TLE8110EE

Switching Inductive Loads

Application Note

Rev.1.0, 2011-04-19

Automotive Power

Abstract

Note: The following information is given as a hint for the implementation of the device only and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.

This Application Note is intended to provide additional information regarding the Clamping Energy capabilities of the TLE8110EE, Smart 10-Channel Low-Side Switch of the coreFLEX family. The document has to be considered as an addendum to the Application Note *Multichannel Low-Side Switches - Switching Inductive Loads*.

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1 Clamping Energy versus Current (SOA)

The TLE8110EE channels can be grouped as following **Table 1**, according to DMOS size and symmetry.

Table 1 TLE8110EE channel groups

Channel Group	$R_{DS(MAX)}$ [Ω]	$I_{LIM(MIN)}$ [A]	$I_{LIM(MAX)}$ [A]
CH1-4	0.6	2.6	5.0
CH5-6	0.5	3.7	6.0
CH7-10	1.2	1.7	2.9

In the following sections the energy SOA will be shown for each channel group in order to give the possibility to the user to check the device capabilities in relation to his specific loads. For detailed description on how to measure/calculate the operating point (I_L, E_{CL}) for each load and how to do the application check, please refer to the TLE8110EE Data Sheet and to the Application Note *Multichannel Low-Side Switches - Switching Inductive Loads*. Three areas of energy will be shown for a cumulative scenario:

- Normal Operation
  - 10^9 cycles
- Mid Energy[1)]
  - either 10^4 cycles
  - or 10^5 cycles
- High Energy
  - 10 single pulses

1) In the case of mid energy area two different plots are shown (10^4 and 10^5 cycles) for more flexibility to the user, but in no case it is allowed to combine both operations at the same time in a cumulative scenario, use either one or the other curve.

