

## Technical Practice

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# LINE COMMANDER

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### 1. General Description

**1.1 PRACTICE** In the event that this practice is reissued, the reason for the reissue will be given in this paragraph.

**1.2 LINE COMMANDER SERIES** The Line Commander Series consists of various hardware assemblies that are used together to provide controlled access to standard 2-wire Central Office (CO) loop start telephone lines. This practice covers the Line Commander/2 and Line Commander/4 versions, more commonly referred to as the Line Commander. The Line Commander is best suited for smaller installations. Each Line Commander is packaged in its own wall mounted cabinet. Also available is the Line Commander Modular System/2 and Line Commander Modular System/4 which utilize plug in circuit cards to contain the main electronic circuitry. Multiple circuit cards can plug into one mounting enclosure, allowing a high mounting density for applications involving many Line Commander channels. Contact Gordon Kapes, Inc. for information on the modular system.

**1.3 BASIC LINE COMMANDER FUNCTIONS** The basic premise of the Line Commander is to restrict access to placing outgoing telephone calls. The maximum duration of any one telephone call is selected upon Line Commander installation. The Line Commander control panel allows a supervisor to control when an outgoing call can be made. Call duration is timed and, if the maximum time is reached, the call is automatically terminated. Extensive capabilities have been implemented through hardware and software to provide a high level of operating features and performance.

**1.4 PHYSICAL DESCRIPTION** The Line Commander consists of two assemblies: a microprocessor-based main unit that directly controls the telephone lines, and a control panel that provides function switches and LED indicator lights. The main unit consists of a precision fabricated printed circuit board, and

an injection molded housing consisting of a base and detachable cover. The thermoplastic material used for the housing conforms to industry recognized flame retardant standards. The main unit wall mounts with four screws. The control panel consists of a precision fabricated printed circuit board mounted onto a custom membrane switch assembly. The control panel mounts in a desk/wall mount enclosure, which is included with each Line Commander.

**1.5 2- OR 4-CHANNEL VERSIONS** The Line Commander is available in a 2-channel version called the Line Commander/2, and a 4-channel version called the Line Commander/4. The installation procedure and the physical size of the two versions are identical.

**1.6 MAXIMUM CALL DURATION** Switches on the main unit are utilized to specify the maximum length of any one call: from two minutes to 17 minutes in one minute increments. The selected time is common to the two or four channels, i.e., all channels have the same maximum call time setting. A microcomputer is utilized to ensure accurate call duration timing.

**1.7 CALL TERMINATION** A telephone call in progress will be terminated for any one of three reasons: if the telephone call reaches the maximum time limit, if the off switch is pushed on the control panel, or if the manual override function is invoked. Telephone call termination is accomplished by disconnecting the CO telephone line from the wiring that connects the main unit to 500/2500 telephone sets, or other terminal devices (PBX, electronic or 1A2 key system, etc.). For security, the telephone line disconnection is physically implemented using an electromechanical relay that switches both the tip and ring leads.

**1.8 WARNING TONES** Two warning tone sequences indicate to the calling and called parties that forced termination is imminent. The warning tone sequences prompt the calling and called parties to complete their call prior to the forced termination. The

first warning tone sequence comes one minute prior to the maximum call duration. The second warning tone sequence comes ten seconds prior to the maximum call duration. A warning tone sequence consists of four short audio tones that occur in rapid succession.

**1.9 TAMPER RESISTANCE** The Line Commander has been designed to be tamper resistant. The design engineers assumed that anything and everything would be done to the Line Commander and associated wiring during attempts to defeat its correct operation. All failure modes lead to calls in progress being terminated, and no additional calls being allowed until the problem is corrected.

**1.10 MANUAL OVERRIDE** The operation of all channels can be disabled through the use of the manual override function. A switch or contact closure can be connected to the main unit to allow all calls in progress to be terminated, and no further calls allowed until manual override is released. The manual override functions of multiple main units can be connected together to provide a group manual override.

**1.11 LED INDICATOR LIGHTS** LED indicator lights are contained on the main unit and control panel to provide operational, installation, and service assistance.

**1.12 CALL TIMING SELECTION** The circuitry can be configured to start telephone call timing from one of two conditions. A switch on the main unit selects normal or reverse battery mode.

*Normal Mode:* timing starts as soon as loop current flows in the telephone line, i.e., timing starts when the telephone set goes off-hook. The maximum call duration includes the time spent dialing, waiting for the called number to ring, etc. A call to a busy telephone number will be timed as a completed call.

*Reverse Battery Mode:* timing starts only upon an indication from the serving CO that the called number was answered. A call to a busy number does not count as a call. The installation of special telephone lines with reverse battery answer supervision is required. This type of line is similar to a standard line, except for the fact that the direction of loop current flow is reversed upon called party answer.

