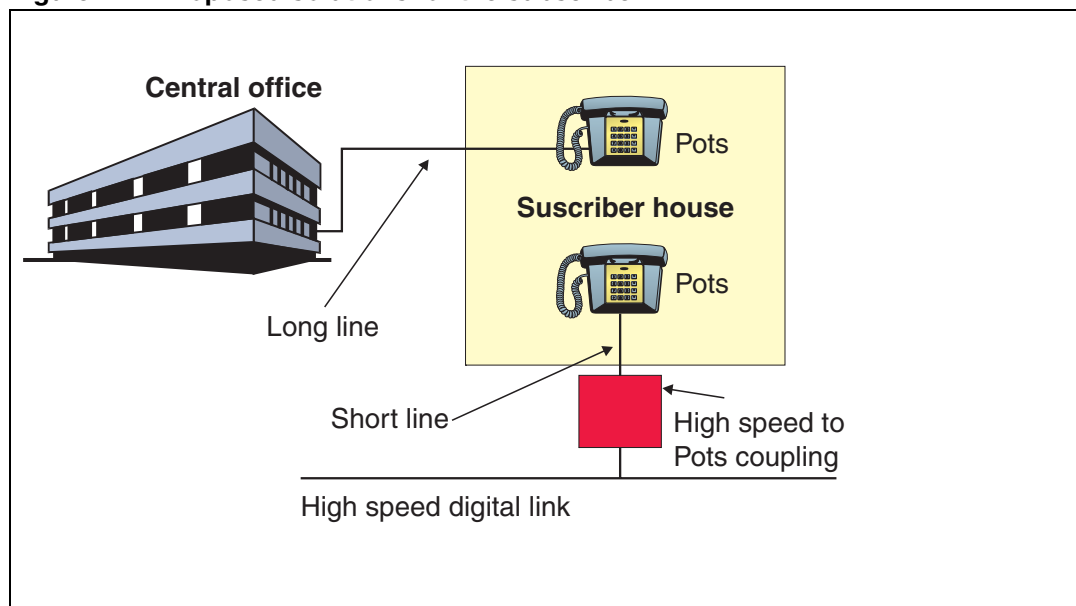


### SLIC protection for both classical and new networks

#### Introduction

Even with booming digital technologies, telecom analog lines remain the most used link in the world. The market opening to new operators, reserved so far to national telecom administration, makes an increase of new applications using this simple and cheap way to supply speech information. POTS (plain old telephone set) is still alive.

**Figure 1. Proposed solutions for the subscriber**



*Figure 1* shows possibilities subscribers already have got and which will be in a growing phase in the near future. This will split the **SLIC** (Subscriber Line Interface Circuit) in two different types according to the application:

- The long lines using the classical copper twisted pairs up to several kilometers long
- The short lines (only a few tens of meter long)

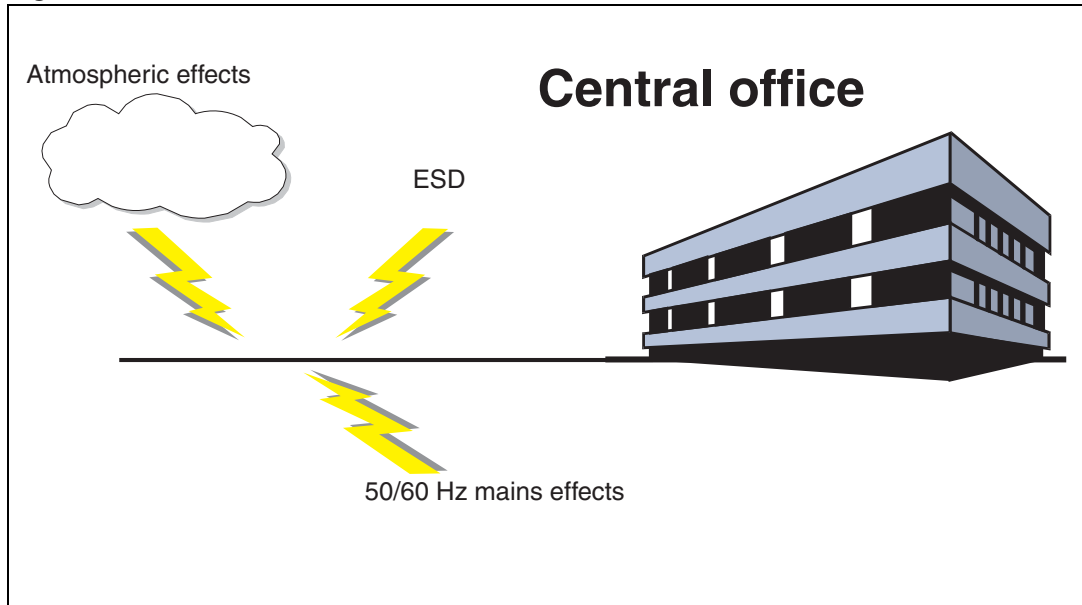
In the second case shown at the bottom of *Figure 1*, the long distance carrying of the signal is assumed by modern digital supports like optical fibers, coax, RF link etc.

For both of these applications the protection needs remain one of the major issues of the system design, so STMicroelectronics, which is one of the major players in the world of telecom protection, already proposes optimized solutions for these two topologies.

# 1 Protect against what?

Telecommunication lines are submitted mainly to two kinds of disturbances. The first one is linked to atmospheric effects while the second one is produced by the 50/60 Hz mains network (see *Figure 2*). These disturbances are well defined in individual country standards and *Table 1* shows the main standards in use.

