Serial Number _____
Options _____

OPERATOR'S MANUAL
MODEL LS15

Micro Seven, Inc.
P.O. Box 5597
Beaverton, OR
97006
U.S.A.
phone: 503-693-6982
fax: 503-693-9742

All requests for repairs should be directed to the factory.

This instrument is warranted against defective workmanship and materials for a period of six months. There will be no warranty when the instrument is misused, or when the factory seal on the instrument is broken.

Printed in U.S.A.

Specification and price change privileges are reserved.

8/30/1998

CONTENTS

SECTION 1

INTRODUCTION

Micro Seven Model LS15, Hand-held Telephone Line Simulator, provides battery operation as well as AC/DC adapter operation. Because it is battery-operated unit, the application include modem and telephone sets testing in engineering, manufacturing, and fields, emergency telephone equipment, telephone line simulators for telephone line installers, and dedicated telephone lines for various outdoor activities including athletic events. The LS15 contains dual frequency call progress tones, 20Hz sine wave ring signal, programmable loop voltage, short primary or programmable secondary telephone number, caller-ID generation, caller-ID on call-waiting generation, stutter dial tone, Visual Message Display messages, 1kHz test tone, distinctive ring signals, and many other test tones. The LS15 also contains line-impairment mode with extra insertion losses and random noise added for long-distance telephone lines. The programmable parameters include caller-ID name and telephone numbers, privacy/out-of-area, single/multiple message format, date and time, battery voltage of 20 or 40V, and many CW-CID parameters. All the programmable parameters are restored back after the power to LS15 is turned. The model LS15 also includes the Sleep mode, a power-saving feature, where the power is shut down when both lines are on-hook for certain period. Therefore, the power switch of LS15 may be left on indefinitely consuming little power. The model LS15 is small and light that technicians may carry it on their shoulders or on waist belts with an optional case. The rechargeable battery inside LS15 provides several hours of battery-power operation, and the battery may be recharged overnight with a provided AC/DC adapter. The LS15 may also be operated by an external DC source with Car Battery Adapter. A carrying case, Car Battery Adapter, and 220V version of AC/DC adapter are available as options. The LS15 is also equipped with a forced-disconnect feature where disconnect signals are sent to calling and called lines. The duration of the disconnect signal is also programmable. Programmable network response delay simulates time delay after completion of dialing. Simulated PBX mode returns dial tone after dialing 9. The secondary call progress tone generates a single-frequency tone instead of dual-frequency call progress tone.

SECTION 2

SPECIFICATIONS

Dialing:

Telephone numbers:

1. Primary telephone number: selected by dialing 043 or line1 or 2 as a factory default.
2. Secondary telephone number: selected by dialing 044.
   A secondary telephone number is same as a calling number in caller-ID.
   Warning: Using secondary telephone number in a privacy mode is prohibited.
   Please read section 4.3 Programming of Caller-ID Parameters for details.

DTMF dialing signal power: -13dBm to +5dBm per a frequency with no more than 4dB difference between frequencies.

DTMF dialing detection time: 45 ms

Pulse dialing: Break period: 45 to 75 ms (60 ms nominal)
Make period: 30 to 60 ms (40 ms nominal)

Simulated PBX Mode:

By dialing "9", dial tone returns when the Simulated PBX Mode was selected.
Dialing "0#252*004*" for Simulated PBX Mode with dual frequency call progress tone or 0#252*012* for Simulated PBX Mode with secondary call progress tone.
Note that the regular dialing methods work as well here. For example, if the secondary dialing method with a telephone number of 3456789012and the PBX mode are enabled, dialing of 3456789012 or 93456789012 would ring the other line. To return to non-PBX mode, dial 0#252*000* with dual frequency call progress tone or dial 0#252*008* with secondary call progress tone.

Line Characteristics:

Input impedance at 1 k Hz: 600 ohms +/- 5%
Signal Bandwidth: 150 HZ to 3.5 k HZ

Line Impairment Mode:

When a number of 00 and line-number is dialed, line impairment circuit with additional 20dB of insertion loss and -55dBm of random noise are added to signals between line 1 and 2. Random noise amplitude is also programmable. Frequency attenuation characteristics and envelope delay distortion of signals are not affected.

Random noise amplitude programming:

0#168*nnn*
The random noise amplitude is set at –55 dBm as a factory default value, but it may be changed by the above dialing method. The factory default value is obtained with nnn=011.
The smaller number, the lower signal power.
i.e. nnn=176 for –31 dBm, nnn=088 for -37 dBm, nnn=044 for -43 dBm,
nnn=022 for -49 dBm, nnn=005 for -61 dBm , nnn=000 for -67 dBm of random noise.

Non-impairment mode:
When a number of 09 and a line number is dialed, the insertion loss between lines becomes only 1 dB, and the random noise is removed. This is the factory default condition.

Battery-feed voltage (loop voltage):
Selection between -20 or -40 volts:
1. -20 volts mode is selected by dialing 041, and it is a factory default condition.
2. -40 volts mode is selected by dialing 042. The battery-feed voltage is changed to -20 volt mode when called line is ringing or in its off-hook state (answered). When the called line hangs up the line, the battery-feed voltage is returned to -40 volts.

Ring Signal:
20 +/- 2% Hz sine wave. Normally 2 sec on 4 sec off with exception of distinctive ringing features programmed.
Amplitude: 67V RMS into open circuit. It is 66 V RMS into RN=0.1, 56 V RMS into RN=0.5, 48V RMS into RN=1, and 40V RMS into RN=1.7.
According to the FCC-part 68 rule, the RN=7000/(equivalent resistive value in ohms) for ring signal of 20Hz +/- 3%.
The ring signal at a called line is disabled by dialing *0. To enable back to ringing at a called line, dial *0 again.

Distinctive ring signal features:
The following distinctive ringing pattern is enabled instead of standard 2 sec on/ 4 sec off ringing pattern:
(a). Dialing 0 * 1 + (line number): 2 sec on/ 4 sec off (default condition)
(b). Dialing 0 * 2 + (line number): 0.8 sec on, 0.4 sec off, 0.8 sec on, 4 sec off
(c). Dialing 0 * 3 + (line number): 0.4 sec on, 0.2 sec off, 0.4 sec on, 0.2 sec off, 0.8 sec on, 4 sec off
(d). Dialing 0 * 4 + (line number): 0.3 sec on, 0.2 sec off, 1 sec on, 0.2 sec off, 0.3 sec on, 4 sec off

Off-hook impedance requirement: 400 ohms maximum DC, 600 ohms nominal AC

Call Progress Tones:
Standard dual-frequency call progress tones: nominal -16 dBm.
Dial Tone: 350 Hz + 440 Hz, continuous unless programmed for stutter dial tone
Ring-back Tone: 440 Hz + 480 Hz, 2 sec ON/4 sec OFF.
Busy Tone: 480 Hz + 620 Hz, 0.5 sec ON/0.5 sec OFF.
Accuracy in frequency component: +/- 1%.

Secondary Call Progress Tones: (480 Hz +/- 1%)
Dialing 07 enables the secondary call progress tones. Instead of generating dual frequency call progress tones, single-frequency tone of 480 Hz is produced with signal power of – 18.5 dBm. Dialing 07 switches back to the dual frequency call progress tones.

Stutter dial tone:
Dialing 046 enables stutter dial tone with three of 0.1 seconds on/off period following with continuous dial tone.
Dialing 045 disables the stutter dial tone. It is a factory default condition.

Line Input Jacks: USOC-RJ11-C, standard modular phone jacks

Power Switch: on when the switch is pushed in, off when the switch is pushed out.

Built-in Battery:
The battery is charged when the LS15 power switch is off.
Battery Capacity: 2.5 hours of battery operation with maximum load of both lines off-hook condition.
Recharging time: 24 hours
Charge/discharge cycles: 100 times minimum
Battery replacement procedure is found in section 3.5.