**Please Note:** The reverse battery mode can only be implemented if the serving CO is capable of providing a telephone line with this characteristic, and that these lines have been installed. *The Line Commander on its own cannot implement anything other than the normal timing mode.*

**1.13 LOCATING THE MAIN UNIT AND CONTROL PANEL** Generally the main unit is installed in a secure location that provides access to the telephone lines. The control panel is located at the supervisor's location.

**1.14 POWER REQUIREMENTS** Each 2- or 4-channel Line Commander requires 10Vac, 180mA maximum for operation. A UL Listed, Class 2 transformer is included with each Line Commander.

**1.15 FCC REGISTRATION NUMBER** The FCC Registration Number is EPR5ZC-17935-OT-N. The ringer equivalence is 0.0B.

## 2. Applications

**2.1 PRIMARY APPLICATION** The primary application for the Line Commander is to provide a controlled environment from which to allow individuals to make telephone calls. Access to making telephone calls may, in many cases, be required by law, regulation, or other contractual requirement. The control

panel allows a supervisor to start a time limited call. The supervisor also has the ability to manually terminate a call if required.

**2.2 FREE CALL TELEPHONES** In certain locations, free call telephones may be installed. An example would be telephones in a university or college student center. Long distance calling will undoubtedly be restricted by other equipment, but access and call duration may need to be restricted to allow access by qualified individuals.

**2.3 MANUAL OVERRIDE** Each main unit has a connection for a manual override switch or contact. The manual override connections of multiple main units can be connected together to provide a single group manual override control. As an example: this would give a manager the ability to override the operation of many Line Commanders spread over a large facility.

## 3. Limitations

**3.1 INCOMING CALLS** The Line Commander is intended to control *only* outgoing calls over standard 2-wire telephone lines. If a line connected to a Line Commander channel is "ringing" when the control panel on switch is activated, the incoming call will be sent to the terminal device, in most cases, a 500/2500-type telephone set. The Line Commander will not be damaged by the presence of high voltage ringing signals, but will not function as intended. It will, however (assuming that the card is set for the normal timing mode), start timing as soon as loop current flows, even on an incoming call. It is recommended that telephone lines connected to Line Commander channels be restricted by the serving CO to be outgoing only. Gordon Kapes, Inc. does not specify the performance of the Line Commander for incoming calls.

**3.2 NO SPLIT CHANNELS** One main unit and one control panel work together to provide two or four channels of control. A 4-channel main unit works with a single 4-channel control panel. You cannot connect two 2-channel control panels to one 4-channel main unit. An installation with four supervisor locations, each with one separate telephone line, requires four 2-channel main units, and four 2-channel control panels.

**3.3 MANUAL TERMINATION** A telephone call in progress can be manually terminated either by the supervisor using the off switch on the control panel, or invoking the manual override function. When this action occurs, the call is immediately disconnected, and no warning tones are given. No advanced warning will be given to the calling or called parties that a termination is going to take place.

**3.4 TIME ADJUSTMENT** The control panel installed at the supervisor's location provides the ability to authorize a call, or to terminate a call in progress. The maximum call duration is not adjustable at the control panel. The maximum call duration is intended to be set at the time of installation and then left. One set of switches on the main unit adjusts the time for both channels on a Line Commander/2 or all four channels on a line Commander/4.

## 4. Installation

**4.1 WORDS OF CAUTION** As with any product, installing the Line Commander requires a safety first approach.

**Warning:** Never install telephone wiring during a lightning storm. Never install telephone jacks in wet locations unless the jack is specifically designed for wet locations. Never touch

noninsulated telephone wires or terminals unless the telephone line has been disconnected at the network interface. Use caution when installing or modifying telephone lines.

**4.2 CHECKING FOR DAMAGE** All Line Commander components, main unit, control panel, etc., should be inspected for damage immediately upon receipt. If damage is found, a claim should be filed with the shipper. Replacement components should be ordered if necessary.

**4.3 INSTALLATION MATERIALS** Included in each shipping carton is an installation kit. Each kit contains four #8 pan head screws and two nylon cable ties. Also included in the shipping carton is a 10Vac transformer and a 2-conductor power cord. In addition, the Line Commander/2 includes two 6-position modular cords; a Line Commander/4 includes four cords.

**4.4 COVER, MAIN UNIT** The main unit's cover is secured via two clamp screws located on the top and bottom of the cover. Remove the cover at this time.

**4.5 MOUNTING, MAIN UNIT** The main unit wall mounts using four #8 screws appropriate for the wall material. Four #8 pan head screws are contained in the installation kit; use these if suitable.

**4.6 CONNECTIONS** All connections to the main unit are made via 6-position modular jacks, and an 8-position screw terminal strip. Figures 1 through 3, located at the end of this practice, give detailed connection information. Refer to these figures when reading the installation procedures.

