INSERT W/IL-40-217

CHECKOUT PROCEDURE FOR LCB-II RELAY

1. Equipment needed besides that listed in the test is set-up equipment for LCB test (Figure 16).

   One trip control switch
   Two breaker simulator resistors (.5 amp D.C.)
   One N.O. switch for open channel control
   One N.O. switch for target reset
   One N.O. switch for direct transfer trip
   One N.O. switch for 52b contact.

   These can all be small toggle switches.

2. The attached listing of tests omits all tone equipment tests, factory calibration tests, final UCTB test box tests (a bulletin on the box should be found), and actual breaker trip tests. Included are stand alone acceptance tests and field installation verification tests. Tests for checking owner's settings are also included.

3. The owner did not specify some link settings. Links were set to eliminate all open channel overcurrent options. A link (TRDS) was also set to desensitive trip for the first 200 nanoseconds to allow for breaker closing-charging inrush.

4. This write-up is to supplement the I.L. but not replace it. Some clarification has been added that I hope will be helpful in doing the job.

5. The only good trip blocking for external fault tests seem to need the VCTB test boxes. Those tests would need to be run with the line service and with a copy of the VCTB test boxes bulletin.

LCB-II - CURRENT DIFFERENTIAL FOR LINE PROTECTION
I.L. 40-217

DESCRIPTION

The LCB-II relay differential uses fiber optic cable to carry the differential signal between the relays located at the ends of the protected line. It has a second channel that may be used if protection for a three terminal line if needed. The electronic relays take balanced inputs from three circuits and develop a composite single phase signal that is

used to modulate a carrier for light-emiting diodes that transfer the signal through the fiber optic cable. One cable connects from the transmitter of the first relay to the receiver of the second. A second cable connects from the transmitter of the second relay to the receiver of the first relay. Maximum light loss per cable is 34 CB for proper operation. Tone channel systems can be used rather than light channel if proper modules are ordered for the relays.

The composite single phase control signal is not a sine wave but a pulse period modulation system patented by Westinghouse. Coincidence of the transmitted and received pulses must be exact in order to block trip. This criteria is so critical that the local (transmitted) signal must be delayed to make it match the signal received from the other relay. The delay on a fiber optic system is set at 2 milliseconds. This seems like it would be too long a delay, but it is actually the lowest delay settings available as a tap, but it is pot adjustable.

A test set is included at each terminal to make routine, periodic in-service operational tests by fault simulation.

TESTING METHODS

Several kinds of testing are shown in the manual including acceptance testing, calibration testing, and field testing. Because of the need to have closely matched phasing and amplitude at each relay, applying three phase current at each end of the line to test the two relays together with the system down would not be practical.

1. BEST ACCEPTANCE TESTING

   The best way to run acceptance tests is to connect a fiber optic cable from the transmitting terminal to the receiving terminal of the relay to be tested so that local and remote signals are the same. Westinghouse supplies two types of cables for the purpose. One is a fixed loss cable about thirty feet long and the other is a variable attenuator cable. The variable attenuator is probably very expensive, but it would make it possible to set the loss equivalent to the line with the highest loss of the two lines and thereby closely match the installed system. The variable attenuator would also make it possible to accurately determine at what level loss or channel would occur.

   The ten meter cable would probably have less than ten DB

loss, with nearly all of that found in the end connectors. Because of economics, it is probably the most used system.

2. ACCEPTANCE TESTING, WITH ONE TERMINAL OF THE LINE ENERGIZED. This a loop testing method, but it is too elaborate to be very practical. Voltage to current auxiliary transformers are used to convert line voltage to equivalent currents that are in phase at each end of the line.

3. Acceptance testing could be made by using actual line currents, but since this would have only one arbitrary value or current it would probably not be satisfactory either.

Acceptance tests, calibration tests, and field set-up and verification tests are listed separately in the manual, but on new installations the relay acceptance tests would not be adequate by themselves to verify the whole system. Tone system tests are interspersed with fiber optic system tests which can be confusing and misleading. This makes a more concise listing necessary.

The following sequence of tests would be proper for the LCB-II installation in Corpus Christi:

1. Equipment needed:

   A. Dual trace oscilloscope with calibrated vertical input.

   B. Frequency counter capable of reading 1700 CPS within +/- 5 CPS.

   C. Digital multimeter to read true RMS voltage. Should have A.C. volts scale as well as an A.C. millivolt scale, reasonably accurate down to 5 mv.