Hot Line Mode:
Dialing 06 enables the Hot Line mode, which calls the other line without dialing a number. To return to non-hot-line mode, dial 06 during the first 0.5 seconds right after off-hook.

Network response delay:
Time delay between the end of dialing and ring-signal application is programmable by the following dialing:
0#170*nnn*, where nnn is a 3-digit decimal number between 1 and 255. The time delay is determined by 8.6 ms x (nnn-1). The number, nnn, should not be zero.
The factory default is 0 seconds.

Forced called-party disconnect:
When two lines are connected and one line hangs up, disconnect signal is generated to both lines.

Programmable disconnect signal:
The disconnect signal, which is interruption of loop current at the end of call when one line hangs up is programmable by the following dialing:
0#169*nnn*, where nnn is a 3-digit decimal number between 1 and 255. The time delay is determined by 8.6 ms x (nnn). The number, nnn, should not be zero.
The factory default is 320 ms.

Sleep Mode (Automatic Power Shut-down):
The Sleep mode is enabled as a factory default condition. When both lines are idle (on-hook)

for thirty seconds and sleep mode is enabled by dialing 049, it goes to the sleep mode with power consumption down to a minimum amount. As a factory default condition, sleep mode is enabled. Any off-hook condition at a line ends the sleep mode. To disable the LS15 to enter the sleep mode, dial 040. The sleep mode is only in LS15 with a battery.

AC/DC Adapter: 117VAC +/- 5%, or 220VAC +/- 5%(for 220V unit)

AC/DC Adapter or Car Battery Adapter input (also as a battery charger): 12VDC unregulated, 800mA maximum

Line Status Display: red LED for each line to indicate off-hook status (continuous on) or ringing status (blinking)

Calibration: not required

Power On Indicator: green LED display on front panel, steady-blinking to indicate low battery condition, dim-blinking to indicate that the battery charge is almost gone.

Dimensions: 19 cm (4") W x 4.5 cm (1.75") H x 10 cm (7.5") L

Weight: 500g (1.1 lbs.)

Environmental: Operating temperature: 0 to 35 degree C, Humidity: 85% RH at 35 degree C

Warranty/Service: 6 months limited warranty. No warranty if any factory seal is broken. Service is performed at the factory, usually within 5 working days.

On-hook and off-hook (call-waiting caller-ID) caller-ID FSK Generation:

Single message and multiple message-format caller-ID FSK generations are supported. Programming parameters includes telephone number, name, date and time, telephone number length, name length, privacy/out-of-area, call qualifier on/off, visual message on/off, marking period before FSK data, silence period after the first ring, continuous caller-ID generation on/off, and wrong checksum generation on/off. No ring signal is produced for the visual messages. It also includes an FSK data expansion capability of caller-ID data.

Caller-ID Signals:

Frequencies: 1200Hz +/- 2 Hz, 2200Hz +/- 5Hz
Signal power: -14dBm into 600 ohms
Dialing 048 repeats caller-ID sequences.

Programmable parameters for caller-ID:

01 + Date + Time, i.e. 0106011230 for 12:30 A.M., June1.

02 + (line number) + (telephone number), i.e. 0225035551212 to assign 5035551212 for line 2. The programmed number is the same as the secondary telephone number. A caller-ID display with a re-dial feature can dial a calling line.

02 + (line number) + *, to assign private status.
Caution: The caller-ID number, which is secondary telephone number, will be destroyed by setting privacy mode; therefore, the caller-ID number must be reprogrammed again.

02 + (line number) + #, to assign out-of-area status.
Caution: The caller-ID number, which is secondary telephone number, will be destroyed by this action; therefore, the caller-ID number must be reprogrammed again.

03 + (line number) + (3-digit ASCII)*(3-digit ASCII)*------
i.e. 0 3 1 0 7 7 * 0 7 3 * 0 6 7 * 0 8 2 * 0 7 9 *0 ------- to assign MICRO--- for line 1 name. All characters must be entered to program a complete name. ASCII equivalent of characters are found in Appendix C, ASCII TABLE.

Multiple-message format: * 1

Single-message format: * 2

Multiple-message format without directory number: * 3

Wrong check-sum generation: * 4
Reset by the above *1, *2, or *3

Visual message waiting ON : * 5
Reset by the above *1, *2, or *3

Visual message waiting OFF : * 6
Reset by the above *1, *2, or *3

Silence period right after the end of the first ringing period before a caller-ID sequence: * 7 n,
where total time is n times 100 ms. "0" is considered as a decimal number of ten. The factory default is 500 ms.

The ring signal may be turned on/off by dialing * 0.

Call qualifier (long distance indication) on/off: *#

Telephone number digit: 0 # 1 7 8 * n n n *, where nnn forms a 3-digit decimal number. The default value is 10 digit. The maximum number is 18.

Name length is programmable by: 0 # 1 7 9 * n n n *

Continuous caller-ID generation may be enabled by dialing 0 4 8. To disable continuous caller-ID generation, dial 0 4 7.

Programmable parameters for Call-waiting caller-ID:

SAS duration (0#161*nnn*), CAS duration (0#162*nnn*), acknowledge period (0#163*nnn*), Caller-ID Data Transmission Delay between DTMF reception and FSK data generation (0#164*nnn*) are programmable. The call-waiting CID sequence is started by dialing 0 5 *. Dialing 048 repeats call-waiting caller-ID sequences.
Subscriber Alert Signal (SAS): 440Hz +/-2 Hz, -19dBm into 600 ohms
CPE Alert Signal (CAS): 2130 Hz +/- 10Hz, 2750 Hz +/- 10 Hz, -20dBm into 600 ohms, tone level tolerance of +/- 1 dB per frequency.

Programming of marking period in caller-ID:

In the on-hook caller-ID, the marking period before the FSK data is programmable by 0#166*nnn*. In the off-hook caller-ID (caller-ID on call-waiting), the marking period is programmable by 0#167*nnn*.

Programming of Channel Seizure Period: 0#165*nnn*

Programmed parameters memory and restoration of factory standard:

All operating parameters are saved in LS15 memory when the power is turned off.

Caution: The maximum number of changing LS15 programmed parameters is limited to two million operations; therefore, continuous programming of LS15 parameters should be avoided.

The restoration of memory to the following factory standard is done by dialing 04#:

-Select primary (short) dialing method.
-Battery-feed voltage of -20V
-No line impairment mode is selected.
-The random noise amplitude is set at -55dBm for the line impairment mode.
-Continuous dial tone, not stutter dial tone.
-The sleep mode is enabled.
-The programmable telephone number and caller-ID telephone numbers if enabled, are set as the following ten digits: line 1: 1234567890, and line 2: 2345678901
-Selects multiple message format display for caller-ID.
-The names of caller-ID parameters are the following in 15 digits:
Line1: ABCDEFGHIJKLMNP, and Line 2: BCDEFGHIJKLMNOP
-The time and date are set as 12:30 p.m., January 1.
-The call qualifier is turned off.
-Marking period before FSK data: 160 ms (on-hook caller-ID generation), 70 ms (off-hook caller-ID display)
-Silence period after the ring: 500 ms
-Disable continuous caller-ID display
-Enable caller-ID generation with ring-signal.
-SAS duration of 300 ms

-CAS duration of 80 ms
-Acknowledgement timeout period of 160 ms
-Wait time between DTMF reception and start of FSK data generation of 50 ms
-Channel Seizure Signal Length of 30 characters of hex55
-No network response delay
-Disconnect signal of 320 ms
-No Hot-line mode.
-Dual frequency call progress tones are selected instead of secondary call progress tones.