**4.7 TELEPHONE LINES** The Line Commander uses modular jacks to bring the CO lines into the main unit, and to send the controlled tip and ring leads to the station telephones, or other terminal equipment. The jacks are located on the main unit's circuit board, and are 6-position type, with four of the six positions used. A brief description of the jacks should be helpful:

*J1:* Connects CO lines one and two to main unit. Mates using a standard (reversing) modular cord with an RJ14C jack.

*J2:* Connects lines one and two to station telephones. Emulates standard RJ14C jack.

*J3:* Present on 4-channel version only. Connects CO lines three and four to main unit. Mates using a standard (reversing) modular cord with an RJ14C jack.

*J4:* Present on 4-channel version only. Connects lines three and four to station telephones. Emulates standard RJ14C jack.

**4.8 MODULAR CORDS** Most people don't realize that a standard modular cord reverses the connections that pass through it. In a 6-position cord, pin 1 on one plug connects to pin 6 on the other plug, pin 2 to pin 5, etc. The modular cords provided with the Line Commander are the standard, reversing type. This is important to remember as the jacks used to link various pieces of telecommunications equipment together must take this into account. The Line Commander's modular jacks that link to the CO lines are intended to connect to an RJ14C via a standard, reversing line cord. The Line Commander's modular jacks that link to the terminal equipment are wired to appear as an RJ14C equivalent.

**4.9 CO TELEPHONE LINES** The CO telephone lines should be terminated in one or two standard RJ14C jacks. One jack is required for a Line Commander/2, two jacks for a Line Commander/4. An RJ14C is similar to an RJ11C but allows access to two lines. Ensure that the correct tip and ring polarity is maintained; ground should be on tip, nominal -48Vdc on ring.

**4.10 CO LINES TO MAIN UNIT** Use one of the modular cords to connect lines one and two on an RJ14C to J1 on the main unit. If you are installing a Line Commander/4: use another of the modular cords to connect lines three and four on an RJ14C to J3 on the main unit.

**4.11 STATION TELEPHONES** The connections to the terminal equipment, which in most cases will be 500/2500-type single line telephones, should be terminated in a mirror image of an RJ14C jack. The mirror image will maintain correct polarity when mating with the main unit via a standard, reversing modular cord. A Line Commander/2 requires one jack, a Line Commander/4 requires two jacks. Use one of the modular cords to connect J2 on the main unit to the jack for station telephones one and two. If you are installing a Line Commander/4: use another of the modular cords to connect J4 on the main unit to the jack for station telephones three and four.

**4.12 MANUAL OVERRIDE** The manual override function can be implemented if desired. A normally open switch or contact should be connected across the terminal strip's MO connections (terminals 5 and 6). When the contact closes (shorts), the Line Commander will be placed in the manual override mode. You can create a manual override group by paralleling the MO connections of multiple units. There is no practical limit to the number of Line Commander's that can be part of your group. Ensure that all pin 5s are connected together, and all pin 6s are connected together. Failure to maintain correct polarity will cause one or more units to "lock" into the manual override mode. Standard 24- or 26-gauge copper telephone cable is recommended to link the main unit(s) to the location of the manual override switch or contact. Refer to the Specifications section of this practice for the maximum wire length allowed.

**4.13 LOCATING THE CONTROL PANEL AND ENCLOSURE** Determine the desired location for your control panel. The enclosure is intended to be wall or desk mounted. Mount the control panel enclosure using the three mounting holes located in the bottom surface of the enclosure. Two cable access points are provided, one in the rear, the other in the bottom. A "dummy" plug is provided to fill the rear access point if it is not to be utilized. A cable tie mounting point, along with a nylon cable tie, is provided in the bottom of the enclosure. Use this to secure the incoming cable to the enclosure.

**4.14 CONNECTING TO THE CONTROL PANEL** Four wires (2-pair) are used to link the main unit with the control panel. Standard 24- or 26-gauge copper telephone cable is recommended. Refer to the Specifications section of this practice for the maximum wire length allowed. Terminal 1 on the main unit connects to terminal 1 on the control panel, terminal 2 to terminal 2, etc.

**Beware:** *THE FOUR WIRES ARE POLARITY SENSITIVE.* If the wires are not hooked up in the correct sequence, the Line Commander will definitely not function—**BE CAREFUL!**

**4.15 CONNECTING POWER** The main unit requires an external source of 10Vac. A transformer is supplied for this purpose. Use the 2-conductor cable to connect the power transformer LOAD terminals to terminals labeled POWER on the terminal strip. Do not plug in the transformer at this time.

**4.16 SECURING THE CONNECTING WIRES** Use a nylon cable tie, provided in the installation kit, to secure any wires connected to the terminal strip to the mounting point molded into the left side of the main unit's base.

**4.17 TIMING MODE CONFIGURATION** One switch on the main unit selects how the call timing will start on all connected channels.

*Normal Mode:* Set the slide switch to the NORMAL position if standard CO lines have been connected.