1.1 Channel Group 1-4[1) 2) 3)]

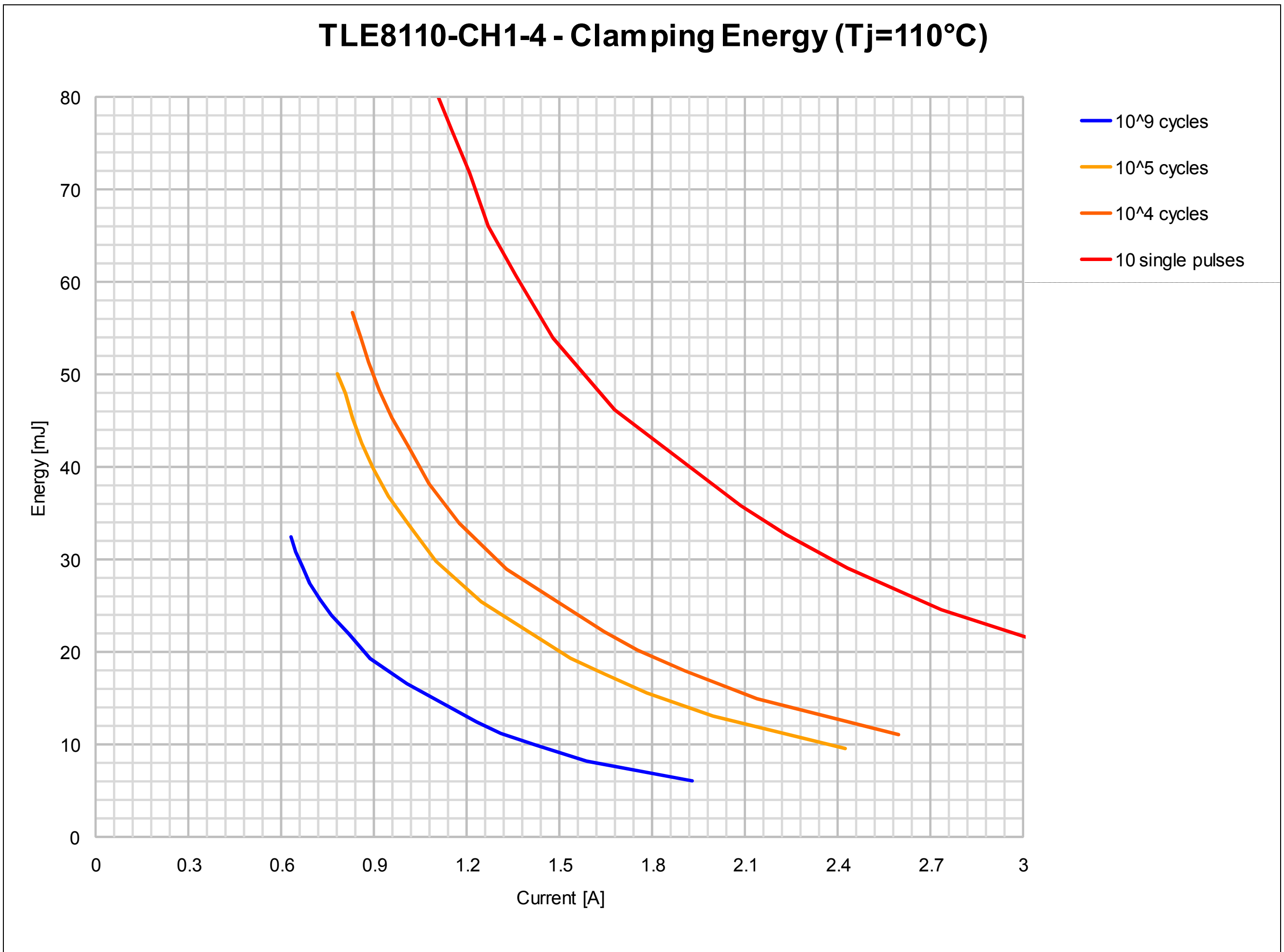

Figure 1 Energy SOA for TLE8110 - CH1-4 (T_J=110°C)

1) Data shown here for starting temperature T_J=110°C are based on extrapolation and not directly from measured data.
2) In the case of mid energy area two different plots are shown (10^4 and 10^5 cycles) for more flexibility to the user, but in no case it is allowed to combine both operations at the same time in a cumulative scenario, use either one or the other curve.
3) Several operating points could be grouped within the same energy level, in that case the total number of cycles allowed by the relative SOA has to be split among the operating points.