Test tones:

The following test-tone are produced after dialing the following:
051: 350 Hz, -18.5dBm
052: 440 Hz, -18.5dBm
053: 480 Hz, -18.5dBm
054: 620 Hz, -18.5dBm
055: 1200 Hz, -14dBm
056: 2200 Hz, -14dBm
057: Channel Seizure Signal (1200, 2200), -14dBm
058: 2130 Hz, -23dBm
059: 2750 Hz, -24dBm
050: CAS (2130+2750), -20dBm
05#: 1004 Hz, on/off by 5 Hz, -12dBm

Options and Accessories:

Carrying case
Car Battery Adapter
230V input AC/DC Adapter (117V input unit is a standard.)

SECTION 3

OPERATION

3.1 Power Supply Selection

The LS15 may be operated with AC/DC Adapter, Built-in Battery, or Car Battery Adapter (external DC operation). AC/DC Adapter and Car Battery Adapter Operations require +12 V DC power input at LS15 Rear Panel. The standard AC/DC Adapter that is supplied with LS15 requires 117V input power. The 220V version of AC/DC Adapter is available as an option.

3.2 Built-in Battery Operation

For Built-in Battery operation, connectors at the power input at LS15 rear panel must be removed. For charging the Built-in Battery inside LS15, either AC/DC Adapter or Car Battery Adapter (external DC operation) may be used, but the Built-in Battery is charged only when the LS15 power switch is off. Depress the front-panel power switch. The power LED on the front panel comes on, and it shows the status of battery charge. When there is a sufficient charge in the battery or power to provide at least about one and a half hour of full instrument operation for having both lines off-hook, the POWER LED is continuously on. When the battery requires charging, it blinks. When there is no charge left in the battery, it flashes dimly. During external DC operation using AC/DC Adapter or Car Battery Adapter operation, the POWER LED is continuously on.

3.3 Sleep Mode (Automatic Power Shut-down)

The Sleep Mode is enabled by dialing **049**, and is disabled by dialing **040**. The sleep mode is only available in LS15 with a battery.
When the Sleep Mode is enabled (factory default), and both lines are on-hook for a certain period, the main power supplies in LS15 are shut down to save power. However, each line's line condition is still monitored continuously during the Sleep period. If either line goes off-hook, the main power supplies in LS15 will be turned back on.

3.4 AC/DC Adapter or External DC Input Operation

An AC/DC Adapter, which is supplied with LS15, also provides battery-charger function. The battery is charged when the power switch of LS15 is turned off to reduce power dissipation inside LS15. It takes 24 hours to charge the battery fully. The AC/DC Adapter may be replaced with an optional Car-Battery Adapter, which is connected to a rear panel connector in LS15.

3.5 Battery Replacement Procedure

The following battery replacement procedure is very complicated and difficult to be done; therefore, Micro Seven does not provide product-warranty nor product liability if the battery is replaced by a customer and the factory seal is broken. It is recommended that a battery

will be replaced by Micro Seven, Inc. at our factory. However, we provide a battery replacement kit, which includes a battery-pack and a replacement LS15 Cover Label.

1. Remove all connectors including AC/DC Adapter, any external DC connector such as a car battery adapter, and all telephone line connections at J1 and J2.
2. Turn off the power switch on the front panel.
3. Remove LS15 Cover Label on the top and factory seal on the side if provided.
4. Remove four long screws that hold top and bottom cases at the bottom of LS15. Remove four rubber bumpers that cover screws if necessary.
5. Gently separate top and bottom of LS15 case.
5. Remove two battery cables at a printed circuit board. Note that there are black and red wires. Make a note of the cable polarity.
7. Remove four brackets, that hold battery to a top case.
8. Install a new battery-pack, restore place brackets and screws on the battery pack.
9. Connect battery cables on the printed circuit board.
10. Place the LS15 cover and bottom pieces together.
11. Place screws from the bottom, and tighten.
12. Replace four bumpers if necessary.
13. Attach a new LS15 Cover Label.

3.6 Front-Panel Description

The front panel of LS15 is shown in Figure 3-1.

1. J1 (RJ11-C): Line 1 Input Jack for connection to telephone sets/modems
2. Line 1 OH/BUSY Indicator: LED to indicate "Off Hook" status or "Line busy" condition. It blinks when it is ringing.
3. J2 (RJ11-C): Line 2 Input Jack for connection to telephone sets/modems
4. Line 2 OH/BUSY Indicator: LED to indicate "Off Hook" status or "Line busy" condition. It blinks when it is ringing.
5. Power ON (when the switch is in.)/OFF (when the switch is out).
6. Power LED: Steady on when the power is on.
   In battery-powered operation, the steady power means that the battery is nearly fully charged. When it is blinking slowly, it means that the battery needs recharging. When the LED is flashing dimly, it means that the battery does not hold no charge, and it needs immediate recharging.

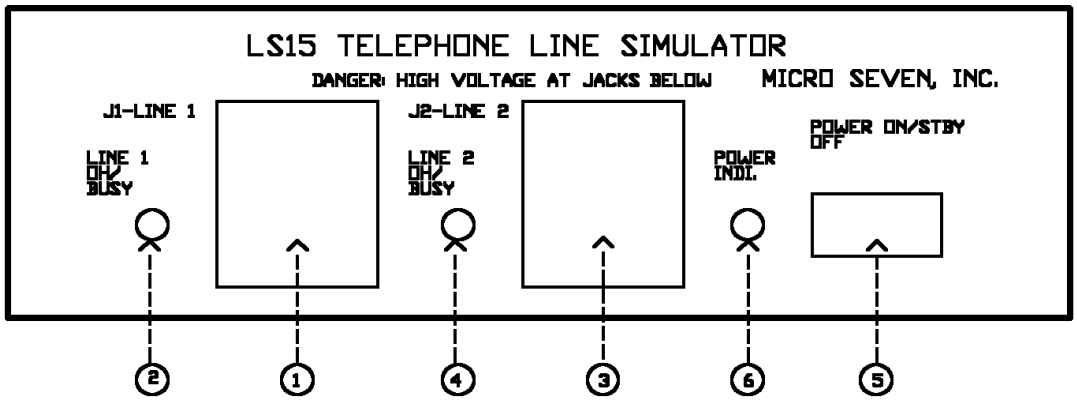


Figure 3-1 Front Panel of LS15

3.7 Rear-Panel Description

The rear panel of LS15 is shown in Figure 3-2. Connect AC/DC Adapter or Car Battery Adapter to a DC Input connector on the rear panel.

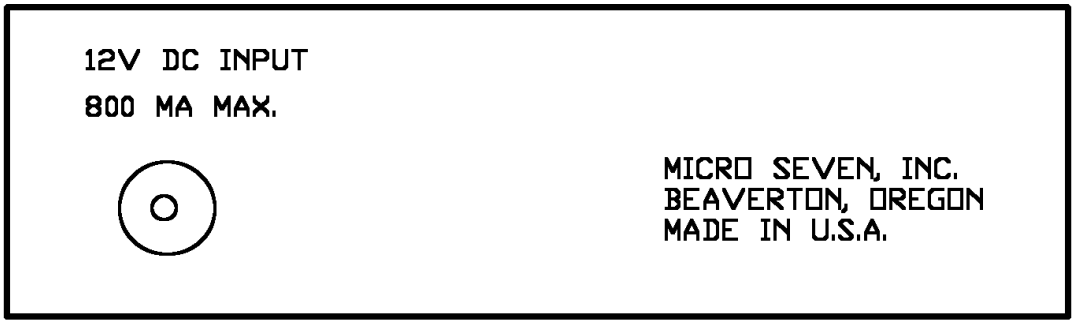


Figure 3-2 Rear Panel of LS15

3.8 First-time Battery Operation and Dialing Primary Telephone Number

Use this procedure when turning the instrument on for the first time. The procedure will also serve to explain the operation of the instrument. Here, two telephone sets, or one telephone set and an auto-answer modem, are required as shown in Figure 3-3.

