APPLICATION NOTE

PABX BIG COST REDUCTION AND PERFORMANCE IMPROVEMENT ARE OBTAINED WITH A NEW SLIC CHIP SET

by W. Rossi

The new L3000N/L3092 SLIC need very few external components, very low power in ON-HOOK and provide innovative functions like Ringing injection, message waiting, line length measurement for autoadaptive systems.

Abstract

The new SGS-THOMSON SLIC (Subscriber Line Interface Circuit) kit L3000N/L3092 suitable for PABX (Private Automatic Branch Exchange), low end C.O. (Central Office) and ISDN terminal adaptor applications is described. The two chip approach allows the integration of innovative functions as ringing generation and injection, line length evaluation, message waiting, loop extension all software programmable. High level DC/AC performances are provided and very low power is requested in on hook condition (less than 10mW from battery and typ. 50mW from ±5V supplies).

1. INTRODUCTION

The '90 years represent a transition period from fully analog solution to fully digital (ISDN) one in PABX systems design. In particular in this new systems generation analog and digital line cards will coexist. The SLICs for this new systems should satisfy the following requirements:

- do not degrade the transmission performances of the digital part (ex: noise due to relay bounces during ringing injection).

- Software programmability of the DC/AC characteristics in order to have an easy adaptation to different countries requirements.

- Signaling self management in order to simplify the card controller software.

- Low number of external components.

- High reliability and low cost.

In order to satisfy the above requirements a complex circuit structure is necessary. Such a structure cannot be integrated in a single chip because high voltage technology is required to interface the subscriber line. Single chip solutions based on present H.V. Technology are possible only giving up most of the above requirements or increasing too much the device size and the external components number. The SGS-THOMSON SLIC family actually in production and based on a two chip approach is able to satisfy the above requirements. In fact only the circuit directly connected to the line is realized in High Voltage Technology while all the control and signal management functions are performed in the control chip realized in high density, Low Voltage Technology. (15V). In addition this approach allows an easy adaptation to different applicative situation only selecting the proper low voltage control chip. In the following the L3000N/L3092 kit is deeply described.

2. L3000N-L3092 GENERAL DESCRIPTION

The SLIC KIT L3000N/L3092 integrate all the functions, except the overvoltage protection, needed to interface a subscriber line. As shown in fig.1 the L3000N chip is a directly connected to the telephone line. On the L3092 chip two interfaces are present. The first is an analog interface (4W) connected to the analog input/output of a Codec/Filter. The second one is a parallel digital interface that allows to set different operating modes of the kit and to transfer information about line status. Because of the internal latches circuit this interface can be connected to a SLIC common control bus driven by the Line Card Controller (see fig. 1). In alternative this interface can be directly connected to the I/O control port of a second generation COMBO as SGS-THOMSON TS5070/TS5071 (see fig. 2). The main features of the L3000N/L3092 are the following :

- Programmable DC feeding resistance and limiting current (25/40/60mA)

- Low power dissipation (50mW) in on hook condition (off-hook detector active).

- Loop extension / Integrated message waiting function.

- Signaling function (ON-HOOK/OFF-HOOK; GROUND-KEY/GROUND-START detection)
- Line length evaluation
- Hybrid function
- Line impedance synthesis (real/complex)
- Balanced ringing signal generation with zero crossing injection
- Automatic ringing stop with zero crossing when OFF-HOOK is detected.
- Parallel latched digital interface for direct connection with 2nd generation COMBO or Card Controller
- Low number of external standard tolerance components.
- Integrated thermal protection that disable output stages when junction temperature exceeds 140°C

Figure 1: The latched parallel digital interface of L3092 allows an easy common bus control structure. The card controller select the proper SLIC via the corresponding CS pin.

