

NEW FAMILY OF DAMPER AND MODULATION DIODES FOR HORIZONTAL DEFLECTION CIRCUIT

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INTRODUCTION

STMicroelectronics is introducing a new family of DAMPER and MODULATION diodes for horizontal deflection circuits in TV and Monitor applications. This application note will discuss the key parameters of the DAMPER diode and its associated losses.

A wide range of DAMPER and MODULATION diodes will be outlined and some criteria will be given to select the appropriate component.

At $t=t_0$ the transistor starts to turn on. The current in the line yoke and in the transistor is given by:

$$I_T = I_L = (V_0 / L)t$$

The voltage V_T across the diode is equal to V_{CEsat} , the DAMPER diode is blocked.

1. KEY PARAMETERS OF DAMPER DIODES IN BASIC HORIZONTAL DEFLECTION CIRCUIT

1.1 Behaviour of the basic circuit of the Horizontal Deflection Power Stage

In order to understand the key parameters of the DAMPER diode, it is interesting to refer back to the behaviour of a basic horizontal deflection circuit.

The basic horizontal deflection circuit (without East-West correction) is shown in Fig. 1 and the main current and voltage waveforms in Fig. 2.

Fig. 1: Simplified diagram of the horizontal deflection stage

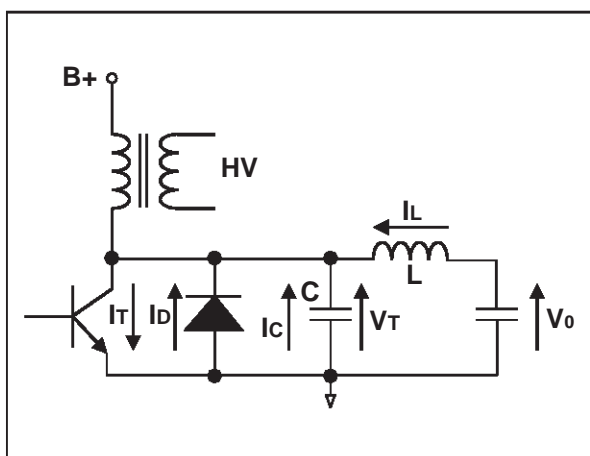
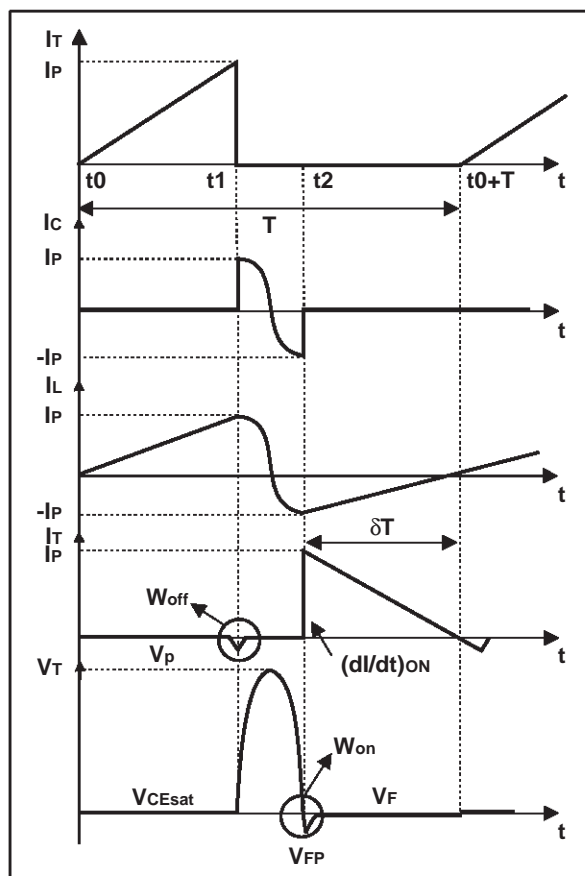


Fig. 2: Waveforms in the basic horizontal deflection circuit



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At $t=t_1$, the transistor turns off. The circuit becomes resonant (V_0 -L-C), a high voltage appears across the diode (typically about 1100V). This is the reason why 1500V components are generally used. The current passes from I_P to $-I_P$.