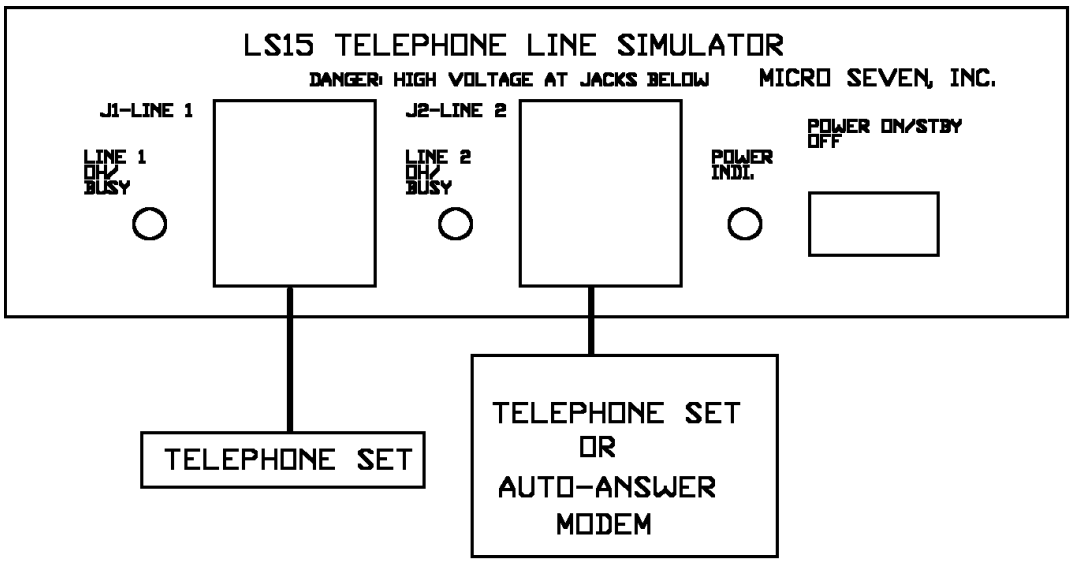


Figure 3-3 Connection for first time operation

Remove all connections to LS15 including any external power supplies and cables. First, assuming that the battery inside LS15 is fully charged and with nothing connected to LS15, push the front panel POWER switch in. Observe that the front panel POWER indicator LED comes on. With nothing connected to any of the line input jacks, the OH/BUSY lights for all lines should be off.

Connect a standard telephone set, either rotary or tone, to J1. Connect an auto-answer modem or another telephone set to J2. Check that the OH./BUSY lights are still off. If any light is on, check to see if the telephone is off-hook, or the modem is in its off-hook condition.

Lift the Line 1 telephone receiver; the Line 1 OH./BUSY light should come on and the dial tone should be audible at the Line 1 receiver. Assuming that the Primary Dialing method (single-digit dialing as factory default) is employed, dial a rotary pulse or DTMF "2" at the Line 1 set; after completing the dialing, the ring-back tone should be audible. The high-voltage ring signal is generated at the J2. Observe that the OH/BUSY light for Line 2 is flashing to indicate ring signal.

When the call from Line 1 is answered at Line 2 by closing relay contacts in the modem or lifting the receiver, the ring-back tone at Line 1 and the high-voltage ring signal at Line 2 will be turned off. Observe also that the OH/BUSY light for Line 2 is now steadily on. A signal path has been established between Line 1 and Line 2.
When an auto-answer modem is used at Line 2, it generally waits 2 to 3 seconds before generating a continuous 2.2 kHz answer tone.

3.9 Checking AC/DC Adapter operation and Dialing Secondary Telephone Number

Next, hang up the telephone sets, and turn off the power switch of LS15. Connect AC/DC Adapter to the rear of LS15, and apply correct input power source, 117V or 220V depending on an AC/DC Adapter. Then push the front panel POWER switch in. Observe that the front panel POWER indicator LED comes on again. Because both telephone sets are on hook, the OH/BUSY lights for two lines should be off. Lift the Line 1 telephone receiver, and dial "044" to select the Secondary Telephone Number, and hang up the receiver. Lift the Line 1 telephone receiver again, dial a rotary or tone "2345678901"; after completing the dialing, the ring-back tone should be audible. And the high-voltage ring signal is generated at the J2 connection. Then hang-up the Line 1 telephone receiver, and dial "043" to return to the Primary Telephone Number. The Secondary Telephone Number is programmable as explained in the caller-ID operation, section 4. Note that the factory default is "1234567890" for the Line 1, and "2345678901" for the Line 2.

3.10 Line Impairment Mode/Non Line-Impairment Mode

The factory default condition is non-impairment mode, so dial "002" at the Line 1 telephone receiver to select the Line Impairment Mode. The Line Impairment Mode adds 20 dB insertion losses for signals between two lines. It also adds a random noise injection to signals between two lines. When the Line 2 answers the call from Line 1, signals between lines are attenuated by 21 dB, and random noise is added to the signals. After the programming for the Line Impairment Mode is completed, either Primary or Secondary Telephone Number will not affect the Line Impairment Mode. To return to non-impairment mode, dial "09" at either line, and hang up. The programming of random-noise signal power is explained in the Section 2, Specifications. The frequency attenuation characteristics nor envelope delay distortion of signals are not affected in LS15.

3.11 Noise Amplitude Adjustment

The random noise in the Line Impairment Mode, which is described in 3.10, may be adjusted by dialing "0#168*nnn*, where "nnn" forms a 3-digit decimal number.
The random noise amplitude is set at -55 dBm as a factory default value with "nnn"=011. The smaller number for "nnn", the lower signal power.

3.12 Dual-Frequency and Secondary Call Progress Tones

As defined in the Section 2, Specifications, the standard call progress tones in LS15 including dial tone, ring-back tone, and busy tone are dual frequency call progress tone types as being used in U.S. and Canada. The Secondary Call Progress Tones of a single frequency of 480 Hz may be selected instead of the dual frequency type by dialing 07 and hang up the receiver. The tone duration will not be affected. To return to the dual frequency call progress tones, dial "0#252*000*" for non-PBX mode or "0#252*004*" for PBX mode.

3.13 Simulated PBX Mode

The Simulated PBX Mode generates dial tone again after receiving dialing of "9" as dialing "9" is required to access an outside line. To enable this Simulated PBX Mode, DTMF dialing of "0#252*004*" for dual frequency call progress tones or dialing of "0#252*012*" for the secondary call progress tones. Note that dialing "9" is not required to complete dialing; for example, dialing "92" or "2" at the Line 1 will ring the Line2. To return to non Simulated-PBX Mode, dial "0#252*000*" for dual frequency call progress tones or "0#252*008*" for secondary call progress tones. Also note that dialing "9" as a primary telephone number in non-Simulated-PBX mode will generate busy signal.

3.14 Battery-Feed (Loop Voltage) Selection Between -20V and -40V

The battery-feed voltage of -20 V is a factory default condition. By dialing "042", it may be changed to -40 V. To save great power dissipation in -40V Batter-Feed, the -40V battery-feed is changed to -20 V battery-feed when the other line is ringing or answers to the ringing. It goes back to -40V when one of two lines goes on-hook.

The factory default condition is -20 V, and it may to switched to -20 after dialing "041".

3.15 Stutter Dial-Tone

By dialing "046", the stutter dial-tone is enabled. By dialing "045", it is switched back to non-stutter dial-tone.

3.16 Hot-Line Mode

The Hot-Line Mode eliminates dialing. When one line goes off-hook and receives dial tone, the other line will be ringing. Dialing "06" enables the Hot-Line Mode, and dial "06" during the 0.5 seconds right after off-hook to disable the Hot-Line Mode.
Caution: Changing back to non Hot-Line Mode is very tricky because requirement of fast dialing.

3.17 Network Response Delay

The network response delay, that is between the end of dialing and start of ring signal application and ring-back tone generation, may be implemented by dialing "0#170*nnn*" where "nnn" forms a 3-digit decimal number. The delay is determined by 8.64 ms multiplied by a number, "nnn".
For example, by dialing "0#170*255*", the network response delay of 2.2 seconds is obtained.