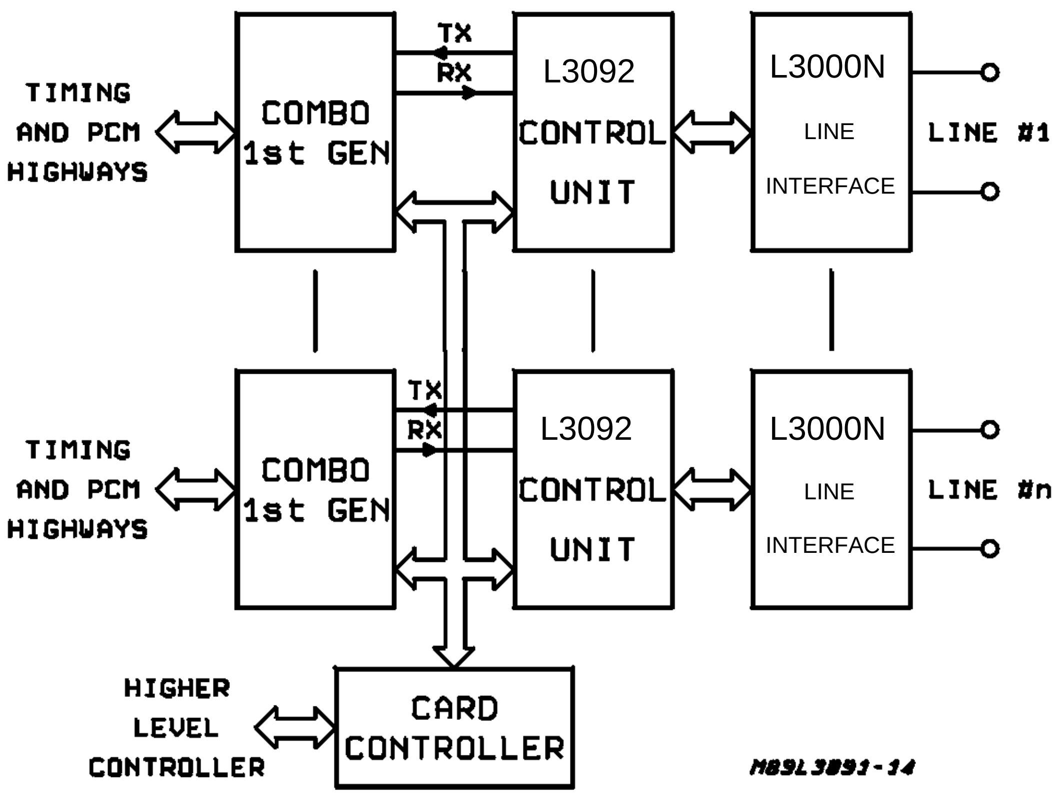
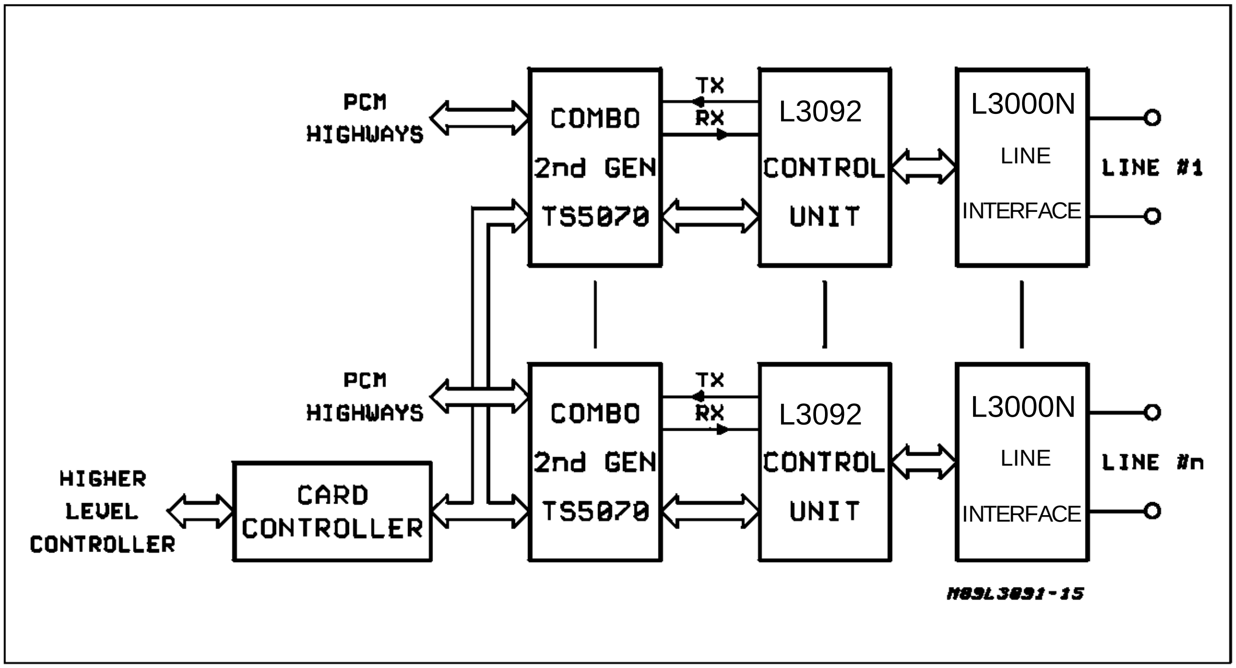


Figure 2: The digital interface of L3092 is directly connected to the COMBOII I/O ports. The card controller manage this I/O digital interface via a 2Mbit serial control port.