At $t=t_2$, the voltage V_T becomes negative and the DAMPER diode starts to turn on. The current through the diode and the yoke is given by:

$$I_D = I_P - (V_0 / L)t$$

At t_0+T a new cycle starts.

1.2 Key parameters of DAMPER diodes and their associated losses

1.2.1 Forward voltage (V_F) and conduction losses (P_{cond})

Conduction losses can be calculated by:

$$P_{cond} = V_{to} \cdot \delta \cdot I_P / 2 + R_d \cdot \delta \cdot I_P^2 / 3$$

with $V_F(I_F) = V_{to} + R_d \cdot I_F$

Example: DTV1500M $V_{to} = 1.37V$
 $R_d = 0.047\Omega$

$I_P = 4A$ $\delta = 0.45$

$P_{cond} = 1.35W$

1.2.2 Peak forward voltage (V_{FP}) and turn on switching losses (P_{on})

At $t=t_2$, when the diode turns on, there is in the same time current and overvoltage across the diode (Fig. 3) causing switching on energy: W_{on} can be calculated by:

$$W_{on} = \int_0^{t_{fr}} v \cdot idt \quad (\text{Fig. 3})$$

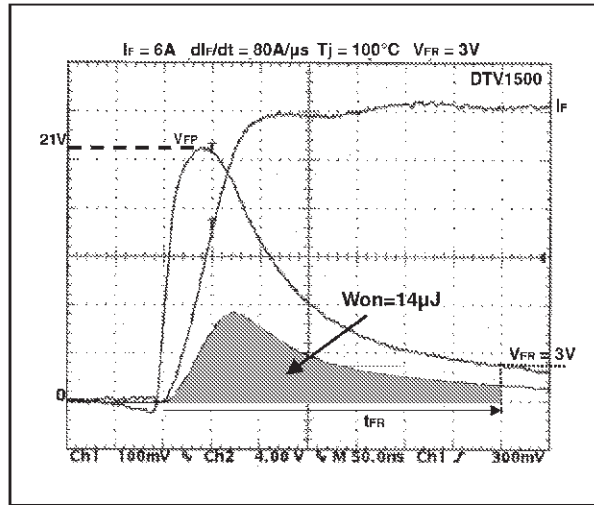
and $P_{on} = W_{on} \cdot F$

Example: DTV1500M in the conditions of Fig.3

$W_{on} = 14\mu J$

$P_{on} = 0.98W$ at 70kHz

Fig. 3 : Current, voltage and switching energy in DAMPER diode at turn on



For high switching frequencies, this example shows that P_{on} is high and V_{FP} becomes a critical parameter. V_{FP} increases with $(di/dt)_{ON}$. In this application, this parameter is mainly fixed by the layout and is generally lower than $100A/\mu s$.

1.2.3 Leakage current and reverse losses

The new family of DAMPER diodes uses new technology allowing a very low leakage current and negligible reverse losses in comparison with the other losses.