   D. Three phase balanced current source with fourth wire neutral ground (wye).

   E. Variable D.C. voltage source.

   F. Optical cable for connecting relay Channel 1 Transmitter to Channel I Receiver of the relay under test.

2. Connect the relay as shown in Test Set-up 16, but leave all power off.

3. Make these links all dial settings, some of which will be changed later.

   A. Relay Module

      (1) Set N to N1

      (2) Set P to P1

      (3) Set Jms to 1 (2ms)

      (4) Set "T-Set" dial maximum clockwise

   B. AXLM Module (Auxiliary Module)

      (1) AL-1 to"S"

      (2) CAI to "S"

      (3) UR to Out

      (4) LC to BLK

      (5) TRDS to "IN"

      (6) 5X,10X Lines to 5X

      (7) 52B - Target Reset

      (8) Set OCC to rated D.C. volts

   C. MC Module (Overcurrent Control Channel)

      (1) Set "OCCC" Link to "Out"
      (Note: At present there is no indication that overcurrent trip for loss of channel will be used at all at this installation. The link will not be reset.

   D. DTT Module (Direct Transfer Trip)

      (1) Set "DTT Key" link to rated D.C. voltage. This module will be used for direct transfer trip in this installation.

      Unless otherwise specified, all readings are made in respect to the "Com" jacks on the front of the modules.

TESTS:

1. First, check the D.C. Power System (ALS Module). Turn on rated volts and see that "D.C. Output" and "D.C.Input" indicators are lit.

   A. Read + 15 volts to be between 14.990 and 15.010 volts.

   B. Read - 15 volts to be between -14.750 and -15.250.

   C. If these readings are not correct, check incoming D.C. on back of module at Terminals 6 and 7. If incorrect D.C. supply is provided, damage will occur.

2. Test of the Sequence Network inside the Relay Module is important to determine if the three phase wye current supply to be used for testing positive and negative sequence is balanced to neutral and undistorted. Test Points 1 through 6 are not shown on any of the drawings so they must be on the extender board.

   A. Turn off the D.C. input and remove the relay board.

   B. The test of the 15 volt D.C. system PSA Relay Contacts 1, 2, 3, and 4 could be made at this point by shorting first +15 volts (Term 19) and then -15V (Term 23) to Com (35) to kill the output indicator and close the PSA contacts but it might be a good idea to examine the output DC conditioning control and protection section of ALS Module to see if this could cause damage. This test is called for in the manual, but the information obtained would come out in the field tests and in using the VCTB test box.

   C. Open the communication channel by removing IFO 1/2 module while the D.C. is still off.

   D. Insert the Relay Module in the extender while the D.C. is off and connect the three phase test supply in (A, B, C) positive sequence on Terminals 1, 3, and 5. 2, 4, and 6 are commoned to Neutral. Turn power on.

   E. Measure AC voltages with 5 amps input:

      TP1 = 0.348 to 0.358 volts
      TP2 = 0.348 to 0.358 volts
      TP3 = 0.348 to 0.358 volts
      TP4 = Less than 5 millivolts

TP5 = 0.348 to 0.358 volts
TP6 = Less than 5 millivolts

F. Reverse Phases A and C at the input to get 5 amps negative sequence and measure voltages:

TP1 = 0.348 to 0.358 volts
TP2 = 0.348 to 0.358 volts
TP3 = 0.348 to 0.358 volts
TP4 = 0.348 to 0.358 volts
TP5 = Less than 5 millivolts
TP6 = Less than 5 millivolts

If these readings are not correct, a problem exists with the sequence network in the relay module or input current.

3. TEST THE PPM MODULATOR (MD MODULE)
This unit produces the 1700 cycle carrier for placing the PPM pulses on the light cable. An accurate frequency counter is needed to set the carrier within +/- 5 cycles of 1700 in order for both transmitters and receivers to be compatible. Deviation in frequency will produce reduction in received signal strength.

A. Monitor the "RFO" test jack with the oscilloscope and frequency counter. Square wave signal level should be 0 volts (trough) and 15 volts (wave tops). This measurement is made with A.C. current inputs off.

B. Null adjustment of the PPM Demodulator is made by monitoring "VR1" Terminal (MD Module) with the A.C. current off but D.C. power on as in Step 1. The carrier should be stripped out completely and the D.C. level reduced to 0 volts at "VR1" test point. If not 0 volts, adjust P4 on the MD Module to get zero volts. (Note: Since this is not a three terminal line, the DTD Module is not in the rack and there is no "VR2" Test Point.)