3. OPERATING MODES

Three input and two output pins represent the parallel digital interface. In addition a CS pin allows to connect the digital interfaces of all the SLICs on the Line Card to the same control bus; the digital datas applied to this interface selects one of the following operating modes:

- Conversation or Active Mode
- Stand-by or On-Hook Mode
- Power Down or Disable Mode
- Ringing Mode

4. CONVERSATION OR ACTIVE MODE

The SLIC is setted in this mode when the off-hook condition has been detected and the communication must be activated; the main functions performed in this mode are:

1) DC current feeding into subscriber loop.

2) Signaling recognition (OFF-HOOK; GND-KEY; DIAL PULSES)

3) Bidirectional transfer of speech band signals between line (2wire) and COMBO (4wire) interfaces.

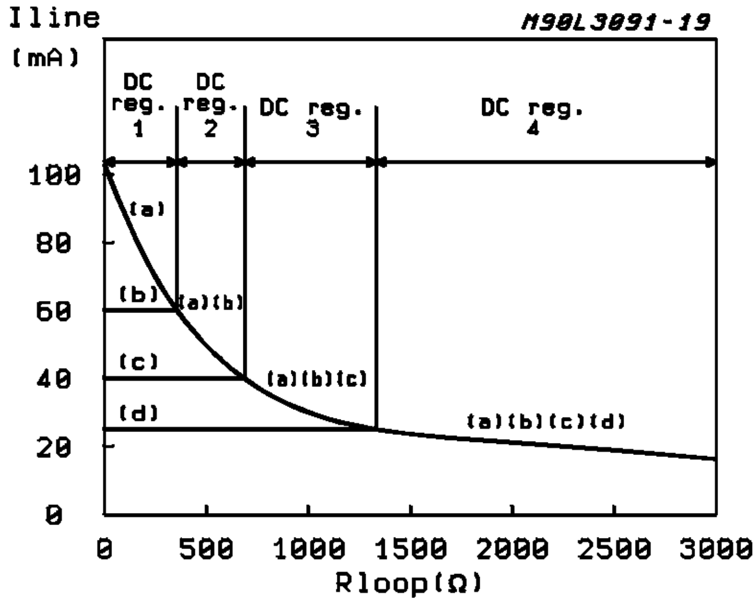
4.1 DC CHARACTERISTIC

One of the main SLIC function is to provide a DC current to the subscriber loop in order to feed properly the connected telephone set. In fig. 3 different DC characteristics Line Current (Il) versus loop resistance (Rl) are shown. The (a) curve represents the DC characteristic obtained with traditional line interface based on transformer; as you can see it is a purely resistive characteristic (Il=VBAT/(2xRFS)) where typical RFS values are 200ohm and 400ohm. The (b), (c), (d) curves represent the three different programmable DC characteristics that can be obtained with the L3000N/L3092 SLIC kit in conversation mode. Each curve is composed by two regions the first with constant line current and the second resistive were the RFS value is programmed by means of one external resistor. The constant current region allows a big power dissipation reduction with short lines if compared with the transformer solution. In addition the possibility to program by software different limiting currents (25,40,60mA) make the system more flexible allowing an easy adaptation to the different administration requirements and the possibility of the line length measurement. In fact when TEST MODE function is activated one of the digital interface output will show if the actual line current is equal or lower than the programmed limiting current value. The possibility to program three different limiting current values allows to distinguish four different line resistances ranges as shown in fig. 3; this information is very useful in order to optimize the transmission performances for each line length.

Figure 3: The (a) curve represents the DC characteristic obtained with traditional line interface based on transformer. The (b), (c), (d) curves represent the three different programmable DC characteristics that can be obtained with the L3000N/L3092 SLIC kit in conversation mode.