*Reverse Battery Mode:* Set the slide switch to the REV BATT START position if CO lines with reverse battery answer supervision have been connected. If you are operating in the reverse battery start mode, again check that the CO tip and ring leads are correctly connected to the RJ14C jack(s). Failure to have the correct tip and ring polarity will prevent the main unit from operating! Measure voltages on the CO line when it is in the on-hook state: ground on the tip lead, and approximately -48Vdc on the ring lead.

**4.18 MAX CALL DURATION SWITCH SETTING** An 8-position DIP-type switch must be set for the desired maximum call duration. The switch is located on the upper right side of the main unit's circuit card. All channels (two or four) on a main unit share the same maximum call duration value. The maximum call length is set for two minutes to 17 minutes, selectable in 1-minute increments.

Maximum Call Duration = Total Time of Switches Set to ON + 2 Minutes

Switch 1 ON adds 8 minutes

Switch 2 ON adds 4 minutes

Switch 3 ON adds 2 minutes

Switch 4 ON adds 1 minute

Switches 5 through 8 not used

Leave in OFF position

Examples:

For time of 4 minutes:

Switch 3 ON, Switches 1, 2, and 4 OFF

For time of 8 minutes:

Switches 2 and 3 ON, Switches 1 and 4 OFF

For time of 2 minutes:

All switches OFF

**4.19 POWERING UP** The main unit and control panel are now ready to be tested and operated. Let the fun begin! Up until this point, power should not have been applied to the main unit.

Review your installation thoroughly. If everything looks acceptable, plug the transformer into a standard 120Vac outlet. The power LED on the main unit should light. The off LEDs on the control panel should be lit steadily. No other LEDs should be lit.

*Line Commander/2:* There are a total of four LEDs on the main unit: power, manual override, and one LED for each of two channels. On the 2-channel control panel there are a total of four LEDs: one off switch for each of two channels, and one on switch for each of two channels.

*Line Commander/4:* There are a total of six LEDs on the main unit: power, manual override, and one LED for each of four channels. On the 4-channel control panel there are a total of eight LEDs: one off switch for each of four channels, and one on switch for each of four channels.

**4.20 PLACING A CALL** Check the telephone line connections using the following procedure. Ensure that the station telephones (or other terminal device) are in the on-hook state. The off LEDs should be lit steadily. Go off-hook on each telephone and ensure that you do not get dial tone, or ground hum. This ensures that the main unit is completely disconnecting the telephones from the CO lines. After checking for all "dead" telephones, go back on-hook.

The top row of switches on the control panel are the on switches for the channels. The channel numbers are marked on the switches. Press and release the on switch for channel one. The channel one off LED should go out and the channel one on LED should blink on and off. Press and release the channel one off switch. The on LED should go out and the off LED should light steadily. Again press and release the channel one on switch. The off LED will go out and the on LED should blink on and off. Go off-hook on the channel one telephone. The channel one on LED should light steadily, and you should get a dial tone. Dial a number and stay on the line. You should hear the warning tone sequences one minute before, and then ten seconds before reaching the maximum call duration you set using DIP switches. At the end of the maximum duration, your call should automatically disconnect. The channel one on LED should go out and the off LED should again light. Repeat this test for the other channel on a Line Commander/2 control panel, and for the other three channels on a Line Commander/4 control panel.

**4.21 TESTING MANUAL OVERRIDE** If the manual override function has been connected, it should now be tested. Shorting the MO connections with the switch or contact closure should cause the manual override LED on the main unit to light. The power LED should remain lit but the channel LEDs should not be lit. On the control panel, the off LEDs should be flashing on and off. The on LEDs should not be lit. Disconnect the short across the MO connections. The manual override LED on the main unit should stop lighting. The off LEDs on the control panel should now be lit steadily. If more than one manual override connection has been connected in parallel, all main units and control panels should act in tandem, i.e., they should all respond in the same way when the manual override switch, or contact is activated.

## 5. Operation

**5.1 USING THE LINE COMMANDER** The following paragraphs describe how the control panel is used to authorize and, if necessary, manually terminate calls.

**Please Note:** This description assumes that the main unit is operating in the normal, not reverse battery start, mode. A paragraph at the end of this section discusses operation in the reverse battery start mode.

**5.2 AUTHORIZING CALLS** The control panel has two switches associated with each channel. An LED indicator is visible in the upper left corner of each switch. The bottom switch is labeled OFF and the top switch is labeled with the channel number. The top switch will be referred to as the on switch. When a channel is in the idle state, with no call in progress, the off LED is steadily lit. To authorize a call, the on switch is to be pushed, then released. If the telephone set connected to the channel is in the on-hook state (not picked up), the off LED will go out, and the on LED will blink on and off. The LED signifies that the channel is in the "ready" state. When the telephone is brought off-hook, timing will start and the on LED will light steadily. If the telephone is off-hook when the on switch is pushed, the on LED will light immediately. All calls follow the maximum time duration limit that was selected when the Line Commander was installed. When the on LED lights, timing starts. As the call approaches the maximum time limit, warning tones are sent to the calling and called parties.

