TA0319
TECHNICAL ARTICLE

New Damper Diodes Family for CRT TV & CRT Monitor
The Coolest Damper Diodes

1 Introduction

STMicroelectronics is well established in the CRT Monitor and CRT TV market and is known for the high reliability and optimized damper devices. As a matter of fact, STMicroelectronics is a market leader for Damper diodes in CRT TV and CRT Monitor.

ST has introduced a new family of **Co-Packed Damper + Modulation** diodes for **horizontal deflection circuits** in CRT Monitor from 15" to 21" and high end CRT TV application such as **100Hz TV** and **HDTV**.

2 Market trends

The CRT market is facing high competition from Flat Panel Displays (FPD) such as LCD TV and Monitor. Indeed, the LCD Monitor market is already overtaking the CRT Monitor market and the LCD TV market is booming. However, the opportunities are there for CRT TV and slim CRT TV as well as CRT HDTV will drive CRT future market.

3 Key parameters of damper diodes

3.1 Behaviour of the basic circuit of the horizontal deflection power stage

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 *Figure 1* and the main current and voltage waveforms in *Figure 2*

Figure 1. Simplified diagram of the horizontal deflection stage

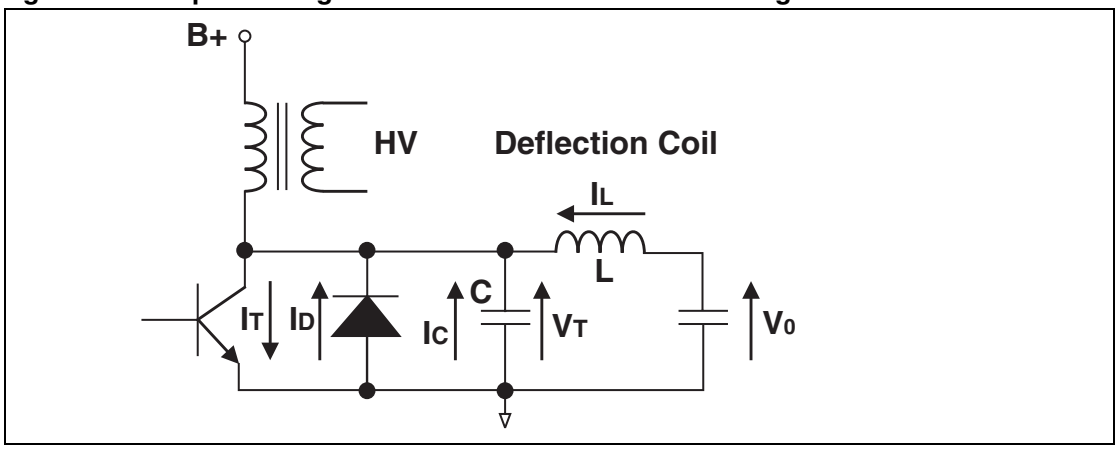
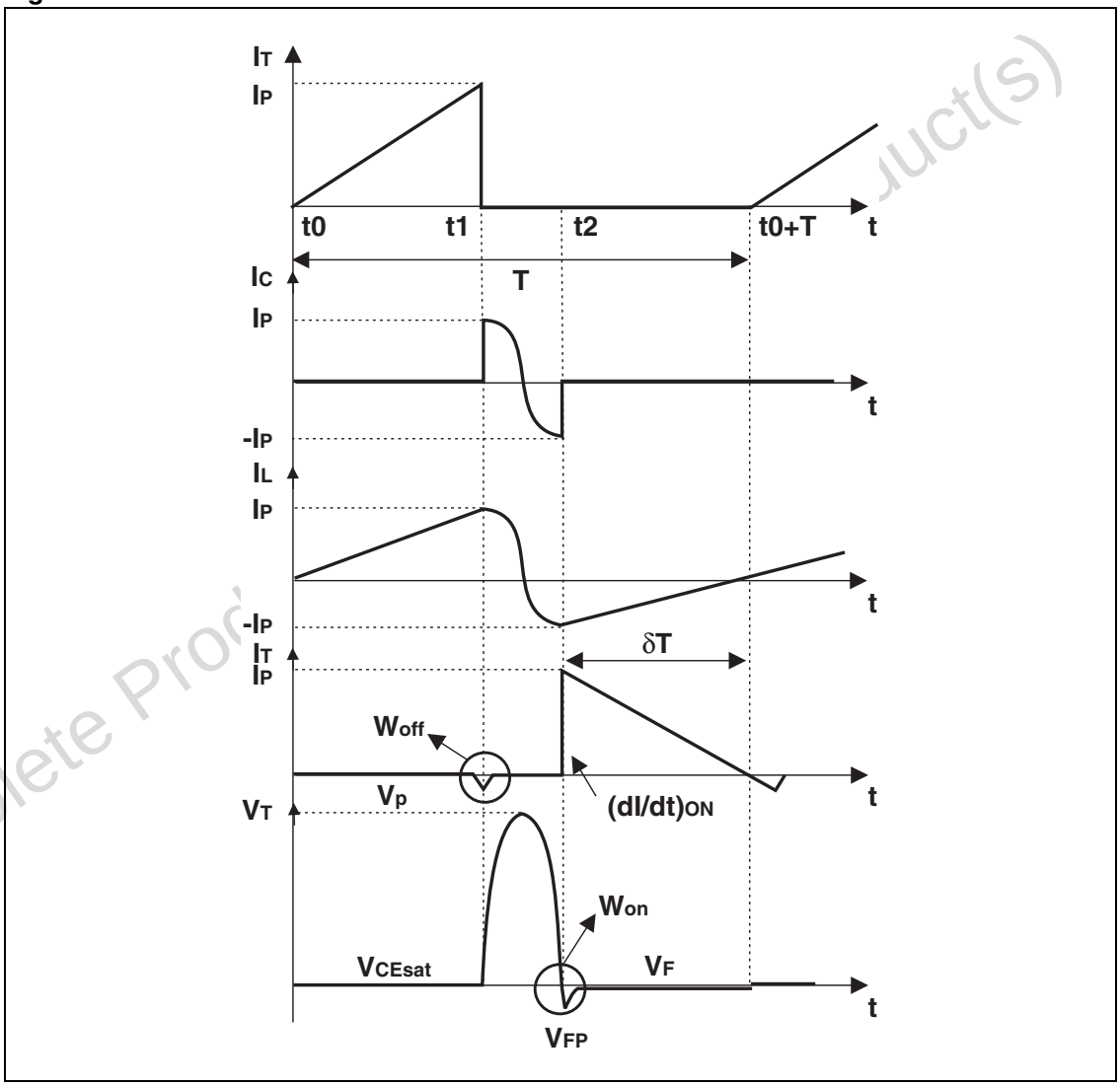