L3000N/3092 DC Characteristic.

feeding resistance: 2 x 200Ω;
batt. voltage 48V



In particular if a second generation COMBO, as SGS-THOMSON TS5070/71 is adopted the line length can be used to select by software proper transmit/receive gains and balance impedances obtaining in this way an autoadaptive system at four states. Another important feature consists in the balanced line feeding circuit; it means that line current variations will produce equal and opposite voltage variations on the A, B, or TIP, RING SLIC line terminations. This characteristic is very important because during dial pulse selection the line current change from zero to the maximum value producing large line voltage variations. The balanced structure avoid high common mode signals generation with very short rise/fall time. It should be noted that this problem is always present when monolithic SLICs with integrated DC/DC converter are adopted in fact in this case doesn't exist voltage symmetry between the two line terminations. This kind of common mode signals produce serious transmission problems on the ISDN line present in the same system; in addition they are also noise sources for the other analog lines. The L3000N/L3092 SLIC kit has been studied not only in order to avoid common mode noise on the line, but also to be less sensitive to the noise present on the battery voltage typically generated by dial pulse selection and ringing injection operations. In particular the noise on the battery voltage is transferred to the line with an attenuation higher than 20dB for low frequency components (10Hz) and with more than 40dB for speech band components (typ. 1kHz).

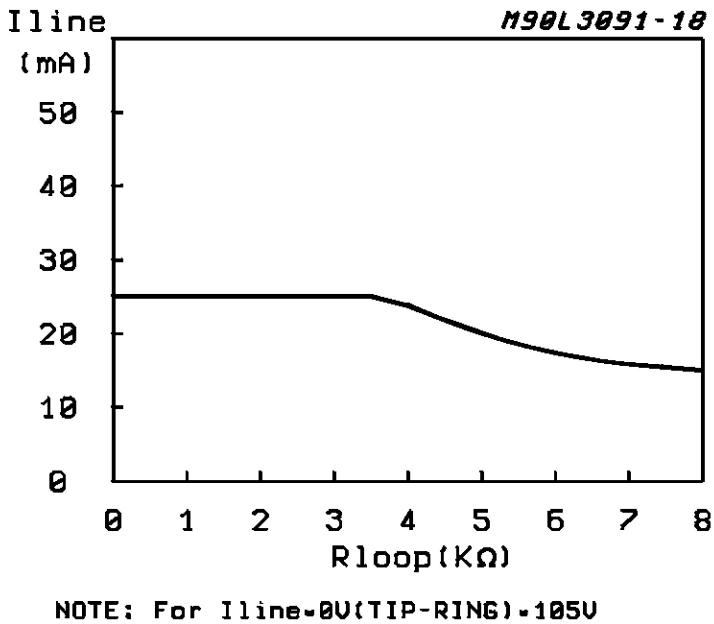
4.2 LONG LINES FEEDING.

The L3000N/L3092 SLIC kit is also suitable for public central office, since in this application is sometimes required to feed very long lines a particular operating mode (Boost Battery) is provided. When the boost battery mode is activated the DC characteristic is modified allowing 20mA of feeding current for 4Kohm of loop resistance equivalent to more than 10Km (see fig.4). Considering PABX dedicated to Hotel applications this operating mode can be used to perform the "MESSAGE WAITING" function. In fact when the Boost Battery mode is selected and the line current is zero the line voltage is greater than 100V; this voltage is high enough to switch on the neon lamp on the telephone set typically used to inform the subscriber to call back the operator. During Boost Battery operation the L3000N line interface circuit fed its internal output stages between the negative battery (typ -48V) and the positive bat-

Figure 4: DC characteristic in Boost Battery mode allows to feed very long lines (20mA/4Kohm) and to perform the "message waiting" function. For line current close to zero the TIP/RING voltage is greater than 100V.

L3000N/3092 DC Characteristic.

feeding resistance: 2 x 200Ω;
Boost Battery mode (tot. batt.: 120V)



tery voltage (typ. +72V) already present for the ringing operation.

4.3 SIGNALING.

When the Conversation operating mode is selected on the two output pins of the digital interface the following informations are provided:
1) ON-HOOK/OFF-HOOK detection
2) GROUND KEY / GROUND START detection.
In addition the off-hook detection delay is very low allowing dial pulse detection with a distortion lower than 1% . On the contrary the ground key information is filtered with a time constant in the range of 100ms.