1.2 Channel Group 5-6[1) 2) 3)]

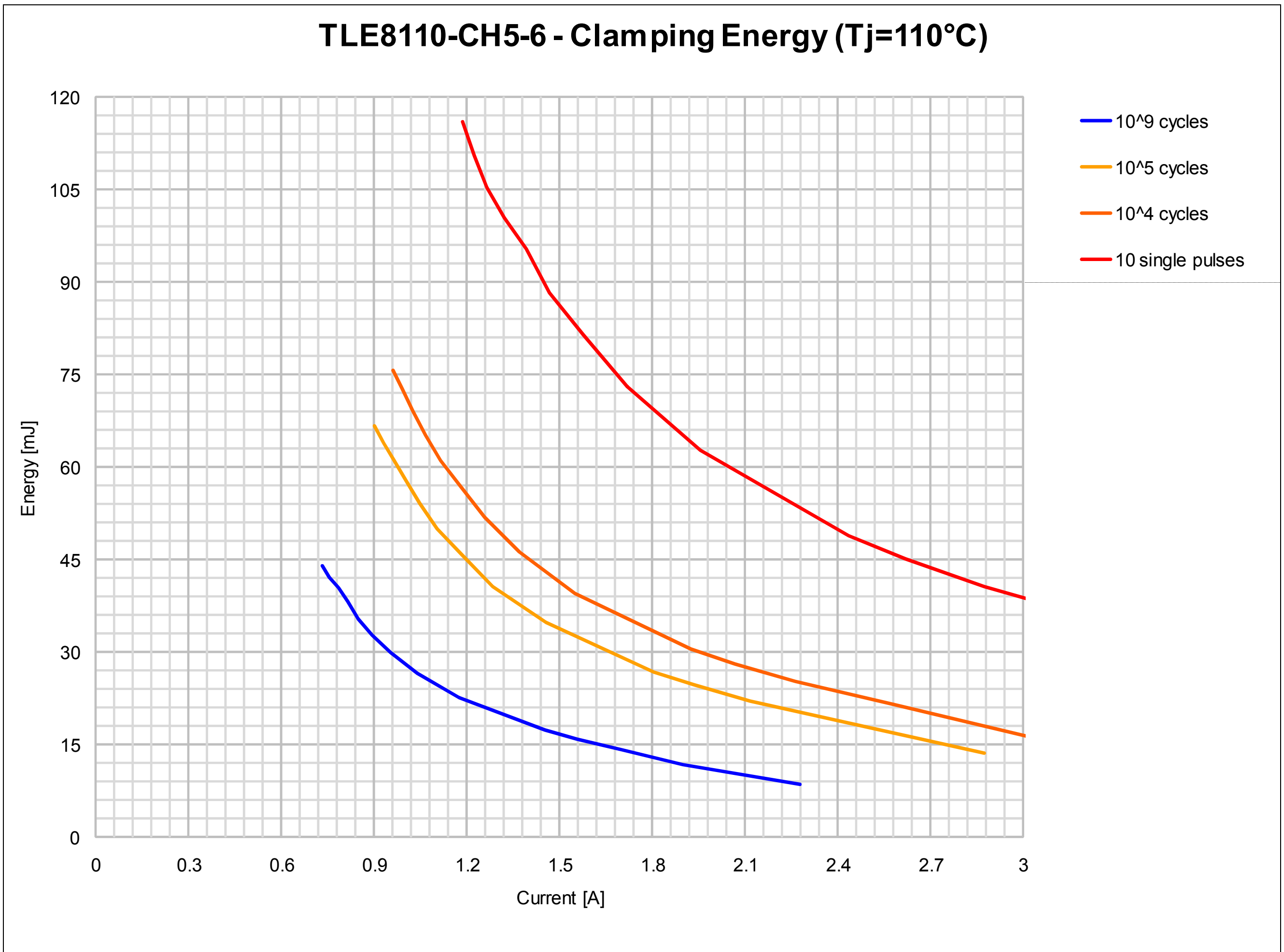

Figure 2 Energy SOA for TLE8110 - CH5-6 (T_J=110°C)

1) Data shown here for starting temperature T_J=110°C are based on extrapolation and not directly from measured data.
2) In the case of mid energy area two different plots are shown (10^4 and 10^5 cycles) for more flexibility to the user, but in no case it is allowed to combine both operations at the same time in a cumulative scenario, use either one or the other curve.
3) Several operating points could be grouped within the same energy level, in that case the total number of cycles allowed by the relative SOA has to be split among the operating points.