3.18 Forced Called-Party Disconnect and Programming Disconnect Signal

When two lines are connected and one line hangs up, disconnect signal, which is interruption of loop current, is generated at two lines for 320 ms.

The disconnect signal duration is programmable by dialing "0#169*nnn*, where "nnn" forms a 3-digit decimal number. The duration is determined by 8.64 ms multiplied by a number, "nnn".

3.19 Enabling / Disabling Ring Signal

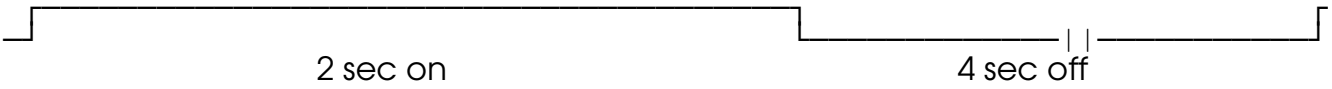
The ring signal may be turned off at a called line by dialing *0 to simulate future expansion of caller-ID signal, which may be available without any ring signal.
To return to normal ring mode, dial "*0" again.

3.20 Distinctive Ring Signal

Instead of the normal ringing interval of 2 sec on / 4 sec off, the following three different ringing patterns are provided:

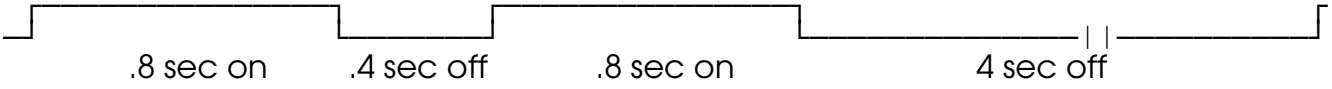
Pattern 1: 2 sec on, 4 sec off

Dial 0 * 1 + (Line Number), default condition



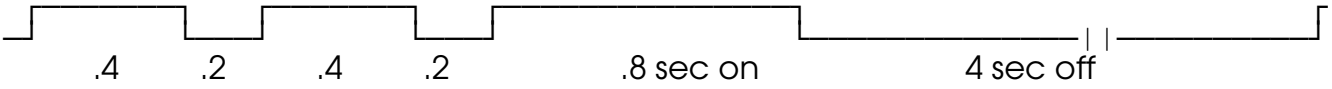
Pattern 2: .8 sec on, .4 sec off, .8 sec on, and 4 sec off

Dial 0 * 2 + (Line Number)



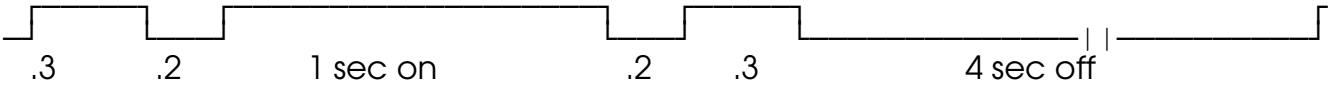
Pattern 3: .4 sec on, .2 sec off, .4 sec on, .2 sec off, .8 sec on, and 4 sec off

Dial 0 * 3 + (Line Number)



Pattern 4: .3 sec on, .2 sec off, 1 sec on, .2 sec off, .3 sec on, and 4 sec off

0 * 4 + (Line Number)



SECTION 4

CALLER-ID

4.1 Introduction

The Caller-ID features of Micro Seven model LS15 simulates caller-ID services with north American single and multiple data format messages from public telephone companies. A calling-line's 10 digit telephone number including an area code and name are transmitted along with date and time during the first silence period of the ringing cycle at a called line. Depending on a pre-programmed condition of a calling line, a privacy or out-of-area status code may be transmitted instead of a calling number and name. However, date and time information are always transmitted. The Caller-ID features provide testing and demonstration of various caller-ID displays or receivers without obtaining caller-ID services from public telephone companies.

The caller-ID information which consists of date, time, calling number (or privacy status or out-of-area status), name (optional), and call qualifier (long distance indication-optional) is transmitted only once during the silent period after the first ringing cycle. If the called line represents an off-hook condition (answers the call) during the first ringing cycle or the first silent period, the transmission of caller-ID information ends. A 10-digit telephone number, or privacy status or out-of-area status for each line, is programmable by dialing a special code. The date and time are programmable by dialing a special code also. To test caller-ID display devices continuously, LS15 may be programmed to generate caller-ID data after every ringing period.

The single or multiple data message format may be selected by entering a special code. The multiple data message format provides name of caller in addition to date, time, directory number, and the long-distance call qualifier. LS15 may also be programmed to transmit Visual Message Waiting Indicator messages without ring signal. The channel-seizure period and marking-period may also be programmed in LS15.

4.2 Specifications

4.2.1 Caller-ID Data Transmission:

Please refer to the Section 2, Specifications, for frequency accuracy and signal power.
Modulation: FSK
Frequency: 1200 Hz for Logical 1 (Mark)
2200 HZ for Logical 0 (Space)
Transmission Rate: 1200 bits per seconds
Transmission Scheme: ASCII characters, least significant bit is transmitted first.
Number of Stop Bit: 1
Number of Character Data bit: 8
Parity Bit: None
Checksum Byte: 2's complement of data between T4 and T7 (single data message format)
or T4 and T9 (multiple data message format), which are defined in section 4.2.2.

4.2.2 Transmission Method of Caller-ID Information

4.2.2.1 Single Data Message Format

CID information is transmitted during the silence period after the first ring signal as follows:

T0: First period of ring signal ends.

T1: 500 ms of silence period, no carrier generated during this period

T2: Turning on carrier and data transmission of 30 each hex 55 (channel seizure period), for 260 ms

T3: Marking for 160 ms

T4: Message Type Word (1 byte), Hex 04, start computing checksum

T5: Message Length Word (1 byte) -Transmission of Hex 09 or Hex 12 depending on type of a calling line. Hex 09 is transmitted for privacy or out-of-area status.

T6: Real time clock information (8 bytes long)
1st Byte: Month (10)
2nd Byte: Month (1)
3rd Byte: Day (10)
4th Byte: Day (1)
5th Byte: Hour (10) in 24 hour format
6th Byte: Hour (1) in 24 hour format
7th Byte: Minutes (10)
8th Byte: Minutes (1)

T7: 10 digit calling in ASCII format
Area Code (3 digit) + Telephone Number (7 digit), or one byte-hex 50 (ASCII "P") for privacy status when a calling number delivery blocking, or one byte-hex 4F (ASCII "O") for out-of-area to indicate unavailable calling number

T8: Check Sum Byte The receiver adds all the data between T4 and T8 with the checksum result should be zero.

T9: Turning off the carrier after 80 ms of marking

4.2.2.2 Multiple Data Message Format

CID information is transmitted during the silence period after the first ring signal as follows:

T0: First period of ring signal ends.