4.4 AC CHARACTERISTIC.

The L3000N/L3092 SLIC kit provide excellent AC characteristics, in addition its internal structure allows an easy programming of the line and balance impedances both real or complex by means of external scaled (by 25) components. It means that in case of complex impedances the external capacitors values will be 25 time lower than the synthetized values. Another peculiarity of the L3000N/L3092 SLIC kit is the possibility to recover the insertion loss due to the external protection resistors connected between the SLIC TIP and RING (A, B) output pins and the line; such resistors cannot be avoided being necessary to limit the line current when surges or other causes produces overvoltages on the line. The major part of the monolithic SLICs available on the market requires low values for the external protection resistors (< 20ohm) being not able to recover the attenuation produced by such components.

This attenuation become a problem in presence of complex line impedance because its value depends also on the frequency. If protection resistors higher than 20ohm are adopted the correspondent amplitude distortion with frequency will not be acceptable and external complex equalizing circuit required.

On the contrary the L3000N/L3092 SLIC kit allows to use protection resistors in the range from 30 to 100ohm increasing in this way the system protection level. In this condition the guaranteed insertion loss flatness (including external protection resistors) between 2W (line) and 4W (COMBO) interfaces is +/- 0.1dB for both real or complex line impedances.

Another important L3000N/L3092 SLIC kit feature for the overall system performances is the capability to work also in presence of high induced longitudinal line current. The longitudinal current can be generated by the following causes:

1) Magnetic/capacitive coupling between the subscriber line and the AC main power distribution network (110/220V; 50/60Hz).

2) Magnetic/capacitive coupling with adjacent subscriber line on which large voltage/current variations are present (ex: dial pulse selection; ringing injection..)

3) Magnetic/capacitive coupling with high frequency electromagnetic waves.

For a proper SLIC operation in presence of the above conditions the following characteristics are necessary:

1) High value of Longitudinal to Transversal Conversion (LTC)

2) High value of Longitudinal to Transversal Conversion also in presence of high common mode current.

3) High value of Longitudinal to Transversal Conversion also in presence of high frequency common mode current.

The L3000N/L3092 SLIC kit is able to satisfy all the above requirements; in particular the LTC guaranteed value is 52dB; the typical is 60dB. This value remain nearly unchanged also for high common mode current (ex. 65mA peak on each wire with 25 mA of transversal DC line current or 50mA peak with 40mA of transversal DC line current).

In addition the high gain-bandwidth product of the L3000N integrated operational amplifiers allows to keep the LTC value very high also for common mode current frequencies up to 200/300kHz. Higher frequencies common mode current can be easily attenuated connecting between the line terminations and ground small capacitors (10/20nF). The low effect of such capacitors on the SLIC AC parameters (gains, impedances, two to four wire conversion....) can be easily recovered acting on the SLIC external components thanks to the high flexibility of the two chip architecture.

In fig.5 are shown the test circuit used for EMI evaluation up to 10MHz and the results obtained with and without the filtering capacitors on line terminations. This excellent result show that the L3000N/L3092 SLIC kit provide very high rejection to EMI signals without requiring expensive H.F. coils.

Figure 5a: Test circuit for EMI evaluation.

