INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE LCB CURRENT DIFFERENTIAL LINE PROTECTION RELAY SYSTEM

TABLE OF CONTENTS

CAUTION

It is recommended that the user of this equipment become acquainted with the information in these instructions before energizing the LCB and associated assemblies. Failure to observe this precaution may result in damage to the equipment.

Printed circuit modules should not be removed or inserted while the LCB is energized. Failure to observe this precaution can result in an undesired tripping output and/or component damage. In addition, modules should not be interchanged between relays without rechecking calibration.

All integrated circuits used on the modules are sensitive to and can be damaged by the discharge of static electricity. Electrostatic discharge precautions should be observed when handling modules or individual components.

APPLICATION

UNIVERSAL APPLICATION

The LCB relay is a 3-phase, solid-state current differential relay system for high speed pilot protection applications. It is suitable for any system voltage, subtransmission through UHV transmission, and may be applied on any length line, up to 250 miles (400 km). The LCB can be supplied loose and unmounted or completely mounted and wired in a panel.

CONSTRUCTION

The basic LCB is a self-contained, 19" wide rack mounting chassis (3 RU high), prewired for all available options. The relay can be supplied with an integral audio tone output suitable for interface with the users leased lines (3002 or equivalent), microwave or carrier with equivalent 3002 characteristics or an optional fiber optic interface can be supplied for direct connection to the users fiber optic cable. An integral direct transfer trip option can be supplied, eliminating the need for separate channel equipment.

When supplied for audio tone application, a separate tone protection package is recommended. The tone protection package consists of a surge protector and isolating transformer in a 19" wide rack mounting panel (2 RU high). For fiber optic applications the relay is supplied with a 6′ long, (50 micrometer core) graded index fiber optic cable with AMP connectors on each end (1 for transmitter, 1 for receiver). The user

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

cuts the cable in half for splicing to his cable bundle or connects directly with an AMP connector. All external connections to the relay are made to terminal blocks on the rear of the chassis.

INSTALLATION AND TESTING

Most adjustments and test points are available from the front panel to simplify installation and testing. An optional test panel consisting of 2 FT-1 switches on a 19″ wide steel panel (3 RU) can be used to disconnect the ac inputs and dc outputs and provide a means for direct connection of the type UCTB portable, functional test box. This allows the user to completely, functionally test the relay system. Card extenders can also be supplied for simplified diagnostics. In addition, options can be added in the field or the system can be converted for 3 terminal line protection by the simple addition of plug-in modules – no rewiring of the relay chassis is required.

FEATURES

Both relay and channel equipment are contained in one chassis, which is prewired for all available options.

Flexibility of communications channel:

- Integral audio tone suitable for interface with leased line, microwave or single-sideband carrier.
- Optional fiber optic interface can be applied on lines up to 8.5 km without repeaters using 50 micrometer core fiber optic cable with maximum loss of 4dB per km.

Fiber optic channel is immune to station ground mat rise or longitudinally induced voltages.

Optional direct transfer trip function (patent pending).

High speed operation:

- Trip Time: 10-22 ms at 30 times pickup.
- Trip Time: 17-29 ms at 4 times pickup.

Current only system – no potential required:

- Extremely low CT burden.
- Accommodates 3 to 1 difference in CT ratios.
- Immune to system swings (out-of-step).

Available for either 1A or 5A CT secondary, 50 or 60 Hz.

Provides 2 terminal line protection, with option for 3 terminal line protection.

Weak feed capability – will trip all terminals if pickup level is reached at any one terminal.

High speed channel monitoring circuits (patent pending) provide condition indication, alarm contacts, and input to trip decision logic.

Fully independent positive, negative and zero sequence sensitivity settings.

True magnitude comparison up to 5 times pickup – then a gradual change to phase comparison above 5 times pickup.

Advanced SNR detection circuit (patent pending) minimizes noise effect on audio tone interface applications.

Self-contained, adjustable channel delay equalization, with independent settings for 2 and 3 terminal applications.

Relay waveform distortion eliminated – comparison based on composite sequence network output with linear response up to 25 p.u.

Unique comparison circuit (patented) performs a true phasor evaluation of the local and remote quantities.

Unique sequence network (patented) vastly improves the phase and magnitude dependency and sequence purity problems found in traditional designs.

Pulse period modulation (patented) provides secure information transmission and accurate, wide-range current phasor reproduction.

Field set-up adjustments and test points available from front panel of modules.

Optional tone protection package consisting of surge protector and isolating transformer in 19 inch rack mounting (2 RU) panel – recommended for all audio tone interface applications to leased lines.

Optional 19 inch rack mounting (3 RU) test panel with FT-1 switches – disconnects ac inputs and dc outputs to facilitate field testing, and provides breaker simulation.

Optional Type UCTB portable test box to perform functional system test.

Optional UME-3 card extender provides access to all adjustments and test points on printed circuit modules.

Meets ANSI C37.90 and IEC-255 specifications.

LCB relay system and all major options identified by a single, unique catalog number.

BENEFITS

Self-contained 19" rack mounting chassis (3 RU high) requires minimal panel or rack space allocation.

Prewired chassis enables user to add functions or change channel interface at any time – no chassis rewiring required.

Provides full range of channel options:

- Audio tone interface for leased line, power line carrier or microwave.
- Fiber optic interface for direct connection to users fiber optic cable.

Use of fiber optic channel eliminates need for separate mutual drainage reactor and neutralizing reactor.

Eliminates need for separate channel equipment by providing integral direct transfer trip option.

High speed operation – applicable to any system voltage.

Current only fault detection simplifies installation – eliminates need for potential input for relay operation.

Accommodation of 3 to 1 difference in CT ratios permits simplified upgrades of existing installations.

Universal application – 1A or 5A CT's, 50 or 60 Hz.

Can be converted for 3 terminal line protection at any time by simple addition of plug-in modules – no field rewiring of chassis required.

Inherent weak feed trip capability – no additional relays required.

Provides the user flexibility of choice in a loss-of-channel condition:

- Block tripping following loss-of-channel (loss-of-channel block).
- Trip as overcurrent relay following loss-of-channel (loss-of-channel trip).
- Trip as overcurrent relay for 150 ms following loss-of-channel (loss-of-channel unblock trip).

Greater installation flexibility – CT neutral does not need to be formed at the relay; LCB input current transformers are connected to phase currents only.

More reliable operation than conventional systems is possible by advanced LCB features, many of which are patented or have patents pending.

Installation, testing and setting simplified – front panel adjustments and test points.

LCB system test is greatly simplified by use of optional test panel, type UCTB portable functional test box, and type UME-3 card extenders.

Ordering information simplified – complete system defined by a single catalog number.

Simplified wiring – all external connections are made to terminal blocks on the rear of the chassis.

Simplified fiber optic connection – a 6′ cable with AMP connectors at each end (one for transmitter, one for receiver) is supplied. The user then cuts the cable in half and splices to his cable bundle – or connect directly with an AMP connector.

CHANNEL CONSIDERATIONS

Audio Tone

The audio tone system contains many security oriented features and provides interface with unconditioned 3002 circuits, microwave channels, single-sideband power line carrier, or circuits with equivalent characteristics. Transmit level is adjustable from +15 to -44 dBm with a 600 ohm balanced output. Receiver sensitivity is adjustable from 0 to -40 dBm and with AGC control has a ±10 dBm dynamic operating range. The system operates with up to a 17 dB signal to noise ratio over a 3 KHz bandwidth.

An optional audio tone surge protection package is available for added telephone line interface protection. Further recommended protection is shown on Figure 13 for both exposed and unexposed leased cable circuits.

Fiber Optic

The most common fiber being used today for communication systems is a graded index fiber with a core diameter of 50 micrometers. This type of fiber attempts to limit pulse dispersion and, as a result, has a very large bandwidth for high density communication systems. If fibers are being installed for high density communications along with fibers in the same cable for use with the LCB, then the 50 micrometer graded index fiber is the best choice. If on the other hand, a fiber is being installed only for the purposes of the LCB then the 50 micrometer fiber is not the best choice. In the latter case, a fiber with a larger diameter would be preferred.

The LCB does not need a large bandwidth, in fact, its bandwidth is limited to about 2 kHz, and all optical fibers can transmit this small bandwidth. The most important items of concern are the amount of light that gets into the fiber and the total loss of the fiber. Since the LED used has a light emitting area of about 300 micrometers in diameter any fiber with a smaller diameter will cause a significant loss of light when coupling to the fiber. When the LED is coupled to a 50 micrometer fiber a light loss of 20 dB is encountered. This is primarily due to the diameter difference of the LED spot and the cable diameter. If a larger cable is used then the loss is less and more light is available for transmission.

The 50 micrometer fiber is the reference in the LCB when considering channel loss capability, and the maximum allowable channel attenuation for this fiber is 40 dB. The 40 dB is based on the given light source and the detector selected. The coupling losses have already been taken into account and the 40 dB is just losses in the fiber optic cable itself, splice losses, and connector losses. The channel attenuation limit listed above allows for a 3 dB system degradation and a minimum of a 20 dB signal to noise ratio at the receiver.

The following is an example of the loss calculation. Assume that the fiber being used has an average loss of 4 dB per km and the optical channel length were 8.5 km with 8 fusion type splices (.5 dB/splice) and connector loss (2) (1 dB/connector). The example described represents the maximum channel loss for this system. If the cable had been a 100 micrometer cable with the same loss per km then the system would handle an added length of 1.5 km. This is because of the extra light which would be coupled to the larger fiber.

For any size fiber then the maximum allowable channel loss is given by the formula:

$$L = 40 + 20 \times \mathrm{LOG}\ (D/50)$$

Where L = maximum channel loss in dB and
D = fiber diameter in micrometers.

The above is true for fibers up to around 300 micrometers. Above this size very little gain is realized due to increasing fiber diameter.

INSTALLATION

Individual chassis are shipped in separate packing cartons except when supplied as part of a complete relay system. Care should be taken when opening to ensure that the equipment is not damaged or scratched.

The LCB relay, test panel (when used) and audio tone protection package (when used) should be mounted on switchboard panels or their equivalent, in a location free from dirt, moisture, corrosive fumes, excessive vibration and heat. Mount the chassis by means of the slotted holes on the front of the case. Additional support should be provided toward the rear of the units in order to protect against warping of the front panel mounting due to extended weight within the chassis.

Care should be taken when wiring the LCB inputs and outputs in order to reduce the possibility of false signals induced between the leads and from external sources. Refer to "Silent Sentinels" publication RPL: 79-2 for recommended protection practices.

System interconnection when associated with the LCB, test panel (when used) and audio tone protection package (when used) is shown on system schematics Figure 6 (tones) and Figure 7 (optical). All chassis should be grounded with 14 AWG (or larger diameter) copper wire to appropriate studs or frame.

All equipment should be operated within an ambient temperature range of -20°C to +60°C. Ventilation may be required to insure that ambient temperature of 60°C is not exceeded within the enclosure in which the equipment is mounted.

CONSTRUCTION

LCB

The Type LCB Relay is mounted on a 19-inch wide panel, 5.25 inches high (3 rack units) with edge slots for mounting on a standard relay rack or panel. For the outline and drilling plan, refer to Figure 8.

The removable front cover has a smoked plexiglass front for viewing of the LED indicators on the various enclosed modules. Two holes in the cover provide accessibility for the dc input power on/off and system indicator reset switches. The front cover is removable with two thumb screws, which also have a hole for sealing if desired.

The rear panel consists of seven 8 point terminal blocks for making all external connections. Screw size is 6-32 and can handle wire sizes from no. 10 to 30 AWG with appropriate lugs. Ground studs are also available on the rear panel for system grounding. A cutout exists in this panel for access to fiber optic connectors on the fiber optic interface modules (when used).

Inside the rear panel, the terminal blocks connect to a circuit board comprised of surge capacitors connected from the terminal to ground, for those leads exposed to the switchyard environment. These capacitors provide the necessary protection from external surges. Between this rear panel and the rear of the module enclosure, the LCB is prewired for all possible available options.

All of the circuitry associated with the LCB operation and suitable for mounting on printed circuit boards is contained in the enclosure behind the front cover. The printed circuit modules slide into position in slotted guides at the top and bottom of the enclosure and engage a printed circuit connector at the rear of the compartment. Each module and connector are keyed so that they cannot be accidently inserted into the wrong slot location. Handles and a front plate on the modules are used for identification of the module name and location, indication description, module removal and insertion and as a bumper with the front cover to prevent the terminals from accidently becoming disconnected from the terminal connector. The modules may be removed for replacement purposes or for use in conjunction with a module extender, Type UME-3, Style 1447C86G01, which permits access to the modules test points and terminals for making measurements while the relay is energized.

All components used in the LCB are completely tropicalized.

TEST PANEL

The optional LCB test panel is mounted on a 19-inch wide panel, 5-1/4 inches high (3 rack units) with edge slots for mounting on a standard relay rack or panel. For the outline and drilling plan refer to Figure 9. This unit consists of 2 type FT-1 10 terminal FT switches and is used to provide interface between the LCB and the power system for such inputs as the current transformer, dc battery, trip circuits and breaker control. Four resistors and a pushbutton are included to simulate breaker trip coil current. Fuses are provided for ac voltage.

AUDIO TONE PROTECTION PACKAGE

The optional audio tone protection package is mounted on a 19-inch wide panel, 3.5 inches high (2 rack units) with edge slots for mounting on a standard relay rack or panel. For the outline and drilling, refer to Figure 10. Mounted behind the panel are 600 ohm isolating/matching transformers and resistor/zener surge protectors. Connection from the pilot pair and LCB tone output is made via terminal blocks at the rear of the panel. Test jacks on the front panel are available for facilitating measurements of the incoming and outgoing tone levels.

PORTABLE TEST BOX (UCTB)

The test box is built to be portable with rubber feet on the bottom or it can be mounted on a 19-inch wide relay rack or panel by means of two thumb screw latches on each side. The height of the unit is 5.25 inches (3 rack units). When mounted in the rack by means of the latches, the bottom should be supported with a steel bracket. Optional rack mounting could be made permanent by means of the edge slots.

A 6-foot harness comes with the test box to provide connection between the box and test panel.

The UCTB contains an isolating step down transformer, loading resistors, FT-1 switch and two rotary switches, one for fault selection and one for fault application.

Outline of the UCTB is shown in Figure 11.

OPERATION

SYSTEM OPERATION

The essential elements of the relay are shown on block diagrams Figure 4 (audio tone) and Figure 5 (fiber optic). The 3-phase currents are transformed to voltages which are then combined into a representative single phase voltage by means of the sequence filter. This active solid state circuit produces a precise, repeatable output as a function of the 3-phase current load or fault conditions. The relative amount of positive (P), negative (N), and zero (Z) sequence may be adjusted independently to best match power system conditions. The only data required for calculating settings are minimum 3-phase fault current from the strongest terminal, minimum phase fault current from the strongest terminal, and maximum expected load current. (Ref. SETTINGS Section.)

The output of the sequence network is simultaneously fed to a local comparison circuit and a channel interface unit. The interface unit transmits the locally generated signal to the other terminal(s) over one channel while receiving a signal from the other terminal(s) on another channel(s).

For the comparison process, two quantities are generated from the local (VLD) and remote (VR1 and VR2) voltages. One is called the operating quantity (VOP) and is derived by the vector addition of the local and remote voltages. This addition is performed by a summing and inverting amplifier located on the RELAY module ("L + R"). The output is rectified and filtered to produce a dc voltage for comparison. The other, the restraint quantity (VRES) is obtained by adding the local (VLD) and remote quantities (VR1 + VR2) on a magnitude basis, after conversion to dc, in a summing and inverting circuit also located on the RELAY module. This output (-VRES) is opposite in polarity to the "operate" voltage (VOP). Further details of the comparison circuit are covered later under "Comparison Technique".

The "operate" and "restraint" voltages are combined and the resultant fed to a level detector which produces a trip signal if the resultant is above the pick-up setting. Variable system pick-up settings are entered by a knob on the front of the RELAY module and may vary from 2 to 20 amperes (5 A CT) or one fifth of that for 1 A CT's. The trip signal lights an indicator labeled "LCB TRIP" on the RELAY module and causes trip relays to operate if tripping has not been blocked by monitoring circuits.

In summary, the local and remote currents are converted to representative voltages at each terminal. By means of a communication channel the remote signals are brought in to each local terminal, compared as to magnitude and phase relation, and a trip signal generated accordingly.

The above description has been greatly simplified to cover just the basic system operation. Before covering added functions and logic provided in the system, some discussion of the modulation technique used for remote data transmission is in order. In order to provide accurate and rapid trip determination, the voltage developed by the sequence network at each terminal is reproduced at the remote terminal(s) with a minimum of delay and distortion. The encoding technique is suitable for both audio tone and fiber optic data channels. The technique employed in the LCB is known as pulse period modulation (PPM), where in the carrier period is varied linearly with the modulating signal amplitude. In essence samples of the line current are taken at a 3.4 kHz rate and reproduced as a stepped signal at the receiving end. The envelope of this output is an accurate representation of the original voltage.

The device which develops the pulse train is called the modulator and the unit which translates the pulses to a magnitude wave is called the demodulator. The demodulator uses a sample and hold technique which minimizes the inherent delay in filter circuitry required by other techniques.

One modulator is required at each terminal to produce a local signal for transmission to the remote terminal(s). This unit is part of the modulator-demodulator (MD) module. A demodulator for the signal from one remote terminal is located on the same module. For three terminal applications a second demodulator is required to convert the signal from the second remote terminal. This demodulator is located on the demodulator/time delay module (DTD).

Further details of the "Modulation Technique" are covered later.

FUNCTIONAL OPERATION

The current transformation package is located behind the relay nameplate and consists of three current to voltage transformers (current to current with loading resistors). These low burden transformers are accurate to 100 p.u. symmetrical (1 p.u. equals one or five amperes). The voltage outputs go to the sequence network previously discussed. While it is desirable that the line current transformers have the same ratio, if there are different ratios, the current settings of the relays (T SET, RELAY module) may be adjusted to provide the same primary current sensitivity at each terminal. The setting range is 2 to 20 amperes for the 5 A unit which generally can accommodate a three to one ratio difference between line transformers. Careful consideration must be given to the current transformer with the lower ratio, since it may saturate before the current transformer with the higher ratio. The very low burden of the relay aids in solving this problem.

Correct and reliable operation of a differential relay requires that the quantities being compared be faithful equivalents of the measured primary quantities. This is especially critical during transient conditions, since unequal response in terms of magnitude, phase or time delay will result in a false comparison. In the LCB relay, the local signal prior to comparison is conditioned by a series of circuits nearly identical to the ones needed to process the remote signal. Since the remote terminal may be far enough away to produce a significant real time delay in the received signal with respect to the local signal, to make a valid comparison the local signal must be delayed so that it reaches the comparison circuit at the same time the equivalent real time signal arrives from the remote terminal.

The local delay in the LCB is provided by an adjustable, distortion free delay equalization circuit. This circuit consists of sectionalized all-pass delay networks which supply adjustable delay times up to 8 ms and is similar to a lumped-parameter delay line circuit. It exhibits a linear phase (constant time delay) characteristic over a wide frequency range. A similar design is also used for equalizing the remote signals of a three terminal line application. The system delay circuitry for the local signal is on the RELAY module. The third terminal delay circuit is on the demodulator/time delay module (DTD).

In the LCB relay all the signals required to transmit information from one terminal to another are generated as an integral part of the relay system. The module which connects the LCB System to the communication channel is the interface module. One module is required for each remote channel. Both are identical, except for the label, for a given type of channel. There are two versions of the interface module, one for a fiber optic channel (IFO) and one for a tone channel (IFT).

The LCB Block Diagram Figure 4 shows the audio tone interface module, IFT (see left hand side). This module may be divided in three functional elements. The blocks across the top of the IFT block diagram constitute the receiver. The incoming signal goes through an isolating transformer, then through a common mode noise rejection circuit to a scaling circuit. Depending on the received signal level, this device may be set by a jumper to act as either an amplifier or attenuator. The signal is then adjusted to the nominal AGC level using a control accessible at the front panel of the module. (RX adjust) The band pass filter eliminates noise and spurious signals outside the desired 1 to 2.5 kHz modulated carrier range. The automatic gain control (AGC) unit maintains a nearly constant magnitude signal going to the demodulator.