**Figure 2. Main telecom line disturbance causes**



*Figure 3* shows an example of lightning surge definition. This is given by the ITU-T K20 standard (International Telecommunication Union). This simulation is based on the discharge of a 20  $\mu\text{F}$  capacitance through resistances. The 20  $\mu\text{F}$  capacitance and the 50  $\Omega$  resistance define the surge wave duration while the 15  $\Omega$  resistance and the 0.2  $\mu\text{F}$  capacitance manage the rise time. In this case the surge is defined as a 10/700  $\mu\text{s}$  wave. The tests shall be managed in both transversal and longitudinal modes.

**Figure 3. ITU-T K20 lightning surge test definition**

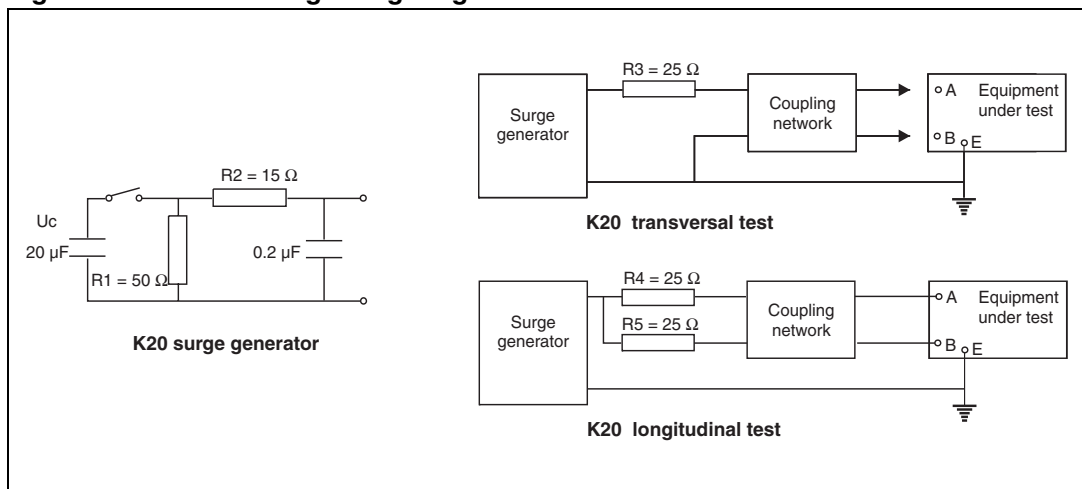


Figure 4 shows the ITU-T requirement for both the mains induction and contact test circuits. This simulation is based on the application of 50/60 Hz through resistance during a programmed duration (i.e. 0.2 s for induction and 15 min. for contact).

Figure 4. ITU-T K20 power induction and power contact surge test definition

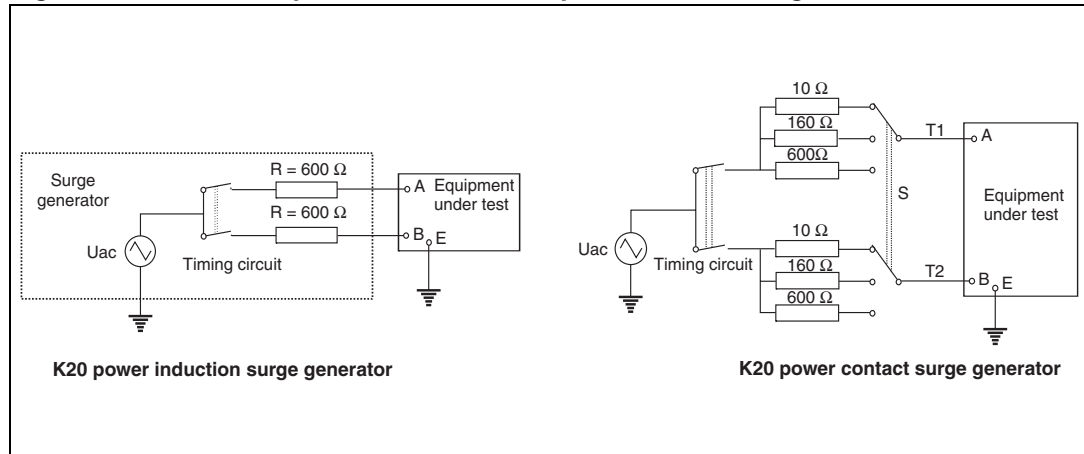


Table 1. Main line card lightning surge standards

Country	Standard	Surge voltage (V)	Waveform	Current (A)
Worldwide	ITU-T K20	1500	10/700 $\mu$ s	37.5
Worldwide	IEC 61000-4-5	1000/4000	10/700 $\mu$ s	25/100
Worldwide	IEC 61000-4-5	1000/4000	1.2/50 $\mu$ s	25/100
USA	GR-1089 Core (Telcordia)	2500	2/10 $\mu$ s	500
USA	GR-1089 Core (Telcordia)	1000	10/1000 $\mu$ s	100

Table 2. GR-1089 Core Intra-building lightning surge standard

Test	Surge Voltage (V)	Waveform	Surge Current per conductor (A)	Repetitions Each polarity
1	$\pm$ 800	2/10 $\mu$ s	100	1
2	$\pm$ 1500	2/10 $\mu$ s	100	1

Table 1 and 2 show the main worldwide lightning surge standards. Table 1 is dedicated to classical wired telecom line cards while the Table 2 is dedicated to intra-building applications. The main worldwide standards for the 50/60 Hz disturbances can be defined by 2 parameters: the applied voltage, between 60 to 1000 V and the test duration, between 0.2 s to 15 min. This type of disturbances obliges the designer to put series elements, like PTC or a fuse between line and protection devices.