T1: 500 ms of silence period, no carrier generated during this period

T2: Turning on carrier and data transmission of 30 each hex 55 (channel seizure period) for 260 ms

T3: Marking for 160 ms

T4: Message Type Word (1 byte), Hex 80, start computing checksum

T5: Message Length Word (1 byte)
Total byte count during T6, T7, and T8

T6A: Parameter Type Word (1 byte), Hex 01
T6B: Parameter Length Word (1 byte), Hex 08
T6C: Real time clock information (8 bytes long)
1st Byte: Month (10)
2nd Byte: Month (1)

3rd Byte: Day (10)
4th Byte: Day (1)
5th Byte: Hour (10) in 24 hour format
6th Byte: Hour (1) in 24 hour format
7th Byte: Minutes (10)
8th Byte: Minutes (1)

T7A: Parameter Type Word (1 byte), Hex 02
T7B: Parameter Length Word (1 byte), Hex 0A
T7C: 10 digit calling number in ASCII format
Area Code (3 digit) + Telephone Number (7 digit)
OR
T7A: Parameter Type Word (1 byte), Hex 04 for reason for absence of DN
T7B: Parameter Length Word (1 byte), Hex 01
T7C: Hex 50 (ASCII P), private status
OR
T7A: Parameter Type Word (1 byte), Hex 04 for reason for absence of DN
T7B: Parameter Length Word (1 byte), Hex 01
T7C: Hex 4F (ASCII O), out-of-area

T8A: Parameter Type Word (1byte), Hex 07 for name delivery
T8B: Parameter Length Word (1 byte), Hex 0F
Note: The name length is variable between one and fifteen.
T8C: Fifteen ASCII characters
If the calling line is Line 1: ABCDEFGHIJKLMNO
If the calling line is Line 2: BCDEFGHIJKLMNOP
OR
T8A: Parameter Type Word (1 byte), Hex 08 to indicate a reason for absence of name
T8B: Parameter Length Word (1 byte), Hex 01
T8C: Hex 50 (ASCII P), privacy
OR
T8A: Parameter Type Word (1 byte), Hex 08 to indicate a reason for absence of name
T8B: Parameter Length Word (1 byte), Hex 01
T8C: Hex 4F (ASCII O), out-of-area

T9A: Call Qualifier Code, Hex 06 (optional)
T9B: Parameter Length: Hex 01 (optional)
T9C: Long Distance Qualifier, Hex 4C (optional)
T10: Check Sum Byte The receiver adds all the data between T4 and T10 with the checksum result should be zero.

T11: Turning off the carrier after 80 ms of marking

4.3 Programming Caller-ID Parameters

Dial the following special codes to program calling numbers, privacy status, out-of-area status, date & time. All Caller-ID parameters will be restored with the power off.

4.3.1 Date & Time

01 + month(10) + month(1) + day(10) + day(1) + hour(10) + hour(1) + minute(10) + minute(1) in 24 hour format.

For example, to set the time at 4:26 p.m., February 20, dial 0102201626 to set the time at 8:15 a.m., December 31, dial 0112310815 and hang up.

4.3.2 Calling Number Programming

02 + line number + telephone number

Note: The telephone number length is defined in Section 4.3.3.

The Calling Number, that is programmed here, is the Secondary Telephone Number, which is defined in Section 2, Specifications.

Example 1: to program 503-987-6543 as a calling number and Secondary Telephone Number for line 1, dial 0215039876543, and hang up.

Example 2: 800-555-1212 for line 2, dial 0228005551212, and hang up.

Factory-default condition of calling numbers:

Line 1: 1234567890
Line 2: 2345678901

4.3.3 Programming telephone number length

Programming for variable length of calling numbers and secondary telephone number is obtained by dialing: 0#178*nnn*, where “nnn” is a 3-digit decimal number between 0 and 18. The maximum telephone number is eighteen digits. The factory default is set at 10 digits.

4.3.4 Privacy Status

02 + line number + *.
Example: to set privacy status for line 2, dial 022*, and hang up.

Warnings:
1. When a line is programmed as a private number, the calling number is destroyed. A new calling number must be programmed again using the above procedure in 4.3.2.1, Calling Number Programming.
2. When a line is set as a privacy status, the Secondary Telephone Number dialing method is not available because the telephone number data is destroyed.

4.3.5 Out-of-Area Status

02 + line number + #.
Example: to set out-of-area for line 1, dial 021#, and hang up.

Warnings:
1. When a line is programmed as an Out-of-Area, the calling number is destroyed. A new calling number must be programmed again using the above procedure in 4.3.2.1, Calling Number Programming.

2. When a line is set as an Out-of Area, the Secondary Telephone Number dialing method is not available because the telephone number data is destroyed.

4.3.6 Visual Message Waiting Indication

The FSK data generation of visual message waiting indication display is enabled after dialing *5 for message waiting indication ON or dialing *6 for message waiting indication OFF. Then dial the other telephone number to deliver the message.

In the multiple message format, the message waiting indication ON data consists of the following bytes: hex 82, 03, 0B, 01, FF, and 70 (checksum). The message waiting indication OFF data consists of the following bytes: hex 82, 03, 0B, 01, 00, and 6F (checksum).
In the single message format, the message waiting indication ON data consists of the following: hex 06, 03, 42, 42, 42, and 31(checksum). The message waiting indication OFF data consists of hex 06, 03, 6F, 6F, 6F, and AA(checksum).
Note that the ring signal is turned off for the visual message waiting indication messages.

To return to a normal caller-ID message mode, *1, *2, or *3 must be dialed.

4.3.7 Single or Multiple Data Message format

Single Data Message format is selected as a power-up default condition.

To select multiple data message format, enter *1.
To select single data message format, enter *2.
To select multiple data message format without transmitting directory number, enter *3. This eliminates the Caller-ID during the time interval of 7A to 7C, which are defined in 4.2.2.1 and 4.2.2.2.

4.3.8 Wrong Checksum Generation

Wrong checksum generation is obtained by dialing ***4**. The complement of checksum is output at the end of caller-ID data. The correct checksum mode is restored by any mode selection entry, *1, *2, or *3 (See the above Section 4.3.7.

4.3.9 Silence Period Programming

The silence period (T1), which is defined in Sections 4.2.2.1 and 4.2.2.2, may be programmed by dialing ***7n, where n is 1, 2, 3, 4, 5, 6, 7, 8, 9, 0**. The period is 100 ms * (n-1). For example, if *75 is dialed, the caller-ID data is output at 400 ms after the end of the first ring period. By dialing *70, the timing is 900 ms. Note that the dialing *71 will result of 0 ms.

4.3.10 Call Qualifier

The Call Qualifier (long distance) generation is complemented by dialing the following: *** #**
The power-up condition is no generation of the Call Qualifier.

4.3.11 Name

A caller's name may be programmed by dialing:
03 + line number + (3-digit ASCII of a character) + "*"
+ (3-digit ASCII of a character) + "*"
+ ----------
+ ----------
The ASCII equivalent of characters are found in Appendix C.

For example, to program MICRO SEVEN, INC for line1, dial:
031077*073*067*082*079*032*083*069*086*069*078*044*073*078*067*

4.3.12 Name Length

The name length may be programmed by dialing:

0#179*nnn*, where “nnn” forms a 3-digit decimal number between 001 and 018. The maximum name length is 18. The factory default is decimal 15.

4.3.13 Ring Signal On/Off

A caller-ID delivery without ring signal applied to a called line may be accomplished by dialing *0, hang up, and dial a number. If a normal ring signal generation at a called line is needed, dial *0 and hang up again.

4.3.14 Marking Period for On-hook Caller-ID

The marking period (T3) in 4.2.1. Single Data Message Format and 4.2.2. Multiple Data Message Format may be changed from the factory default value of 160 ms to a new value as follows:

0#166*nnn*, where “nnn” forms 3-digit decimal number. The total marking period is equal to 8.64 ms x (nnn+1). For example, 0#166*010* generates 86 ms marking period.

4.3.15 Continuous Caller-ID Generation

Normally, a caller-ID FSK generation occurs only once, but caller-ID FSK generations may be repeated continuously for on-hook caller-ID and call-waiting caller-ID by dialing 048. To disable continuous caller-ID generations, dial 047.

4.3.16 Programming of Channel Seizure Period

The channel seizure period (T2) in 4.2.1. Single Data Message Format and 4.2.2. Multiple Data Message Format may be changed from the factory default value of 30 each of hex 55 to a new value of “nnn” as follows:

0#165*nnn*, where “nnn” forms 3-digit decimal number. For example, 0#165*050* generates decimal 50 of hex 55 data.

Section 5

CALLER-ID ON CALL WAITING

5.1 Introduction

The Caller-ID on Call Waiting feature simulates Call Waiting/Caller-ID data transmission service from public telephone companies. Unlike regular caller-ID data transmission, caller-ID data is transmitted during off-hook condition. The called party automatically receives caller' s information by FSK data transmission after a sequence of handshake with LS15. The Caller-ID on Call Waiting data transmission does not require channel seizure signal, and it also have a shorter mark period before FSK data.