The middle series of blocks represent the received tone signal monitoring circuits. The AGC control voltage is used for high and low signal level monitoring as well as the reference for signal-to-noise (SNR) monitoring.

In the high/low limit monitoring circuit, the AGC control voltage is compared with predetermined levels. The differential comparison function of the relay is permitted to perform only when the incoming carrier is within these set limits (±10dB).

In the SNR monitoring circuit, the carrier signal output from the AGC circuit is conditioned by a band reject circuit (carrier removal), and only the noise voltage will remain at the output of this circuit. An absolute-value circuit is used to further process the noise into a dc quantity which in turn is to be compared with a voltage derived from the AGC control voltage for the desired SNR level. If the noise voltage equals or exceeds the set level, a logic signal is sent to the relay circuit to terminate the differential comparison. The use of the AGC control voltage for the SNR level setting permits the SNR monitoring to be a truly relative function not tied to any specific input signal or noise level. The noise voltage obtained in this circuit is used yet for another purpose.

In the relay design, as described earlier, the remote and the local current quantities are evaluated by circuits which perform the vector comparison and magnitude comparison. The outputs of the two comparisons are then combined to determine a trip. If the recovered remote current contains noise due to a noisy channel, it is desirable that this noise can be recognized and eliminated. The very nature of the comparison technique and the characteristics of random noise have already provided some inherent noise rejection. However, additional noise rejection is achieved by relating the noise voltage (VN) to the trip reference. This feature provides an adaptively desensitized trip maintaining the comparison accuracy in the presence of channel noise.

The high/low carrier frequency detector is a fast responding detection circuit which directly senses the carrier signal and provides an output if the signal is outside of its range for more than one cycle. This monitoring together with the SNR and high/low monitorings merge into one logic output indicating the channel status.

The bottom series of blocks represent the tone transmitter. The transmitter level control is a combination unit similar to the receiver which is used to adjust the transmitter output to the level required by the tone channel to be used at the relay location. The signal conditioning converts the incoming square wave to a sine wave and the protection and isolation unit provides a safe and matched connection to the channel.

The LCB Block Diagram Figure 5 shows the optical interface, IFO (see left hand side) which connects the relay system directly to the fiber channel. The transmitter is an amplifier – diode combination which turn an LED on and off to generate light pulses with the off/on period determined by the pulse period modulation output. The receiver consists of a photo diode producing electric pulses which are then amplified through a trans-impedance amplifier, passed through a band pass filter and into an automatic gain control circuit thereby providing a relatively constant amplitude carrier signal for the demodulator.

The channel condition monitoring section comprises two detection circuits. The low carrier signal detection uses the AGC control voltage to detect carrier signals that are below a preset level. A low carrier signal signifies a malfunction in the channel. Since the AGC voltage is a relatively slow responding signal, this detection is implemented primarily to provide an early warning indication that problems are developing in the channel. An adequate margin has been given in the design to accommodate the time delay effect in the AGC voltage. The carrier frequency monitor, on the other hand, is a fast responding detection circuit. By sensing the carrier signal directly, any fast interruption or change in the channel lasting for more than one carrier cycle will activate this circuit instantly. The two detection outputs are combined to produce a channel malfunction signal.

The channel trouble outputs (EN) on the channel interface modules are applied to logic on the RELAY module to immediately discard the remote signal and block tripping. The LCB under this condition can still be used as an overcurrent function after 22 ms by using the local sequence quantity only, if desired, (link selectable).

Time delayed indication and alarm is provided for sustained loss of channel by means of a 500 to

5000 ms timer, CA-1 or CA-2 indicators and alarms on the AXLM module.

Final breaker tripping control is accomplished by means of type AR relays mounted on the LCB trip module (ARTM-1 for LCB trip, AR-1), (ARTM-2 for DTT trip, AR-2). Each AR is provided with four (4) normally open contacts, two (2) for tripping and two (2) for spares. Those contacts for tripping have a series reed relay, which when energized with dc currents in excess of 0.5 amperes operate to cause an LED trip indication.

The AR tripping circuits and relay indication are blocked from false operation for a period of approximately 3.5 seconds during dc power up conditions in order to permit associated relay and communication circuits to become stable. This power control circuit also blocks the system immediately during momentary loss or dip of +15 Vdc. PSME from the ALS power supply actuates this circuit as well as blocking the modulator output during power up/down.

Other features incorporated in the LCB system are the ability to reset indicators remotely, desensitize trip on line energizing and provision for "Unblock Tripping" as an overcurrent relay for a limited period of time. These are all included as part of the AXLM module.

External reset of targets is accomplished by applying a signal to the LCB target reset input which is optically isolated and voltage selectable depending on the system battery voltage and signal source. Reset of indicators can also be performed with the system indicator reset pushbutton on the LCB trip module.

Trip desensitizing is a feature occasionally used on power systems where excessive line charging inrush may occur on the closing-in of a breaker. This circuit (link selectable) provides trip blocking (BS) for 200 ms after closing the breaker unless the magnitude of the trip voltage (VTRIP) as determined by the operate and restraint quantities is at some level above the trip point as determined by the "T" setting. Depending on the power system parameters, this desensitized level can be calibrated at a level of 1 to 10 times the normal pickup. Operation of this feature is dependent upon the breaker 52b contact for indication of breaker status – Input of the 52b contact information status is through an optically coupled, voltage selectable isolated buffer.

Unblock tripping is a link selectable feature and is commonly used where the channel medium is power line carrier, where momentary loss of channel could occur during some internal faults. As employed in the LCB, tripping is allowed for 150 ms following loss-of-channel, if the local current is sufficient. Following this time, trip is blocked. If trip did occur, then, if selected, unblock trip on reclose will be permitted again for up to 150 ms assuming the trip had occurred in the preceding 2.5 seconds. Unblock trip on reclose requires 52b breaker status information which is obtained via an optically isolated, voltage selectable input buffer as described earlier.

An optional feature available for LCB systems is direct transfer trip (DTT). The breaker or breakers at the remote terminal(s) of a protected line can be tripped at high speed from the local terminal using elements of the LCB and the same communications channel. An additional module, direct transfer trip (DTT), is required at each terminal. To initiate transfer tripping, some external device (keying circuit) must connect battery voltage to terminals DTTBP and DTTBN on the local LCB. The DTT initiate circuit provides optical isolation from battery transients and has a jumper which must be set prior to inserting the module to match the battery voltage.

Referring to the block diagrams, the transfer trip signal is conditioned and then switches the operation of the PPM modulator to cut out the local current signal input. At the same time the PPM is modulated to represent a magnitude greater than the maximum current signal at a 420 Hz rate. This signal is transmitted by the channel interface unit to the remote terminal(s).

At the receiving terminals, the signal is processed by the channel interface and demodulator elements. The DTT detector and recognition circuitry checks both frequency and magnitude of the signal from the demodulator. A valid direct transfer trip signal will be higher in magnitude. If these criteria are met the remote signal is switched off (DTI, DT) to disable to comparison circuit and block LCB tripping on the RELAY module. The 50/60 Hz demodulated signal and at a higher frequency (420 Hz) transfer trip signal starts a timer which produces a trip output if the transfer trip signal is maintained for 10 milliseconds. This time is supervised by the channel monitoring circuitry (TB) to prevent tripping in the presence of channel problems.

COMPARISON TECHNIQUE

As mentioned earlier (System Operation), two quantities are generated from the local and remote signals. The first is called the operating quantity and is derived by the vector addition of the local delayed signal, VLD, and the summed remote signals (VR1 and VR2), VR. This is accomplished by a sum and inverting circuit whose output is "L + R". Once summed, the resultant "L + R" signal is converted to a dc level and amplified by unity gain to produce the operating voltage, VOP. The operating quantity is given by equation (1).

$$VOP = |VLD + VR| \qquad (1)$$

where VOP = operating quantity
VLD = delayed local voltage vector
VR = sum of remote voltage vectors
| | indicates absolute value

The restraint quantity is obtained by adding the local and remote voltages on a magnitude basis, thus phase angle does not enter the result. In reference to the block diagram, the local quantity, VLD, and remote VR are individually converted to a dc magnitude, summed and amplified (gain = .7) to produce a negative dc magnitude referred to as VRES. The restraint quantity is shown in equation (2).

$$VRES = -0.7\,(|VLD| + |VR|) \qquad (2)$$

where VRES = the restraint voltage

The quantities VOP and VRES are then summed and filtered to determine if the fault is internal or external to the protected line. Equation (3) shows how this is accomplished

$$VOP + VRES = VPU \qquad (3)$$

where VPU = a preset pickup threshold

The combined equation is as follows (4)

$$|VLD + VR| - 0.7\,(|VLD| + |VR|) \geq VPU \qquad (4)$$

This signal is fed to a trip comparer where the final trip output, TRC, is set for VPU with the pickup setting potentiometer.

Figure 14 represents the characteristic of the comparison circuit if the fault currents at the two ends of the line are either in-phase (internal fault) or out-of-phase (external fault). This curve indicates that tripping occurs for in-phase currents and also for out-of-phase where the differential between them is significant. Since many times the currents at the two ends are not exactly in- or out-of-phase, Figure 15 shows the relay characteristic when the local (VL) is at three times pickup, and the remote varies in-phase and magnitude. A family of curves similar to Figure 15 could be drawn for different magnitudes of local voltage. It can be seen that the relay system will operate for small amounts of out-feed at the remote terminal. This is the differential aspect of the LCB, and provides out-feed trip capability in weak terminal applications. As observed in the drawing the relay has about an 82° characteristic; that is, the two quantities can be up to 82° out-of-phase and the relay will trip for any set of magnitudes above pickup.

MODULATION TECHNIQUE

The modulation technique used in the LCB is PPM – pulse period modulation. PPM provides a means of accurately transmitting and receiving the sequence quantity output, while also providing the capability of working over fiber optics or a 3002 unconditioned or equivalent channel without change.

PPM, where the carrier time period is varied linearly to the modulating signal amplitude, is similar to FM when the deviation ratios are small. A prominent merit of the PPM scheme is the comparatively miniscule filter requirements in the demodulator. A sample-and-hold process implemented in the demodulator virtually removes the carrier frequency content without the need of a filter. This feature greatly enhances the relay speed and also simplifies the circuit that is needed to compensate the local sequence signal. Diagrams illustrating the PPM operation are shown in Figure 16 (modulator) and Figure 17 (demodulator).

The modulator formation is based on the charging time of capacitor Cm under a constant current Im. The voltage on Cm is compared to the modulating voltage Vm. When the voltage on Cm reaches Vm, flip-flop FF-1 is toggled and Cm is reset, commencing another charging cycle. This encoding operation is performed at 27.2 kHz center frequency which is then counted down by 16 to 1.7 kHz for transmission. Performing modulation at a higher frequency permits a more practical design and produces a digitally selectable center frequency.

The PPM modulation can be characterized by the equation,

$$T(t) = To + Km \times Vm(t) \quad (1)$$

where T (t) = period of modulated carrier
To = period of unmodulated carrier
Km = Cm/Im, a design constant
Vm(t) = the modulating voltage

T (t) and Vm (t) are time functions.

In the demodulator, the incoming carrier is first shaped to a square wave. Two pulse signals, P1 and P2, generated from transitions of the square wave are used respectively for the sample-and-hold operation and capacitor Cd reset function. Constant current Id charges Cd to produce a linear ramp voltage. Prior to reset (P2 function) of the ramp, Cd voltage is sampled (P1 function) and stored in capacitor C3. C3 holds the sampled ramp voltage until the next P2 pulse appears. Assume that the modulating signal in the carrier is a 60 Hz (50 Hz) sinusoidal wave then the recovered signal at the holding circuit output will be a stepped 60 Hz (50 Hz) sinusoidal wave carrying very little residual carrier frequency components. A simple filter removes the steps accurately recreating the original signal. The demodulator operation is given by the equation,

$$Vo(t) = Kd \times T(t) \quad (2)$$

where Kd = Id/Cd, a design constant.

To demonstrate the overall PPM process, one can substitute T (t) by the expression given by equation (1). Then

$$Vo(t) = Kd \times To + Km \times Kd \times Vm(t) \quad (3)$$

KdxTo is a constant voltage term and can be removed by a simple highpass filter leaving Vo(t) = KxVm(t). K = KmxKd = CmxIm/CdxId, a constant term representing the gain of the PPM process.

It is noted that the demodulation is performed on each half of the carrier signal. This yields an effective sampling rate of 3.4 kHz, or approximately 57 samples per cycle of 60 Hz frequency (68 samples at 50 Hz). This is a more than adequate rate to insure good representation of the original modulating signal.

LCB CHARACTERISTICS

1. ac Ratings:

ct Ratio Secondary-A	Continuous Rating-A	Ohm Burden	1 Second Rating-A
5	10.0	.002	250
1	2.0	.006	50

2. Setting Range (amperes):

ct Ratio Secondary	3-Phase Fault Sensitivity (A)	Phase to Ground Fault Sensitivity (A)
5	2.0 to 40.0	0.23 - 4.4
1	0.4 to 8.0	0.046 - 0.88

3. Power System Frequency: 50 or 60 hertz

4. Carrier Frequency: 1700 hertz, unmodulated.

   Maximum Deviation: ±200 hertz without DTT option.

   Modulation Technique: Pulse period. (PPM)

5. Direct Transfer Trip (Option): 420 hertz modulating frequency.

6. Channel Delay Equalizer:
   Adjustable 0 to 8 ms. (local signal)
   Adjustable 0 to 4 ms. (third term)

7. Input Current Transformers: Linear response up to 100 per unit (1 p.u. = 5 A or 1 A symmetrical current) with an accuracy of 1%.

8. Power Supply Voltages:

Nominal	Range
48/60 Vdc	38-70
110/125 Vdc	72-145
220/250 Vdc	170-290

9. dc Burden (Watts):

	2 Terminal	Added Drain for DTT	3 Terminal
Standby	20	5	5
Operate	35	15	5

10. a. Non Seal-in Indicating Lights (LED):

Module	Functions
ALS (switching power supply)	DC INPUT DC OUTPUT
IFT (audio tone interface)	SNR (Signal-to-noise) HI (High Level) LO (Low Level)
IFO (fiber optic interface)	LO (Low Level)

b. Seal-in Indicating Lights (LED):

Module	Functions
RELAY	LCB TRIP
DTT (direct transfer trip)	DTT KEY DTT TRIP
AXLM (auxiliary logic)	CA-1 (Channel Alarm-1) CA-2 (Channel Alarm-2) OC/UB TRIP DES TRIP
ARTM-1 (trip)	LCB TRIP #1 LCB TRIP #2
ARTM-2 (trip)	LCB TRIP #1 LCB TRIP #2 DTT TRIP #1 DTT TRIP #2

11. Indicator Reset:

A. Manual Reset on ARTM Module. (System Indicator Reset)

B. AXLM Module has input to allow indicators to be reset remotely. Isolated input buffer, link selectable, for 15, 48, 125 or 250 Vdc.

12. Output Contacts:

Module	(No.) Contacts
ARTM-1	(2) Independent, heavy duty, seal-in contacts for tripping 2 breakers. (LCB trip) (2) Light duty contacts for auxiliary function such as breaker failure initiate or reclose initiate. (LCB trip)
ARTM-2	(2) Independent, heavy duty, seal-in contacts for tripping two breakers. (LCB trip) (2) Light duty contacts for auxiliary functions such as breaker failure initiate or reclose initiate. (LCB trip) (2) Independent, heavy duty, seal-in contacts for tripping 2 breakers (DTT trip). (2) Light duty contacts for auxiliary functions such as reclose block (DTT trip).
AXLM	(1) Form C channel #1 alarm. (1) Form C channel #2 alarm.
ALS	(2) Form B loss of dc alarm

13. Contact Rating:

AR Heavy Duty (Tripping):
Make and carry 30 amperes for a minimum of 100 ms.

AR Light Duty (Auxiliary):
3 amperes continuous.

	Interrupting Rating (Amperes)	
	Resistive	Inductive
48 Vdc	3.75	1.75
125 Vdc	0.5	0.35
250 Vdc	0.25	0.15

Form C Alarm – make, continuous, and interrupt 100VA, resistive.

Form B Alarm – make continuous, and interrupt 50VA, resistive.

14. Channel Alarm (Contacts and Indication) output has adjustable time delay of 500 to 5000 ms. (Factory set at 2500 ms)

15. Fiber Optic Cable Interface:

    Frequency response: 1.0 – 2.5 kHz

    Minimum optical power input to maintain 20 dB SNR is 0.5 nanowatts.

    Low signal level setting – 0.5 nanowatts.

    Optical channel capability is 40 db when using a 50 micrometer core fiber cable.

    Optical power output – 1.0 milliwatts.

16. Audio Tone Interface:

    Transmitter:

    Output Level – Adjustable within the following ranges:
    +15 to -5 dBm
    -4 to -25 dBm
    -23 to -44 dBm
    Amplitude Stability ±1 db
    Output Impedance 600 ohms, balanced
    Frequency stability 1%
    Frequency bandwidth 1.0 to 2.5 kHz.

    Receiver:

    Input sensitivity +10 to -40 dBm, selectable, with a 20 dB (±10 dB) window dynamic range

    Input impedance 600 ohms, balanced

    Signal-to-noise ratio 20 dB over 1.5 kHz bandwidth

17. Audio tone interface can be applied over a 3002 unconditioned circuit or equivalent.

18. Temperature range -20°C to +60°C around chassis. Storage temperature -40°C to +80°C.

19. Dielectric Capability: 2000 Vac (50/60 Hz)/ 2850 Vdc, 1 minute, exposed terminals. 1000 Vac (1450 Vdc) between contacts and across open contacts.

20. Surge withstand capability per ANSI-C37.90 and IEC-255 specifications.

SETTINGS

There are several Settings and Link Options required for the LCB. They are dependent upon the system configuration, dc voltage, channel considerations and user relaying practices.

Required settings/link options:

1. Positive sequence sensitivity (P) – RELAY module.

2. Negative sequence sensitivity (N) – RELAY module.

3. Zero sequence sensitivity (Z) – RELAY module.

4. Current sensitivity adjustment (T) – RELAY module.

5. Channel block configuration (L-B,U) – RELAY module.

6. dc input selection for

   a) DTT initiate (15, 48, 125, 250) – when used – DTT module.
   b) Target reset (15, 48, 125, 250) – AXLM module.
   c) 52b contact (15, 48, 125, 250) – AXLM module.

7. Loss of channel alarm seal-in selection (AL1, AL2) and time delay – AXLM module.

8. Trip desensitizing level (DES ADJ) and selection (TRDS) – AXLM module.

9. Unblock feature selection (UNBLK, UR) – AXLM module.

10. Trip seal-in feature (J1, J2, J3, J4) – ARTM-1/2 module.

NOTE: The settings listed in this section are in addition to the FIELD SET UP procedure where

the transmitters and receivers for tones (when used) are adjusted and the local and remote magnitude and channel delays are equalized.

SEQUENCE (P, N, Z) AND CURRENT (T SET) SENSITIVITIES – RELAY MODULE

In order to calculate these sensitivities, the following power systems information is required:

I3P = The minimum three phase fault current from the strongest terminal.

Ig = The minimum phase to ground fault current as fed from the strongest terminal.

IL = The maximum expected load current through the protected line.

The above quantities are always the secondary current magnitudes.

The sequence network voltage output referenced to secondary current quantities is shown in equation (1).

VF = (14.14/T) (C1xIa1+C2xIa2+C0xIa0) (1)

Where VF = voltage output of network
T = current setting of the relay
C1 = positive sequence network constant
C2 = negative sequence network constant
C0 = zero sequence network constant

Ia1, Ia2, and Ia0=A phase positive, negative, and zero sequence current components respectively (phasor quantities)

Table 1 shows the actual constant values of C1, C2, and C0 for various jumper settings. The T setting may vary between 2 to 20 amperes. The network output voltage needed to operate the system is 1.414 volts by design. Therefore, at system pickup equation (1) becomes:

(C1xIa1+C2xIa2+C0xIa0)/T = 0.1 (2)

Equation (2) may be used by those desiring to check detailed pickup for various fault conditions. The right side of equation (2) must be equal to or greater than the left side in order for the system to operate.