Section 2 presents the protection concept used to protect both short and long lines.

## 2 LCP concept

Figure 5. LCP15xx concept behavior

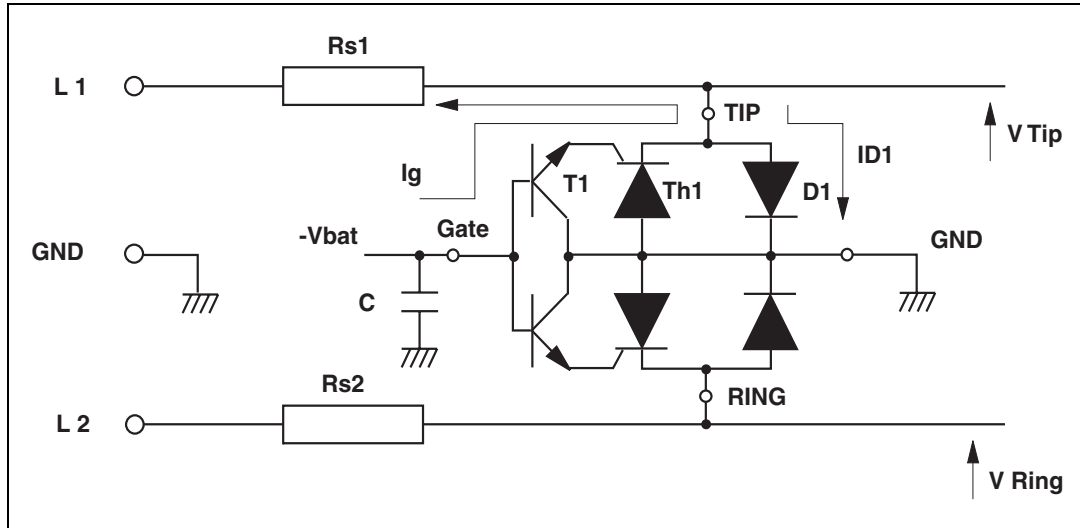


Figure 5 shows the classical protection circuit using the LCP15xx crowbar concept. This topology has been developed to protect the new high voltage SLICs. It allows the system to be programmed for the negative firing threshold while the positive clamping value is fixed at GND.

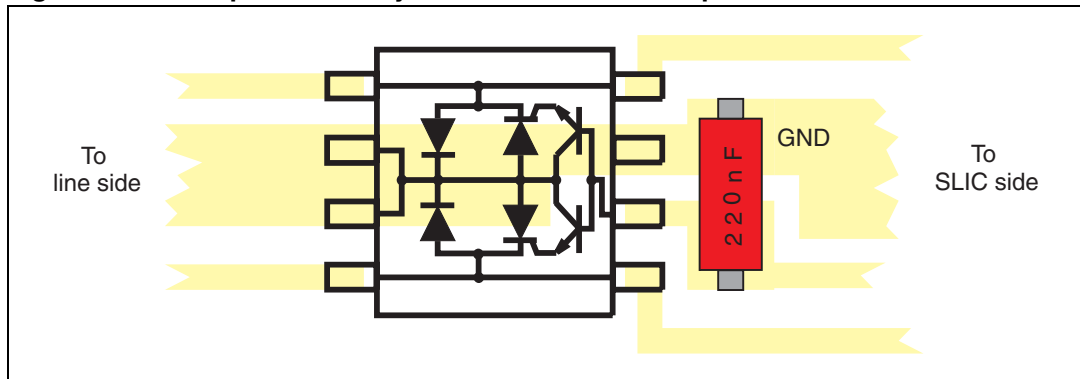
When a negative surge occurs on one wire (L1 for example), a current  $I_g$  flows through the base of the transistor T1 and then injects a current in the gate of the thyristor Th1. Th1 turns on and all the surge current is short circuited to ground. After the surge, when the current flowing through Th1 becomes lower than the holding current  $I_h$ , then Th1 switches off.

When a positive surge occurs on one wire (L1 for example) the diode D1 conducts and the surge current is short circuited to ground.

In order to minimize the remaining voltage across the SLIC inputs during the surge, a 4 point structure has been implemented (Pins 1 and 8 for TIP / Pins 4 and 5 for RING). This fact allows the board designer to connect the track as designed in Figure 6. With such a PCB design, extra voltages caused by track stray inductance and current slope ( $L_{di}/dt$ ) remain located on the line side of the LCP and do not affect its SLIC side.

The capacitor C is used to speed up the crowbar structure firing during the fast negative surge edges. This allows the dynamic breakover voltage at the SLIC Tip and Ring inputs to be minimized during fast strikes. Please note that this capacitor is generally present around the SLIC  $-V_{bat}$  pin. So to be efficient it has to be moved as close as possible to the LCP15xx Gate pin and to the reference ground track (or plan) (see Figure 6). Optimized value for C is 220 nF.