Figure 2. Waveforms in the basic horizontal deflection circuit



At t=t0 the transistor starts to turn on. The current in the line deflection coil 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.

At t=t1, 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=t2, 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 t0+T a new cycle starts.

3.2 Key parameters of DAMPER diodes and their associated losses losses (P_{cond})

The power losses are broken down as follow :

P_{on}: Switch-on power losses depending on peak forward voltage (V_{FP})

P_{cond}: Conduction power losses depending on forward voltage (V_F)

P_{rev}: Reverse power losses depending on leakage current (I_R)

P_{off}: Switch-off power losses depending on reverse recovery time (t_{rr})

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

Conduction losses can be calculated by:

$P_{cond} = Vt_0.\delta.I_p/2 + R_d.\delta.I_p^2/3$

With $V_F(I_F) = Vt_0 + R_d.I_F$ and $\delta = (t_1-t_0)/T$

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

At t=t2, when the diode turns on, there is in the same time current and overvoltage across the diode (*Figure 3*) causing switching on energy: W_{on} can be calculated by:

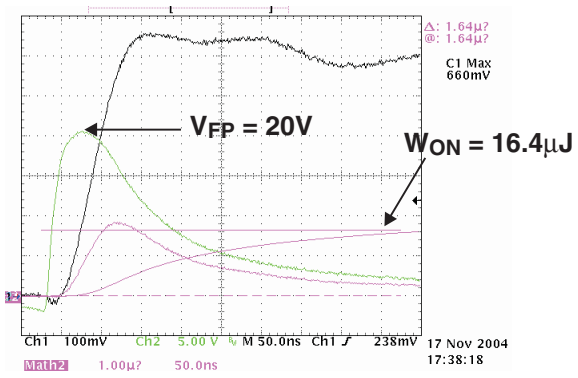
$$W_{on} = \int_0^{tfr} V.i\ dt \qquad \text{(See Figure 3)}$$

And the corresponding switching on power losses

$P_{on} = W_{on}.F$

Example: W_{on}= 16.4 J, with F=32kHz, Pon=0.52W

Figure 3. Current, voltage and switching energy in DAMPER diode at turn on (DTV1500HDFP)



For high switching frequencies, 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 and is generally lower than 100A/µs.

3.2.3 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.

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

At t=t0, 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 t0 and t1). 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 still charges when the transistor turns off (at t1). In this situation the reverse recovery charge is evacuated over a high voltage inducing high switching energy W_{off} (*Figure 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 t0).

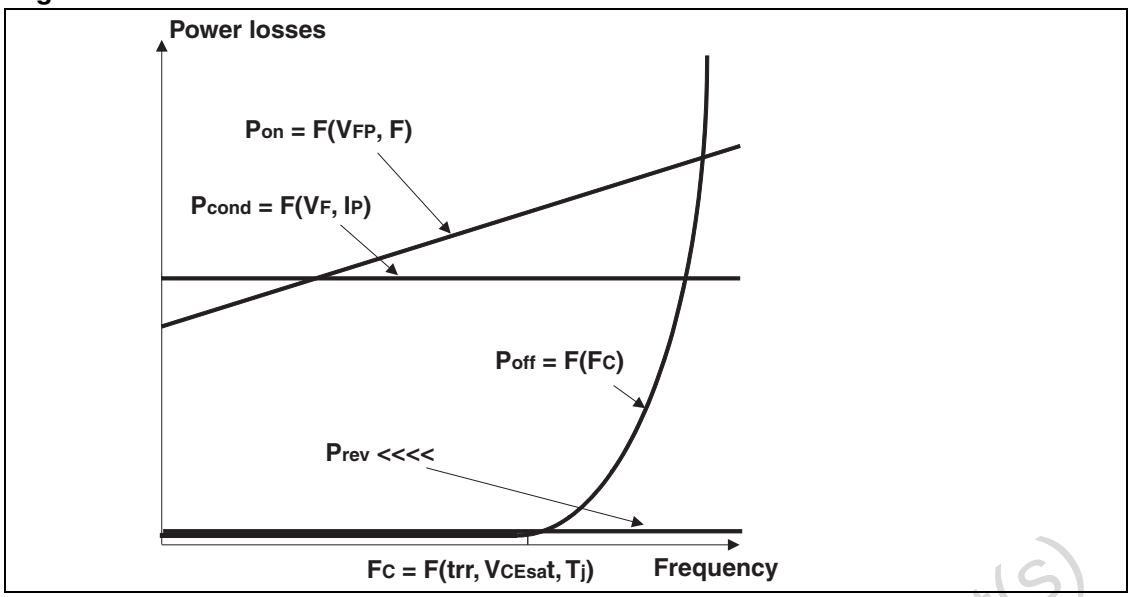
Above F_C, the switching energy increases very rapidly and can lead to a thermal runaway problem. This critical frequency depends not only on the reverse recovery time, but also on the operating junction temperature of the diode and V_{CEsat} of the transistor.

This is the reason why STMicroelectronics has developed two DAMPER diode families with t_{rr} optimized for the CRT TV deflection frequencies and optimized for CRT monitor frequencies.