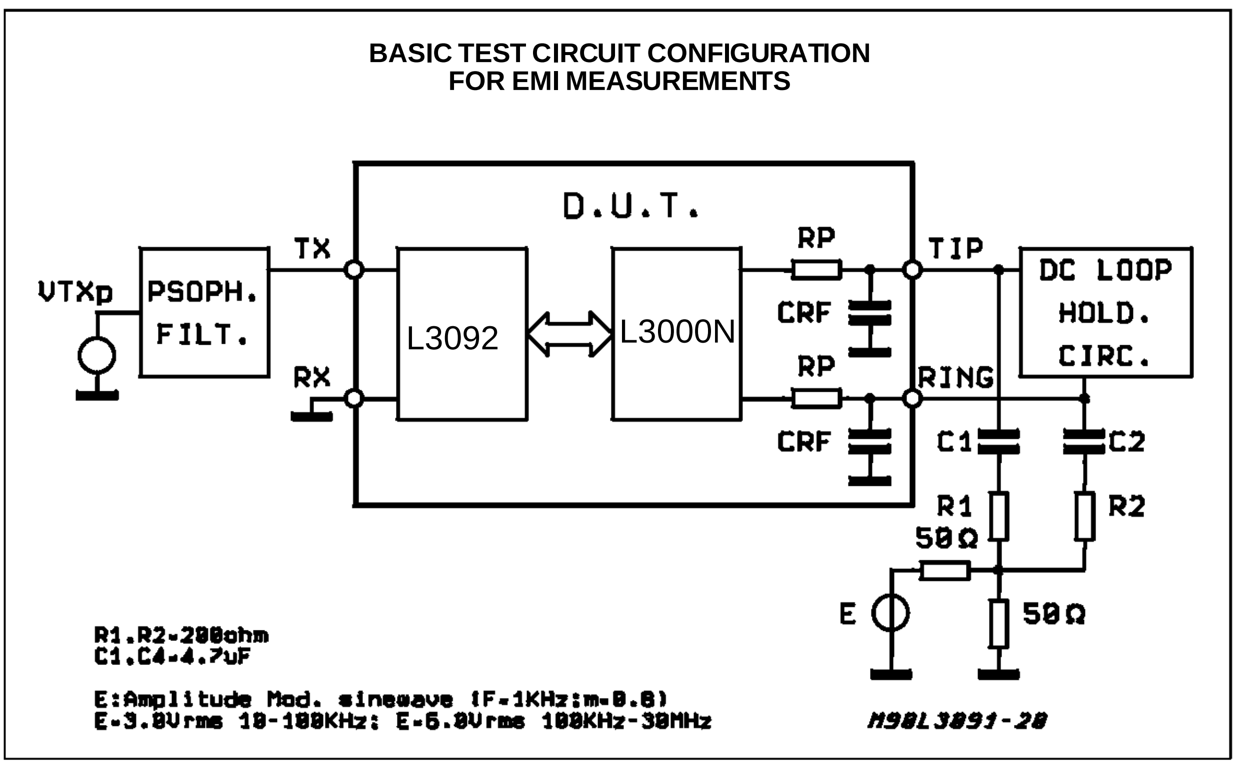
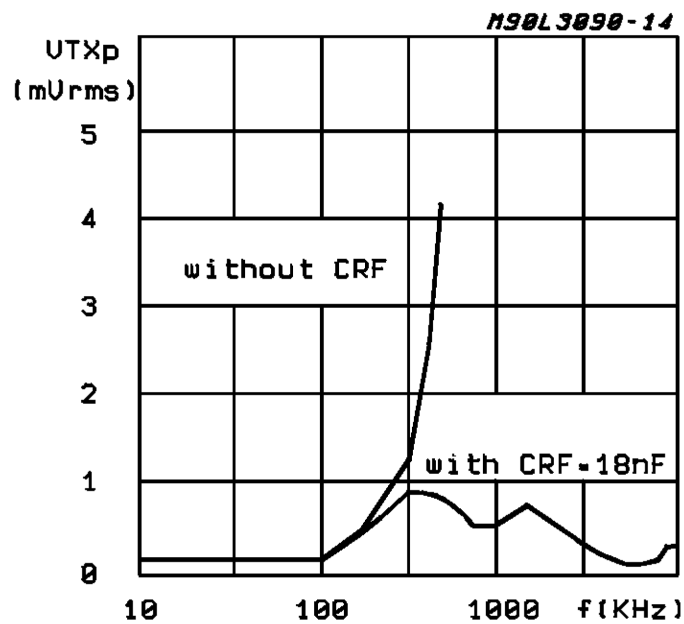


Figure 5b: The high bandwidth and high current capability of L3000N output operational amplifier allows an excellent rejection to longitudinal EMI signals up to 200kHz (a) curve. This good performances are maintained for higher frequencies using two inexpensive small capacitors (Crf=10/20nF).

L3000N/3092 EMI measurements

Test circuit: see FTZ 12 TR1 Teil 21



5. STAND-BY OR ON-HOOK MODE

The L3000N/L3092 SLIC kit is usually programmed in Stand-By mode when the connected telephone set is in on-hook condition; the only functions performed in this mode are:

1) DC line feeding with low limiting current value (10mA)

2) OFF-HOOK detection This second function is performed by a sophisticate circuit that allows a proper off-hook detection also in presence of high common mode currents induced on the line therefore the off-hook information provided by the SLIC doesn't need additional processing by the card controller. The reduced number of functions provided in this mode allows a significative SLIC power dissipation reduction (150mW).