One minute prior, and ten seconds prior to the maximum time duration, a short sequence of warning tones will be heard. If the call is still in progress when the maximum time duration is reached, it will terminate automatically. The on LED will go out, and the off LED will light. If the parties hang up before the maximum time duration is reached, the on LED will go out and the off LED will light. The telephone line is then disconnected from the telephone, preventing another call from immediately being placed. Placing another call requires authorization by pushing the on switch.

**5.3 THE OFF SWITCH** In most cases, the off switch will not be used. Normally, a call will be authorized using the on switch. The call will end by the telephone set going back on-hook, or the maximum time duration being reached and the call automatically terminating. The off switch acts in two ways. If a call has been authorized, but not started, the on LED will be blinking on and off. The authorization can be stopped by pressing and releasing the off switch. If a call is in progress, as seen by the on LED being lit, it can be terminated by pressing and releasing the off switch. No warning tones are given over the phone lines when the off switch terminates a call.

**5.4 TWO-SECOND DELAY** A two-second time delay occurs anytime a call terminates: manually or automatically. The on switch remains inactive for these two seconds. This ensures that the first call fully terminates prior to the next one being authorized.

**5.5 MANUAL OVERRIDE FUNCTION** Terminating all Line Commander calls in progress and preventing further calls can be achieved by activating the manual override function. This function is not available via a switch on the control panel. This function may or may not have been implemented in your system. It would most likely be installed for use by a supervisor or other personnel at a location physically separate from the control panel. If it has been installed, and is activated, the off LEDs will start blinking on and off. After the manual override is released, the off LEDs will light steadily and calls can now be authorized.

**5.6 LINE COMMANDER SYSTEM ERROR INDICATION** An error with Line Commander circuitry or wiring can result in all on and off LEDs being steadily lit. This is designed to alert the user of a problem. Service personnel should be alerted if this condition occurs.

**Note:** All LEDs may briefly light when the power is applied to the Line Commander circuitry. Only when all lights stay steadily lit would a problem be likely. In this error mode, no calls can be authorized.

**5.7 REVERSE BATTERY OPERATION** The Line Commander can operate in conjunction with reverse battery answer supervision telephone lines. This special type of line gives an indication to the calling party that the called party has actually answered a call. When the Line Commander is set to operate in this mode, call timing starts only when the called party answers. If the calling party dials a number that is busy, the Line Commander will not start timing. The person may hang up the telephone, pick it up and dial again. Only when a called party answers will timing start. The supervisor operating the control panel would see some differences in how the on LEDs act. Let us start our example with a channel that is in the idle state; the off LED is steadily lit. Press and release the on switch and the on LED will start blinking on and off. The telephone can

be brought off-hook and dialed, the on LED will stay blinking on and off. If the called number is busy and the telephone is hung up again, the on LED still blinks. Only when the calling party answers, and the telephone company gives an indication to the Line Commander, will the timing start. The call can now last up to the maximum duration before automatically terminating.

## 6. Circuit Description

**6.1 GENERAL** This circuit description is intended to familiarize you with the Line Commander for engineering and applications use.

### 6.2 MAIN UNIT

*Microcomputer:* The "heart" of the Line Commander is a Motorola 6805 series microcomputer (MCU) integrated circuit. The MCU contains RAM, ROM, and EPROM memory, a clock, and input/output (I/O) ports. The software that runs the Line Commander's functions is permanently stored in the EPROM memory. A watchdog circuit is implemented in hardware to ensure that glitches, noise spikes, etc. do not cause the MCU to hang or crash. If program operation stops, the hardware reset is activated and the program will start running again. The MCU uses HMOS construction for reliable, but not very power efficient operation.

*Off-hook Sensing:* A loop current detection circuit monitors the ring side of each telephone line to determine the on-hook/off-hook status. The core of the detection circuit is a two section optical coupler. One section of the coupler monitors the current flow in the normal direction; tip lead at ground potential and ring lead at negative battery. The other section monitors for current flow in the other direction. These two sections determine if the current is in normal or reverse battery mode. The output of the reverse battery coupler connects directly to an input on the MCU. The output of the normal coupler connects to the same MCU port via one section of the NORMAL/REV BATT START switch. When the switch is set for normal operation, the output of the normal coupler connects to the MCU, in the other switch position it does not. Debouncing of the optocoupler output signal is performed by the MCU. The optocouplers are protected from excessive current flow with a semiconductor transient voltage suppressor.

*Warning Tone Generation:* The MCU produces a sequence of 900Hz square wave waves to serve as the warning tones. The square waves are buffered by an operational amplifier before being coupled to the telephone line by a matching transformer. The transformer is a high impedance type, capacitor coupled to the telephone line to minimize insertion loss, and minimize damage by transients on the telephone line.