Figure 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 (Vt_0,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 t_{rr}, T_j, V_{CEsat}

Figure 4. Main features of the different losses



3.3 DAMPER diodes design rules

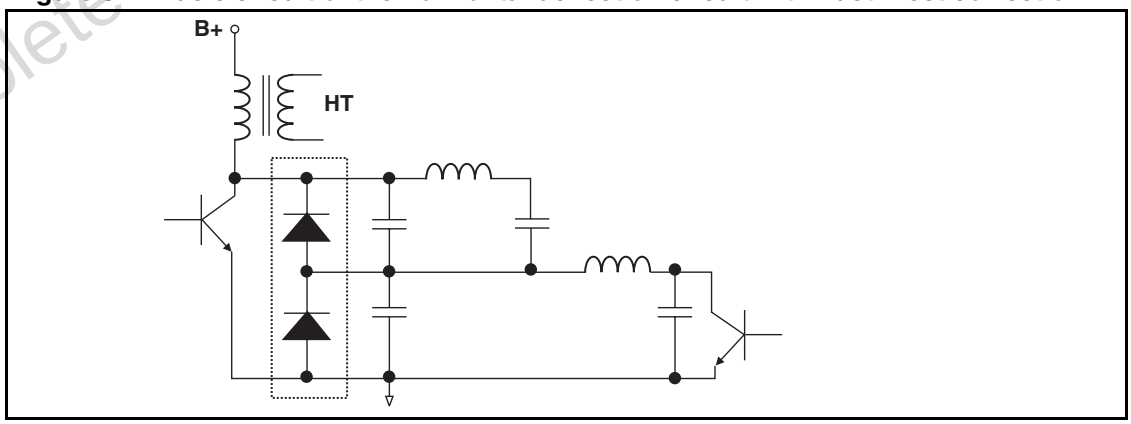
For CRT TV applications, the deflection frequency in a 100Hz or HDTV CRT TV design is lower than 56kHz. Therefore, a maximum t_{rr} of 250ns is fully compatible with high end CRT TV designs. For CRT Monitor application, where deflection frequencies can go up to 110kHz, the t_{rr} value becomes a critical parameter to minimize the power losses.

The qualification criteria for damper diodes, in addition to good screen image quality, is the temperature of the case and the leads at the solder joins (consequence of power losses). This temperature has to remain inside the design rules (lower than a defined value).

Also, a key qualification criteria is the total solution cost of the deflection circuit.

In addition, for big screen size, the deflection circuit is enriched with an east-west correction circuit. This circuit needs 600V diodes. These diodes are either standalone (in axial or through hole package) or integrated with the damper diode in a 3-pin full molded TO-220 package. The choice between stand alone and integrated solution is based on the cost / performance trade-off.

Figure 5. Basic circuit of the horizontal deflection circuit with East-West correction



4 The best trade-off

To meet market requirements and to provide optimized cost and market segment differentiation STMicroelectronics has enhanced its damper diode range and has released a new damper range for CRT TV and new 3-pin full molded TO-220 package for CRT Monitor.

4.1 CRT TV application

For CRT TV application the maximum deflection frequency is 56kHz (HDTV). Both DTV1500SDFP and DTV1500HDFP are optimized and fit CRT TV horizontal deflection designs assuming the design rules are fulfilled.

For example, when the design rules are more severe (as regards to the case temperature (T_c)) or when the deflection frequency increases (V_{FP} becomes more critical) the choice can turn to the DTV1500HDFP.

Table 1. New CRT TV damper diodes

P/N	CONDITIONS	DTV1500SDFP	DTV1500HDFP
V_{RPM}		1500V	1500V
V_F (Typ)	6A, 125°C	1.1V	1.0V
V_{FP} (Typ)	6A, 80A/µs, 100°C	26V	21V
t_{rr} (max)	1A, -50A/µs, V_R=30V - 25°C	250ns	250ns

Table 1 shows new ST NEW DAMPER diodes: **DTV1500SDFP** (Standard Definition TV) and **DTV1500HDFP** (High Definition TV) with their respective key parameters.

Both diodes are also available with modulation diode integration in a **NEW 3-pin full molded TO-220FPAB** package : **DMV1500SDFD** (Standard Definition TV) and **DMV1500HDFD** (High Definition TV).