Table 1
Sequence Network Constants

Constant	Position	Value
C1	P1 P2 Off (P)	-0.10 -0.05 0
C2	N1 N2 N3 Off (N)	0.23 0.22 0.20 0
C0	Z1 Z2 Off (Z)	2.45 1.25 0

For vast majority of applications the above detailed calculations need not be made, and the following general criteria will be adequate. Table 2 shows the preferred combinations of link settings, and these should be used unless special circumstances dictate otherwise.

Table 2
Preferred Jumper Combinations

Comb	Jumper
#	Position
1	P1, N1, Z1
2	P1, N1, Z2
3	P2, N2, Z1
4	P2, N2, Z2
5	Off, N3, Z1
6	Off, N3, Z2
7	P1, Off, Z1
8	P1, Off, Z2
9	P2, Off, Z1
10	P2, Off, Z2

The criteria are as follows:

I3P $\geq$ |0.1xT/C1| (3)

IL $\leq$ |1.25x(0.1xT/C1)| See note below (4)

IG $\geq$ |0.3xT/(C1+C2+C0)| (5)
| | symbols indicate absolute value

NOTE: If the system is strapped to block on loss of channel then criterion (4) may be ignored.

The first step in picking the relay settings is to determine the smallest value of C1 and calculate the value of T in order to satisfy criterion (3). Then check to see if criterion (4) is met. If criterion (4) is not satisfied then C1 and T must be varied in order to satisfy both criteria (3) and (4) or link "L" must be set to B position. When a value for current setting T and C1 has been selected then the setting for C2 is obtained from Table 2. The next step is to select link CO, and this is done by using criterion (5). Criterion (5) assumes that $Ia1 = Ia2 = Ia0$.

If the current transformers at the two ends of the line are not the same ratio then use the higher of the two ratios to make all the calculations described above. Raise the T current setting at the terminal with the lower ratio current transformer by a factor equal to the higher ratio divided by the lower ratio.

$$DS = 1082.5 - 2000/T$$

where, DS = Dial Setting
T = Tap Value in Amperes

CHANNEL BLOCK CONFIGURATION (L-B/U) – RELAY MODULE

Link "L" has two positions, B and U. Position B means the relay system will block trip during a loss of channel condition, and U means that each terminal operates as an independent overcurrent relay during loss of channel. Position U is the preferred position unless criterion (4) above cannot be satisfied.

If the unblock option described later is chosen, then U is required for this setting.

DC INPUT SELECTIONS

1. Target Reset Input – AXLM Module

Electrical (remote) reset of seal-in indicating lights. Set "TARGET RESET" link for the desired input dc voltage (15, 48, 125, 250).

2. 52b Contact Input – AXLM Module

52b breaker contact input used in conjunction with line energizing trip desensitizing and/or unblock trip capability. Set "52B" link for the desired input dc voltage (15, 48, 125, 250).

3. DTT Initiate Input – DTT Module (When Supplied)

Set link "JC" for the desired input voltage. J1-15V, J2-48V, J3-125V, or J4-250V.

LOSS OF CHANNEL ALARM SEAL-IN AND TIME DELAY – AXLM MODULE

Loss of channel alarms AL-1 for channel 1 and AL-2 for channel 2 (3 terminal lines) can be set to seal-in by placing links "AL1" and "AL2" on "S", or to follow the signal by placing the links on "NS".

Time delay for alarm after loss of channel is factory set at 2500 ms. If a different time between 500-5000 ms is desired, refer to the Calibration Section.

TRIP DESENSITIZING – AXLM MODULE

This feature when utilized allows the LCB trip level to be desensitized for 200 ms when energizing the line. Factory calibration is for a desensitized level of 5 times (5X) pickup but the link activating this feature is "OUT". If this feature is desired, then link "TRDS" must be set on "IN". If a different multitude of trip level setting is required, then recalibrate per the CALIBRATION Section.

UNBLOCK TRIPPING – AXLM MODULE

This feature when selected (generally used where the communication medium is power line carrier) allows the LCB relay to trip as an overcurrent relay only for a period of 150 ms following a loss of channel. Settings associated with this feature are as follows:

If unblock trip is desired, set link "UNBLK" to "IN" and link "L" on the RELAY module to "U" to allow overcurrent trip on loss of channel. If unblock trip is not desired, set "UNBLK" to "OUT".

In addition to normal unblock trip, unblock tripping on reclose within 2.5 seconds of a trip can be selected by setting link "UR" to "IN". If this feature is not desired, set "UR" to "OUT".

TRIP SEAL-IN SELECTION – ARTM-1/2 MODULE

Links J1 (LCB-Trip), J2 (LCB-Trip 2) on the ARTM-1 and Links J3 (DTT-Trip 1), J4 (DTT-Trip 2) on the ARTM-2 when in, permit the trip AR to be sealed in providing 0.5 amperes dc is flowing through the respective trip contacts. With the links removed, the AR relays will be energized only when an LCB or DTT trip signal exists.

RECOMMENDED ROUTINE MAINTENANCE

Periodic checks of the LCB including the relaying as well as the communication portions of the system are advisable to verify the stability of the settings or possibly indicate component degradation. These checks will allow corrective action to be taken before settings may drift out of tolerance or components actually fail.

Any accumulated dust should be removed at regular maintenance intervals.

The AR relays used for tripping and mounted on the ARTM module should be periodically inspected for proper contact action and wear. For worst case operating conditions; 30 amperes resistive, contact make duty; the contacts should be inspected each year or 50 operations and replaced when necessary. Reference, I.L. 41-759. Note: ARTM-1 contains one AR for LCB trip; ARTM-2 contains two AR's, one for LCB trip and one for DTT-Trip.

In normal operation, or through functional testing, the monitoring function (LED's) on the various modules provide a check on the performance of the system.

The areas set and checked during the SET UP procedure as well as those areas that can be calibrated (CALIBRATION section) are key areas to verify at regular maintenance intervals. Ref: LCB SYSTEM FUNCTIONAL TEST/SYSTEM VERIFICATION PROCEDURE.

RECOMMENDED TEST EQUIPMENT

The following is recommended test equipment and associated test devices for an LCB system.

1. Dual trace oscilloscope.
2. Frequency counter.
3. Digital multimeter with true rms.
4. Three phase 50/60 Hz current source with meters.
5. dc voltage source.
6. UME-3 board extender – Westinghouse 1447C86G01.
7. Variable attenuator (600 ohm) – tone systems.
8. Random noise generator – tone systems (optional).
9. Optical attenuator – optical systems (optional).

LCB ACCEPTANCE TEST PROCEDURE

It is recommended that an Acceptance Check be applied to the LCB system to verify that the circuits and system components are functioning properly.

The LCB test diagram shown on Figure 12 aids in test of the unit on a stand-alone basis. If the LCB is to be acceptance tested in an operating system, then the communication channel should be set initially as per the FIELD SET UP procedure.

The CALIBRATION section of this I.L. gives further detail on those portions of the LCB that can be calibrated.

NOTE: When removing or inserting modules, dc power should be turned off.

I. Preliminary

A. Links and Dial settings:

RELAY Module:
N-N1, P-P1, Z-Z1, J-J1, L-B, T-SET – Max clockwise

IFT-Tone Interface Module(s):
XDB to "+15", R to "AMP" (when used)

AXLM Module:
AL-1 to "S", AL-2 to "S", UR to "OUT" UNBLK to "OUT", TRDS to "IN" 5X, 10X links to "5X"; 52B, and TARGET RESET to rated dc voltage

DTT Module (when used):
JC to rated dc voltage.

B. Test Setup

Connect relay to rated dc voltage and 3-phase current source in accordance with Figure 12.

NOTE: All measurements are with respect to "COM" unless otherwise specified.

II. Power Supply (ALS Module)

Energize relay with rated dc voltage, and with the ALS module power switch on.

A. Check that the "DC INPUT" and "DC OUTPUT" indicators are on.

B. Measure +15 Vdc to be between +14.990 and +15.010 Vdc.

C. Measure -15 Vdc to be between -14.750 and +15.250 Vdc.

D. Insert a board extender in place of the RELAY module. Short the (+15) volt terminal 15 to common, terminal 35; the DC OUTPUT indicator should go off and the PSA relay contacts (PSA-1, 2 and PSA-3, 4) should close. Repeat by shorting (-15) volt terminal 19 to common, terminal 35.

III. Sequence Network (RELAY Module)

A. Open communication channels by removing interface module(s). (IFT-1, 2, or IFO-1, 2)

B. Apply 3-phase balanced positive sequence current at CT rating (5A or 1A): measure ac voltage per table below.

TP1	TP2	TP3
.348-.358	.348-.358	.348-.358
TP4	TP5	TP6
<5 mv	.348-.358	<5 mv

C. Apply 3-phase balanced negative sequence current at CT rating (5A or 1A); measure ac voltage per table below.

TP1	TP2	TP3
.348-.358	.348-.358	.348-.358
TP4	TP5	TP6
.348-.358	<5 mv	<5 mv

D. Apply zero sequence currents by applying single phase to neutral current. Measure ac voltage on TP6 to be 113 to 123 mv.

IV. Dial Setting (T-SET) – (RELAY Module)

A. Open Z jumper, and leave communication channels open.

B. Apply 3-phase positive sequence current at 4 amps for 5A CT or .8 Amp for 1A CT.

C. Slowly adjust T-SET for "just trip" by monitoring TP-TRC voltage to fall from +15 Vdc to -15 Vdc (approx.). "LCB TRIP" should light.

Dial setting should be between 560 and 600.

TP-7 voltage should be between 1.400 and 1.430 Vrms.

Measure V-TRIP testpoint (TP14) voltage to be between .45 and .60 Vdc.

NOTE: There is approx. 15% hysteresis in the trip setting. In order to assure proper readings, set T-SET dial to maximum clockwise to "remove trip" then slowly turn T-SET counterclockwise until "just trip" is observed. Repeat several times to verify reading.

D. Refer to Table 3 for verification of pickup values versus other sequence settings and fault types (3-phase, AB, BC, CA, AN, BN, CN).

V. Desensitized Trip (AXLM Module)

A. With channel interface modules still removed, apply single phase current (IB-N) at 2 amp for 5 Amp CT or .4 Amp for 1 Amp CT). Set T-SET dial for "just trip" as monitored at TP-TRC. "LCB TRIP" indicator should light. (Dial setting approx. 100 or less).

B. Close 52b test switch (see Figure 12).

Press "SYSTEM INDICATOR RESET" button, "LCB-TRIP" indicator on RELAY module should turn off.

C. Increase input current until "LCB-TRIP" indicator just lights. Input current should be approximately 10 amperes for 5 A CT or 2 amperes for 1 A CT. "DES TRIP" indicator should also light.

D. Open 52b switch. Push "SYSTEM INDICATOR RESET" button; "LCB-TRIP" indicator should remain lit, "DES TRIP" will be off. (Note: "DES TRIP" is disabled 200 ms after opening 52b.)

E. Remove input current and press "SYSTEM INDICATOR RESET" button to reset indicators.

VI. Channel Interface (IFT or IFO Modules)

Reinsert IFT or IFO interface modules.

A. Transmitter Output

1. Tone Interface Module(s) IFT-1 and IFT-2 (when used).

Use ac voltmeter (preferably true rms) to measure output at TB3-7, 8 (XMTR #1) or TB3-5, 6 (XMTR #2) or at the two XMTR OUT terminals on the front of the IFT modules.

Check transmitter output level by moving link and adjusting "TX-ADJ" per table below.

TX-ADJ	Link	Link	Link
	-23	-4	+15
Max cw	-41dB (7mv)	-24dB (49mv)	-5dB (.43V)
Max ccw	-22dB (62mv)	-3dB (.55V)	+16dB (4.8V)

Set output level at 775 mv (0 dbm, 600 ohm) (+15 link) for the remainder of the acceptance checks.

2. Optical Interface Module(s) IFO-1 and IFO-2 (when used).

There is no transmitter adjustment.

B. Receiver Sensitivity

1. Tone Interface Module(s) IFT-1 and IFT-2 (when used).

Set attenuator to read -15 dbm (138 mv) at RCVR terms TB3-3, 4 (R1), TB3-1, 2 (R2).

Adjust "RX-ADJ" to read 137 mVrms at TP-AGC.

Vary attenuator to check the various indicator thresholds per table below. Note: all voltages are measured at received input terms.

Received Level	"LO" Indicator On	"LO" Indicator Off	"HI" Indicator On	"HI" Indicator Off	"SNR" Indicator On	"SNR" Indicator Off
- 3dbm (548mv)		X	X			X
- 7dbm (350mv)		X		X		X
-15dbm (138mv)		X		X		X
-22dbm (61.5mv)		X		X		X
-27dbm (34.6mv)	X			X		X
-35dbm (13.7mv)	X			X	X	

2. Optical Interface Module(s) IFO-1 and IFO-2 (when used).

If an optical attenuator is available and connected between transmitter output and receiver inputs; vary attenuator until "LO" indicator goes on. This attenuation should be -40 db or less, including optical attenuator insertion loss. AGC should read -6 Vdc (±.5 Vdc) when the light turns on.

If optical attenuator is not available, then simply disconnect fiber cable between transmitter and receiver, observe "LO" indicator lights.

3. Noise evaluation test (IFT modules only)

a. Connect a noise generator through an attenuator to TP9 (or printed circuit board (PCB) terminal 5) and COM.

b. With the noise generator turned off, but attenuator connected to TP9 and set for at least -10 dB attenuation; measure and record the signal at "AGC IN" with the normal received tone signal (measure in dB).

c. Disconnect the incoming signal at the receiver input.

d. Increase noise until the level as measured in step b is obtained.

e. Leave noise on and reconnect the incoming tone to the receiver.

f. "SNR" indicator should light.

g. Reduce noise level until the "SNR" indicator just resets.

h. Disconnect the incoming receiver input and measure the signal at "AGC IN". It should be 20 dB (±2 dB) less than the signal measured in step b.

VII. PPM Modulator (MD Module)

A. With no ac input current applied, monitor the "RFO" test jack. Adjust P1 on MD module for a frequency of 1700 Hz ±3 Hz. RFO voltages should be a square wave from 0 to +15 Vdc.

VIII. PPM Demodulator [MD and DTD (when used) Modules]

A. Set channel attenuation to nominal signal level.

1. Tone Interface – Set received signal level to -15 dBm (138 mv).

2. Optical Interface – No attenuation or nominal attenuation representing expected loss for users optical system.

B. Null Adjustment (residual carrier signal removal)

1. With no ac current input applied, monitor "VR1" terminal (MD module) and "VR2" (DTD module when used) with a scope. Adjust P4 on MD module or DTD module for a null. The waveform should be at zero dc level with minimum separation.

C. Demodulator Gain (MD Module) Channel #1

1. Set T-SET dial (RELAY module) to 580 and apply single phase ac current (IB-N) at 5 amperes for 5 A CT or 1 ampere for 1 A CT.

2. Use dual trace scope to monitor "VLD" and "VR" terminals on the RELAY module.

   Set "DEM GAIN" on the MD module so that waveform on "VR" is equal in magnitude to "VLD".

   NOTE: While adjusting "DEM GAIN" on MD module, channel #2 should be open or DTD module removed.

D. Demodulator Gain (DTD) module (when used – Channel #2 – 3 term lines).

1. Open communication channel #1 or remove MD module.

2. Repeat step C using "DEM GAIN" on the DTD module.

E. Channel #2 Delay (DTD Module) (when used – Channel #2 – 3 term lines)

1. Set "J" link on RELAY and DTD modules to J1.

   Apply single-phase ac current (IB-N) input of 5 amperes for 5 A CT or 1 ampere for 1 A CT.

2. With communication channel #1 open and channel #2 normal, monitor "VLD" and "VR" terminals on the RELAY module.

   Observe "VLD" and "VR" waveforms for time delay between respective zero crossings.

   Adjust "DELAY-ADJ" on DTD module; observe the adjustment range to be approx. 2 ms.

   Adjust "DELAY ADJ" to bring both waveforms in phase.

3. Move "J" link on DTD module to J2, J3 positions to check the effect of each. (2 ms additional delay per link).

4. Reset "J" link to J1.

IX. Channel Delay Equalizer Circuit (RELAY Module)

A. Open channel #2 communication circuit by removing connection between transmitter and receiver circuit (when used).

   Apply single-phase ac input current at 5 amperes for 5 A CT or 1 ampere for 1 A CT.

B. Monitor "VR" and "VLD" terminals on the RELAY module.

   With "J" link set on J1; adjust "DELAY ADJ" on the RELAY module to observe a range of adjustment approximately 2 ms.

Set "DELAY ADJ" so that waveforms are in phase.

C. Move "J" link to J2, J3 and J4 positions. Check the effect of each adding 2 ms per link position.

D. Reset "J" link to J1.

X. Loss of Channel Alarm Logic (AXLM Module)

A. Set channel attenuation (between transmitter and receiver) of each channel to receive normal signal level.

Remove ac input current.

Push "SYSTEM INDICATOR RESET" button to reset all indicators.

B. Momentarily open channel #1 communication by removing connection to receiver terminals; observe "CA-1" indicator light after approximately 2.5 seconds. AL-1 relay should pick up.

Restore normal channel; "CA-1" indicator should remain on; AL-1 should remain picked-up.

Push "SYSTEM INDICATOR RESET" button to turn "CA-1" indicator off and dropout AL-1.

C. Repeat B with AL-1 link set to NS. In this case the CA-1 light will seal in, but AL-1 will drop out when the channel is restored.

D. Repeat the above procedures for communication channel #2 (if used); observe "CA-2" indicator and AL-2 relay.

XI. Trip Blocking Logic – Loss of Channel

A. Open communication channels #1 and #2 (if used).

B. With T-SET dial (RELAY Module) set at 580; apply single-phase ac current input (IB-N) at 6 amperes for 5 A CT or 1.2 amperes for 1 A CT: "OC/UB TRIP" indicator on AXLM module and "LCB-TRIP" indicator on RELAY Module should remain off.

XII. Overcurrent Tripping Logic – Loss of Channel

A. Open communication channels #1 and #2 (if used). Set "L" link on RELAY module to "U".

B. With T-SET dial (RELAY Module) set at 580; apply single-phase (IB-N) current at 6 amps for 5 Amp CT or 1.2 Amps for 1 Amp CT: "OC/UB TRIP" (AXLM module) and "LCB TRIP" (RELAY Module) indicators should light.

C. Remove input current; press "SYSTEM INDICATOR RESET" button and "OC/UB TRIP" and "LCB-TRIP" indicators should turn off.

XIII. Trip Blocking/Unblocking Logic – Loss of Channel

A. Set "UNBLK" jumper to "IN" on AXLM Module.

Set communication channels to normal whereby receivers are receiving nominal level.

Set T-SET (RELAY module) to 580.

Make sure that "L" link on RELAY module is set on "U".

B. Monitor TP-"TRC" on the RELAY module and PCB terminal 2.

Apply single-phase input current (IB-N) at 6 amperes for 5 A CT or 1.2 amperes for 1 A CT.

TP-TRC voltage should fall to approximately -15 Vdc.

"LCB TRIP" LED should light.

PCB terminal 2 voltage should fall to approximately 0 Vdc.

C. Open channel #1 communication by removing input signal to receiver.

TP-TRC voltage should remain at approximately -15 Vdc PCB terminal 2 voltage should rise to +15 Vdc (approx.). Note: PCB terminal 2 becomes +15 Vdc for 20 ms immediately following channel loss then returns to 0 Vdc for approximately 130 ms and rises to +15 Vdc, and remains at that level. Press "SYSTEM INDICATOR RESET", "LCB TRIP" should turn and remain off.

D. Repeat C above using channel #2 (if used).

E. Remove input current.

XIV. Reclose Unblock Tripping/Blocking – Loss of Channel

A. Set links as follows: L-U (RELAY Module) and TRDS – "OUT", UNBLK – "IN", UR "IN" (AXLM module). T-SET dial at 580.

B. With the channel(s) set for normal received signal, close 52b switch (see Diagram 1489B12) and apply single phase ac current (IB-N) of 6 amperes for 5 A CT or 1.2 amperes for 1 A CT's. "LCB TRIP" indication should occur.

C. Open channel #1 by removing the input signal, reset indicators with "SYSTEM INDICATOR RESET", remove input current, then reapply input current, ALL within 2.5 seconds. "LCB TRIP" should reoccur.