1.3 Channel Group 7-10[1) 2) 3)]

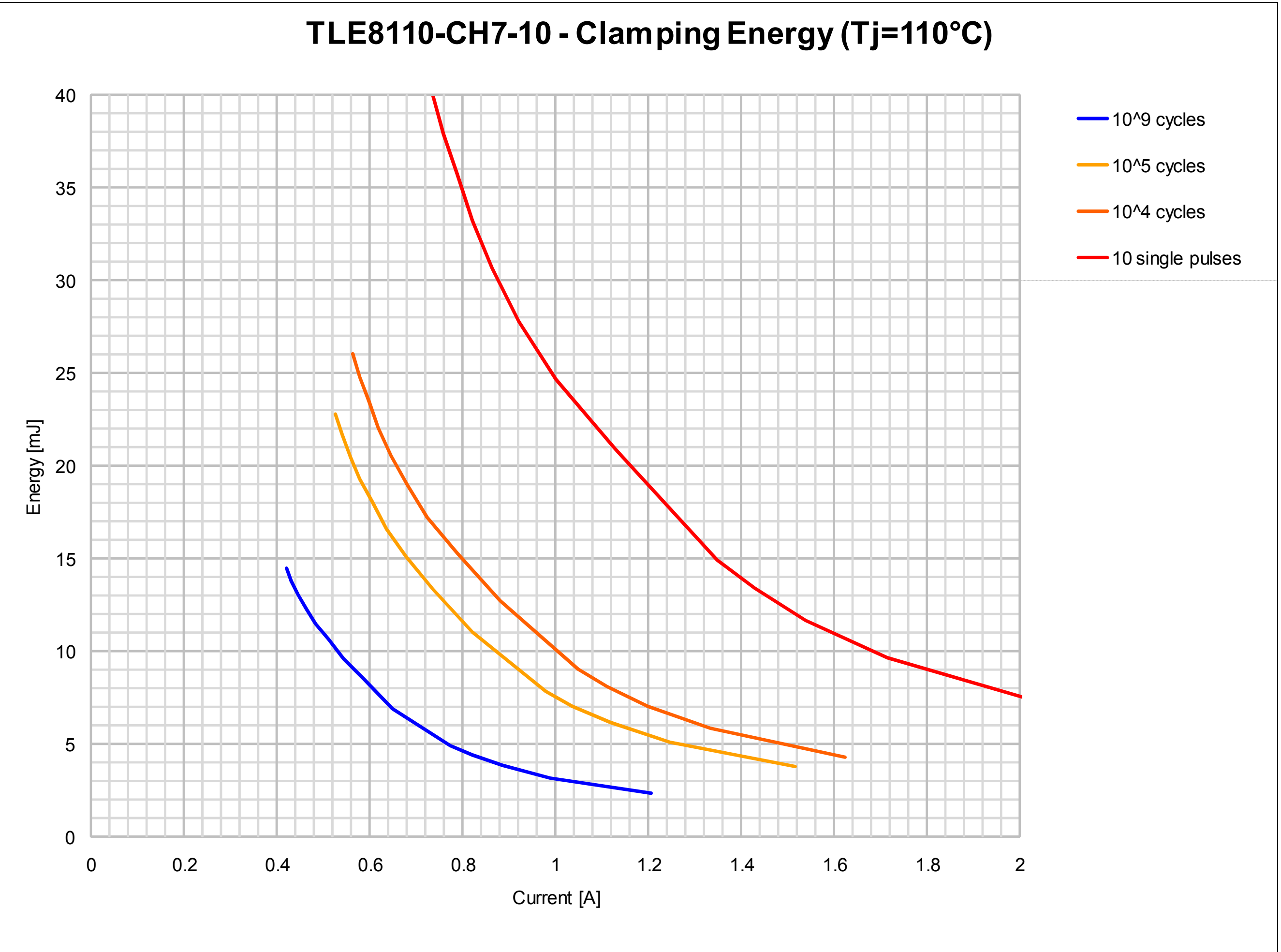

Figure 3 Energy SOA for TLE8110 - CH7-10 (T_J=110°C)

1) Data shown here for starting temperature T_J=110°C are based on extrapolation and not directly from measured data.
2) In the case of mid energy area two different plots are shown (10^4 and 10^5 cycles) for more flexibility to the user but, in no case it is allowed to combine both operations at the same time in a cumulative scenario, use either one or the other curve.
3) Several operating points could be grouped within the same energy level, in that case the total number of cycles allowed by the relative SOA has to be split among the operating points.

2 Clamping Energy for Parallel Mode Operation

The TLE8110EE is equipped with a structure which improves the performance of parallel-connected channels, for more details please refer to the TLE8110EE data sheet. The provided energy SOAs can be utilized to evaluate the capabilities of the device also for parallel connected channels. Three cases need to be distinguished:

- PM-bit set (PMx=1[1], improved parallel capabilities)
- PM-bit not set (PMx=0)
- PM-bit lost after Reset

When DMOS switches are connected in parallel, the current is not necessarily equally shared, especially in dynamic regime (e.g. clamping event) due to layout asymmetries, differences in timing and parameters shift over temperature. Assuming that one of the two parallel connected channels will take a largest part of the current during the clamping event, we can express the sharing as:

$$I_{CHmax} = a \cdot I_{TOT} \quad ; \quad I_{CHmin} = (1-a) \cdot I_{TOT} \tag{1}$$

where I_{TOT} is the total current and I_{CHmax} , I_{CHmin} are the currents flowing through the 2 channels and $a > 0.5$. The coefficient a depends on several factors and may vary device to device, channel to channel. For the TLE8110 the value of a is show in **Table 2**.