Table 2. New 3-pin full molded TO-220FPAB package for CRT TV

	P/N	CONDITIONS	DTV1500SDFD	DTV1500HDFD
DAMPER	V_{RPM}		1500V	1500V
	V_F (Typ)	6A, 125°C	1.1V	1.0V
	V_{FP} (Typ)	6A, 80A/µs, 100°C	26V	21V
	t_{rr} (max)	1A, -50A/µs, V_R=30V - 25°C	250ns	250ns
MODULATION	V_{RPM}		600V	600V
	V_F (Typ)	6A, 125°C	1.0V	1.0V
	V_{FP} (Typ)	6A, 80A/µs, 100°C	TBD	TBD
	t_{rr} (max)	1A, -50A/µs, V_R=30V - 25°C	80ns	80ns
	PACKAGE		TO-220FPAB	TO-220FPAB

Table 2 shows new ST 3-pin full molded TO-220 package: **DMV1500SDFD** (Standard Definition TV) and **DMV1500HDFD** (High Definition TV) with their respective key parameters.

The **new** family of **DAMPER diodes** have very good dynamic (**low V_{FP}**) and static parameters (low V_F) to meet CRT TV technical requirements.

4.2 CRT monitor application

In CRT Monitor application, frequencies are spread from 32kHz to 110kHz.

STMicroelectronics has dedicated and optimized damper diodes for CRT monitor application. The recommended choice comes to DTV1500LFP, DTV1500MFP and DTV1500HFP.

Table 3. CRT Monitor Damper diodes

P/N	CONDITIONS	DTV1500LFP	DTV1500MFP	DTV1500HFP
V_{RPM}		1500V	1500V	1500V
V_F (Typ)	6A, 125°C	1.1V	1.2V	1.25V
V_{FP} (Typ)	6A, 80A/µs, 100°C	28V	21V	18V
t_{rr} (max)	1A, -50A/µs, V_R=30V - 25°C	130ns	110ns	95ns

Table 3 shows CRT Monitor DAMPER diodes: **DTV1500LFP** (17"), **DTV1500MFP** (19") and **DTV1500MFP** (21") with their respective key parameters.

All diodes are also available with modulation diode integration in a **NEW 3-pin full molded TO-220FPAB** package.

Table 4. New 3-pin full molded TO-220FPAB package for CRT monitor.

	P/N	CONDITIONS	DTV1500LFD	DTV1500MFD	DTV1500HFD
DAMPER	V_{RPM}		1500V	1500V	1500V
	V_F (Typ)	6A, 125°C	1.15V	1.2V	1.25V
	V_{FP} (Typ)	6A, 80A/µs, 100°C	28V	21V	18V
	t_{rr} (max)	1A, -50A/µs, V_R=30V - 25°C	130ns	110ns	95ns
MODULATION	V_{RPM}		600V	600V	600V
	V_F (Typ)	6A, 125°C	1.1V	1.1V	1.1V
	V_{FP} (Typ)	6A, 80A/µs, 100°C	8V	8V	8V
	t_{rr} (max)	1A, -50A/µs, V_R=30V - 25°C	35ns	35ns	35ns
	PACKAGE		TO-220FPAB	TO-220FPAB	TO-220FPAB

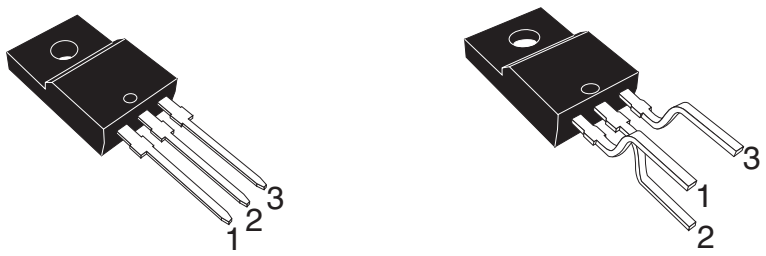
Table 4 shows new ST 3-pin full molded TO-220FPAB package: **DMV1500LFD** (15"), **DMV1500MFD** (17") and **DMV1500HFD** (19") with their respective key parameters.