*Tip and Ring Control:* Tip and ring control of the telephone line is performed by sealed, bifurcated communications type relays. Both the tip and ring leads of the telephone line are switched. The MCU sends a logic signal to a relay driver integrated circuit which in turn energizes the relays. LEDs, in series with the relay coils, provide channel status indication.

*Max Call Duration Selection:* Four sections of DIP-type switch directly address I/O ports on the MCU to select the maximum call duration.

*Data Link:* An asynchronous data link is implemented to connect the main unit with the control panel. Software in the MCU creates a software Universal Asynchronous Receiver Transmitter (UART) that communicates with the control panel;

sending LED status and receiving switch status information. An MCU output pin carrying the outgoing data connects to one section of the integrated circuit comparator. The output of the comparator serves as a rugged, current limited data line driver. The comparator is powered by +13Vdc so the data output swing is capable of driving long lines. The main unit provides a current source on the data input line. Data from the control panel modulates this line by current sinking. Another comparator on the main unit monitors the current drawn by the control panel, and recovers the transmitted data.

*Manual Override:* Two connections are provided to the outside world via the terminal strip for activating the manual override function. One connection provides current limited +13Vdc as a power source. The other connection goes via a current limiting resistor and filter capacitor to the input of one section of the relay driver integrated circuit that serves as an input buffer. The output of the relay driver connects to an input pin on the MCU, as well as to an indicator LED. When the manual override connections are shorted together, the input to MCU changes state and the LED lights. The manual override input is designed to allow paralleling of multiple Line Commander manual override connections.

*Power Supply:* Nominal 10Vac enters the main unit via the terminal strip. It is fed to a bridge rectifier and filter capacitor to produce nominal +13Vdc. The +13Vdc is used to power the telephone line control relays, as well as being fed via a power resistor to the terminal strip, providing current limited power for the control panel. The +13Vdc is also fed to a 5V power supply section. A 3-terminal integrated circuit regulator produces the clean 5Vdc required by the MCU, watchdog, and warning tone circuitry.

### 6.3 CONTROL PANEL

*UART:* The core of the control panel is a Universal Asynchronous Receiver Transmitter (UART) integrated circuit. The transmitter section of the UART sends data words that represent the state of the switches. The receiver section of the UART receives data words from the main unit that represents the desired state of the LED indicators. The UART has sufficient drive current to directly light the LEDs. The UART is of CMOS construction for low power consumption.

*Clock:* A very nice integrated circuit provides the UART clock signal. An external crystal and internal inverting buffer gates generate 3.579545MHz. This signal is then binary divided to get the required UART clock frequency.

*Data Link:* Data sent by the main unit enters the control panel via one section of the comparator integrated circuit. The output of the comparator connects to the receive data input of the UART. The transmit data output of the UART is sent to another section of comparator that acts as a current sink. The comparator modulates a current source provided by the main unit. *Power Supply:* Current limited +13Vdc is provided to the control panel by the main unit. A 3-terminal integrated circuit regulator produces the 5Vdc required by the UART, LEDs and clock.

**6.4 4-WIRE LINK** As previously mentioned in bits and pieces, the main unit and the control panel connect to each other using four wires. One wire carries current limited +13Vdc, another wire carries ground, a third wire carries data from the control panel, and a fourth wire carries data to the control panel. The 4-wire link has been designed with minimal chance of being damaged due to incorrect connection or abuse. Shorting any,

or all of the four wires together will not lead to damage. The MCU software will detect connection errors, and terminate Line Commander operation until the error has been corrected.

**6.5 2- AND 4-CHANNEL VERSIONS** The circuitry for the Line Commander/2 and the Line Commander/4 are basically identical.

## 7. Specifications

### POWER REQUIREMENT

10Vac ( $\pm 20\%$ / $-10\%$ ), 180mA maximum.

### FCC REGISTRATION NUMBER

EPR5ZC-17935-OT-N

### RINGER EQUIVALENCE

0.0B

### ENVIRONMENT

0 to 50 degrees C, humidity to 95% (no condensation)

### RELIABILITY

MTBF 17.0 years, per Method I of Bellcore TS-TSY-000332, Issue 2, July 1988

### INTERCONNECTION, MAIN UNIT CO LINES

Mates with standard RJ14C jacks.

One jack for Line Commander/2, two for Line Commander/4.

### TERMINAL EQUIPMENT

Provides connection similar to standard RJ14C jacks.

One jack for Line Commander/2, two for Line Commander/4.

### POWER, MANUAL OVERRIDE, TO/FROM CONTROL PANEL

8-position screw terminal strip

### INTERCONNECTIONS, CONTROL PANEL

4-position screw terminal strip

### NUMBER OF CHANNELS

Line Commander/2: Two channels

Line Commander/4: Four channels

### MANUAL OVERRIDE

Manual override connections on multiple Line Commander units can be bridged (connected in parallel). The switch or contact connected to manual override must be capable of handling 4mA at 16Vdc for every main unit connected in a group.

