metallized capacitor. (Note: Don't be mislead by the "1206" number, these parts are far from SMT sized.)

EFC's manufactures several different lines of Snubber products. Also, EFC will manufacture to any non-standard value and size.

Electronic Concepts, Inc. manufactures the 5MP2 Snubber Polypropylene Capacitor (among others such as the MP80 and MP88 capacitors).

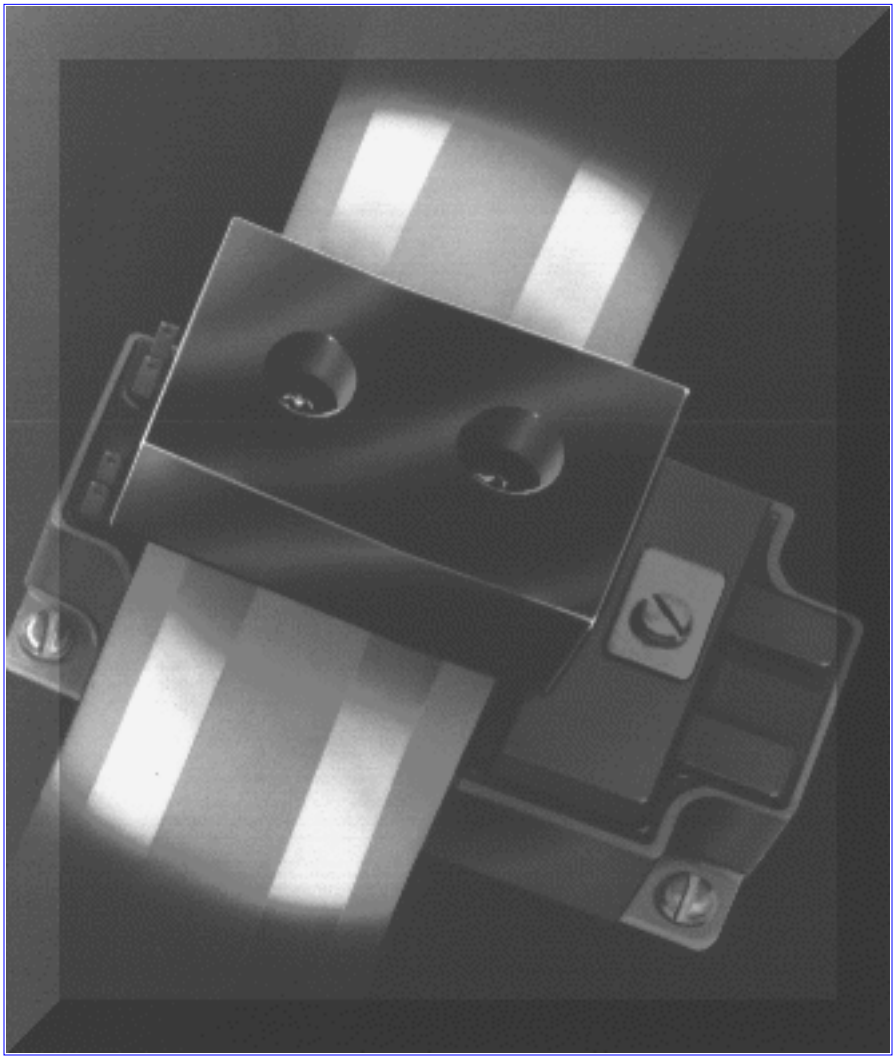


The MP80 and MP88 capacitors are especially designed for protecting IGBT's used in inverters and chargers in electric vehicles.

Key benefits:

- reduces inductance up to 90% and eliminates spiking

- voltage ratings of 400 to 1500 VDC
- continuous current carrying capacity to 45 A
- ESR as low as 0.003 ohms.
- operating temperature: –55°C to 105°C



GE Industrial Systems

General Electric Industrial Systems has capacitors and Surge Protection Devices the sizes of railroad box cars.

HIGH ENERGY CORP.

High Energy's commutation and snubber capacitors are designed to be used in high-powered thyristor circuits. Applications include motor drives, inverters, and

traction.

Norfolk Capacitors Limited (NCL) focuses on the design and supply of capacitors in the field of power electronics. Capacitors for traction applications are the core business, so if you need a snubber for a railroad sized application, they are the place to look for Snubbers. Check out their Thyristor Snubber Capacitors.

To go along with railroad sized capacitors you'll need resisters sized to match from C. Schniewindt KG.

Nissei-Arcotronics is a global supplier of film capacitors and Snubbers.

Spark Quenching R-C Networks for inductive and solid-state relay protection reduce the back EMF surges associated with inductive loads from Okaya Electric America, Inc.

I thought the 20-lb., 100-kW Resonant Snubber Inverter for Hybrid Vehicles was interesting even if its not really a Snubber per se.

While conventional invertors use six power switches to achieve the desired voltage output, the new Snubber inverter adds three small auxiliary switches that temporarily (and briefly) deliver current, then route it back to one of the six main switches. This diversion, lasting only a few microseconds, produces a zero voltage across the switch and helps reduce damaging power spikes.