6. POWER DOWN MODE

This mode is used in all those condition in which it is necessary to reduce to zero the power delivered to the line (power failure, emergency, line not connected ....). In power down mode the line interface circuit L3000N is completely switched off therefore not able to detect OFF-HOOK, its impedance at line terminations is 1Mohm and the current sinked from the battery is reduced to zero. In this mode the power dissipation from the +/-5V supplies is typ. 50mW. In case a very low power dissipation is requested also when the telephone is in on-hook and in such condition it doesn't sink more than 500µA the Automatic Stand-by Mode can be selected. The Automatic Stand-by Mode combine the advantages of the two previous operating modes, in particular:

1) Accurate OFF-HOOK detection

2) Low power consumption (50mW from +/-5V and <10mW from battery).

When this mode is selected the L3000N is normally in Power-Down Mode. A dedicated circuitry inside L3092 will sense the line voltage and will automatically program in Stand-by Mode the L3000N if a possible off-hook condition is detected.

7. RINGING MODE

One of the L3000N/L3092 SLIC kit main characteristic is the possibility to inject directly the ringing signal on the line without request of external electromechanical relay and high level ringing generator. In order to obtain from the L3000N the proper level for the ringing signal an additional positive voltage source is requested (typically +72V).

The ringing signal is obtained amplifying a low level signal (1.5Vrms) applied to the SLIC, this low level oscillation can be obtained either from a local oscillator or from the COMBO RX path. The ringing signal is injected on the line in balanced mode with a nominal amplitude of 60Vrms that can be increased up to 70Vrms.

During the ringing injection the SLIC output impedance is just equal to the two series protection resistors (dohm); this characteristic allows to use lower ringing signal amplitude compared with the standard solutions where the ringing generator series impedance is typically 800ohm. In fig.6 is represented the effect of the low output impedance with different ringer load and compared with the traditional solution with a source voltage of 75Vrms and 800ohm of output impedance.

A dedicated circuitry guarantee that the ringing signal is injected and disconnected from the line always in presence of the zero voltage crossing transition, avoiding the generation of very fast voltage transition on the line.

During ringing injection a sophisticate circuit will perform a complete ring trip detection; when off-hook condition is recognized the SLIC will automatically stop the ringing signal without waiting for the card controller command.

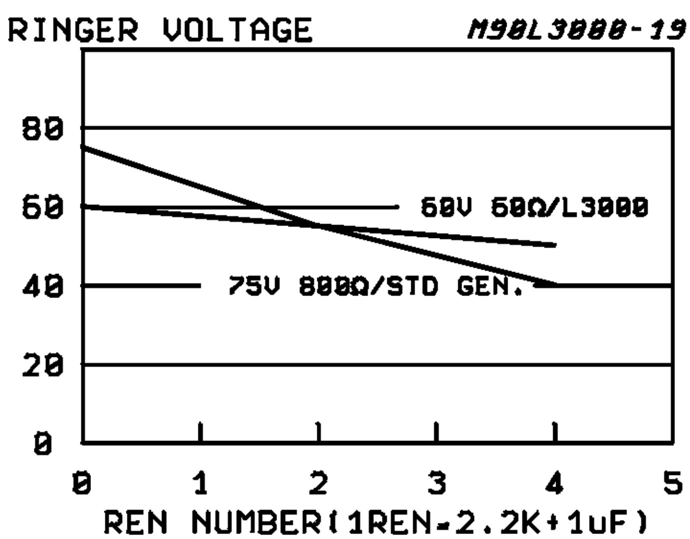
In conclusion the L3000N/L3092 SLIC kit allows to save:

- The centralized H.V. ringing generator
- all the ringing relays
- all the zero crossing circuitry
- all the software for ring trip detection.

Figure 6: Comparison between L3000N/L3092 SLIC kit and standard solutions ringing performances. The voltage across the ringer load after 1Km line (280ohm) is shown for different REN (Ringer Equivalent Number). The L3000N low output impedance in ringing mode allows to recover the lower source voltage (60Vrms versus 75Vrms) and to be better than standard solution when the REN increase.