**Figure 6. Example of PCB layout based on LCP15xx protection**



The series resistors  $R_{s1}$  and  $R_{s2}$  designed in [Figure 5](#) represent the fuse resistors or the PTC which are mandatory to withstand the power contact or the power induction tests imposed by the different country standards. Taking into account this fact, the actual lightning surge current flowing through the LCP is equal to:

$$I_{\text{surge}} = V_{\text{surge}} / (R_g + R_s)$$

With:

- $V_{\text{surge}}$  = peak surge voltage imposed by the standard
- $R_g$  = series resistor of the surge generator
- $R_s$  = series resistor of the line card (e.g. PTC)

For a line card with  $30 \Omega$  of series resistors which has to be qualified under GR-1089 Core 1000 V, 10/1000  $\mu\text{s}$  surge, the actual current through the LCP1521S is:

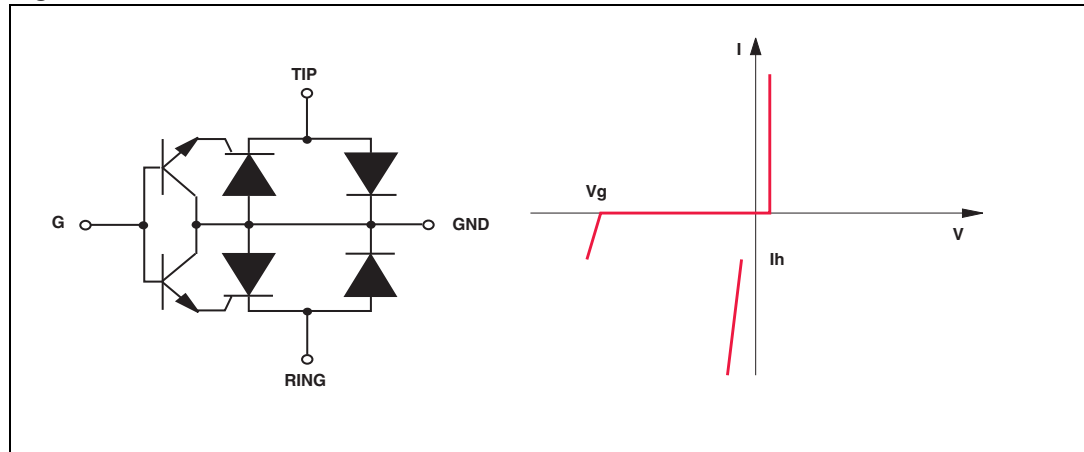
$$I_{\text{surge}} = 1000 / (10 + 30) = 25 \text{ A}$$

### 3 LCP topology based protection family

The family of protection systems based on the LCP concept has two kinds of products.

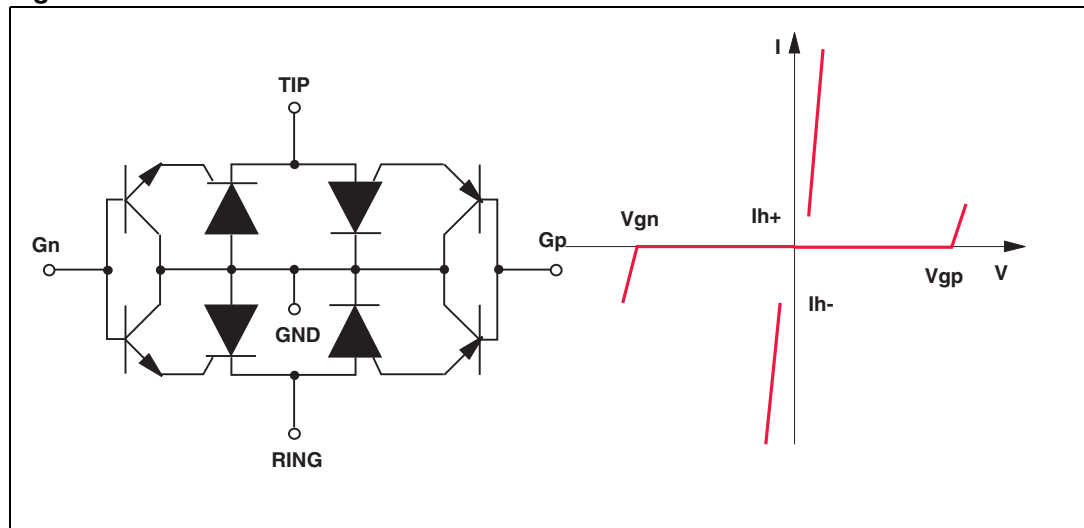
- The LCP15xx protects lines within the range of GND to  $-V_{bat}$ . The electrical characteristics given in [Figure 5](#) shows the asymmetry of this protection function. The  $V_g$  threshold voltage is programmed by the negative voltage on the gate pin. This voltage is within the range of 0 to  $-175\text{ V}$  for the LCP1521S

**Figure 7. LCP15xx circuit and electrical characteristics**



- The LCPx2-150B1 is designed to protect the lines where the normal operating voltage can be negative as well as positive and located between  $-V_{bat}$  and  $+V_b$ . The electrical characteristics given in [Figure 6](#) show a crowbar adjustable function for both positive and negative parts of the curve. The knee of the positive part of the curve is programmed by the voltage on the gate  $G_p$  pin while the knee of the negative part is programmed by the voltage on the gate  $G_n$  pin.

**Figure 8. LCPx2 circuit and electrical characteristics**



## 4 Long line protection

The long line concept is used in case of the classic wired telecom network. With this topology, the core of the system is a huge central office from where many lines connect the subscribers. In this case the line length can reach several kilometers. This type of subscriber based on silicon integrated SLIC can be classified in two families:

- With external ring signal management
- With internal ring signal management

The classical one uses a mechanical relay to manage either ring generation or speech mode.