D. Repeat step B then C, but wait longer than 2.5 seconds in step C. "LCB TRIP" should not reoccur.

E. For systems utilizing channel #2, repeat above by opening channel #2.

F. Open 52b switch.

XV. Trip Output Circuit (ARTM Module)

A. With communication channels set for normal condition, and T-SET dial (RELAY module) set at 580, apply single-phase input current (IB-N), at 6 amperes for 5 A CT or 1.2 amperes for 1 A CT: AR-1 trip relay should pick up, "LCB TRIP" should light.

B. Close Trip control switch (ref. Figure 12). "LCB TRIP-1" and "LCB TRIP-2" indicators should light.

C. Remove input current and press "SYSTEM INDICATOR RESET". "LCB TRIP-1" and "LCB TRIP-2" indicators should remain on and AR1 should remain picked up. "LCB TRIP" indicator (RELAY module) should turn off.

D. Open Trip control switch; AR-1 should drop out but "LCB TRIP-1" and "LCB TRIP-2" indicators should remain on.

E. Press "SYSTEM INDICATOR RESET" button; "LCB TRIP-1" and "LCB TRIP-2" indicators should reset.

XVI. Direct Transfer Trip (DTT Module) – When Supplied

A. With the channels set for normal signal, and no ac current applied, close DTT switch (ref. Figure 12). "DTT KEY" and "DTT TRIP" indicators on the DTT module must light, and AR-2 on the ARTM-2 module will operate.

B. Close Trip control switch; "DTT TRIP-1" and "DTT TRIP-2" indicators (ARTM-2) must light.

C. Open DTT switch; all indicators should remain on.

D. Push "SYSTEM INDICATOR RESET": "DTT TRIP 1 and 2" indicators (ARTM-2) should remain on, "DTT KEY and TRIP" indicators (DTT) should turn off, AR-2 should remain picked up.

E. Open Trip control switch, push "SYSTEM INDICATOR RESET" – all indicators must turn off, AR-2 must drop out.

F. Apply single-phase ac input current (IB-N) at 6 amperes for 5 A CT or 1.2 amperes for 1 A CT with T-SET dial at 580. "LCB TRIP" indicator should light.

G. Close DTT switch. "DTT KEY and TRIP" indicators should light.

H. Press "SYSTEM INDICATOR RESET": "LCB TRIP" indicator should turn off, "DTT KEY and TRIP" indicators should remain on.

I. Remove ac current, open DTT switch. Press "SYSTEM INDICATOR RESET" – "DTT KEY and TRIP" indicators should turn off.

XVII. Target Reset (AXLM Module)

A. Set up an LCB trip condition as in step XV or a DTT trip as in step XVI. Open the trip control switch and remove ac current (LCB trip) or DTT Key (DTT trip). Trip indicators should be on and sealed-in.

B. Close the target reset switch TR (ref. Test Diagram, Figure 12). All sealed-in indicators must reset, and remain reset when TR is opened.

XVIII. Power-Up Trip/Indication Block (ARTM Module)

A. Set up an LCB trip condition as in step XV or a DTT trip as in step VI.

B. Turn off dc power switch. Trip AR(s) will drop out and indication will turn off.

C. Turn on dc power switch. Trip AR(s) will operate and indication will occur 2.5 to 4.5 seconds after turning on dc.

D. Remove trip condition and reset indicators.

XIX. At Completion of Acceptance Test, Refer to "SETTINGS" Section for Desired Position of Links

Table 3

Fault Current Magnitudes in Multiples of T-Setting for All Combinations of Sequence Tap Settings

Sequence Taps	Positive (P)	Negative (N)	Zero (Z)	Fault Current in Multiples of T	Sequence Taps	Positive (P)	Negative (N)	Zero (Z)	Fault Current in Multiples of T
3-Phase	0	0	1	INFINITE	A-B or	0	0	1	INFINITE
Fault	0	0	2	INFINITE	C-A	0	0	2	INFINITE
	0	1	0	INFINITE	Fault	0	1	0	.748
	0	1	1	INFINITE		0	1	1	.748
	0	1	2	INFINITE		0	1	2	.748
	0	2	0	INFINITE		0	2	0	.785
	0	2	1	INFINITE		0	2	1	.785
	0	2	2	INFINITE		0	2	2	.785
	0	3	0	INFINITE		0	3	0	.864
	0	3	1	INFINITE		0	3	1	.864
	0	3	2	INFINITE		0	3	2	.864
	1	0	0	1.000		1	0	0	1.732
	1	0	1	1.000		1	0	1	1.732
	1	0	2	1.000		1	0	2	1.732
	1	1	0	1.000		1	1	0	.861
	1	1	1	1.000		1	1	1	.861
	1	1	2	1.000		1	1	2	.861
	1	2	0	1.000		1	2	0	.905
	1	2	1	1.000		1	2	1	.905
	1	2	2	1.000		1	2	2	.905
	1	3	0	1.000		1	3	0	.998
	1	3	1	1.000		1	3	1	.998
	1	3	2	1.000		1	3	2	.998
	2	0	0	2.000		2	0	0	3.464
	2	0	1	2.000		2	0	1	3.464
	2	0	2	2.000		2	0	2	3.464
	2	1	0	2.000		2	1	0	.821
	2	1	1	2.000		2	1	1	.821
	2	1	2	2.000		2	1	2	.821
	2	2	0	2.000		2	2	0	.864
	2	2	1	2.000		2	2	1	.864
	2	2	2	2.000		2	2	2	.864
	2	3	0	2.000		2	3	0	.959
	2	3	1	2.000		2	3	1	.959
	2	3	2	2.000		2	3	2	.959

Table 3 (Contd.)

Sequence Taps	Positive (P)	Negative (N)	Zero (Z)	Fault Current in Multiples of T	Sequence Taps	Positive (P)	Negative (N)	Zero (Z)	Fault Current in Multiples of T
B-C Fault	0	0	1	INFINITE	A-Neutral Fault	0	0	1	.124
	0	0	2	INFINITE		0	0	2	.242
	0	1	0	.748		0	1	0	1.296
	0	1	1	.748		0	1	1	.113
	0	1	2	.748		0	1	2	.204
	0	2	0	.785		0	2	0	1.359
	0	2	1	.785		0	2	1	.113
	0	2	2	.785		0	2	2	.205
	0	3	0	.864		0	3	0	1.497
	0	3	1	.864		0	3	1	.114
	0	3	2	.864		0	3	2	.208
	1	0	0	1.732		1	0	0	3.000
	1	0	1	1.732		1	0	1	.129
	1	0	2	1.732		1	0	2	.263
	1	1	0	.523		1	1	0	2.282
	1	1	1	.523		1	1	1	.117
	1	1	2	.523		1	1	2	.219
	1	2	0	.540		1	2	0	2.484
	1	2	1	.540		1	2	1	.118
	1	2	2	.540		1	2	2	.220
	1	3	0	.577		1	3	0	2.988
	1	3	1	.577		1	3	1	.119
	1	3	2	.577		1	3	2	.224
	2	0	0	3.464		2	0	0	6.000
	2	0	1	3.464		2	0	1	.126
	2	0	2	3.464		2	0	2	.252
	2	1	0	.615		2	1	0	1.653
	2	1	1	.615		2	1	1	.115
	2	1	2	.615		2	1	2	.211
	2	2	0	.640		2	2	0	1.757
	2	2	1	.640		2	2	1	.115
	2	2	2	.640		2	2	2	.213
	2	3	0	.692		2	3	0	1.995
	2	3	1	.692		2	3	1	.116
	2	3	2	.692		2	3	2	.216

Table 3 (Contd.)

Sequence Taps	Positive (P)	Negative (N)	Zero (Z)	Fault Current in Multiples of T
B-Neutral or C-Neutral Fault	0	0	1	.124
	0	0	2	.242
	0	1	0	1.296
	0	1	1	.129
	0	1	2	.263
	0	2	0	1.359
	0	2	1	.129
	0	2	2	.262
	0	3	0	1.497
	0	3	1	.129
	0	3	2	.260
	1	0	0	3.000
	1	0	1	.121
	1	0	2	.232
	1	1	0	1.019
	1	1	1	.126
	1	1	2	.248
	1	2	0	1.055
	1	2	1	.126
	1	2	2	.247
	1	3	0	1.132
	1	3	1	.125
	1	3	2	.246
	2	0	0	6.000
	2	0	1	.122
	2	0	2	.237
	2	1	0	1.153
	2	1	1	.128
	2	1	2	.255
	2	2	0	1.202
	2	2	1	.127
	2	2	2	.254
	2	3	0	1.307
	2	3	1	.127
	2	3	2	.253

LCB CALIBRATION PROCEDURE

The proper adjustments to insure correct operation of the LCB have been made at the factory and should not be disturbed after receipt by the customer. However, if the adjustments or any components have been changed or modules interchanged, then that portion of the LCB should be recalibrated and acceptance checked, and the Field Setup procedure rechecked.

The following procedure applies to those areas of the LCB that can be recalibrated, and does not cover those adjustments required for Field Setup. All measurements are with respect to "COM" unless otherwise specified.

I. ALS Power Supply Module

The output adjust potentiometer on the front panel is used to adjust the +15 Vdc output to +15.000 (±.01). Once adjusted, -15 Vdc should be -15.0 (±.2) Vdc.

II. DTD Module – 3 Terminals Lines

With the channel levels properly set, (refer to Field Setup), and a signal being received either from the remote terminal or connected back to back, adjust P4 for minimum residual carrier signal (minimum waveform separation) at "VR2" as observed on a scope. If the received signal is modulated, the waveform at "VR2" will be a sine wave, if not modulated, a zero dc level will exist.

III. MD Module

A. Modulator

With no modulation (no 50/60 Hz input current to the relay), set potentiometer P1 for 1700 Hz as measured with a counter on "RFO".

B. Demodulator

With the channel levels properly set (refer to Field Setup) and a signal being received either from the remote terminal or connected back to back, adjust P4 for minimum residual carrier signal (minimum waveform separation) at "VR1" as observed on a scope. If the received signal is modulated, the waveform at "VR1" will be a sine wave, if not modulated, a zero dc level will exist.

IV. Audio Tone Interface Modules (IFT-1 and IFT-2 for 3 Terminal Lines)

A. "HI" Level Adjustment

With the channel receiving a signal either from the remote terminal or back to back, adjust the signal at "AGC IN" to 0.436 Vrms with "RX ADJ". At this level (+10dB from normal) adjust potentiometer R72 so that the "HI" level indicator just lights.

B. 1700 Hz Trap Adjustment

With the channel receiving an unmodulated signal (1700 Hz), adjust potentiometer P1 for minimum negative dc voltage at TP5.

V. RELAY Module

A. Negative Sequence

Apply a balanced 3-phase positive sequence current at power system frequency (50 or 60 Hz) and CT rating (5A or 1A). Adjust P1 for a null at TP4.

B. Positive Sequence

Apply balanced 3-phase negative sequence current (reverse phase A and B) at the power system frequency (50 or 60 Hz) and CT rating (5A or 1A). Adjust P2 for a null at TP5.

C. Trip Pickup

1. This setting requires local quantities only, and 1) the channel "lost" from the remote terminal(s) ("LO" level), or 2) the channel interface cards (IFT-1/2 or IFO-1/2) removed so that they don't affect calibration. In addition, if either the "UNBLK" or "TRDES" option on the AXLM module have been selected, then this module should be removed to prevent trip blocking.

2. Apply 3-phase or single phase current to obtain 1.414 Vac rms at test point TP7. This level is more readily settable by applying a fixed current and adjusting the "T" dial to obtain the 1.414 Vrms. The waveform should be a clean undistorted sine wave. (Note: Due to the high gain associated with zero sequence, and depending on the cleanliness of the current source used, it may be advisable to temporarily remove the zero sequence sensitivity link (Z)).

3. Adjust potentiometer P5 for trip to just occur. This can be observed by 1) observing the "LCB TRIP" indicator and 2) tip jack "TRC" should fall from "1" (+15 Vdc) to "0" (-15 Vdc. The value for trip as measured at VTRIP (TP4) or terminal 28 should be approximately 0.5 Vdc.

4. Repeat several times to insure the proper setting. Note: The trip output has some hystersis (approximately 15%), so to recheck the trip level it must first be reset below the trip hystersis level by removing and reapplying the input ac current, or changing the "T SET" dial.

VI. AXLM Module

A. Line energizing trip desensitizing. Initial factory calibration is for a desensitized level of 5 times pickup. For different multiples of trip level setting, then the following recalibration is required.

1. Determine the multiple of trip for desensitizing. For 1 to 5 times pickup, set link on 5X. For 5 to 10 times, set link on 10X.

2. Apply current to the LCB relay to just cause an LCB trip (per method as described for the RELAY module). The voltage as measured on VTRIP should be .45 to .60 Vdc.

3. Apply signals to simulate the desired desensitized trip level by one of the following methods:

   a. Apply current at the desired multiple.

   b. Simulate the VTRIP voltage level (multiple times VTRIP level at pickup) by,

      1. Removing the RELAY module and place the AXLM module on a board extender.

      2. Jumper TP9 to TP8 and adjust potentiometer P3 for the desired dc voltage.

(NOTE: REMOVE JUMPER ON COMPLETION OF FINAL SETTING).

4. With the proper current or VTRIP dc voltage applied, adjust P1 "DES ADJ" so that the "TRDES" jack just changes from "0" to "1" (+15 Vdc).

B. Channel alarm (AL-1 or AL-2) time delay. Initial factory calibration is for 2500 ms. For different times, then the following recalibration is required. (Note: The timer is common for channel 1 and 2.)

a. Simulate a low signal by increasing attenuation. (Open channel).

b. Adjust potentiometer P2 for the desired time between 500 to 5000 ms.

FIELD SETUP AND VERIFICATION PROCEDURE

This adjustment procedure assumes that the LCB has been checked per the Acceptance Test, set for proper sequence sensitivities, pickup and link selections per the Settings, and that the relay is wired into a relay system and connected to a communications channel. This procedure must be followed before closing the breaker trip circuits.

I. Communication Channel Adjustment

A. Transmitter

1. Optical Channel

a. Channel 1 (IFO-1) – no adjustment is required.

b. Channel 2 (IFO-2) – 3 terminal lines – no adjustment is required.

2. Audio Tone Channel

a. Channel 1 (IFT-1)

1) Set link (XDB) on the IFT-1 module for the desired transmitter output range (XDB to "+15" for -5dBm to +15dBm; "-4" for -25dBm to -4dBm; "-23" for -44dBm to -23dBm).

2) Connect a true rms ac VM to the transmitter output "XMTR OUT" on the IFT-1 module and adjust "TX ADJ" for the desired output level (Ref: 0dBm = 0.775 Vrms).

NOTE: This level can also be measured on the rear terminal block, TB3-terminals 7 and 8; or the output of the audio tone protection package, with level reduced by several dB.

b. Channel 2 (IFT-2) -3 terminal lines. For normal 3 terminal line operation, only one transmitter output is used. Therefore, when not used, set transmitter link to minimum (XDB to "-23") and adjust "TX ADJ" for minimum output.

B. Receiver (Note: Transmitters must be adjusted first)

1. Optical Channel

a. Channel 1 (IFO-1) – no adjustment is required but insure that the "LO" indicator is not on.

(NOTE: "LO" indicator should light with 40dB or more fiber optic cable, connector and splice losses.)

b. Channel 2 (IFO-2) – 3 terminal lines – no adjustment is required but insure the "LO" indicator is not on.

2. Audio Tone Channel

a. Channel 1 (IFT-1)

1) With a true rms ac VM, measure the normal received signal at "RX IN" with respect to COM. (Note: This signal can also be measured at the output of the audio tone protection package or on the LCB rear terminal block, TB3, terminals 3 and 4.) Set link "R" on the IFT-1 module to "ATT" if the measured signal is -15dBm to +10dBm or to "AMP" if the signal is -40dBm to -15dBm.

2) Measure the level at "AGC IN" with respect to COM with a true rms ac VM and adjust "RX ADJ" for 137 mv ac (-15dBm/600 ohm).

3) Insure that "HI" and "LO" level and "SNR" indicators are not on. (NOTE: "HI" and "LO" level will come on with a +10dB or -10dB signal around the adjusted level.)

b. Channel 2 (IFT-2) – 3 Terminal Line

1) With a true rms ac VM, measure the normal received signal at "RX IN" with respect to COM. (Note: This signal can also be measured at the output of the audio tone protection package or on the LCB rear terminal block, TB3, terminals 1 and 2). Set link "R" on the IFT-2 module to "ATT" if the measured signal is -15dBm to +10dBm, or to the "AMP" if the signal is -40dBm to -15dBm.

2) Measure the level at "AGC IN" with respect to COM with a true rms ac VM and adjust "RX ADJ" for 137 mv ac (-15dBm/600 ohm).

3) Insure that "HI" and "LO" level and "SNR" indicators are not on.

II. Carrier Frequency Verification

A. With no modulation at the local terminal (no 50/60 Hz current applied) verify that the RFO signal is measured with a counter on the front of the MD module is 1700 ±5 Hz.

B. If required, this frequency can be fine tuned with potentiometer P1 on the MD module (not front accessible).

III. Demodulated Signal Verifications

A. With modulation from the remote terminal(s) (50/60 Hz current applied) monitor VR1 (MD module) and VR2 (DTD module – 3 terminal lines) with a scope. The waveform(s) should appear as a clean sine wave(s) with minimum distortion and no waveform separation.

B. If the waveform appears distorted or separated the residual carrier frequency can be removed by readjusting potentiometers P4 on the MD module (VR1) or DTD module (VR2). This potentiometer is not front accessible.

IV. Signal Level Equalization Adjustment

A. With no modulation at any terminal (no 50/60 Hz current to any LCB), temporarily set the channel delay equalization link to minimum (link "J" to "J1", RELAY module).

B. At the local terminal, connect a jumper between the RELAY module "SETUP" and the MD module "SETUP" front test jacks.

C. Channel 1

1. At the remote terminal for channel 1 only, connect a jumper between the RELAY module "SETUP" and the MD module "SETUP". (Note: For 3 terminal lines, this jumpering must be done separately for each channel).

2. At the local terminal, measure signal "VLD" and "VR" on the RELAY module with an ac VM.

3. Adjust "DEMOD GAIN" on the MD module so that "VR" is the same magnitude as "VLD".

D. Channel 2 (3 Terminal Lines)

1. At the remote terminal for channel 2 only, connect a jumper between "SETUP" on the RELAY and MD modules.

2. At the local terminal, measure signals "VLD" and "VR" on the RELAY module with an ac VM.

3. Adjust "DEMOD GAIN" on the DTD module so that "VR" (which is now VR2) is the same magnitude as "VLD".

E. Remove all SETUP jumpers and return the delay equalization jumpers to the original position.

V. Channel Delay Equalization Adjustment

NOTE: For 3 terminal line systems, channel 1 must be the slowest channel since additional delay equalization adjustment is available for channel 2. In addition, each channel must be done separately.

A. Channel 1

1. Set the "channel delay equalization links" on the RELAY module for the anticipated channel delay. Link J-J1 = 0 to 2 ms, J-J2 = 2 to 4

ms, J-J3 = 4 to 6 ms, J-J4 = 6 to 8 ms. Optical channels will generally be set on J-J1, whereas audio tone channels will generally be longer.

2. Apply equal modulation at each terminal of channel 1 only.

This is done by energizing each LCB relay with a single phase current which is in phase. In phase currents are most easily derived from voltage to current auxiliary test transformers which have a consistent angle between input voltage and output current. This angle must be the same at both terminals. Of course, this technique also requires in-phase voltages at the two line terminals. The most direct way to obtain in-phase voltage is to energize the transmission line from one end only and use line side potential supply at the open breaker terminal, and either bus or line side potential supply at the closed breaker terminal.

Equal modulation also requires the sequence sensitivity settings (P, N, and Z) to be identical at each station, and for the "T" pickup setting to be the same, or for different CT ratio's, the magnitude of single-phase current to be proportionally different.

3. Monitor waveforms "VR" and "VLD" (RELAY Module) on an oscilloscope (dc coupled). With in-phase current simulation (internal fault) at each terminal, "VR" and "VLD" will appear as sine waves, equal in magnitude and close in-phase. Adjust "DELAY ADJ" (RELAY Module) so that VLD is exactly in-phase with VR. To check this, "L + R" will be a maximum.

To further prove validity of this calibration, one of the input currents can be reversed 180^{o} to simulate an external fault. In this case "VLD" and "VR" will be equal and opposite (180^{o} out-of-phase). "L + R" in this case will be a minimum.