4.3 Package

As explained, all damper diodes are also available with modulation diode integration in a **NEW 3-pin full molded TO-220FPAB package**. This new package offers full isolation and very good thermal resistance to minimize case and leads temperature during diodes operation.

Also, to comply with most of the design rules, this package is available with several optional lead bending.

Figure 6. Package lead bending options

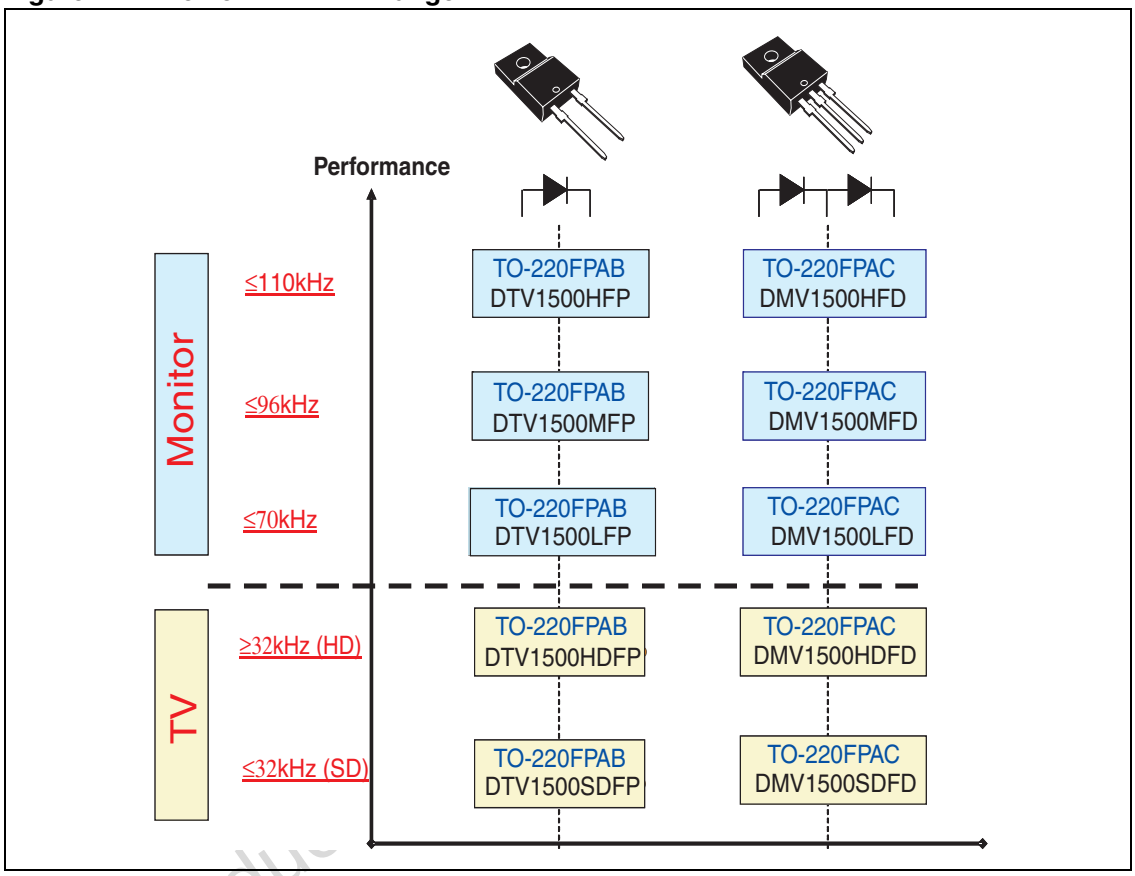


TO-220FPAB TO-220FPAB FD6

5 Conclusion

To offer the best in class trade off between price and performance for each CRT application, STMicroelectronics has introduced differentiated products for CRT TV and CRT monitor, on top of a new low cost full molded TO-220FP package.

Figure 7. The new DAMPER range.



The NEW Damper and NEW Co-packed Damper + Modulation devices from STMicroelectronics are the most optimized diodes on the market to achieve the new challenges of the CRT TV and CRT Monitor markets and designs as regards to the performance and competitiveness.