### COMMUNICATION LINK BETWEEN MAIN UNIT AND CONTROL PANEL

Asynchronous binary data type

Four conductors: power, ground, send data, receive data

### MAXIMUM CABLE LENGTHS

Based on 25.67 ohms/1000' for 24-gauge

40.81 ohms/1000' for 26-gauge

Solid copper telephone type cable at 68 degrees F

MAIN UNIT TO CONTROL PANEL @3000' of 24-gauge @1800' of 26-gauge

(Based on main unit to control panel maximum resistance of 75 ohms per conductor)

**MAIN UNIT TO MANUAL OVERRIDE SWITCH OR CONTACT**  
Bridged connection of 25 manual override functions:  
4600' of 24 gauge, 2900' of 26 gauge.  
Bridged connection of 50 manual override functions:  
2300' of 24 gauge, 1450' of 26 gauge.  
(Based on main unit to manual override switch maximum  
resistance of 3k ohms per conductor for a single main unit)

**TELEPHONE LINE TYPE NORMAL START MODE OPERATION**  
Compatible with standard central office 2-wire loop start lines.  
Lines should be restricted to outgoing calls only.

**TELEPHONE LINE TYPE REVERSE BATTERY START MODE  
OPERATION**  
Compatible with standard central office 2-wire loop start lines  
that provide loop current reversal after called party answers.  
Lines should be restricted to outgoing calls only.

**LOOP CURRENT FOR CORRECT OPERATION**  
15 minimum, 120mA maximum

**OFF-HOOK/ON-HOOK RECOGNITION**  
Loop current must flow for 150mSec to be recognized as valid  
off-hook.  
Loop current must cease flowing for 150mSec to be recog-  
nized as valid on-hook.

**WARNING TONE SEQUENCE**  
Two tone sequences are implemented prior to disconnect. The  
first occurs 1 minute prior to the maximum call duration time.  
The second occurs 10 seconds prior to the maximum call  
duration. The warning tone sequence consists of 900Hz  
square wave 0.5 seconds on, 0.25 seconds off repeated four  
times.

**MAXIMUM CALL DURATION ADJUSTMENT**  
Switch selectable from 2 minutes to 17 minutes in 1-minute  
increments.

**TIME ACCURACY**  
Better than  $\pm 1$  second for all maximum time duration settings.

**DIMENSIONS, MAIN UNIT**  
8.75 inches high (22.23cm)  
8.75 inches wide (22.23cm)  
3.25 inches deep ( 8.26cm)

**WEIGHT, MAIN UNIT**  
Approximately 2.0 pounds (0.9kg)

**MOUNTING, MAIN UNIT**  
Wall mounts with four #8 pan head screws.

**DIMENSIONS, CONTROL PANEL**  
4.13 inches high (10.49cm)  
5.88 inches wide (14.94cm)  
1.17 inches deep ( 2.97cm)

**WEIGHT, CONTROL PANEL**  
6 ounces (0.17kg)

**MOUNTING, CONTROL PANEL**  
Control panel wall mount/desk top enclosure, part number  
20359, included with each Line Commander.

**DIMENSIONS, CONTROL PANEL ENCLOSURE**  
4.25 inches high (10.80cm)  
6.00 inches wide (15.24cm)  
2.00 inches deep ( 5.08cm)

**WEIGHT, CONTROL PANEL ENCLOSURE**  
1 pound (0.45kg)

**LINE COMMANDER PART NUMBERS**  
Line Commander/2: 20373  
Line Commander/4: 20374  
2-channel Control Panel: 20362  
4-channel Control Panel: 20364  
Control Panel Enclosure: 20358

## **8. Incorrect Operation**

**8.1 DIFFICULTIES** Should problems arise in the operation of  
the Line Commander, review Section 4—Installation. Ensure that  
all connections and switch settings have been made properly.  
If another main unit and control panel is available, substitute  
and retest.

**8.2 LEDS** The LEDs on the main unit and the control panel  
are useful tools when troubleshooting the Line Commander.  
Use them to give you a system status check before proceeding  
to shoot trouble.

**8.3 APPLICATION LIMITATIONS** The Line Commander was  
designed to operate correctly with most standard loop start  
telephone lines. However, Gordon Kapes, Inc. does not  
guarantee that the Line Commander is compatible with all of  
these types of lines, or specific lines within the types. The  
functions of the installed Line Commander must be thoroughly  
tested before being placed into service.

**8.4 SAVE TIME** You are encouraged to contact Gordon  
Kapes, Inc. for technical support. We much prefer a telephone  
call BEFORE you tear your hair out! We do not mind “walking”  
you through an installation, or performing a verbal review prior  
to your actually getting started. Please have a copy of this  
technical practice and adequate tools with you. In addition, it is  
very helpful to have a digital VOM, such as the wonderful Fluke  
70 or 80 series, a lineperson’s handset, and some cross  
connect wire. (For those rare cases, it’s not a bad idea to have  
some aspirin and the telephone number of an Italian place with  
homemade lasagna to go.)