Caller-ID information is transmitted as shown in Figure 5-1.

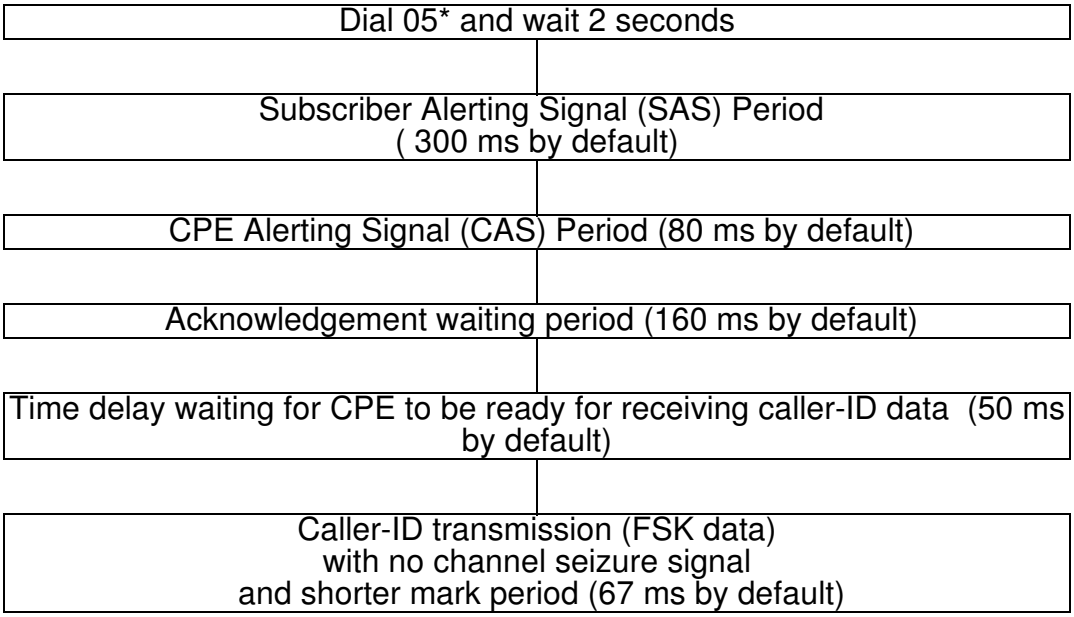


Figure 5-1 Transmission of LS15 Caller-ID Data in Call Waiting

5.2 Call-Waiting Caller-ID Start Command

By dialing 05*, the sequence of a call-waiting caller-ID starts after two seconds. The pseudo-caller is an opposite line. For example, dialing 05* at the Line 1 , the caller-ID data is for the Line 2.

5.3 Signal Definition and Programming of Parameters

5.3.1 Subscriber Alert Signal (SAS)

The 440HZ sine wave signal that is generated to alert a called line that a call is waiting. Normally, the SAS tone is produced always no matter caller-ID data is successfully transmitted, and it is normally generated every 10 seconds. But, in the LS15, the SAS tone is generated only once. The duration of SAS tone, which is 300 ms as a factory default condition (nnn=034), may be programmable by the following dialing command:

0#161*nnn*

where 8.64 ms multiplied by a 3-digit decimal number(must be three digits), nnn.
For example, 0#161*064* would provide 550 ms long SAS tone.

5.3.2 CPE Alert Signal (CAS)

The CAS tone consists of 2130 and 2750 Hz sine waves, and it is to signal CPE (customer provided equipment) that CID data is available. The duration of CAS tone, which is 80 ms as a factory default condition (nnn=009), may be programmable by the following command:

0#162*nnn*
where 8.64 ms multiplied by a 3-digit decimal number(must be three digits), nnn.

The Bellcore' s specification is 80 ms CAS tone period, but it may be programmed to set up a shorter CAS tone period for testing purposes, i.e., 50 ms, the command is 0#161*006*.

5.3.3 Acknowledgement Signal

Right after LS15 generates SAS and CAS tones, it waits for receiving a DTMF A or D tone for a maximum period of 160 ms. The DTMF tone must not be generated before the end of CAS tone. And also, the DTMF tone must be turned off before the acknowledgement timeout expires. The acknowledgement timeout is 160 ms in Bellcore' s documentation, but a shorter timer like 100 ms may be programmed to test a receiver. The general format to program acknowledgement timeout is by the following command:

0#163*nnn*

where 8.64 ms multiplied by a 3-digit decimal number(must be three digits), nnn.
For example, 0#163*011* would set for 100 ms timeout.

The DTMF tone must meet the specifications below:

The DTMF A tone consists of 697 and 1633 Hz signals.
The DTMF D tone consists of 941 and 1633 Hz signals.
Minimum DTMF signal duration: 45 ms
DTMF Signal Power: -13 dBm minimum, +5 dBm maximum per a frequency.

5.3.4 Marking Period

The marking period in call-waiting caller-ID is shorter than one in on-hook caller-ID. Marking period as defined as T3 the sections 4.2.1. Single Data Message Format and 4.2.2. Multiple Data Message Format may be changed from the factory default value of 67 ms to a new value as follows:

0#167*nnn*, where “nnn” forms 3-digit decimal number. Note: It must be 3-digits long. The total marking period is equal to 8.64 ms x (nnn+1). For example, 0#167*010* generates 86 ms marking period.

5.3.5 Caller-ID Data Transmission Delay

Minimum time delay of 50 ms after detecting ACK signal before sending caller-ID data is recommended by Bellcore in February, 1995. The purpose of the delay is to wait for CPE to be ready for receiving data after CPE sends DTMF signal (ACK signal). The DTMF detection by LS15 is based on the presence of DTMF signal, and it is not based on the end of the DTMF signal. If CPE sends long DTMF signal, caller-ID data may collide with DTMF signal.
The factory default of 50 ms Caller-ID Data Transmission Delay is set for LS15 (nnn=009), and it is programmable by the following command:

0#164*nnn*

where 8.64 ms multiplied by a 3-digit decimal number(must be three digits), nnn.
For example, 0#164*015* provide 129 ms time delay.

SECTION 6

FCC RULES, PART-15

Warning

This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Sub-part J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which cases the user at his own expense will be required to take whatever measures may be required to correct the interference.

APPENDIX A

PROGRAMMING SUMMARY

Note: “nnn” is a 3-digit decimal number. It must be 3 digit long.

Enable the SLEEP mode: 049 (factory default)
Disable the SLEEP mode: 040
-20V Battery Feed: 041 (factory default)
-40V Battery Feed: 042
Primary Telephone Number: 043 (factory default)
Secondary Telephone Number: 044
The telephone number length: 0#178*nnn*, 10 digits default
Line Impairment mode: 00
No Line-Impairment mode: 09 (factory default)
Distinctive Ringing : 0*n where n=1-4
Tone Generation (in Hz):
050: 2130+2750 (CAS)
051: 350
052: 440
053: 480
054: 620
055: 1200
056: 2200
057: channel seizure signal(1200, 2200)
058: 2130
059: 2750
05#: 1004Hz test tone (5Hz rate)
045: disable stutter dial tone (default)
046: enable stutter dial tone
04#: restore programmed parameters to the factory default conditions
06: switch from/to the Hot Line mode
07: switch from/to the secondary call progress tone
0#169*nnn*: disconnect signal programming
0#170*nnn*: network response delay
0#252*004* or 0#252*012* (with secondary dial tone): PBX mode
0#252*000* or 0#252*008* (with secondary dial tone): no PBX mode
Ring Signal On/Off: *0
Random Noise Amplitude Programming: 0#168*nnn*

Caller-ID and Related Programming:

where nnn forms a 3-digit decimal number, must be 3-digit long.
The time is determined by 8.64 ms *(nnn)