Note: According to TLE8110EE data sheet, a Reset[2] input causes a reset of all registers to their default values and consequently PMx is set to 0, moreover the channels will be switched off causing a clamping event. After the reset pulse, the current sharing at the turn-off will be the same as per PMx=0 condition, but while the reset pulse is still High, the sharing of the current shows an improved behavior. Therefore the third case (PM-bit lost) cannot be characterized as depending on the duration of the Reset pulse, but it can be stated that the PM-bit lost condition can be better or equal to the PMx=0 condition in terms of clamping energy.

Table 2 TLE8110EE a-coefficient

	PMx=1	PMx=0	PM-bit lost
a-coefficient[1]	0.6	0.8	-[2]

1) The coefficient is valid for dynamic conditions (e.g. clamping event) and takes into account variations of current sharing over Temperature and over Current, for all channel groups.
2) Coefficient cannot be extracted in this case as it is depending on the duration of the Reset pulse.

Similar to the current also the clamping energy will be shared between channels:

$$E_{CHmax} = a \cdot E_{TOT} \quad ; \quad E_{CHmin} = (1-a) \cdot E_{TOT} \tag{2}$$

Knowing the total current and the total clamping energy of the load, with **Equation (1)** and **Equation (2)** we can evaluate the current and the clamping energy of the dominant channel (I_{CHmax}, E_{CHmax}) and use those values as entry point for the provided SOA. The same considerations made for single channel applies then also for the parallel-connected channels.

The same reasoning can be generalized and extended to more than 2 channels in parallel, in that case a has to be replaced by the coefficient λ:

$$I_{CHmax} = \lambda \cdot I_{TOT} \quad ; \quad E_{CHmax} = \lambda \cdot E_{TOT} \quad ; \quad \text{with } \lambda = \frac{a}{a + (n-1) \cdot (1-a)} \tag{3}$$

where n is the number of channels in parallel[3] with the same coefficient a[4].

1) Please refer to device data sheet for PMx register configuration.
2) The Reset can be also due to an under-voltage of the logic supply.

2.1 Application Check example for Parallel Mode Operation

Let's consider an example (for simplicity we only analyze the normal operation) with a load showing following characteristics[1] :

– I_{TOT}=1.5A
– E_{TOT}=30mJ
– applied on CH1 and CH2 in parallel

Using **Equation (1)** and **Equation (2)** we obtain the values summarized in **Table 3**.

Table 3 TLE8110EE a-coefficient

	PM-bit set	PM-bit not set	PM-bit lost
I_{CHmax} [A]	0.9	1.2	-
E_{CHmax} [mJ]	18	24	-

If we project those values into the SOA of channel group 1-4 of the TLE8110EE, see **Figure 4**, we can draw the following conclusion:

- if PM-bit is set: the load can be driven on CH1//CH2 for 10^9 cycles
- if PM-bit is not set: the same load can be driven up to a maximum of 10^5 cycles

At the same time we could also draw some conclusion on the loss of PM-bit configuration due to the following considerations:

– loss of PM-bit configuration happens after a Reset (or a Logic Supply under-voltage), therefore is a low probability event whose occurrence rate can be estimated
– during loss of PM-bit the clamping capabilities can be approximated as worst case with the case of PM-bit not set

In a cumulative scenario the PM-bit lost condition can be considered as an additional mid-energy condition, therefore we could state that the load can be driven on CH1//CH2 for:

- 10^9 cycles with PM-bit set
- + 10^5 cycles with PM-bit lost + other mid-energy conditions (to be verified)
- + 10 single pulses in high-energy condition (to be verified)

3) TLE8110 allows to connect in channels in parallel via PM-bit only if belonging to the same group (1-4, 5-6, 7-10) and only if they are adjacent in numbering, please refer to device data sheet.

4) **Equation (3)** is valid only if channels have the same a-coefficient, which is the case for TLE8110.

1) In real application case also the mid-energy and high-energy could be considered applying the same equations.