1.2.4 Reverse recovery time (t_{rr}) and turn off switching losses (P_{off})

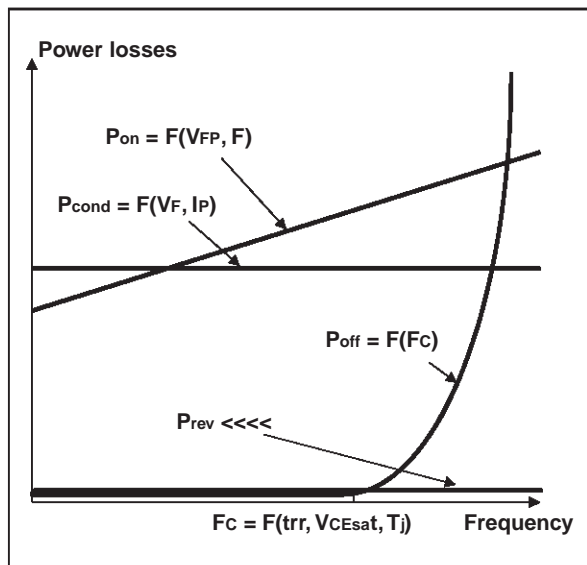
At $t=t_0$, when the diode turns off, the reapplied voltage is low (V_{CEsat} of the transistor), and the corresponding switching energy W_{off} is also very low (between t_0 and t_1). Due to this low reapplied voltage, the DAMPER diode takes time to evacuate all these reverse recovery charges. For a given frequency, if t_{rr} is too high, there are always charges when the transistor turns off (at t_1). In this situation the reverse recovery charge is evacuated over a high voltage inducing high switching energy W_{off} (Fig. 2). We can consider this as a critical frequency F_C . Below F_C , W_{off} is negligible (the DAMPER diode has evacuated all the reverse recovery charges at t_0). Above F_C , the switching energy increases very rapidly and can lead to a thermal runaway problem. This critical frequency depends not only on the reverse recovery time, but also on the operating junction temperature of the diode and V_{CEsat} .

The higher the V_{CEsat} , the higher F_C (the diode evacuating these charges more quickly). In a deflection design it is important to have a negligible W_{off} (to keep the junction temperature under control). This is the reason why STMicroelectronics has developed DAMPER diodes with a low reverse recovery time.

The Fig. 4 summarizes the main features of the different losses as follows:

- P_{on} are proportional to V_{FP} and F
- P_{cond} depend on V_F (V_{t0}, R_d), I_P and δ
- P_{rev} are negligible
- P_{off} are negligible for $F < F_C$ and increase very quickly for $F > F_C$
- F_C depends on trr , T_j , V_{CEsat}

Fig. 4: Main features of the different losses



2. ST DAMPER FAMILY

In new monitor designs, horizontal deflection frequency is becoming higher and higher. In a conventional 15 inches monitor, the maximum frequency can be higher than 70kHz, and in a high end monitor this frequency can reach 130kHz.

This evolution has led STMicroelectronics to develop a new family of DAMPER diodes with very good dynamical parameters (low V_{FP} and trr).

The new ST DAMPER diodes have a low trr in order to get a higher critical frequency (F_C). This new technology allows V_{FP} to be reduced and as a consequence, the turn on switching losses are also reduced.

The table in Fig. 5 shows the four different types of DAMPER diode: the L, M, H and UH families with their key parameters. Every device is available in TO-220AC, TO-220FPAC and ISOWATT220AC.

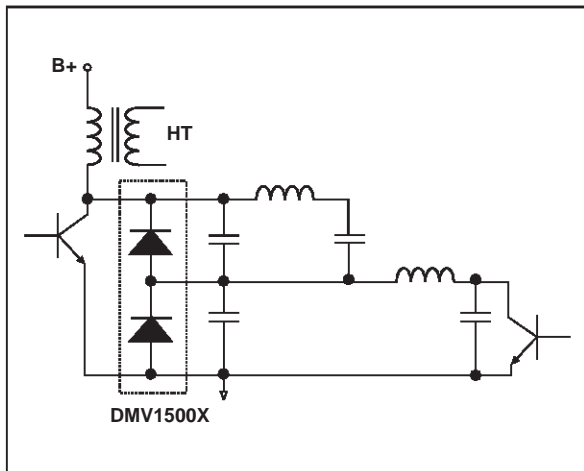
Fig. 5: Key parameters of the different DAMPER diodes

	V_F max (6A, 125°C) (V)	trr max (1A, 50A/ μ s 30V, 25°C) (ns)	V_{FP} typ (6A, 80A/ μ s 100°C) (V)	V_{RM} (V)
	(4A)		(4A)	
DTV1500L	1.5	170	28	1500
DTV1500M	1.65	135	21	1500
DTV1500H	1.7	125	18	1500
DTV1500UH	1.3	125	12	1500

For TV and 14, 15, 17 inches monitors the DAMPER diode is generally associated with a MODULATION diode for East-West correction Fig. 6.