**Figure 9. SLIC with external ring signal management**

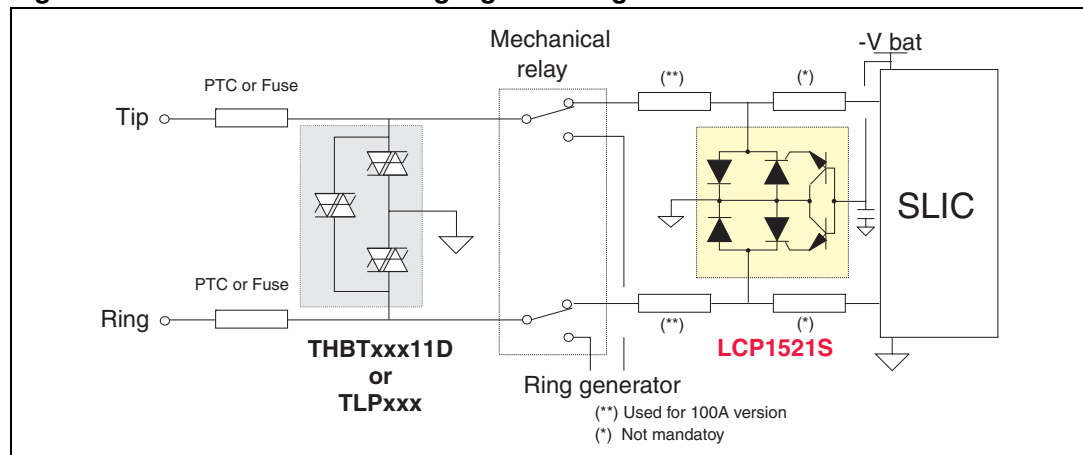


Figure 9 shows the protection circuit of a SLIC with mechanical ring relay. The protection function is implemented in two stages. One is located between the line and the ring relay, while the other is located between the ring relay and the SLIC.

The first stage, dedicated to the ring generator protection, supports a three-way protection (THBTxxx11D for 30 A applications or TLPxxx for 100 A requirements). This stage acts symmetrically at + or - V (For example +/-200 V) where V is chosen as slightly higher than the maximum ring voltage trip.

The goal of the second stage is to manage a fine protection level in phase with the requirements of the high integration technology modern SLIC. This stage must switch on for a voltage higher than the voltage supply of the SLIC.

The resistors referenced by (\*\*) allow the LCP15xx to manage both 100 A and 50 A applications when no resistance is permitted at the PTC or fuse stage. In this case, when a surge occurs the LCP15xx starts to act and before the current becomes too high in the LCP15xx, the drop voltage across the resistor (\*\*) allows the TLPxxx device to be fired. Then all the surge current flows through the TLPxx device.

The resistors referenced (\*) are not mandatory and are added when the SLIC to be protected is very sensitive to the latch up phenomena.

Figure 10. LCP15xx behavior during 10/700µs negative surge

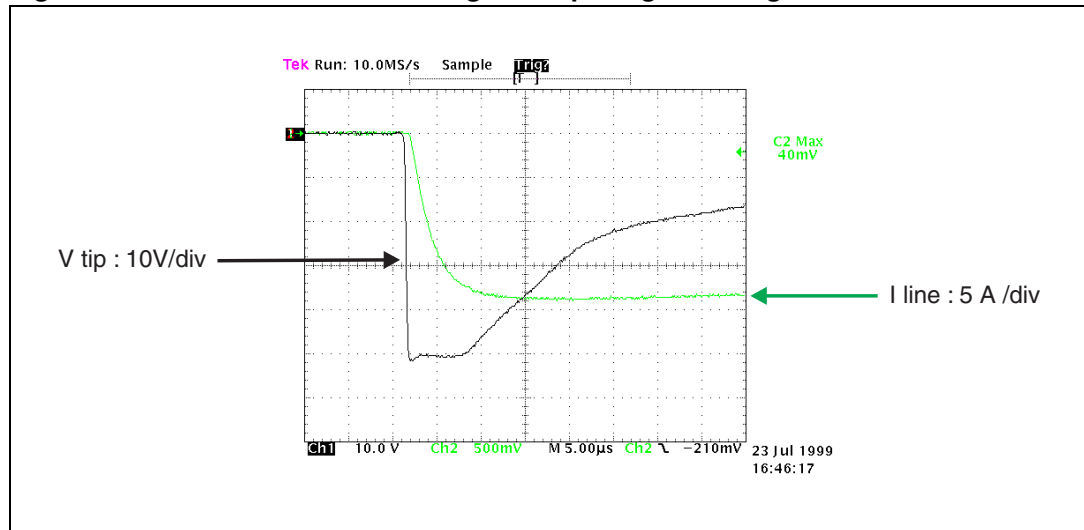
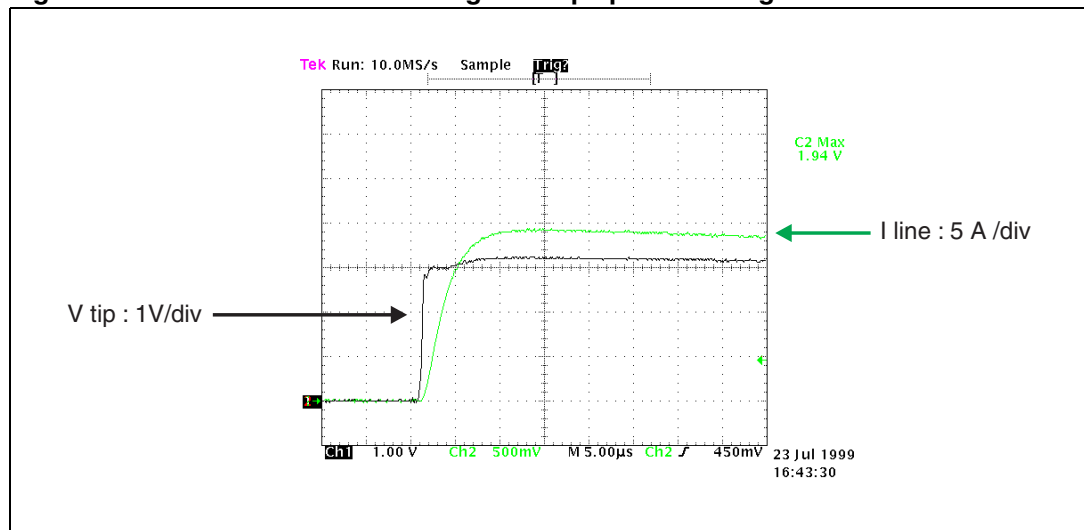


Figure 10 shows both surge current through the TIP pin of a LCP15xx and the voltage across it when submitted to a 20 A 10/700 µs ITU-T K20 surge. The TIP voltage falls to the battery voltage (-48 V) and then fires.