L30XX/3000N SLIC KITs

EFFECT OF LOW OUTPUT IMPEDANCE DURING RINGING INJECTION (after 280Ω line)



8. CONCLUSIONS

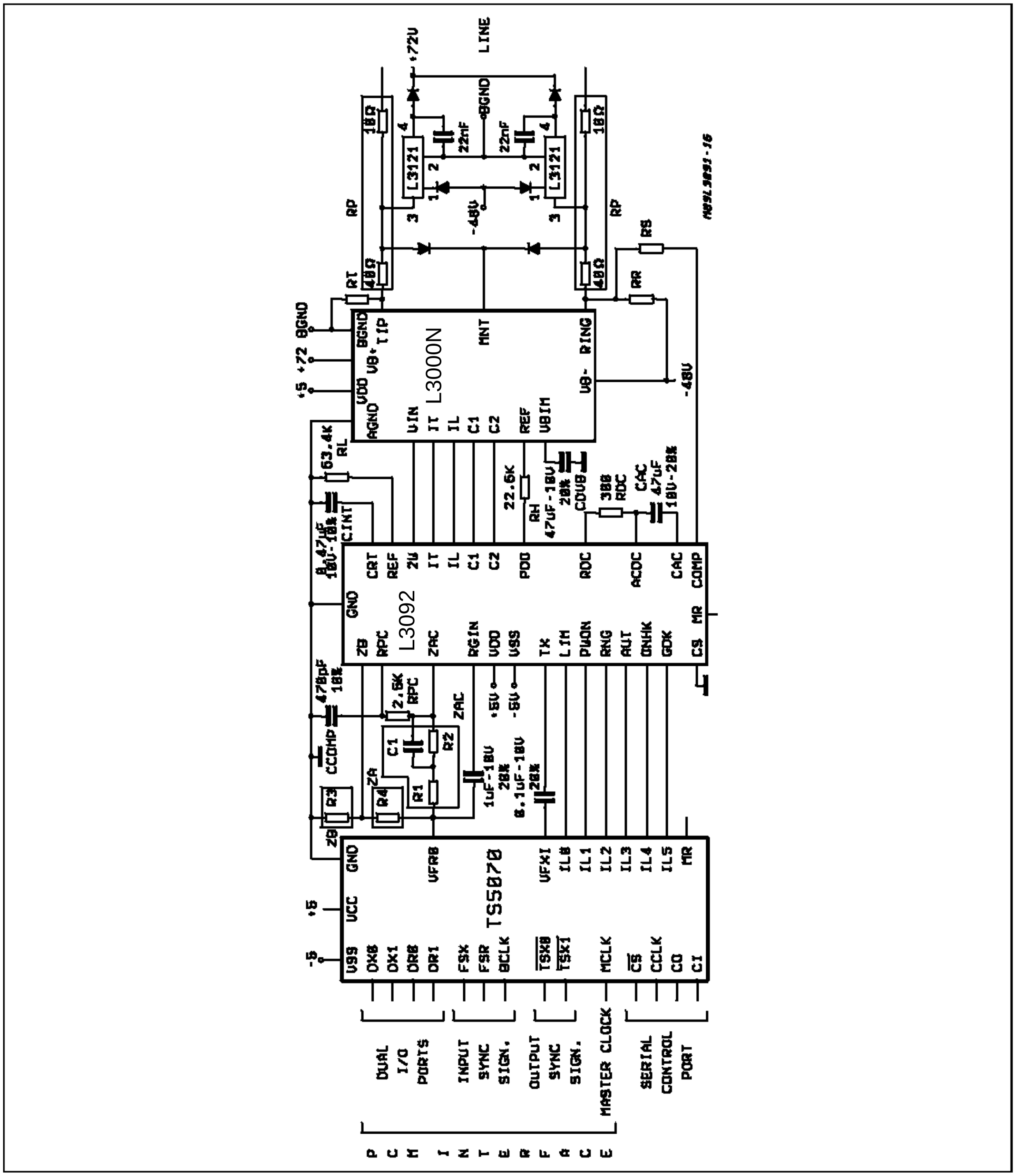
The complete circuitry needed to interface the PCM system highways to the subscriber line is shown in fig.7. The SLIC two chip approach allows to reduce drastically the number of external components, to save the centralized ringing generator, the ringing relay, the zero crossing ringing control and to implement the "message waiting" function. In addition the combination of the

L3000N/L3092 SLIC with COMBOII increase the system flexibility and performances. In particular the card controller can select by software:

- DC feeding currents (25/40/60mA)
- TX and RX gains (25dB range; 0.1dB step) - Balance networks
- Time slot assignment (up to 64x2 slots)

In addition the Test Mode implemented on L3092 in conjunction with COMBOII allows to realize a four step autoadaptive balance system.

Figure 7: Complete application circuit needed to interface a subscriber line with system PCM highways. Very low number of external components and high flexibility are achieved due to the SLIC two chip architecture.



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