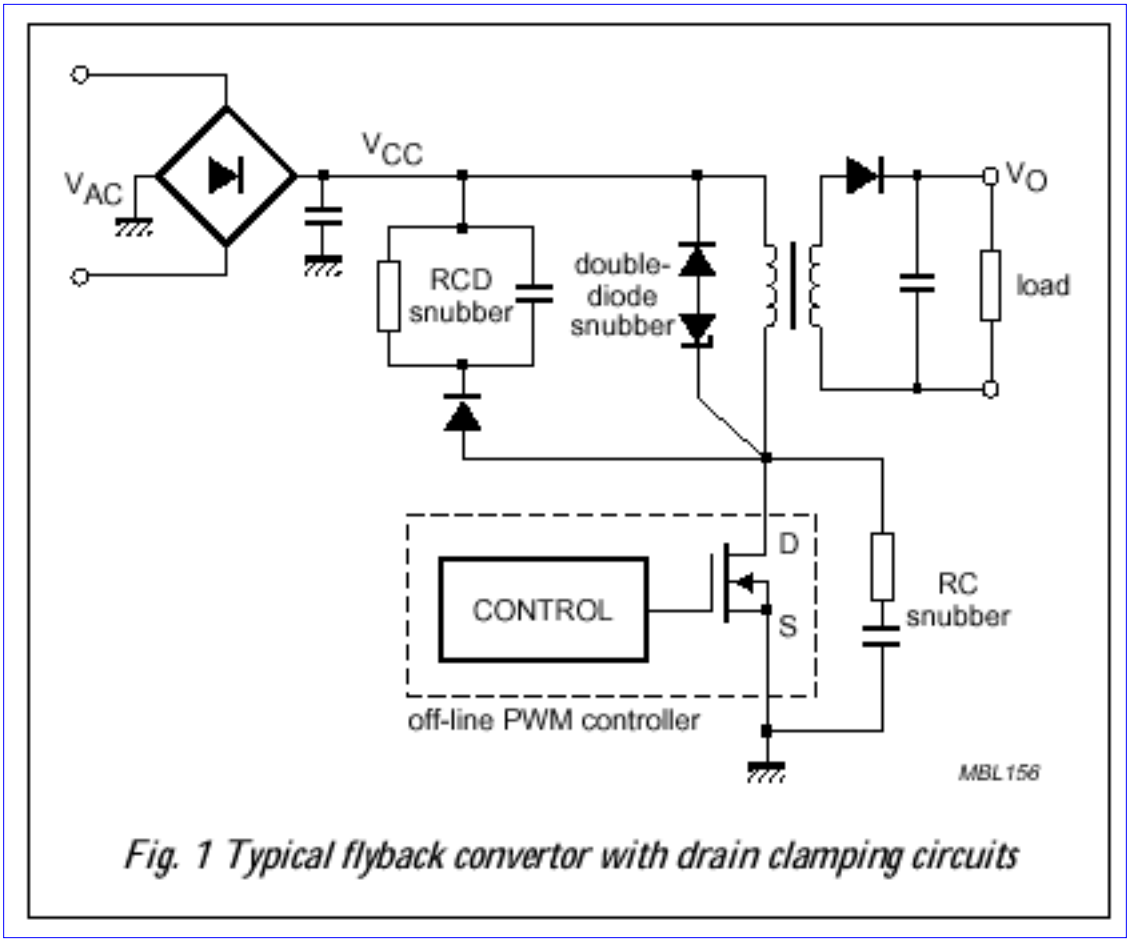


Fig. 1 Typical flyback convertor with drain clamping circuits

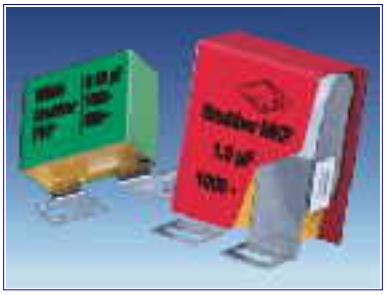
The Philips Semiconductor ZenBlock™ replaces double-diode-, RCD-, or RC-snubbers in flyback convertors. The new components offer circuit designers the important benefits of lower component count and board usage, reduced EMI, optimal clamping at all loads, and higher efficiency.

Application note: "Zener with integrated blocking diode Philips Semiconductors' new ZenBlock™"

Ridely Engineering offers some design tips on Snubber Design.

SOUTHERN ELECTRONICS is known for producing precision and close tolerance capacitors, custom designs as well as standard types. More than 50% of SOUTHERN ELECTRONICS production consists of non-standard capacitors.

Alas, all I could get online about their Snubber's was the message "Data Table & Specs will be available soon."



WIMA polypropylene Snubber capacitors are developed to meet the demands of high-power converter technology and are available in manifold connecting configuration.

Stop by the
Circuit Cellar News Sever
and join some of the interesting discussion,

or start one of your own.
See you there...

If you would like to add any information on this topic or request a specific topic to be covered, contact Bob Paddock.

Circuit Cellar provides up to date information for engineers, www.circuitcellar.com for more information and additional articles.