Figure 11. LCP15xx behavior during 10/700µs positive surge



During a positive surge on TIP wire, the diode between TIP to GND conducts and then all the surge current flows through the ground. This behavior is shown in Figure 11.



**Figure 12. LCP15xx behavior during ITU-T K20 power crossing test (600 Ω)**

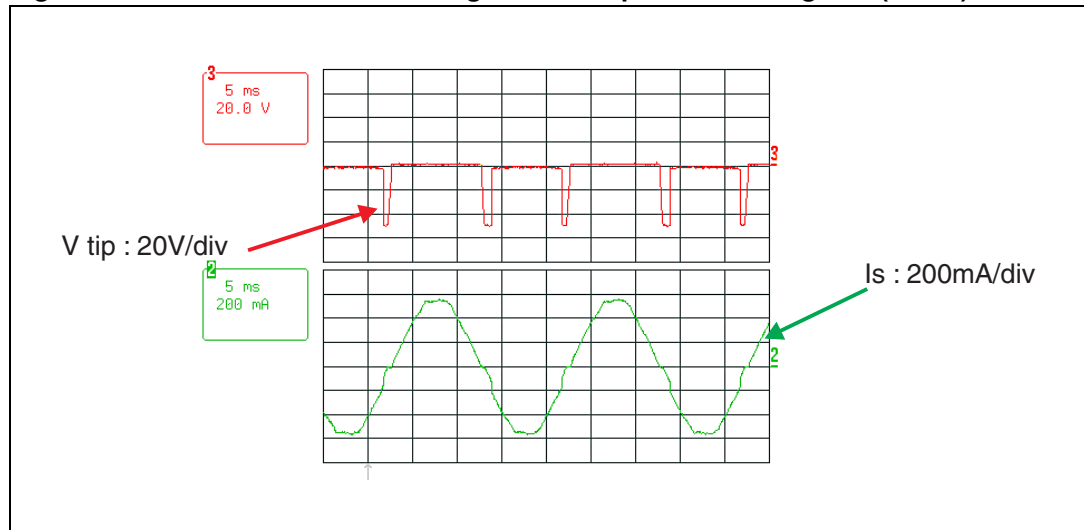
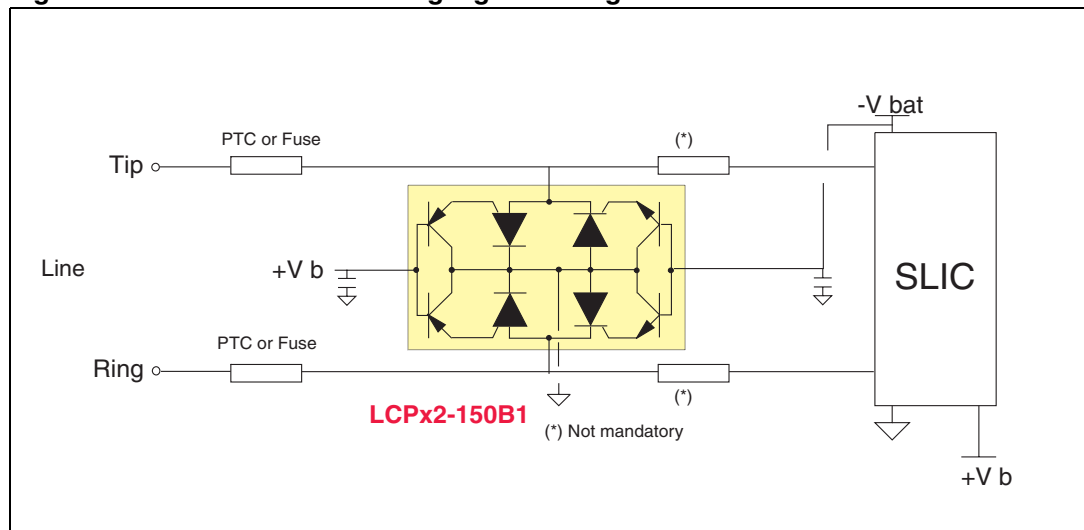


Figure 12 shows both voltage across the TIP pin of a LCP15xx and current through it when submitted to a 230 V<sub>rms</sub> 600 Ω power crossing ITU-T K20 surge. The voltage trip at the TIP pin is roughly between +1 V and the battery voltage (-48 V).

**Figure 13. SLIC with internal ring signal management**



In the case of Figure 13 the SLIC is supplied by one positive +V<sub>b</sub> and one negative -V<sub>bat</sub>. This allows the output pins to manage a signal within this voltage range and in particular to operate in DC biased ring signal mode. For this topology only one protection stage is needed to perform a fine response when a transient reaches the +V<sub>b</sub> or -V<sub>bat</sub> limit.

The LCPx2-150B1 covers the 30 A 10/1000 μs applications without any series resistance while it needs series resistance R<sub>s</sub> (for example PTC) for 50 A applications.