B. Channel 2 (3 Terminal Line Systems only)

1. Set the second channel (fastest channel) "channel delay equalization links" on the DTD module for the anticipated additional delay required to match channel 1 (the slowest channel).

2. Apply equal modulation at each terminal of channel 2 only.

3. Monitor waveforms "VR" and "VLD" (RELAY Module) on an oscilloscope (dc coupled). With in-phase current simulation (internal fault) at each terminal, "VR" and "VLD" will appear as sine waves, equal in magnitude and close in-phase. Adjust "DELAY ADJ" (DTD module) so that VR is exactly in-phase with VLD. To check this, "L + R" will be a maximum.

To further prove validity of this calibration, one of the input currents can be reversed 180^{o} to simulate an external fault. In this case, "VLD" and "VR" will be equal and opposite (180^{o} out-of-phase). "L + R" in this case will be a minimum.

LCB SYSTEM FUNCTIONAL TEST/SYSTEM VERIFICATION PROCEDURE

After commissioning, the LCB system should be tested at routine maintenance intervals to verify operation. The exact functional test varies depending upon particular user preference. The recommended "standard" functional tests are performed with the LCB relay and associated channel equipment in place, properly set and operating. The tests require an operator at each terminal with voice communications between operators.

FUNCTIONAL TEST EQUIPMENT

The following "standard equipment" is recommended.

- Test Panel: Test panel with 2 FT-1 switches and breaker trip current simulator as described earlier.
- Test Box: Type UCTB test box as described earlier.
- ac/dc voltmeter for channel magnitude equalization verification, and for tone channels, AGC level verification.
- Dual trace oscilloscope for channel delay equalization and residual carrier signal removal verification.
- Electronic counter for carrier signal frequency verification.

FUNCTIONAL TEST PROCEDURE

The following is the suggested procedure. If the standard test panel was not supplied, please refer to the customer's supplementary instructions.

I. Disconnect Outputs

The first step is to prevent false breaker operations by disconnecting the trip output circuits at all line terminals by opening the red FT-1 switches on the Test Panel, followed by the auxiliary trip contacts, DTT key and 52b inputs with the black FT switches.

II. Disconnect LCB relays from the CT's by operating the current shorting blades in the FT-1 switch on the Test Panel at each station.

III. Verify status at each station.

A. dc power switch is on and "DC OUTPUT" and "DC INPUT" indicators on the ALS module are on.

B. All channel status and trip indicators are off.

IV. Current Differential Test

At each station (for 3 terminal lines, test two stations at a time, not all three) connect the UCTB or equivalent test box using the FT-1 switches and the multiconductor cable furnished with the UCTB. NOTE: BE SURE TO PLUG THE PERSONNEL SAFETY GROUND WIRE ON THE FT-1 PLUG INTO THE SPECIAL JACK ON THE FT-1 PLUG. After connecting, check that the "Test Box Energized" light is ON.

A. At both stations, turn the fault selector (FS) switch on the UCTB to position phase A.

B. At station B, turn the fault applicator (FA) switch on the UCTB to the forward (FWD) position. A single end feed trip condition will be satisfied at both stations as indicated by the "LCB TRIP" indicator on the RELAY module. Also, both the "LCB TRIP-1" and "LCB TRIP-2" indicators on the ARTM module will indicate and seal when the pushbutton on the test panel is depressed.

C. At station A, also turn the FA to FWD. All conditions now exist for a double end feed internal fault. Press "SYSTEM INDICATOR RESET" (on ARTM module) at both stations. All indicators as in step B should remain on.

D. At station A, return the FA switch to normal, then reverse, REV. This simulates an external fault. Press "SYSTEM INDICATOR RESET" at both stations. All indicators at both stations should turn off.

E. At station B, turn FA switch to NORMAL and then REV, trip indication should occur and remain at both stations, both in NORMAL and REV.

F. At station A, turn FA to NORMAL then FWD. Press "SYSTEM INDICATOR RESET". All indicators at both stations should reset.

G. Repeat this procedure for phase B and phase C faults. For three terminal line applications, repeat the procedure for the third terminal.

H. Reset all indicators at completion of tests and insure that the trip AR's are not operated by depressing the pushbutton on the test panel.

V. Loss of Channel/Overcurrent Trip Test

A. At station B, turn off the dc with the ON-OFF switch on the ALS module. At station A, "LO" indication should occur on the channel interface module. CA-1 or CA-2 will indicate, and its associated alarm relay on the AXLM module will operate after approximately 2.5 seconds.

B. Overcurrent Trip or Block

1. For systems strapped to trip on loss of channel (link L-U, RELAY module and, link UNBLK-OUT, AXLM module): At station A, apply a FWD or REV fault for phase A, B, and C. "LCB TRIP" and "OC/UB" trip should occur.

2. For systems strapped to block on loss of channel (link L-B, RELAY module) or if unblock tripping is chosen (link UNBLK-IN, AXLM module): At station A, apply a FWD or REV fault for phase A, B and C. "LCB TRIP" and "OC/UB TRIP" should not occur.

C. Repeat steps A and B above by reversing the procedure i.e. turning off the dc at station A and applying current at station B.

D. Reset all indicators and restore dc at completion of tests and insure that the trip AR's are not operated by depressing the pushbutton on the Test Panel.

VI. Desensitized Trip

A. Simulate an open breaker (52b contact closed) at both stations by applying rated positive dc to the open FT-1 switch (Test Panel) associated with 52b.

B. For systems strapped for desensitized trip: TRDS link – IN, AXLM module.

1. At both stations, turn the fault selector switch FA on the UCTB to phase A.

2. At station B turn the fault applicator (FA) to FWD. A single end feed trip condition will be satisfied at both stations as indicated by an "LCB TRIP" and "DES TRIP" indication. (Note: This is assuming the 12 amperes (5A CT) or 2.4 amperes (1A CT) phase to neutral current from the UCTB is above the desensitized relay pickup (Ref: Table I of LCB Acceptance Test).

3. At station A, turn FA to FWD. This simulates a double end feed internal fault. Press "SYSTEM INDICATOR RESET" at both stations. All indicators as in step 2 should remain on. (Note: If in step 2, trip indication did not occur due to users settings, this step due to feed from both terminals is twice as sensitive and in most cases should permit desensitized trip.)

4. At station A, turn FA to REV. This simulates an external fault. Press "SYSTEM INDICATOR RESET" – all indicators must reset and remain off.

5. Repeat for phase B and C if desired. At completion of tests remove current and reset all indicators.

C. For systems strapped for no desensitized trip: TRDS link – OUT, AXLM module, the LCB should respond as per step IV–current differential test.

VII. Direct Transfer Trip Test (When Supplied)

A. Direct transfer trip keying can be simulated by applying rated positive dc to the Test Panel FT-1 switch associated with the DTT key input.

B. At station B, simulate DTT key initiation as per step A.

1. At station B, the "DTT KEY" indicator will turn on.

2. At station A, "DTT TRIP" will light, and "DTT TRIP-1" and "DTT TRIP-2" will indicate when the TEST pushbutton on the test panel is depressed.

C. Reverse procedure by simulating DTT key at station A, and observing DTT trip at station B.

D. With no DTT simulated at either station, apply an internal fault by setting the UCTB fault selector to phase A and fault applicator FA to FWD at both stations. "LCB TRIP" and "LCB TRIP-1" and "LCB TRIP-2" should occur at both stations.

1. With an LCB trip sustained, simulate DTT KEY at station B as described earlier.

   a. At station B, "DTT KEY" indicator should occur and "LCB TRIP" should remain.

   b. At station A, DTT TRIP should occur and take priority over LCB TRIP. Press "SYSTEM INDICATOR RESET" then depress the TEST pushbutton on the test panel. "DTT TRIP" only (no "LCB TRIP") should indicate.

2. Repeat 1, except simulate DTT KEY at station A and observe station B.

E. At completion of tests, remove current and DTT key inputs, and reset indication.

VIII. System Restoration (CT's, DTT, 52b)

A. Remove UCTB test harness assembly at all stations.

B. Close the FT-1 switches on the test panel associated with the CT circuits at all stations.

C. Close the FT-1 switches on the test panel associated with the DTT key and 52b inputs at all stations.

IX. System Trip Restoration (AR's)

A. Press "SYSTEM INDICATOR RESET" at all stations: all indicators except those indicating DC INPUT/OUTPUT must be off.

B. Depress the TEST pushbutton on the test panel at each station to insure that no standing trips exist.

C. Restore the trip circuits by closing the remaining FT-1 switches on the test panel at each station, red ones last.

SYSTEM CALIBRATION VERIFICATION PROCEDURE

The following is a recommended procedure to perform on a periodic basis and generally in conjunction with the Functional Test procedure. This procedure verifies those calibrations as made during the FIELD SET UP PROCEDURE.

I. As in the Functional Test Procedure, first insure that all trip outputs are disconnected from the breaker trip circuits; then disconnect the CT and remaining circuits with the appropriate FT-1 switches on the Test Panel.

NOTE: Measurements are with respect to "COM" unless specified otherwise.

II. Receive Levels

A. Audio Tone Channel(s) (when used)

1. Measure the ac level at "AGC IN" on the IFT module(s). A reading of 137 mVrms should be obtained for a normal received signal level.

2. "HI", "LO", and "SNR" indication must be off.

B. Optical Channel(s) (when used)

1. Measure the dc voltage at "AGC" on the IFO module(s). A reading between -10 to -14 Vdc (typically -13 Vdc) should be obtained for a normal received signal level.

2. "LO" level indication must be off.

III. Carrier Frequency Verification

A. Measure the frequency at "RFO" on the MD module. It must read 1700 Hz (±5 Hz).

B. Fine tuning of this frequency can be made by extending the MD module and adjusting potentiometer P1.

IV. Signal Level Equalization Adjustment Verification

A. At the local terminal, connect a jumper between the RELAY module "SET UP" and the MD module "SET UP" front test jacks.

B. Channel 1

1. At the remote terminal for channel 1 only, connect a jumper between the RELAY module "SET UP" and the MD module "SET UP". (Note: For 3 terminal lines, this jumpering must be done separately for each channel.)

2. At the local terminal, measure signal "VLD" and "VR" on the RELAY module with an ac VM. They should be equal in magnitude.

3. For fine tuning, adjust "DEMOD GAIN" on the MD module so that "VR" is the same magnitude at "VLD".

C. Channel 2 (3 terminal lines)

1. At the remote terminal for channel 2 only, connect a jumper between "SET UP" on the RELAY and MD modules.

2. At the local terminal, measure signals "VLD" and "VR" on the RELAY module with an ac VM. They should be equal in magnitude.

3. For fine tuning, adjust "DEMOD GAIN" on the DTD module so that the "VR" (which is now VR2) is the same magnitude as "VLD".

D. Repeat above procedure for all line terminals, then remove all SET UP jumpers.

V. Demodulated Signal Verifications

A. At remote terminal(s), connect the UCTB test box to the Test Panel as in the Functional Test Procedure. Set the fault selector (FS) to phase A and the fault applicator (FA) to FWD.

B. At the local terminal, monitor "VR1" (MD module) and VR2 (DTD module – 3 terminal lines) with a scope. The waveform(s) should appear as a clean sine wave with minimum distortion and waveform separation.

C. If the waveform(s) appear to have slight distortion, fine tuning can be accomplished by extending the MD module, and, for 3 terminal lines, the DTD module, and readjusting potentiometer P4.

D. Repeat above procedure for all line terminals. At completion of tests, remove the simulated fault current by turning FA off on the UCTB.

VI. Channel Delay Equalization Verification

NOTE: For 3 terminal line system, channel 1 will be the slowest channel since additional delay equalization is provided for channel 2. In addition, each channel must be checked separately.

A. Channel 1

1. Connect the UCTB to both line terminals of channel 1. Set the fault selector (FS) and applicator (FA) to the same positions at each terminal (i.e. A and FWD). For proper delay verification, the voltage source energizing the UCTB must be in phase at both terminals.

2. Monitor waveforms "VR" and "VLD" (RELAY module) with a dual trace oscilloscope (dc coupled). These waveforms should be equal in magnitude and in phase. Fine tuning of the phase relationship can be accomplished with the "DELAY ADJ".

3. Reverse the fault polarity at one terminal by changing the fault applicator (FA) to REV. The waveforms must now appear equal in magnitude but opposite in polarity.

B. Channel 2

1. Repeat the procedure as in channel 1 except apply current to the 2 line terminals of channel 2 only.

2. Fine tuning of this delay is accomplished with the "DELAY ADJ" on the DTD module.

C. Above procedure A and B should be performed at all line terminals.

VII. System Restoration (CT's, DTT, 52b)

A. Remove UCTB test harness assembly at all stations.

B. Close the FT-1 switches on the test panel associated with the CT circuits at all stations.

C. Close the FT-1 switches on the test panel associated with the DTT key and 52b inputs at all stations.

VIII. System Trip Restoration (AR's)

A. Press "SYSTEM INDICATOR RESET" at all stations: all indicators except those indicating DC INPUT/OUTPUT must be off.

B. Depress the TEST pushbutton on the test panel at each station to insure that no standing trips exist.

C. Restore the trip circuits by closing the remaining FT-1 switches on the test panel at each station, red ones last.

LCB CATALOG NUMBER

The following illustrates the LCB system catalog number designations.

Catalog Number: LCB 2 T 1 F D N P
Position: 123 4 5 6 7 8 9 10

Position	Code	Description
1,2,3	LCB	Current Differential Relay-Standard
4	2	Two terminal line
	3	Three terminal line-fiber optic
	4	Three terminal line-audio tone
5	T	Direct transfer trip
	N	No transfer trip
6	4	48/60 Vdc power supply
	1	110/125 Vdc power supply
	2	220/250 Vdc power supply
7	F	Fiber optic output
	T	Audio tone output

Position	Code	Description
8	A	1A CT, 50 Hz
	B	1A CT, 60 Hz
	C	5A CT, 50 Hz
	D	5A CT, 60 Hz
9	A	Two terminal tone protection package
	B	Three terminal tone protection package
	N	No tone protection package
10	P	Standard Test panel
	N	No test panel

Following are the associated Westinghouse style numbers of the components/modules associated with the LCB catalog number.

Basic standard LCB Relay includes:
LCB chassis – 1346D04G01
MD Module (POS D) – 1586C13G01
RELAY Module (POS G) – 1586C15G01
AXLM Module (POS L) – 1581C23G01

Audio Tone Channel – 2 terminal
IFT1 Module (POS F) – 1586C07G01

Audio Tone Channel – 3 terminal
Includes 2 terminal interface plus,
IFT2 Module (POS E) – 1586C07G01
DTD Module (POS C) – 1586C13G02

Fiber Optic Channel – 2 terminal
IF01 Module (POS F) – 1586C11G01 and cable 1586C73G03

Fiber Optic Channel – 3 terminal
Includes 2 terminal interface plus,
IF02 Module (POS E) – 1586C11G01 and cable 1586C73G03
DTD Module (POS C) – 1586C13G02

dc Power Supply
48/60 Vdc: ALS Module (POS A) – 1349D85A01
110/125 Vdc: ALS Module (POS A) – 1349D85A02
220/250 Vdc: ALS Module (POS A) – 1349D85A03

Trip Output (No transfer trip)
ARTM-1 Module (POS M) – 1581C25G01

Direct Transfer Trip
DTT Module (POS K) – 1586C09G01
ARTM-2 Module (POS M) – 1581C25G02

Frequency and CT rating
50/60 Hz, 5A-CT:
Transf. Assembly (POS J) – 1581C70G01
50/60 Hz, 1A-CT:
Transf. Assembly (POS J) – 1581C70G02

Audio Tone Protection Package (Separate item)
2 terminal – 2047D16G11
3 terminal – 2047D16G07

Test Panel (Separate item) 1579C61G02

Following are additional items that can be supplied as part of an LCB system, but are not included in the catalog number system.

UCTB Test Box:
50/60 Hz, 5A-CT: 1337D24G02
50/60 Hz, 1A-CT: 1337D24G03

UME-3 Board Extender: 1447C86G01

LCB – GLOSSARY OF TERMS

MODULES

Name	Description
ALS	Analog Logic dc Power Supply
ARTM1	AR Trip – One AR
ARTM2	AR Trip – Two AR's
AXLM	Auxiliary Logic
CT	Current Transformation Assembly
DTD	Demodulator and Time Delay
DTT	Direct Transfer Trip
IFO	Fiber Optic Interface
IFO1	Fiber Optic Interface – Channel 1
IFO2	Fiber Optic Interface – Channel 2
IFT	Audio Tone Interface
IFT1	Audio Tone Interface – Channel 1
IFT2	Audio Tone Interface – Channel 2
MD	Modulator and Demodulator
RELAY	Relay Sensing Logic

INPUT SIGNALS

Name	Source	Description
BP	ALS	Battery Positive
BN	ALS	Battery Negative
GND	ALS	Chassis Ground
IA	CT	Phase A Current
IAR	CT	Phase A Current Return
IB	CT	Phase B Current
IBR	CT	Phase B Current Return
IC	CT	Phase C Current
ICR	CT	Phase C Current Return
RCVR1	IFT1	Audio Tone Receiver – Channel 1
RCVR2	IFT2	Audio Tone Receiver – Channel 2
OR1	IFO1	Optical Receiver – Channel 1
OR2	IFO2	Optical Receiver – Channel 2
52bBP	AXLM	52b Contact – Battery Positive
52bBP	AXLM	52b Contact – Battery Positive
TRBP	AXLM	Target Reset Contact – Battery Positive
TRBN	AXLM	Target Reset Contact – Battery Negative
DTTBP	DTT	DTT Contact – Battery Positive
DTTBN	DTT	DTT Contact – Battery Negative

OUTPUT SIGNALS

Name	Source	Description
XMTR1	IFT1	Audio Tone Transmitter – Channel 1
XMTR2	IFT2	Audio Tone Transmitter – Channel 2
OT1	IFO1	Optical Transmitter – Channel 1
OT2	IFO2	Optical Transmitter – Channel 2
PSA1	ALS	Form b Contact – Loss of dc
PSA2	ALS	Form b Contact – Loss of dc
PSA3	ALS	Form b Contact – Loss of dc
PSA4	ALS	Form b Contact – Loss of dc
CA1NC	AXLM	Form c Contact – Loss of Channel 1
CA1COM	AXLM	Form c Contact – Loss of Channel 1
CA1NO	AXLM	Form c Contact – Loss of Channel 1
CA2NC	AXLM	Form c Contact – Loss of Channel 2
CA2COM	AXLM	Form c Contact – Loss of Channel 2
CA2NO	AXLM	Form c Contact – Loss of Channel 2
LCB TRIP 1	ARTM 1/2	LCB AR Trip 1 Contact
LCB TRIP 2	ARTM 1/2	LCB AR Trip 2 Contact
LCB SPARE 1	ARTM 1/2	LCB AR Spare 1 Contact
LCB SPARE 2	ARTM 1/2	LCB AR Spare 2 Contact
DTT TRIP 1	ARTM 2	DTT AR Trip 1 Contact
DTT TRIP 2	ARTM 2	DTT AR Trip 2 Contact
DTT SPARE 1	ARTM 2	DTT AR Spare 1 Contact
DTT SPARE 2	ARTM 2	DTT AR Spare 2 Contact

INTERNAL ANALOG SIGNALS

Name	Source	Description
VA	CT	IA Current Voltage
VB	CT	IA Current Voltage
VC	CT	IC Current Voltage
RFI1	IFT1/IFO1	RF Input – Channel 1
RFI2	IFT2/IFO1	RF Input – Channel 2
VN1	IFT1	Noise Voltage – Channel 1
VN2	IFT2	Noise Voltage – Channel 2
NT1	IFT1	Noise Test – Channel 1
NT2	IFT2	Noise Test – Channel 2
AGC IN	IFT	AGC Input
AGC	IFO	AGC Output
VR1	MD	Remote Voltage – Channel 1
RFO	MD	RF Output
RFIF1	MD	RF Input Filtered – Channel 1
VR2	DTD	Remote Voltage – Channel 2
VR2D	DTD	Remote Voltage Delayed – Channel 2
RFIF2	DTD	RF Input Filtered – Channel 2
VL	RELAY	Local Voltage
VLD	RELAY	Local Delayed Voltage
VRES	RELAY	Restraint Voltage
VR	RELAY	Combined Remote Voltage
VOP	RELAY	Operate Voltage
VTRIP	RELAY	Trip Voltage
L + R	RELAY	Voltage Local + Remote

INTERNAL DIGITAL SIGNALS

Name	Source	Description
PSMP	ALS	Multi Power Supply Control
PSME	ALS	Power Supply dc Status
NA1	IFT1	Noise Alarm – Channel 1
NA2	IFT2	Noise Alarm – Channel 2
LA1	IFT1	Low Alarm – Channel 1
LA2	IFT2	Low Alarm – Channel 2
HA1	IFT1	High Alarm – Channel 1
HA2	IFT2	High Alarm – Channel 2
EN1	IFT1/IFO1	Channel Loss – Channel 1
EN2	IFT2/IFO2	Channel Loss – Channel 2
CA1	IFT1/IFO1	Channel Loss Alarm – Channel 1
CA2	IFT2/IFO2	Channel Loss Alarm – Channel 2
LCB TRIP	RELAY	LCB Trip Output
RST	RELAY	Indicator Reset
TB	RELAY	Trip Block/Loss of Channel
TRC	RELAY	Trip Comparator
DTTDS	DTT	DTT Disable
DTI	DTT	DTT Key Initiate
DTQ	DTT	DTT Receive (Solid Output)
DT	DTT	DTT Receive (Pulse Output)
DTT TRIP	DTT	DTT Trip Output
BS	AXLM	Block Trip Signal
TRDS	AXLM	Trip Desensitize Output

MISCELLANEOUS TERMINOLOGY

Name	Source	Description
Z, Z1, Z2	RELAY	Zero Sequence Component
P, P1, P2	RELAY	Positive Sequence Component
N,N1,N2,N3	RELAY	Negative Sequence Component
T SET	RELAY	Tap Dial Pickup Setting
DEM GAIN	MD/DTD	Demodulator Gain Control
DELAY ADJ	RELAY/DTD	Channel Delay Equalization Adjust
OUTPUT ADJ	ALS	+15 Vdc Adjust
DES ADJ	AXLM	Desensitize Trip Adjust
TX ADJ	IFT	Tone Transmitter Adjust
RX ADJ	IFT	Tone Receiver Adjust
SET UP	RELAY/MD	Amplitude Setup Calibration

LCB SYSTEM I.L. REFERENCE

The following is a list of additional LCB system supporting instruction leaflets.