Date & Time: 01 + month(10) + month(1) + day(10) + day(1) +
hour(10) + hour(1) + minute(10) + minute(1) in 24 hour format.
Calling Number and Secondary Telephone Number: 02 + line number + telephone number
Privacy: 02 + line number + *
Out-of-Area Status: 02 + line number + #
Multiple data message format: *1
Single data message format: *2
Multiple data message format without directory number: *3
Wrong Checksum Generation: *4
Visual Message Indication ON: *5 (dial *1, *2, or *3 to return to CID)
Visual Message Indication OFF: *6 (dial *1, *2, or *3 to return to CID)
Silence Period Programming (Time between ringing and CID generation):
*7n, programming from 0 ms to 900 ms
Calling Number Digit Length: 0#178*nnn*
Ring Signal On/Off: *0
Complementing(On/Off) Call Qualifier Generation: *#
Programming of names:03 + line number + 3-digit ASCII + * +3-digit ASCII + *
+3-digit ASCII + * +----------
Variable Name Length: 0#179*nnn*
Marking Period Programming (on-hook Caller-ID): 0#166*nnn*
Marking Period Programming (call-waiting Caller-ID): 0#167*nnn*
Continuous Caller-ID or Call-waiting Caller-ID sequence: 048
Single Caller-ID or Call-waiting Caller-ID sequence: 047
Channel Seizure Period: 0#165*nnn*
Subscriber Alert Signal (SAS) Duration (300 ms default): 0#161*nnn*
CPE Alert Signal (CAS) Duration (80 ms default): 0#162*nnn*
Acknowledgement Timeout (160 ms default): 0#163*nnn*
Caller-ID Data Transmission Delay (50 ms default): 0#164*nnn*
Start CW-CID sequence : 05*

APPENDIX B

REFERENCES

Bellcore TR-NWT-000030, Issue 2, October 1992
Voiceband Data Transmission Interface Generic Requirements

Bellcore TR-NWT-000575, Issue 1, October 1992
CLASS Feature: Calling Identity Delivery on Call Waiting

Bellcore TR-NWT-000575, Issue 1, October 1992, Revision 1, Dec 1994
CLASS Feature: Calling Identity Delivery on Call Waiting

APPENDIX C

ASCII TABLE

Decimal	Hex	Character	Decimal	Hex	Character
032	20H	space	080	50H	P
033	21H	!	081	51H	Q
034	22H	“	082	52H	R
035	23H	#	083	53H	S
036	24H	$	084	54H	T
037	25H	%	085	55H	U
038	26H	&	086	56H	V
039	27H	‘	087	57H	W
040	28H	(	088	58H	X
041	29H	)	089	59H	Y
042	2AH	*	090	5AH	Z
043	2BH	+	091	5BH	[
044	2CH	,	092	5CH	\
045	2DH	-	093	5DH	]
046	2EH	.	094	5EH	^
047	2FH	/	095	5FH	_
048	30H	0	096	60H	`
049	31H	1	097	61H	a
050	32H	2	098	62H	b
051	33H	3	099	63H	c
052	34H	4	100	64H	d
053	35H	5	101	65H	e
054	36H	6	102	66H	f
055	37H	7	103	67H	g
056	38H	8	104	68H	h
057	39H	9	105	69H	i
058	3AH	:	106	6AH	j
059	3BH	;	107	6BH	k
060	3CH	<	108	6CH	l
061	3DH	=	109	6DH	m
062	3EH	>	110	6EH	n
063	3FH	?	111	6FH	o
064	40H	@	112	70H	p
065	41H	A	113	71H	q
066	42H	B	114	72H	r
067	43H	C	115	73H	s
068	44H	D	116	74H	t
069	45H	E	117	75H	u
070	46H	F	118	76H	v
071	47H	G	119	77H	w
072	48H	H	120	78H	x
073	49H	I	121	79H	y
074	4AH	J	122	7AH	z
075	4BH	K	123	7BH	{
076	4CH	L	124	7CH	|
077	4DH	M	125	7DH	}
078	4EH	N	126	7EH	~
079	4FH	O			

APPENDIX D

SIGNAL POWER TABLE (dBm)

1. dBm versus peak-to-peak voltage of sine wave with no harmonic distortion

dBm = 10 $\log_{10}$(((peak-to-peak voltage)*0.3535)^2/600E-3)

dBm	Peak to-Peak Voltage								
10	6.92716	-7	0.97849	-24	0.13822	-41	0.01952	-58	0.00275
9	6.17384	-8	0.87208	-25	0.12318	-42	0.01740	-59	0.00245
8	5.50244	-9	0.77724	-26	0.10979	-43	0.01551	-60	0.00219
7	4.90405	-10	0.69272	-27	0.09785	-44	0.01382	-61	0.00195
6	4.37074	-11	0.61738	-28	0.08720	-45	0.01232	-62	0.00174
5	3.89543	-12	0.55024	-29	0.07772	-46	0.01098	-63	0.00155
4	3.47180	-13	0.49041	-30	0.06927	-47	0.00979	-64	0.00138
3	3.09425	-14	0.43707	-31	0.06173	-48	0.00872	-65	0.00123
2	2.75775	-15	0.38954	-32	0.05502	-49	0.00777	-66	0.00109
1	2.45785	-16	0.34718	-33	0.04904	-50	0.00693	-67	0.00097
0	2.19056	-17	0.30943	-34	0.04371	-51	0.00617	-68	0.00087
-1	1.95234	-18	0.27578	-35	0.03895	-52	0.00550	-69	0.00077
-2	1.74002	-19	0.24579	-36	0.03472	-53	0.00490	-70	0.00069
-3	1.55080	-20	0.21906	-37	0.03094	-54	0.00437	-71	0.00061
-4	1.38215	-21	0.19523	-38	0.02758	-55	0.00390	-72	0.00055
-5	1.23184	-22	0.17400	-39	0.02458	-56	0.00347	-73	0.00049
-6	1.09789	-23	0.15508	-40	0.02191	-57	0.00309	-74	0.00043

2. dBm versus RMS voltage

dBm = 10 $\log_{10}$ (V^2/600 E-3)

Note: The term "dBm" is defined as a log-scale comparison of signal power into 600 ohms to 1 milliwatts.

dBm	RMS VOLTAGE								
10	2.44949	-7	0.34600	-24	0.04887	-41	0.00690	-58	0.00097
9	2.18311	-8	0.30837	-25	0.04356	-42	0.00615	-59	0.00086
8	1.94570	-9	0.27484	-26	0.03882	-43	0.00548	-60	0.00077
7	1.73411	-10	0.24495	-27	0.03460	-44	0.00489	-61	0.00069
6	1.54552	-11	0.21831	-28	0.03084	-45	0.00436	-62	0.00061
5	1.37745	-12	0.19457	-29	0.02748	-46	0.00388	-63	0.00054
4	1.22765	-13	0.17341	-30	0.02450	-47	0.00346	-64	0.00048
3	1.09415	-14	0.15455	-31	0.02183	-48	0.00308	-65	0.00043
2	0.97516	-15	0.13775	-32	0.01946	-49	0.00275	-66	0.00038
1	0.86911	-16	0.12276	-33	0.01734	-50	0.00245	-67	0.00034
0	0.77460	-17	0.10942	-34	0.01546	-51	0.00218	-68	0.00030
-1	0.69036	-18	0.09752	-35	0.01377	-52	0.00195	-69	0.00027
-2	0.61528	-19	0.08691	-36	0.01228	-53	0.00173	-70	0.00024
-3	0.54837	-20	0.07746	-37	0.01094	-54	0.00155	-71	0.00021
-4	0.48874	-21	0.06904	-38	0.00975	-55	0.00138	-72	0.00019
-5	0.43559	-22	0.06153	-39	0.00869	-56	0.00123	-73	0.00017
-6	0.38822	-23	0.05484	-40	0.00775	-57	0.00109	-74	0.00015