Figure 14. LCPx2-150B1 behavior during GR-1089 Core 10/1000µs +1kV test, RS = 50 Ω

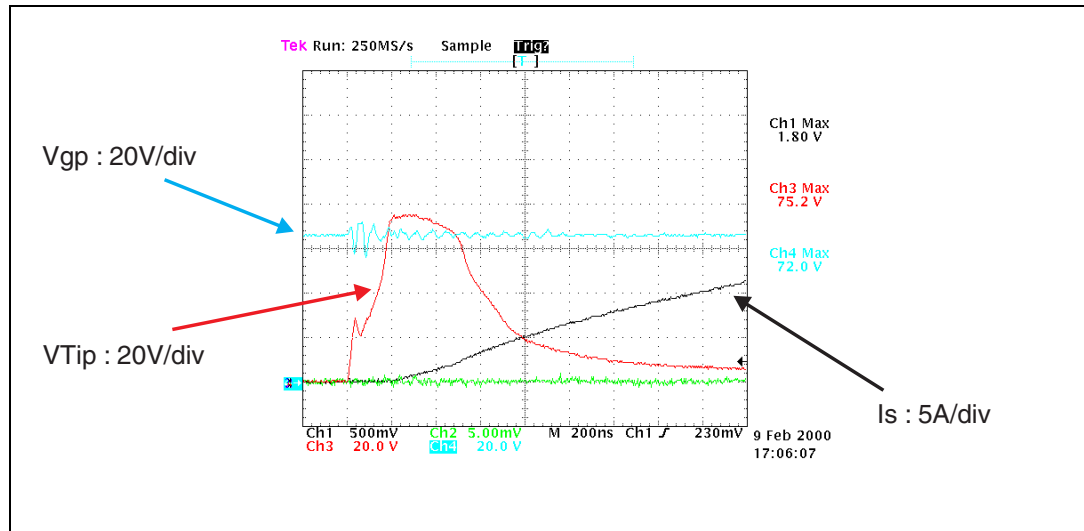


Figure 15. LCPx2-150B1 behavior during GR-1089 Core 10/1000µs -1kV test, RS = 50 Ω

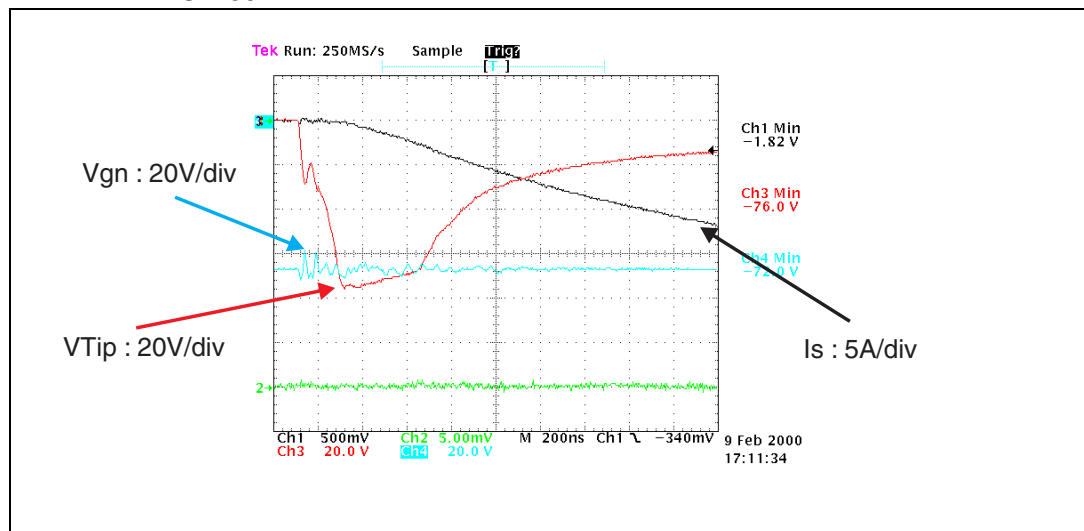


Figure 14 and 15 show currents and voltages for the LCPx2-150B1 during both positive and negative GR-1089 Core 10/1000 µs tests. These measurements were done at ±1 kV on a board equipped with series resistance RS 50 Ω. For these measurements the positive gate G<sub>p</sub> and negative gate G<sub>n</sub> are connected to 220 nF speed up capacitors and are respectively biased at + and - 65 V. In such a condition the maximum remaining voltage during the firing phase is roughly ± 75 V.

Figure 16. LCPx2-150B1 behavior during GR-1089 Core first level AC test, 600V, RS = 50 Ω