Description	
Power Supply (ALS, DLS, DDS) Module	I.L. 41-830.11
Demod/Time Delay Module (DTD)	I.L. 40-216.1
Modulator/Demod Module (MD)	I.L. 40-216.2
Audio Tone Interface Module (IFT-1,2)	I.L. 40-216.3
Optical Interface Module (IFO-1,2)	I.L. 40-216.4
Relay Module (RELAY)	I.L. 40-216.5
Transformation Assembly (CT)	I.L. 40-216.6
Direct Transfer Trip Module (DTT)	I.L. 40-216.7
Auxiliary Logic Module (AXLM)	I.L. 40-216.8
Trip Module (ARTM-1,2)	I.L. 40-216.9
UCTB Test Box	I.L. 40-250
Tone Protection Package	I.L. 40-475
Application Data	A.D. 40-215

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable spare modules or components can be furnished to the customers who are equipped for doing repair work. When ordering parts (components, modules, etc.) always give the complete catalog number and appropriate Westinghouse style number(s).

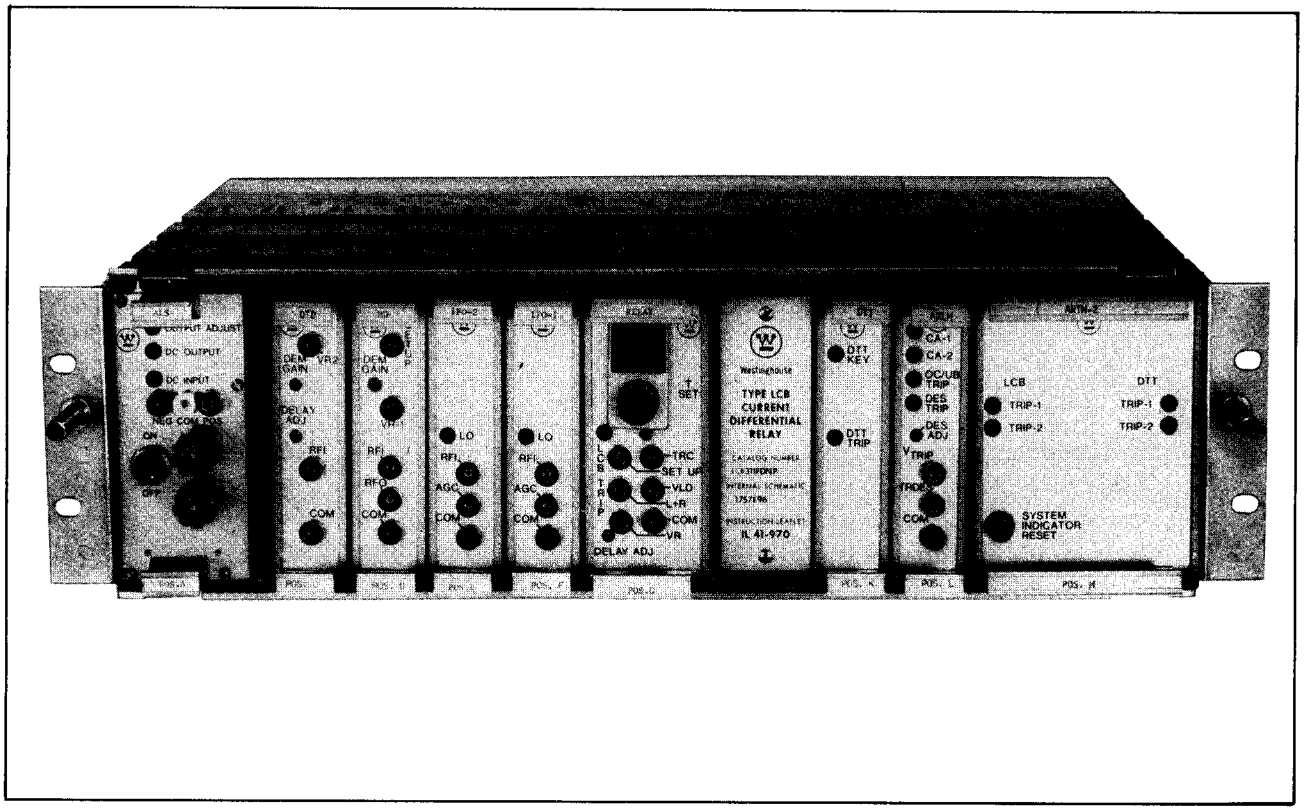


Fig. 1. LCB Photograph – Front View

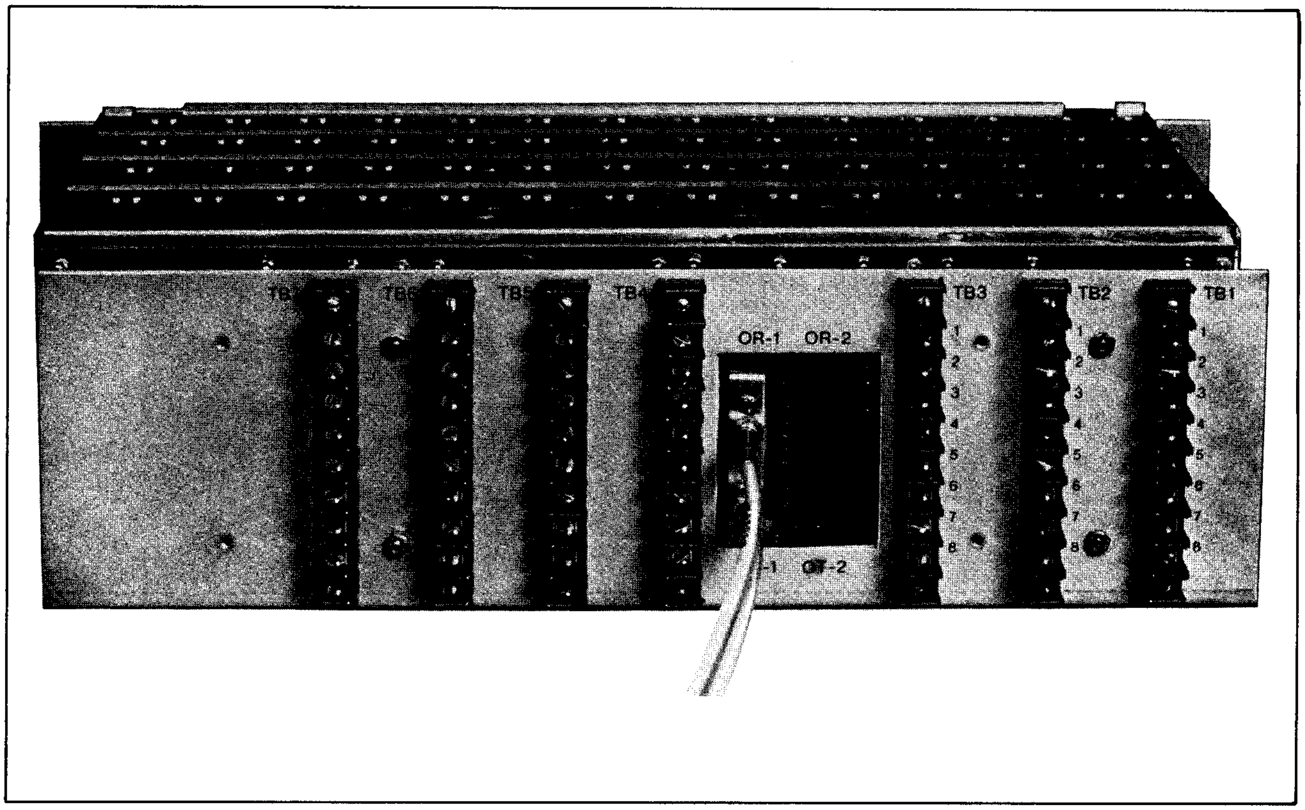


Fig. 2. LCB Photograph – Rear View

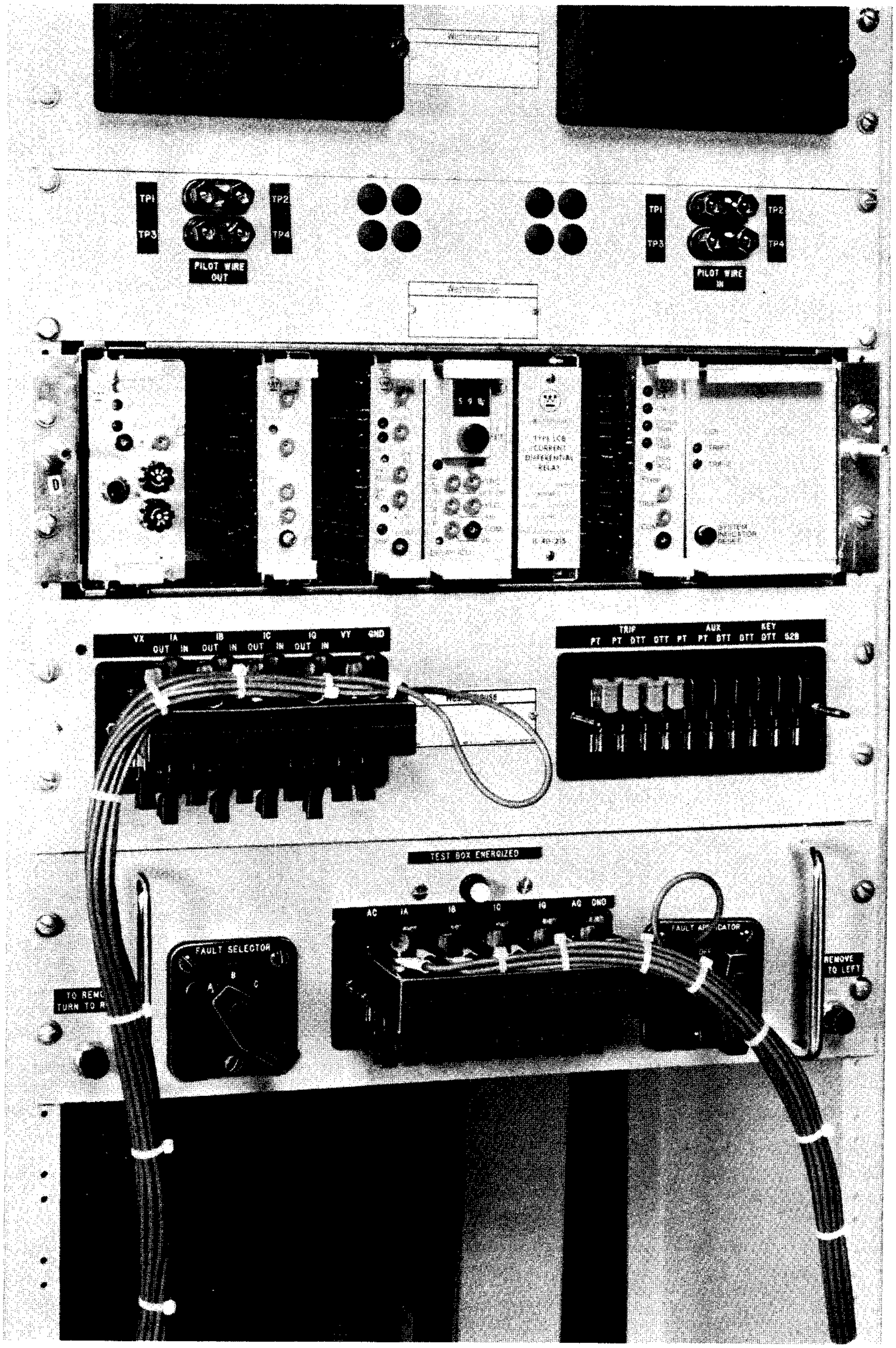


Fig. 3. LCB Tone System Photograph

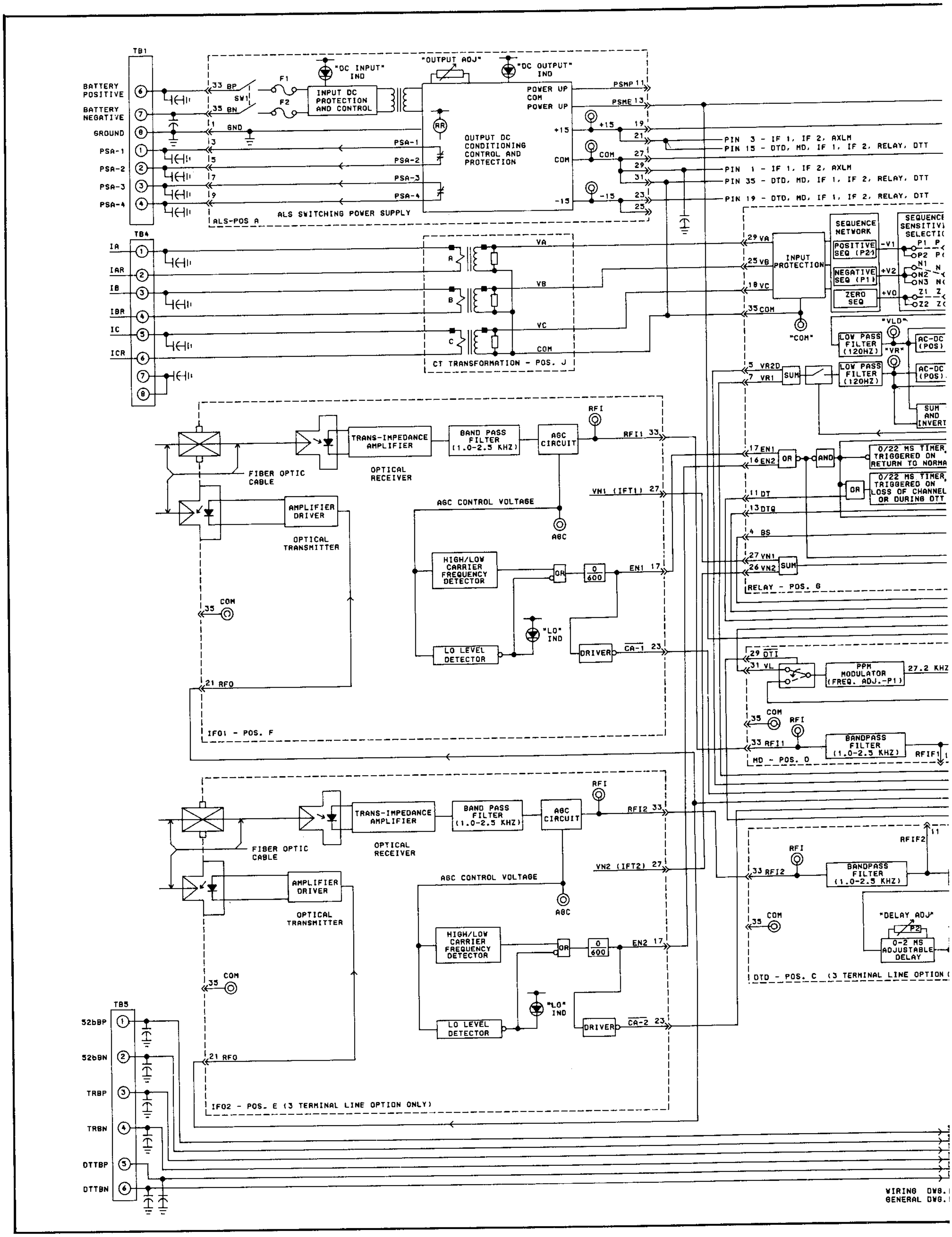
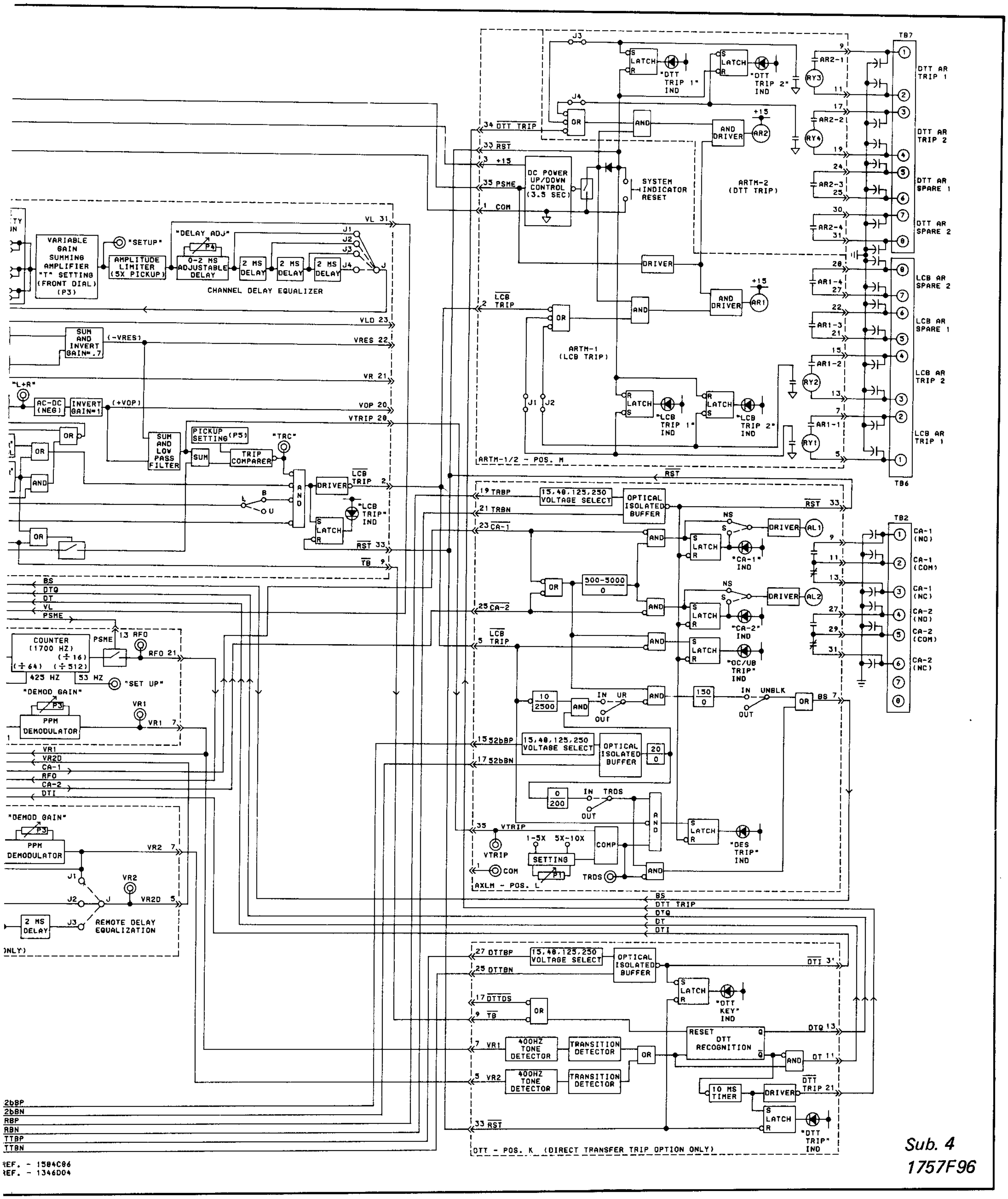
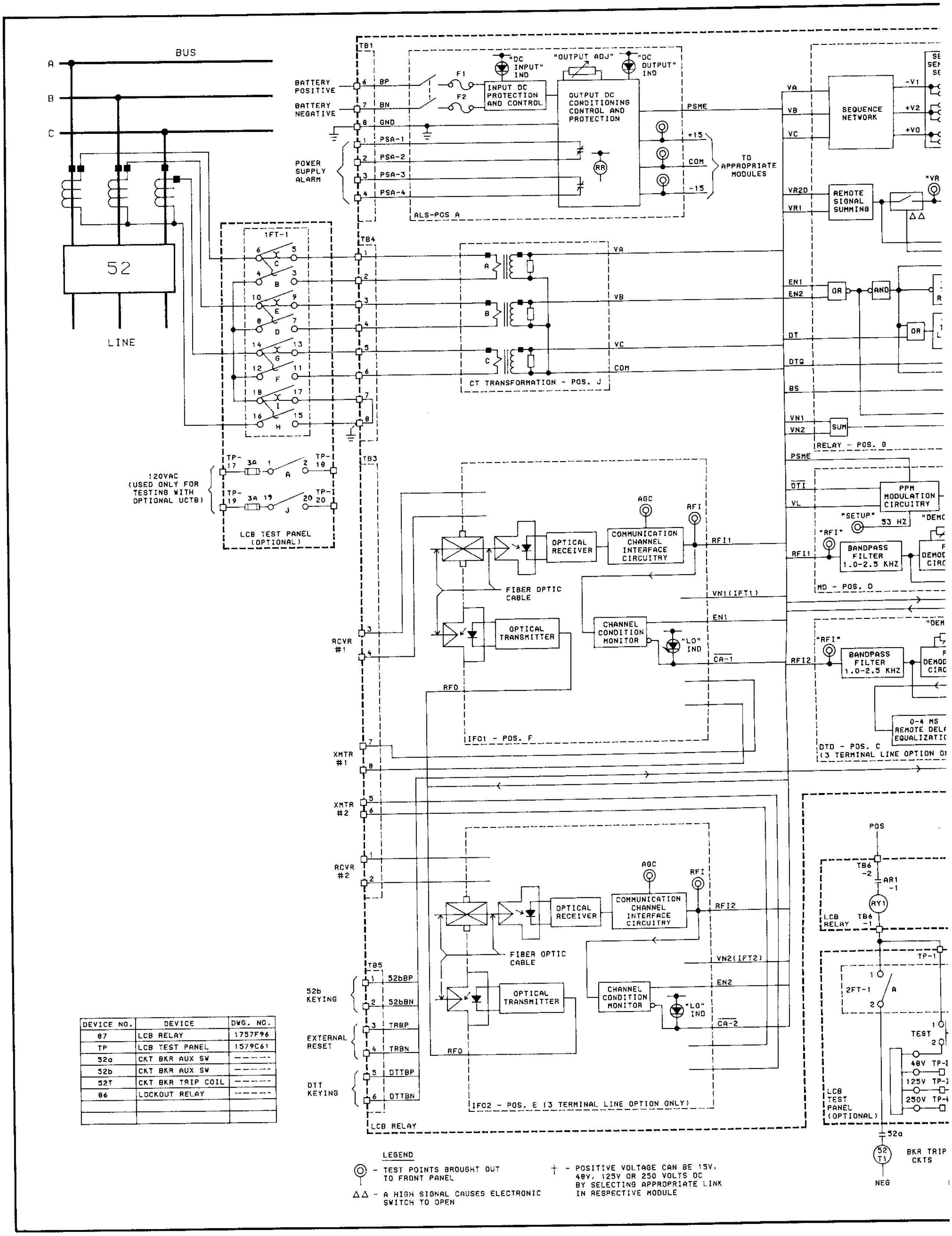