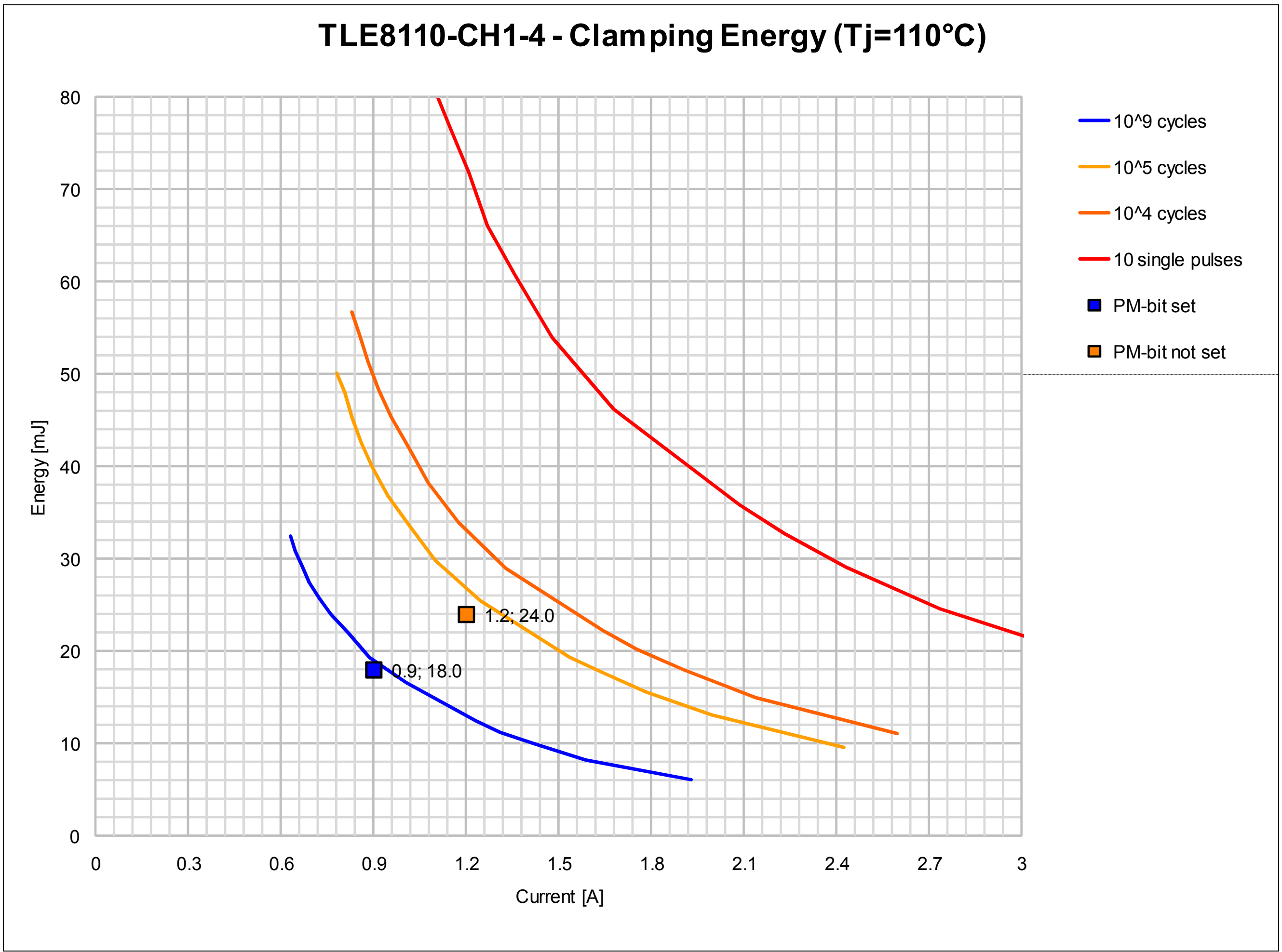

Figure 4 Clamping Energy in Parallel Mode

3 Conclusion

In this document the clamping energy capabilities of the TLE8110EE have been presented. Then the Parallel Mode operation was taken in consideration for clamping event and the specific condition of Parallel Mode lost due to Reset has been treated and described.

This addendum, together with the more general Application Note *Multichannel Low-Side Switches - Switching Inductive Loads*, represents a guide-line for safe and efficient design using the TLE8110EE.

4 Additional Information

- Existing App. Note (*Multichannel Low-Side Switches - Switching Inductive Loads*)
- For further information you may contact **http://www.infineon.com/**

5 Revision History

Revision	Date	Changes
1.0	2011-04-19	Release of the Document

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