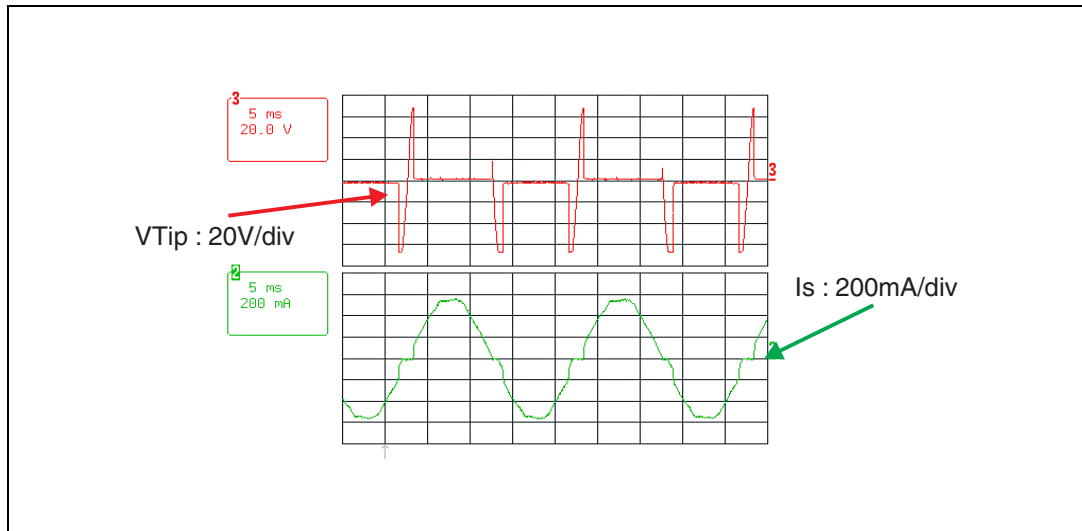
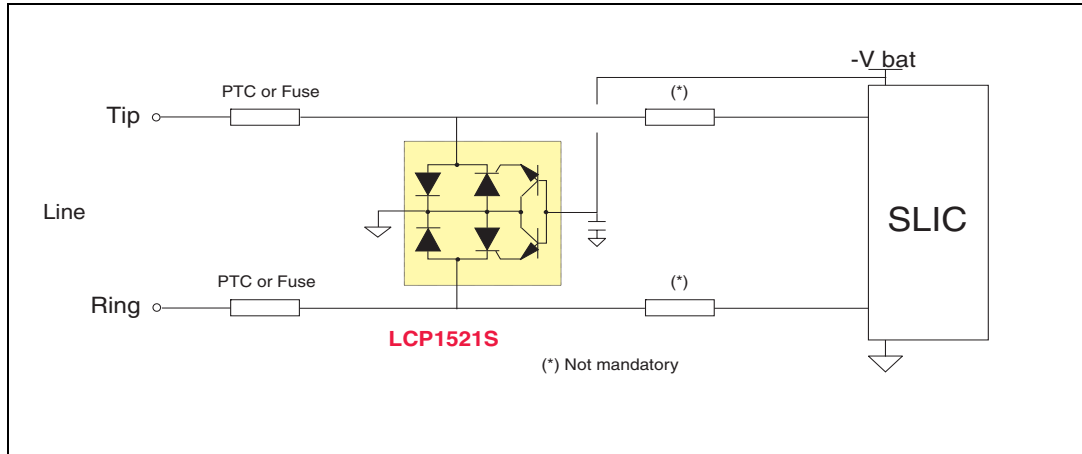


Figure 16 shows current and voltage waveforms for the LCPx2-150B1. This shows that the maximum remaining voltage across the TIP or RING line versus ground is roughly equal to the  $G_p$  and  $G_n$  gate bias voltage  $\pm 65$  V.

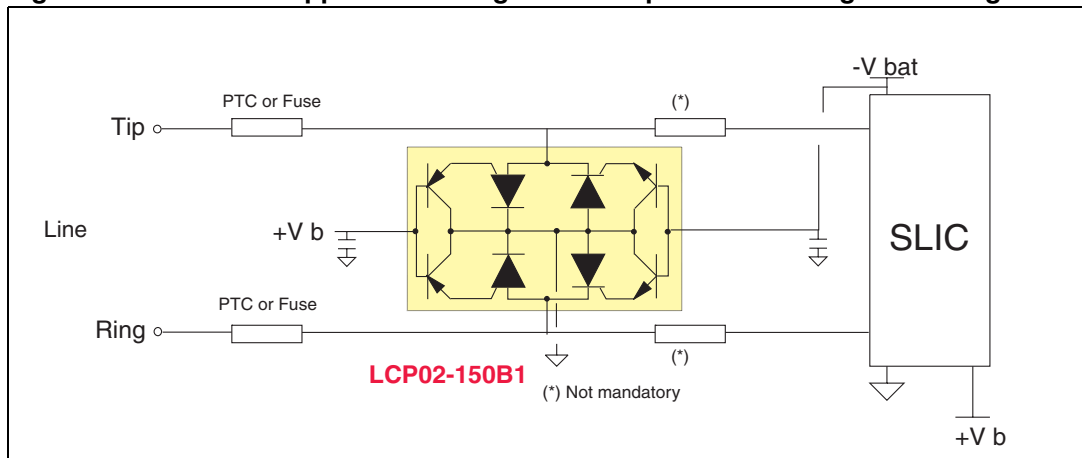
## 5 Short line protection

The short line concept is used in case of new telecom networks. This kind of line is linked to the new applications like WLL, fiber on the corner, NT1+, phone over cable TV network, telecom by 50/60 Hz supply network etc. Their need for battery voltage as well as the ringing voltage is lower than those for long line applications. This allows the use of a new generation of high voltage SLIC circuit which can be either single or double voltage supplied.

**Figure 17. Short line application using high voltage SLIC**



**Figure 18. Short line application using SLIC with positive and negative voltages**



## 6 Conclusion

The telecom deregulation everywhere in the world generated two kinds of line needs. The long ones are dedicated to the classic telecommunication networks while the short ones are linked to the emerging remote applications. These quite new systems are based on optic fiber, WLL, phone over TV network or over 50/60 Hz supply network. For both long and short line applications, protection is one of the major issues. STMicroelectronics is the major player in the telecom protection field for both wired and wireless equipment. As far as the analog telecom lines are concerned, the LCP concept is well adapted to protect SLIC. The LCP15xx and LCPx2-150B1 cover the protection of all the SLIC of the market.

## 7 Revision history

**Table 3. Document revision history**

Date	Revision	Changes
11-May-2005	1	Initial release.
24-Jun-2011	2	Updated references to standards throughout the document.

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