TB1
BATTERY POSITIVE
BATTERY NEGATIVE
GROUND
PSA-1
PSA-2
PSA-3
PSA-4
"DC INPUT" IND
"OUTPUT ADJ"
"DC OUTPUT" IND
INPUT DC PROTECTION AND CONTROL
OUTPUT DC CONDITIONING CONTROL AND PROTECTION
POWER UP
COM
ALS SWITCHING POWER SUPPLY
ALS-POS A
PIN 3 - IF 1, IF 2, AXLM
PIN 15 - DTD, MD, IF 1, IF 2, RELAY, DTT
PIN 1 - IF 1, IF 2, AXLM
PIN 35 - DTD, MD, IF 1, IF 2, RELAY, DTT
PIN 19 - DTD, MD, IF 1, IF 2, RELAY, DTT
TB4
CT TRANSFORMATION - POS. J
INPUT PROTECTION
SEQUENCE NETWORK
POSITIVE SEQ (P2)
NEGATIVE SEQ (P1)
ZERO SEQ
LOW PASS FILTER (120HZ)
TRANS-IMPEDANCE AMPLIFIER
BAND PASS FILTER (1.0-2.5 KHZ)
AGC CIRCUIT
FIBER OPTIC CABLE
OPTICAL RECEIVER
AMPLIFIER DRIVER
OPTICAL TRANSMITTER
AGC CONTROL VOLTAGE
HIGH/LOW CARRIER FREQUENCY DETECTOR
LO LEVEL DETECTOR
"LO" IND
DRIVER
IF01 - POS. F
0/22 MS TIMER, TRIGGERED ON RETURN TO NORMA
0/22 MS TIMER, TRIGGERED ON LOSS OF CHANNEL OR DURING DTT
RELAY - POS. G
PPM MODULATOR (FREQ. ADJ.-P1)
BANDPASS FILTER (1.0-2.5 KHZ)
MD - POS. D
IF02 - POS. E (3 TERMINAL LINE OPTION ONLY)
"DELAY ADJ"
0-2 MS ADJUSTABLE DELAY
DTD - POS. C (3 TERMINAL LINE OPTION
TB5
52bBP
52bBN
TRBP
TRBN
DTTBP
DTTBN
WIRING DWG.
GENERAL DWG.

Fig. 5. LCB Bl

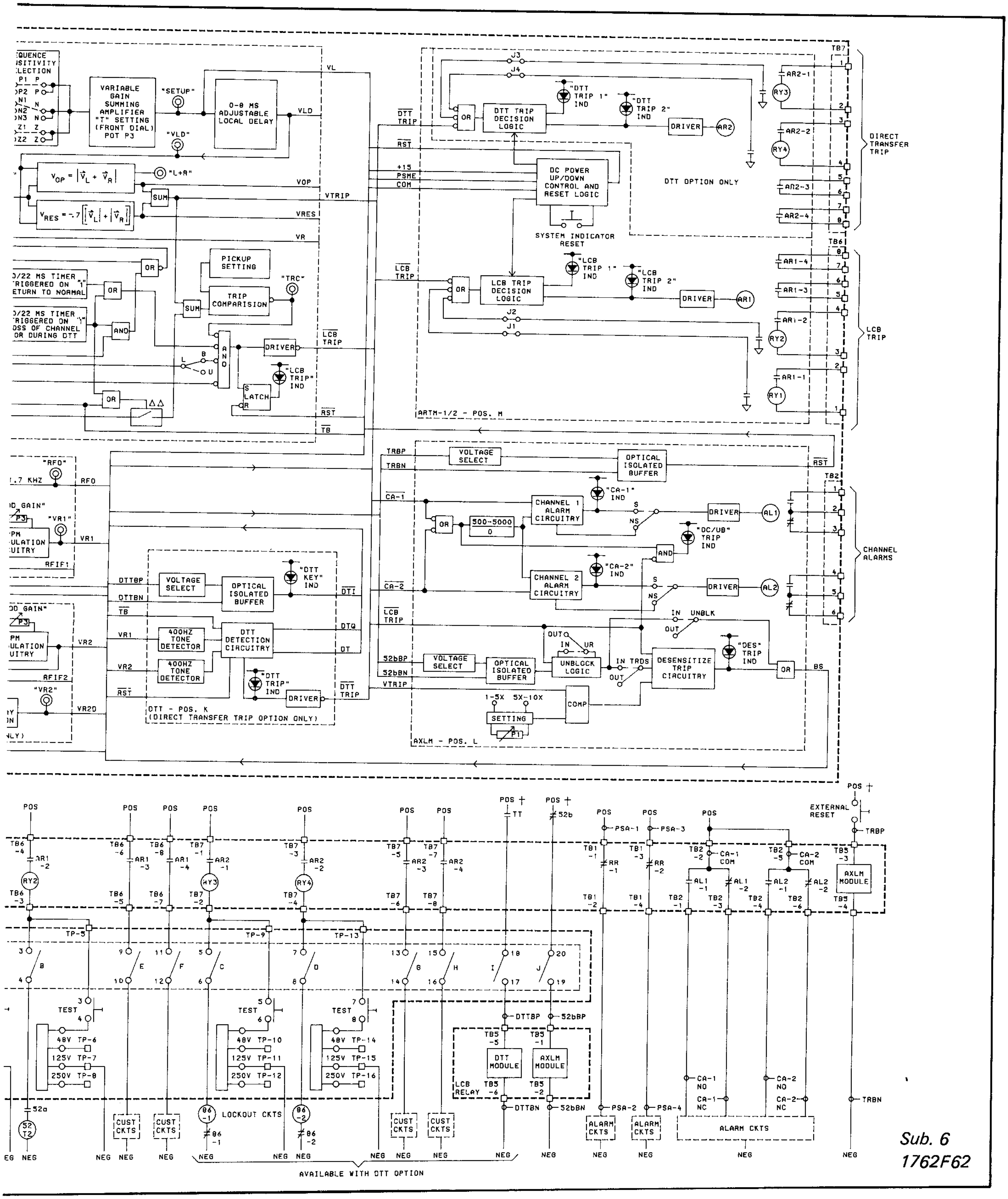


ıck Diagram – Fiber Optic



DEVICE NO.	DEVICE	DWG. NO.
87	LCB RELAY	1757F96
TP	LCB TEST PANEL	1579C61
52a	CKT BKR AUX SW	------
52b	CKT BKR AUX SW	------
52T	CKT BKR TRIP COIL	------
86	LOCKOUT RELAY	------

