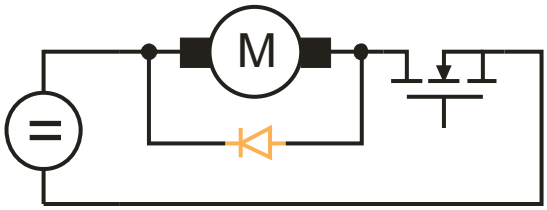
Free-Wheeling Diodes for Inductive-Load Switches in Motors and Relays

Free-wheeling diodes are mandatory devices in every application where inductors – such as motor coils or relay windings – are used. Inductive loads like that are normally controlled by a switch. The complexity of the control can hereby vary: from a simple on/off switch to a complex 3-phase control method. In many cases, the switch is a realized electronically, such as a MOSFET or IGBT. But why a diode is needed? It is the nature of an inductor to keep an electric current flowing, once it has started. The physical description of this behaviour is done by the formula

$$v = L \times di/dt \quad (1)$$

The circuit below shows a very common industrial application: a speed-controlled DC motor. As long as the switch (MOSFET) is closed, a current flows through the motor coils. During the off time of the switch, the current through the coils needs to continue to flow. Since the switch is open, the current finds a so-called free-wheeling path through the diode. Without that device, an extreme di/dt would occur, causing an extreme voltage spike v – according to formula (1). At ignition coils that peak is desired, but in other applications it can destroy the switch component. Therefore a free-wheeling diode is mandatory.



In low voltage systems, a Schottky diode is in many cases the preferred choice. However, Schottkys have a limited breakdown voltage. At 100V their V_F is no longer competitive. Schottkys are advantageous at very high switching frequencies f_S; but in most industrial applications f_S is quite low – below 40kHz – to avoid EMI problems. At low and medium switching frequencies, Fast to Ultrafast Recovery rectifiers can be used. In simple on/off DC systems even Standard Recovery devices are possible.

The high switching speed of a MOSFET, and also sparks generated by the collector of DC motors can generate inductive voltage spikes, which can harm the diode. So careful analysis is needed to make sure the diode is not destroyed by reverse energy. A new solution for all of these applications are the so-called **Protectifiers®** developed by Diotec Semiconductor:

Protectifiers® are "protected rectifiers", having a low forward voltage drop V_F and a very robust reverse characteristic, comparable to suppressor diodes (TVS). They are much more rugged than some Schottky diodes on the market where a certain (low) reverse avalanche energy is given. Parts can be supplied with a reverse recovery time of about 200ns, allowing them to be used up to several 10 kHz.

Protectifiers® are characterized and tested with 10/1000µs lightning pulses to determine the reverse energy they can absorb; they can easily withstand the lower energy ESD pulses. The guaranteed reverse energy capability and tested clamping voltage is an advantage for the designer. It eliminates uncertainty in the circuit and in some applications it also allows a reduction in the voltage of the MOSFET used. This can be a significant cost saving!

One of the first available devices is the KT20xx series, a 20A/120V...150V device in TO-220AC package. Complete Datasheet see http://www.diotec.com/