INSTRUCTIONS

TYPE

LCB

CURRENT DIFFERENTIAL LINE PROTECTION RELAY SYSTEM

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION   CORAL SPRINGS, FL.

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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.

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.

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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 channel suitable for interface with the users leased lines (3002 or equivalent), microwave or single-sideband carrier, 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 cuts the cable in half for splicing to his cable bundle. 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 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 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.

Accomodates 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 - slowly changing to phase comparison above 5 times pickup.

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

Self contained, adjustable channel delay equalization, with independent settings for 2 & 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 (patent pending) performs a true phasor evaluation of the local and remote quantities.

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

Pulse Period Modulation (patent pending) 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.

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.

Type UCTB portable test box and Type UME-3 card extender are identified by separate style number.

BENEFITS

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

Pre-wired 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, single side band 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.

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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 on 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 wiring when associated with the LCB, test panel (when used) and audio tone protection package (when used) is shown on system wiring drawings 1762F61 (tones) and 1762F62 (optical). All chassis should be grounded with 12 AWG copper wire to appropriate studs or frame.

All equipment should be operated within an ambient temperature range of -20 deg. C to +55 deg. C. Ventilation may be required to insure that ambient temperature of 55 deg. C is not excluded 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 drawing 1598C09.

A removable front cover has a shaded plexiglass front for viewing of the LED indicators on the various enclosed modules. Two holes in the cover provide accssability 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 terminal strips (8 position) for making all external connections. Screw size is 6-32 and can handle wire sizes from no. 12 to 30 AWG. 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 from each field exposed terminal to ground. 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 drawing 1598C23. 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.

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 drawing 1598C25. 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 coule 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 drawing 3520A69.

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OPERATION

System Operation

The essential elements of the relay are shown on block diagrams 1757F95 (audio tone) and 1757F96 (fiber optic). The three 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 three 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 three phase fault current from the strongest terminal, minimum phase fault current from the strongest terminal, and maximum expected load current. (Ref. Setting 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.

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 d.c. voltage for comparison.

The restraint quantity 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).

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 pickup settings are entered by a knob on the front of the RELAY module and may vary from 2 to 20 amperes (5 amp CT) or one fifth of that for 1 amp 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 reporduced 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).

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 ampere 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).

Block diagram 1757F95 shows the block diagram of the audio tone interface module. 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 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 acuracy 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.

Drawing 1757F96 shows the block diagram of the optical interface 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 consist 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 unit 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 used 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 inteface 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 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 immeidately during momentary loss or dip of +15 Vdc.

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 X 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 mediam 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 Dicect Transfer Trip (DTT). The breaker or breakers at the remote terminals(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 400 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 check circuitry checks both frequency and magnitude of the signal from the demodulator.

A Valid direct transfer trip signal will be higher in magnitude and be at a frequency of 413 Hz. If these criteria are met the remote signal is switched off to disable to comparison circuit and block LCB tripping on the RELAY module. The 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.

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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	Three 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. Frequency: 50 or 60 hertz

4. Carrier Frequency: 1700 hertz, unmodulated.

   Maximum Deviation: +/- 200 hertz without DTT option.

   Modulation Technique: Pulse period.

5. Direct Transfer Trip (Option): 413 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	38-66
110/125Vdc	80-145
220/250Vdc	170-290

9. dc Burden (Watts):

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

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

Module	Functions
ALS (switching power supply)	Input dc Output dc
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):

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 Modules. (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

13. Contact Rating:

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

Heavy Light Duty: 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, & interrupt 100VA, resistive.

14. Channel Alarm (Contacts & Indication) output has adjustable time delay of 0.5 to 5.0 seconds.

15. Fiber Optic Cable Interface:

Frequency response: 1.0 - 2.5 kHz

Minimum optical power input to maintain 20dB SNR is 2 nanowatts.

Low signal level alarm setting - 2 nanowatts.

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

Optical power output - 1.5 milliwatts.

16. Audio Tone Interface:

Transmitter

Output Level - Adjustable within the following ranges:

-5 to +15 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 (+/-10dB) window dynamic range

Input impedance 600 ohms, balanced

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

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

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

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

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

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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 secondard current magnitudes.

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

$$VF=(14.14/T)\ (C1\times Ia1+C2\times Ia2+Co\times Ia0) \quad (1)$$

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:

$$(C1\times Ia1+C2\times Ia2+C0\times Ia0)/T = 0.1 \quad (2)$$

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.

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 jumper settings, and these should be used unless special circumstances dictate otherwise.

The criteria are as follows:

$$I3P \geq [0.1\times T/C1] \quad (3)$$
$$IL \leq [1.25\times(0.1\times T/C1)] \text{ See note below} \quad (4)$$
$$IG \geq [0.3\times T/(C1+C2+C0)] \quad (5)$$

[ ] 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 jumper 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 Jumper C0, and this is done by using criterion (5). Criterion (5) assumes that Ia1 = Ia2 = Iao.

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.

TABLE 1
SEQUENCE NETWORK CONSTANTS

CONSTANT	POSITION	VALUE
	P1	-0.10
C1	P2	-0.05
	OFF (P)	0
	N1	0.23
C2	N2	0.22
	N3	0.20
	OFF (N)	0
	Z1	2.45
CO	Z2	1.25
	OFF (Z)	0

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

DS = 1082.5 - 2000/T where, DS = Dial Setting
T = Tap Value in Amperes

CHANNEL BLOCK CONFIGURATION (L-B/U) - RELAY Module

Jumper 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 link "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 500-5000ms 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 calibraiton is for a desensitized level of 5X pickup but the link activitating 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

Jumpers J1 (LCB-Trip 1), J2 (LCB-Trip 2) on the ARTM-1 and jumpers 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 jumpers removed, the AR relays will be energized only when an LCB or DTT trip signal exists.