Fig. 7. LCB Syst



...em Schematic – Fiber Optic

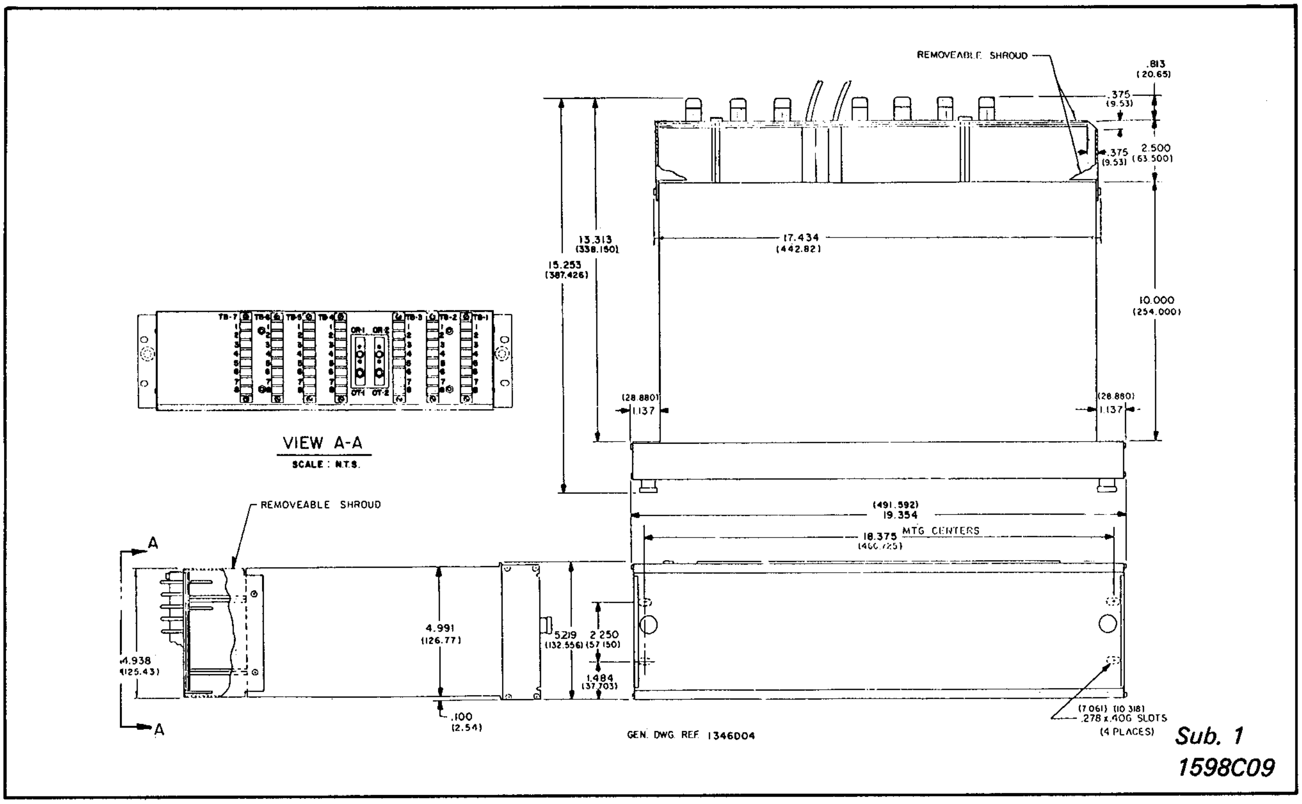


Fig. 8. LCB Outline and Drilling

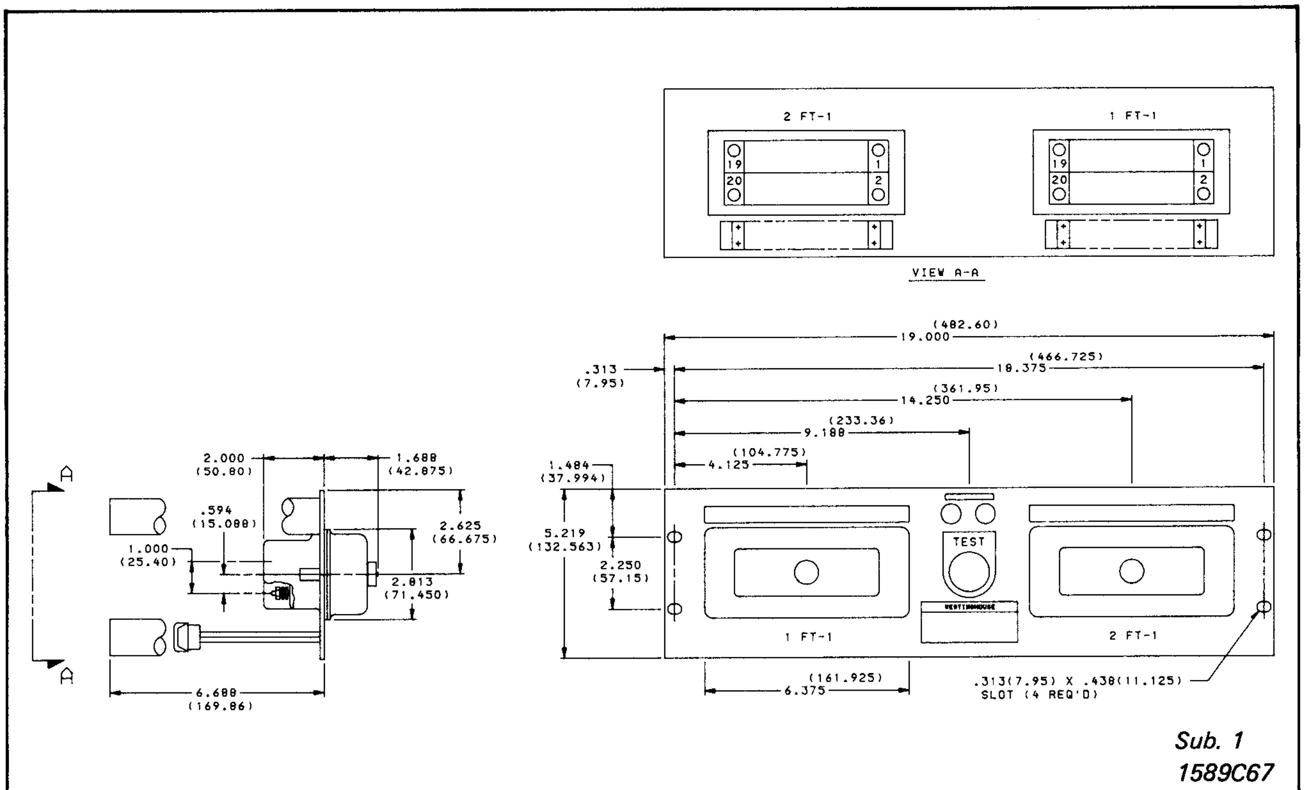


Fig. 9. Test Panel-Outline and Drilling

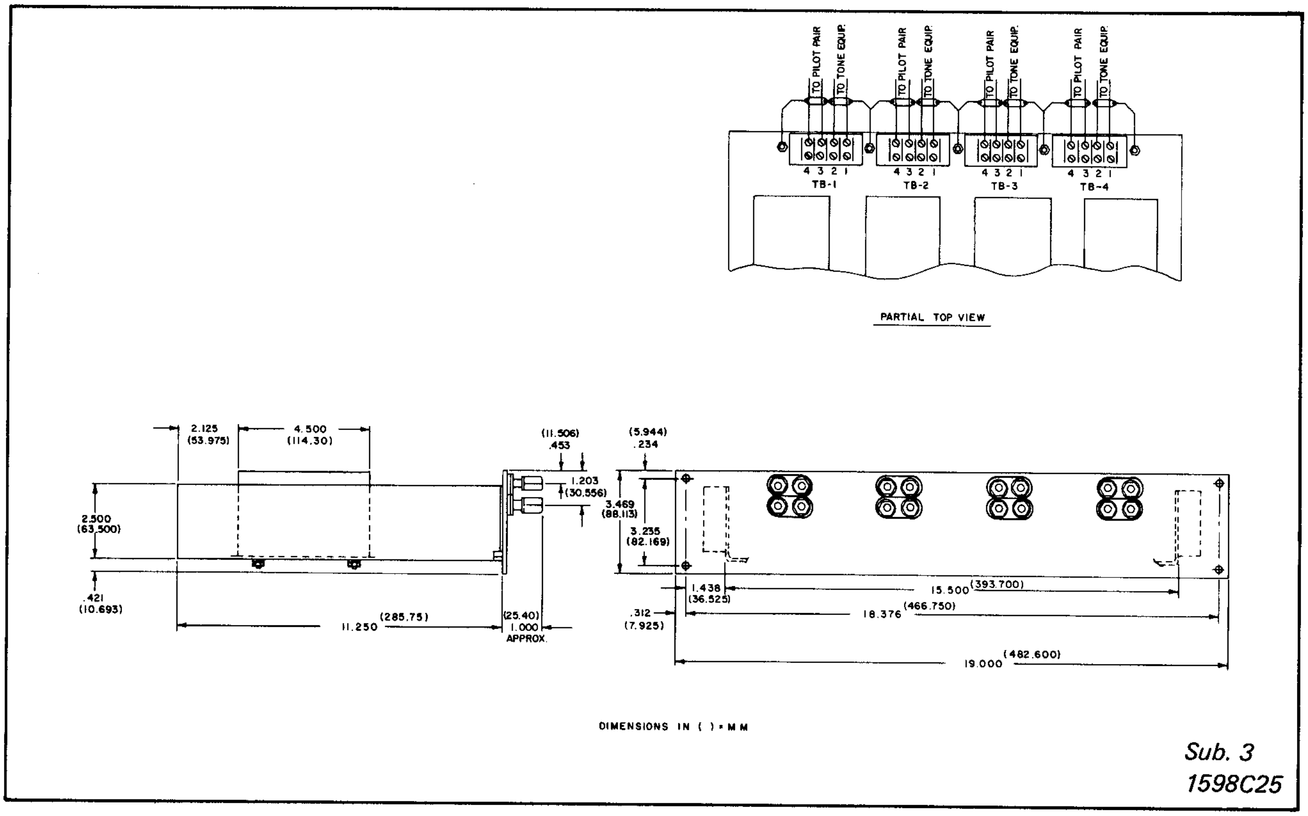


Fig. 10. Tone Protection Package-Outline and Drilling

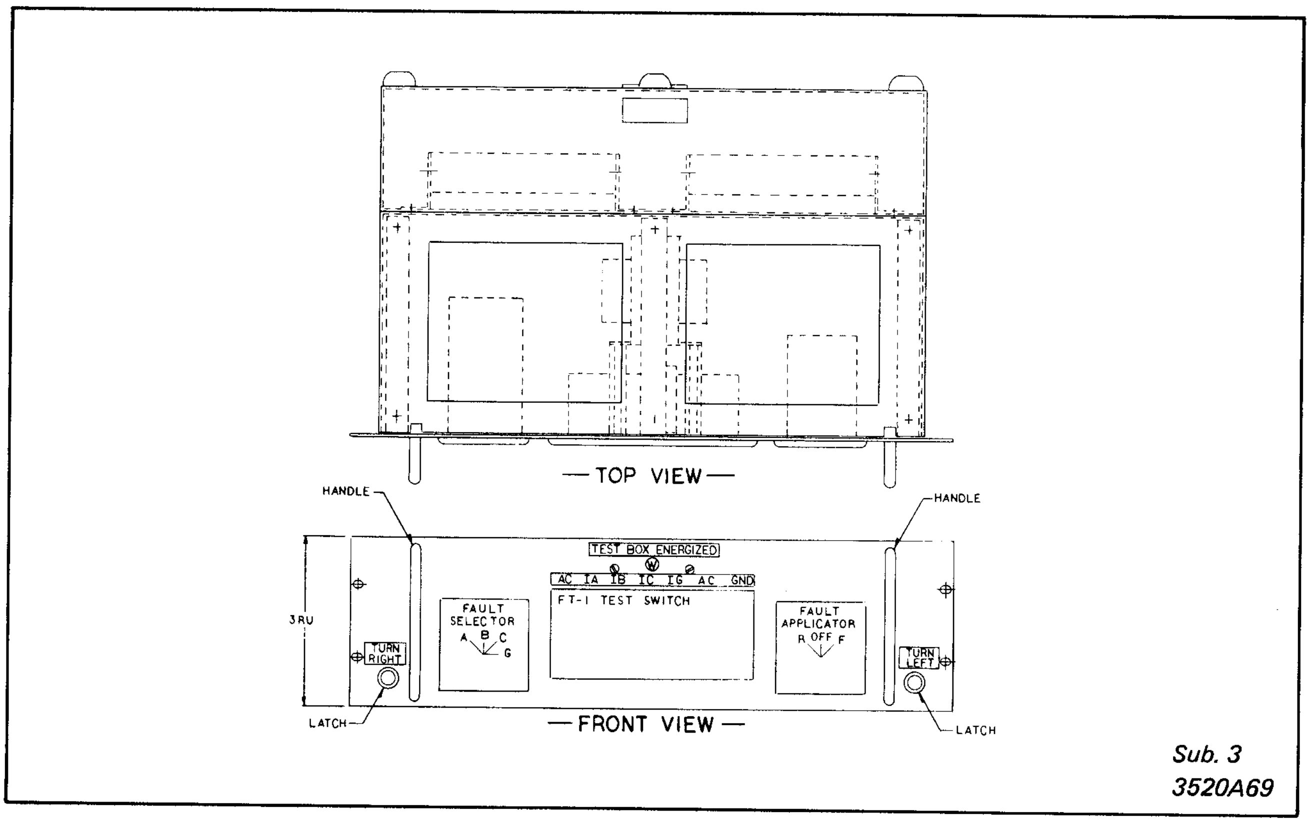


Fig. 11. UCTB Test Box Outline

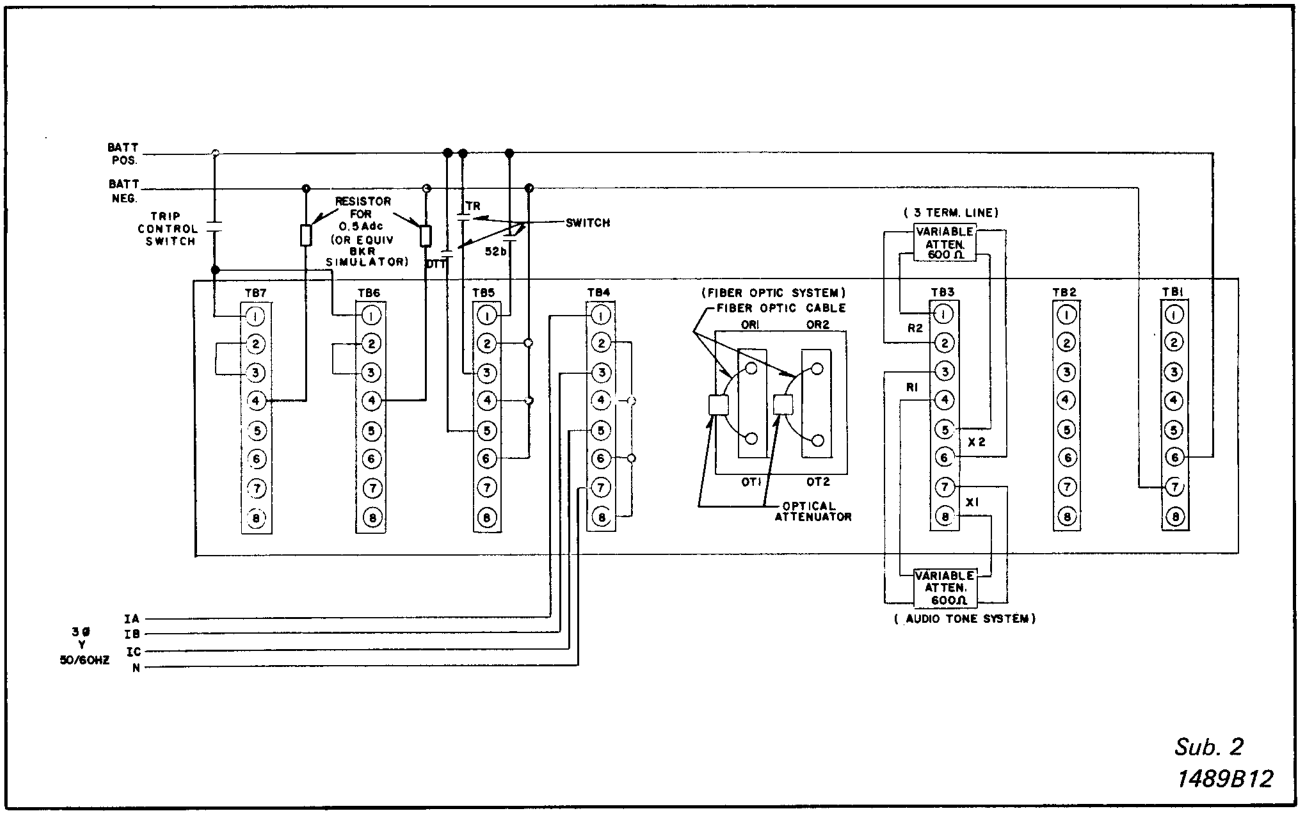


Fig. 12. LCB Test Diagram

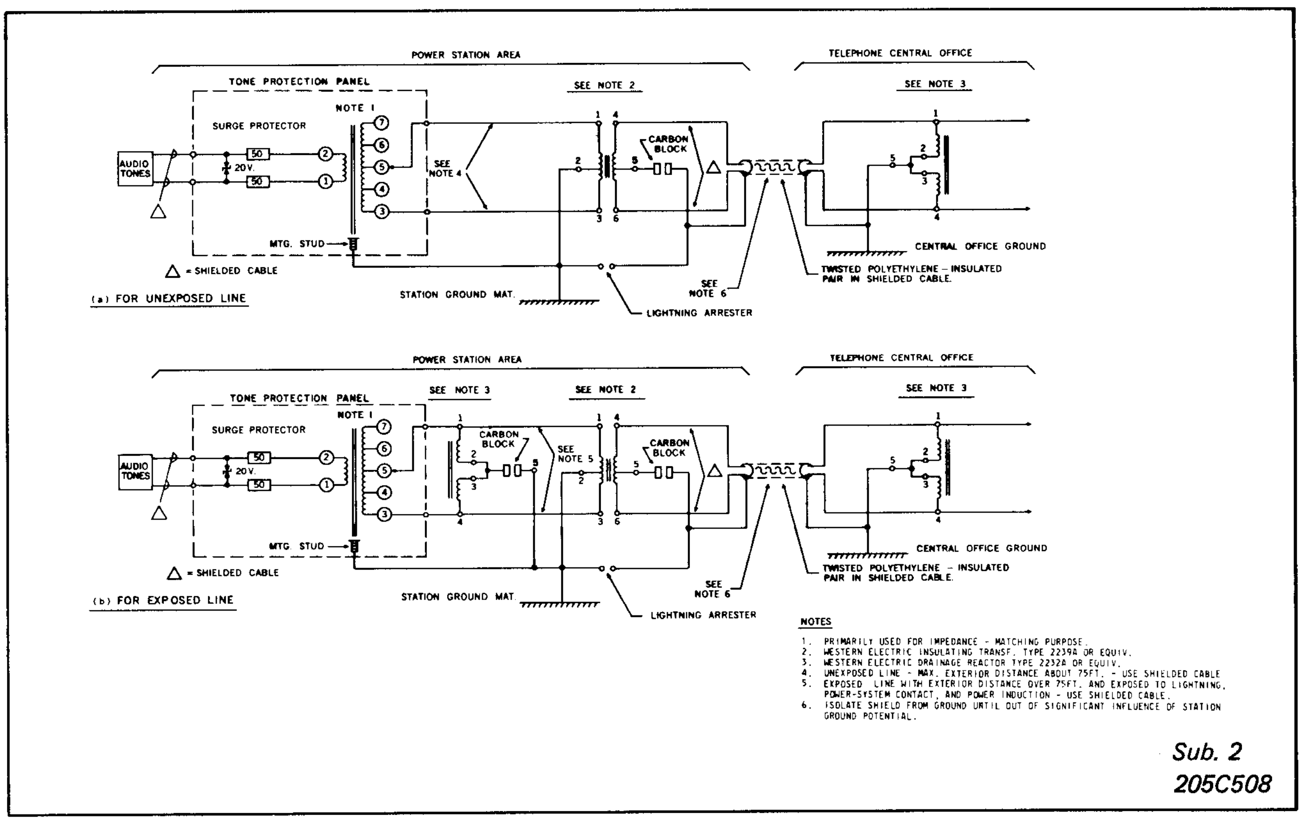
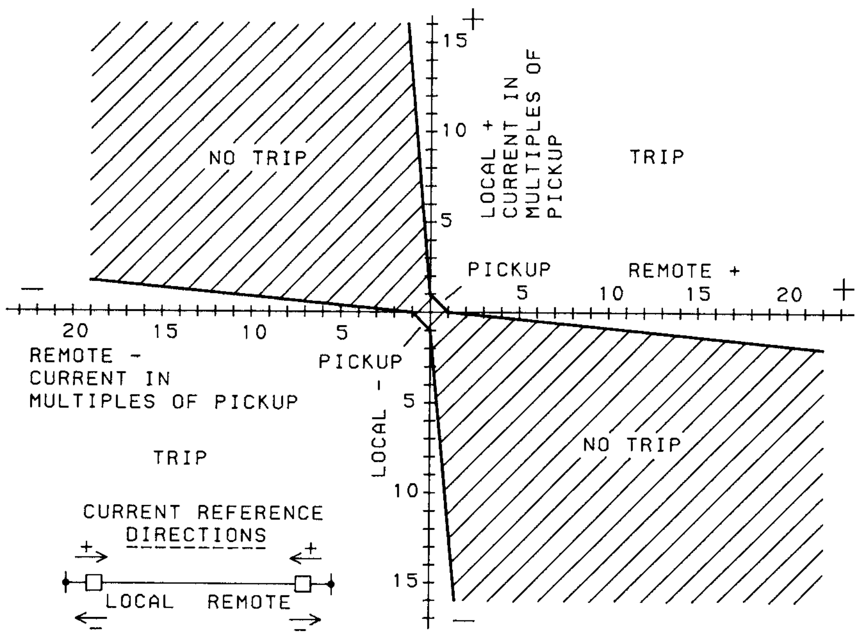
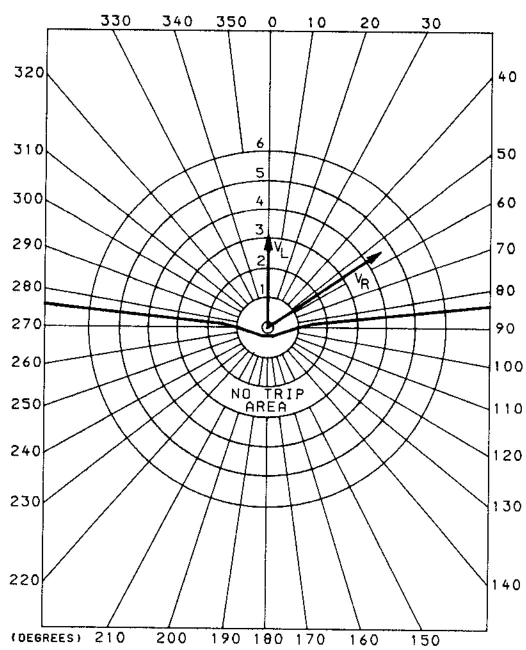


Fig. 13. Leased Cable Circuit Protection



Sub. 1
3537A17

Fig. 14. LCB Operating Characteristic (In/Out Phase)



Sub. 1
3537A18

Fig. 15. LCB General Operating Characteristics

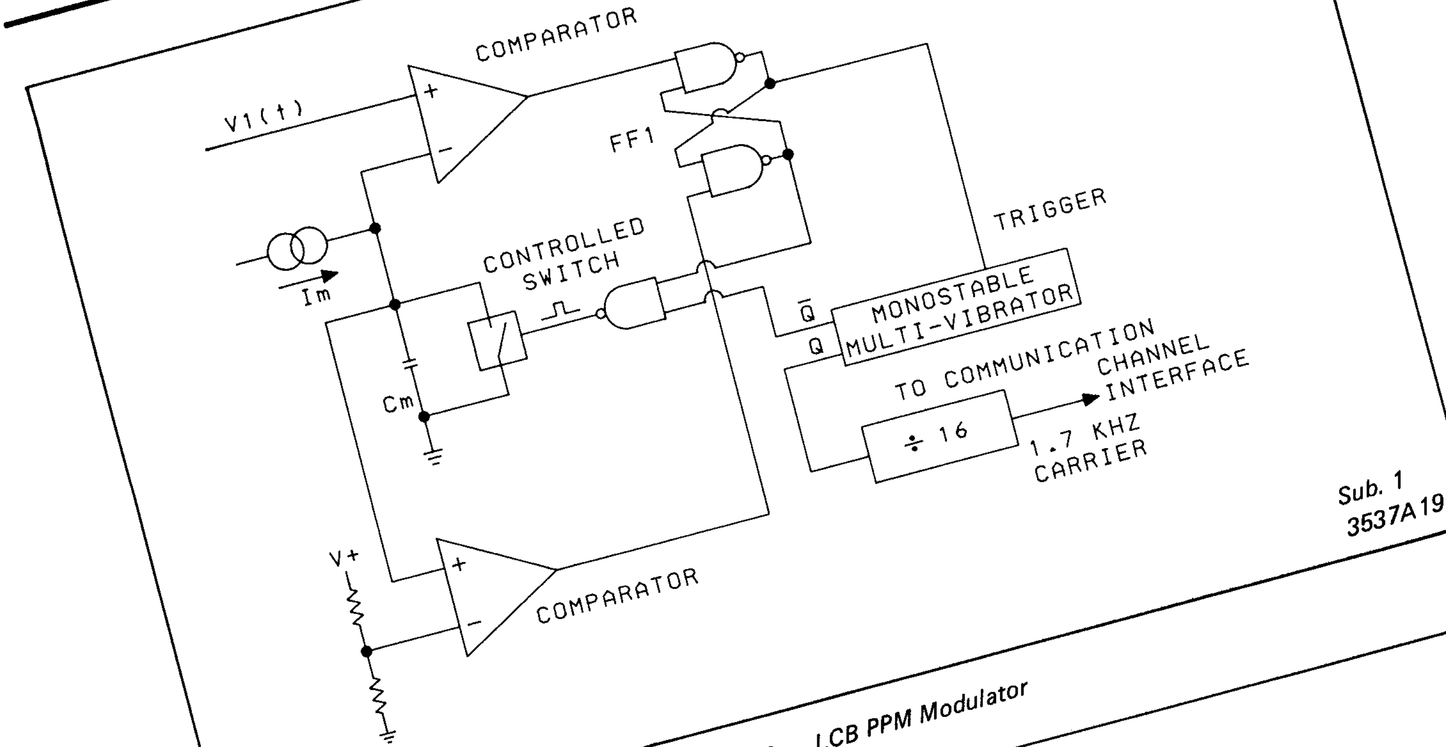


Fig. 16. *LCB PPM Modulator*

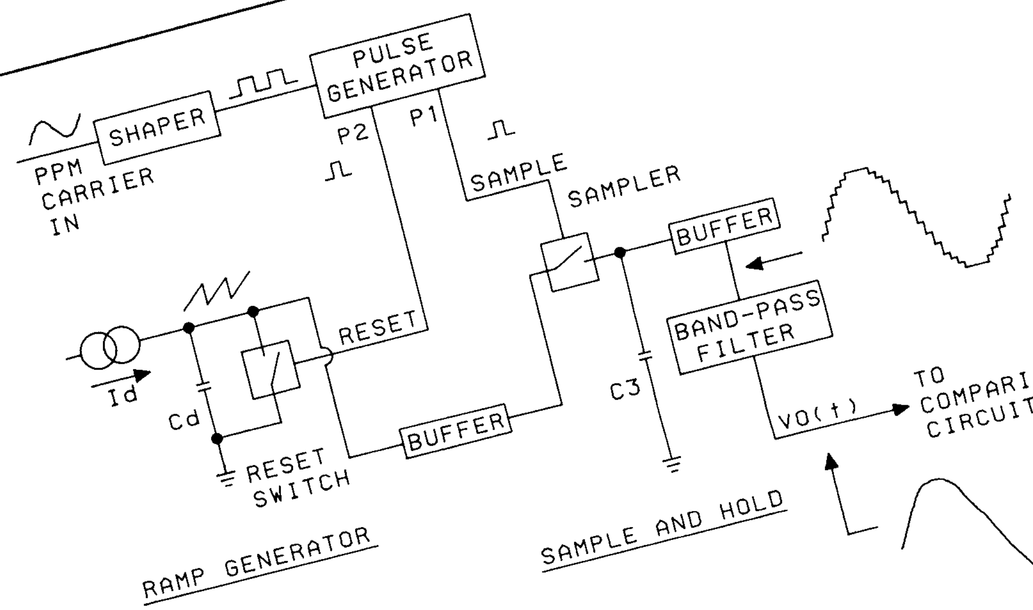


Fig. 17. *LCB PPM Demodulator*

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