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Fig. 6: Basic Circuit of the Horizontal deflection circuit with East-West correction



STMicroelectronics offers an axial MODULATION diode STTH306 and a DMV family DMV1500L, DMV1500M, DMV1500H.

The DMV1500X device is a DAMPER diode with a MODULATION diode in an isolated TO-220 package.

Electrical parameters of the DAMPER diode are the same as the DTV1500L, DTV1500M, and DTV1500H respectively. The MODULATION diode is a 600V device with very good dynamical parameters (low trr and V_{FP}).

The main parameters of the MODULATION diode are:

$$trr_{max} (1A, 50A/\mu s, 30V, 25^{\circ}C) = 50ns$$

$$V_{Fmax} (3A, 125^{\circ}C) = 1.4V$$

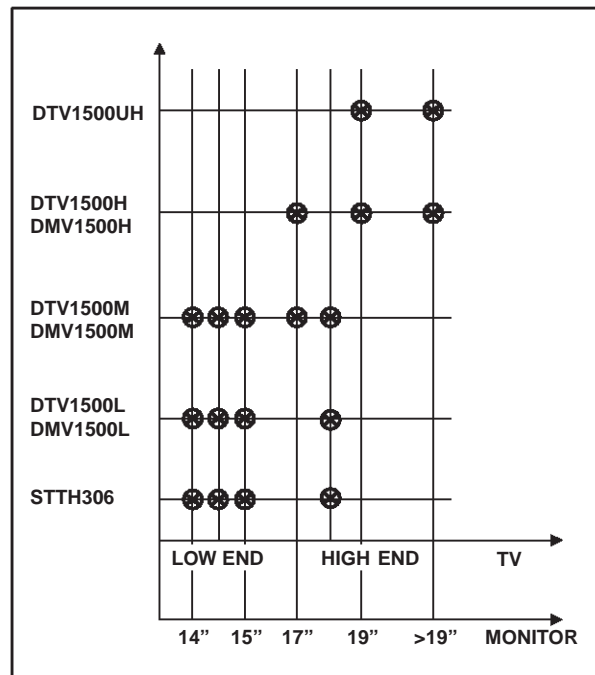
$$V_{FPmax} (3A, 80A/\mu s, 100^{\circ}C) = 8V$$

Generally, monitor manufacturers have the following rule to design DAMPER and MODULATION diodes: the case temperature of the device has to be lower than $100^{\circ}C$ for a room temperature equal to $40^{\circ}C$.

A very common question is: is it possible to use a DAMPER or a MODULATION diode with a peak current I_P higher than the average current ($I_{F(AV)}$) given in the datasheet? The answer is yes. The only limitations are the $I_{F(RMS)}$ value and the operating junction temperature. With the rule $T_{case} < 100^{\circ}C$, there is generally no problem when using these components with an I_P higher than $I_{F(AV)}$.

Fig. 7 shows the device generally used versus TV and Monitor size.

Fig. 7: DAMPER and MODULATION diode versus TV and monitor size



CONCLUSION

STMicroelectronics has developed an optimized family of DAMPER and MODULATION diodes specifically for TV and Monitor applications.

With the horizontal deflection frequency becoming higher and higher, ST has developed devices with very good dynamical parameters (low trr and V_{FP}).

ST offers a wide range of DAMPER and MODULATION diodes allowing the designer to choose an appropriate performance-cost solution.

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