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LCB FIELD SET UP 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.

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 moudle 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: OdBm = 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.

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-2)

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.

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. 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 "SET UP" and the MD module "SET UP" front test jacks.

C. Channel 1

1. At the remote termial 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.

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 "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.

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.

III. 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.

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 tranformers 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 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 deg. to simulate an external fault. In this case "VLD" and "VR" will be equal and opposite (180 deg. out of phase). "L + R" in this case will be a minimum.

B. Channel 2 (3 terminal line 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" "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 deg. to simulate an external fault. In this case, "VLD" and "VR" will be equal and opposite (180 deg. out of phase). "L + R" in this case will be a minimum.

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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 amps resistive, contact make duty; the contacts should be inspected each year or 50 operations and replaced every two years or 100 operations. Reference, IL 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 moitoring function (LED's) on the various modules provide a check on the performance of the sytem.

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.

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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 - (W) 1447C86G01
7. Variable attenuator (600 ohm) - tone systems.
8. Random noise generator - tone systems.
9. Optical attenuator - optical systems (optional).

CALIBRATION

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 Set Up 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 Set Up. All measurements are with respect to "COM" unless otherwise specified.

A. 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.

B. DTD module - 3 terminals lines

With the channel levels properly set, (refer to Field Set Up), 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 sinewave, if not modulated, a zero dc level will exist.

C. MD module -

1. 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".

2. Demodulator

With the channel levels properly set (refer to Field Set Up) 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 sinewave, if not modulated, a zero dc level will exist.

D. Telephone Interface modules (IFT-1 and IFT-2 for 3 terminal lines)

1. "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.

2. 1700 Hz trap adjustment

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

E. RELAY module

1. 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.

2. 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.

3. Trip pickup

a. 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.

b. 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).

c. 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.

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

F. AXLM module

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

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

   b. Apply current to the LCB relay to just cause an LCB trip (per method on RELAY module). Measure the dc voltage at VTRIP (approx. 0.5 Vdc). Multiply by the multiple of trip desired. If unable to measure the VTRIP level, assume 0.5 Vdc for trip and make settings accordingly.

   c. Apply the calculated voltage for setting to VTRIP by one of the following methods:

      1) Apply sufficient input current to produce the VTRIP level.

      2) Simulate the voltage by,

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

         b) Jumper TP9 to TP8 and adjust potentiometer P3 for the desired dc voltage (NOTE: REMOVE JUMPER ON COMPLETION OF FINAL SETTING).

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

2. Channel alarm (AL-1 or AL-2) time delay. Initial factory calibration is for 2500 ms. For different times, then the following recalibration is reuired. (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.

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LCB SYSTEM FUNCTIONAL TEST

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.

1. Test Panel: Test panel with 2 FT-2 switches as described earlier.

2. Test Box: Type UCTB test box as described earlier.

3. ac voltmeter for channel magnitude equalization verification (optional).

4. Dual trace oscilloscope for channel delay equalization verification (optional).

Functional Test Procedures

The following is the suggested procedure.

1. Disconnect Outputs. The first step should be to prevent false breaker operations by disconnecting the trip output circuits.

2. Disconnect LCB relays from CT's by operating the current shorting blades in the FT-1 switch on the test panel at each station.

3. PROCEDURE TO BE SUPPLIED BY APPLICATION AND SYSTEMS ENGINEERING LATER. (APRIL 1983)

4. After completion of functional test, restore the equipment to normal - restore the CT's, reset all indicators and reconnect trip circuits.

Optional system verification - TO BE SUPPLIED BY APPLICATION AND SYSTEMS ENGINEERING LATER.

1. Channel magnitude equalization verification.

2. Channel delay equalization verification.

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
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

IFO1 Module (POS F) - 1586C11G01 and cable 1586C73G03

Fiber Optic Channel - 3 terminal

Includes 2 terminal interface plus,
IFO2 Module (POS E) - 1586C11G01 and cable 1586C73G03
DTD Module (POS C) - 1586C13G02

dc Power Supply

48/60 Vdc: ALS Module (POS A) - 1349D85A01
110/125Vdc: ALS Module (POS A) - 1349D85A02
220/250Vdc: 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. Assy. (POS J) - 1581C70G01
50/60 Hz, 1A-CT: Transf. Assy. (POS J) - 1581C70G02

Audio Tone Protection Package (Separate item)

2 terminal - 6666D71G11
3 terminal - 6666D71G07

Test Panel (Separate item)

1579C61G01

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

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LCB SYSTEM I.L. REFERENCE

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

DESCRIPTION	I.L.
Power Supply (ALS,DLS,DDS) Module	41-830.11
Demod/Time Delay Module (DTD)	40-216.2
Modulator/Demod Module (MD)	40-216.3
Audio Tone Interface Module (IFT-1,2)	40-216.4
Optical Interface Module (IFO-1,2)	40-216.5
Relay Module (RELAY)	40-216.6
Direct Transfer Trip Module (DTT)	40-216.8
Auxiliary Logic Module (AXLM)	40-216.9
Trip Module (ARTM-1,2)	40-217
UCTB Test Box	40-250
Tone Protection Package	40-475
Application Data	A.D.40-215

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RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts 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).

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