## **9. Repair and Replacement**

**9.1 NOT SO FAST** Statistically, most equipment returned to  
Gordon Kapes, Inc. for repair actually has nothing wrong with  
it. A telephone call to Gordon Kapes, Inc. technical support can  
often help to get the equipment operating correctly. We don’t  
mind spending time with our customers getting a site up and  
running.

**9.2 SEND IT BACK** If you determine that one or more Line  
Commander components are defective, return for repair or  
replacement according to the Gordon Kapes, Inc. Warranty/  
Repair and Return policy.

**9.3 ONLY WE FIX IT** In the event repairs are ever needed, they  
should only be performed by Gordon Kapes, Inc. or an  
authorized representative. For further information, contact  
Gordon Kapes, Inc.

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## 10. Maintenance

**10.1 ROUTINE MAINTENANCE** The Line Commander requires no routine maintenance.

**10.2 CONTROL PANEL CLEANING** The switch section of the control panel assembly is of high quality membrane technology construction. The top surface is sealed with a wear resistance polycarbonate material. Normal soiling should be cleaned off with a solution of mild soap and water applied with a soft cloth. Do not use solvents of any kind or the surface may get damaged and/or ruined. The control panel is designed for lots of operating wear and tear but is not chemical resistant.

## 11. FCC Requirements

**11.1 TYPE OF SERVICE** Your Line Commander is designed to be used on standard device telephone lines. The Line Commander connects to the telephone line by means of standard jacks called the USOC RJ14C. Connection to telephone company-provided coin service (central office implemented systems) is prohibited. Connection to party line service is subject to state tariffs.

**11.2 TELEPHONE COMPANY PROCEDURES** The goal of the telephone company is to provide you with the best service it can, within the constraints of receiving a good return on shareholder equity. In order to do this, it may occasionally be necessary for them to make changes in their equipment, operations, or procedures. If these changes might effect your service or the operation of your equipment, the telephone company will give you notice, in writing, possibly in advance, to allow you to make any changes necessary to maintain uninterrupted service.

If you have any questions about your telephone line, such as how many pieces of equipment you can connect to it, the telephone company will provide this information upon request.

In certain circumstances, it may be necessary for the telephone company to request information from you concerning the equipment which you have connected to your telephone line. Upon request of the telephone company, provide the FCC registration number and the ringer equivalence number (REN) of the equipment which is connected to your line; both of these items are listed on the equipment label. The sum of all of the RENs on your telephone line should be less than five in order to assure proper service from the telephone company. In some cases, a sum of five may not be usable on a given line.

**11.3 IF PROBLEMS ARISE** If any of your telephone equipment is not operating properly, you should immediately remove it from your telephone line, as it may cause harm to the telephone network. If the telephone company notes a problem, they may temporarily discontinue service. When practical, they will notify you in advance of this disconnection. If advance notice is not feasible, you will be notified as soon as possible. When you are notified, you will be given an opportunity to correct the problem and be informed of your right to file a complaint with the FCC. You have the right to remain silent, if you waive your right to remain silent...

Specifications and information contained in this technical practice subject to change without notice.



## Figure 1 Description of Main Unit Jacks

**Main Unit Jack J1**  
Connects CO Lines 1 and 2 to Line Commander

J1 Pin No.	Connection
1	
2	Ring Line 2
3	Tip Line 1
4	Ring Line 1
5	Tip Line 2
6	

**Main Unit Jack J3 (Line Commander/4 only)**  
Connects CO Lines 3 and 4 to Line Commander

J3 Pin No.	Connection
1	
2	Ring Line 4
3	Tip Line 3
4	Ring Line 3
5	Tip Line 4
6	

**Main Unit Jack J2**  
Connects to Single Line Telephones 1 and 2

J2 Pin No.	Connection
1	
2	Tip Line 2
3	Ring Line 1
4	Tip Line 1
5	Ring Line 2
6	

**Main Unit Jack J4 (Line Commander/4 only)**  
Connects to Single Line Telephones 3 and 4

J4 Pin No.	Connection
1	
2	Tip Line 4
3	Ring Line 3
4	Tip Line 3
5	Ring Line 4
6	

## Figure 2 Terminal Strip Connection Diagrams

**Line Commander Main Unit**

Pin No.	Connection
1	Power to Control Panel
2	Ground to Control Panel
3	Data from Control Panel
4	Data to Control Panel
5	MOR COM
6	MOR
7	AC Common
8	±10Vac

**Line Commander Control Panel**

Pin No.	Connection
1	Power
2	Ground
3	Data Output
4	Data Input

## Figure 3 USOC RJ14C Connection Diagram

**Two-line, Bridged Tip and Ring, 6-position Jack**

Pin No.	Connection
1	
2	Tip 2
3	Ring 1
4	Tip 1
5	Ring 2
6	

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