C. Check the Demodulator Gain (MD Module - Channel 1). Put dual track scope on "VLD" and "VR1F" test points. Common to "Com" (or Term 35). Connect 5 amps A.C. between phase B input and neutral. Check relative wave shapes and magnitudes. Enter these values into a test sheet. Measure A.C. volts on TP6 to be 113 to 123 millivolts.

4. DIAL SETTING (T-SET) RELAY MODULE

A. Open "Z" Jumper to disable Zero sequence current and leave communicator channel open (IFO 1/2 removed). (Never remove or install modules with power on the unit.)

B. Apply 4 amps of positive sequence current with "/T-Set" at maximum ten turns clockwise.

C. Monitor "TRC" test jack and watch voltage fall from +15 to -15 as the dial is slowly backed down. "LCB Trip" should light and the dial setting should be between 560 and 600. (Note: Make sure the breaker simulator resistors are installed as shown on Figure 16.)

D. TP7 voltage should be measured between 1.4 and 1.430 volts.

E. Measure "V Trip" test jack (TP14) to be 0.45 to 0.60 volts.

F. Verify trip reading by repeating Step (3) several times. Record dial position of trip in the test sheet.

G. Leave the J(MS)=2 jumper out for the remainder of the acceptance tests and then reconnect it.

5. CHECK DESENSITIVED TRIP OF THE AXLM AUXILIARY MODULE.

A. With IFO 1/2 still removed, apply single phase current of 2 amps B phase to neutral. Back down "T-Set" dial to just trip to light "LCB Trip" indicator. Dial should turn out to be set at 100 or less. Record dial position in test sheet.

B. Close the 52B switch that was installed while connecting circuit as shown in Figure 16.

C. Press "System Indicator Reset" button and the "LCB Trip" Indicator light should go off.

D. Increase input current until "DES Trip" indicator light comes on. This should be at about 10 amps and "LCB Trip" light should also come on.

E. Open Switch 52B and push "system indicator Reset" button. "LCB-Trip" light will remain lit but "DES Trip" light should go off in about 200 milliseconds.

F. Remove input current and press "System Indicator Reset" to reset all indicators.

6. TEST THE INTERFACE (IFO) MODULE.

A. Kill the power and insert IFO Module. There is no transmitter adjustment on this module.

B. With A.C. current input off, turn on D.C. power.

C. Adjust the "DM Gain" pot on the MD Module until the "VRIF" wave form is equal in magnitude to "VLD" as measured with an A.C. True RMS Voltmeter. VLD is on the Relay Module. Compare these wave forms on the dual trace scope.

7. ADJUST THE CHANNEL DELAY EQUALIZER CIRCUIT ON THE RELAY MODULE.

A. Connect dual trace scope to "VLD" (Relay Module) and "VRIF" (MD Module).

B. Check "J (MS)" link to be on 2MS.

C. Apply single phase current to B to neutral input. Run 5 amps.

D. Use the vertical positioning control of the scope to bring the wave forms on top of each other.

E. Adjust "Delay Adjust" on the Relay Module to bring the two signals exactly in phase.

F. The J (MS) link will probably be used in 2MS position, but it should be moved to "4", "6", and "8" positions to observe the phase shifting effect. If necessary, the adjustment could be used to bring the signals in phase when the operating fiber optic cables are connected between the relays. Coincidence of the waves should be checked again as part of the overall field tests. For now, leave J (MS) link on 2MS (Position 1).

8. CHECK EFFECT OF LOSS OF CHANNEL ON ALXM LOGIC

A. With A.C. current off, push "System Indicator Reset".

B. Remove cable connection to receiver. "CA" indicator light should come on in 2.5 seconds and AL-1 pick up.

C. Restore cable connection and "CA" should stay lit and AL-1 should stay picked up.

D. Move "AL-1" and "CA" links to "NS" and repeat the tests. This time they should both drop out when the channel is restored.

E. As preferred by the customer, the links may be left for automatic alarm reset when the channel comes back to operating level or the option to retain the alarm to indicate the channel had been out may be used. This preference should be checked with the owner.

9. OVERCURRENT TRIP ON LOSS OF CHANNEL OPTIONS TEST

A. It is my present understanding that the customer does not want any of loss of channel overcurrent trip options. If that is true, place LC link in "BLK" position and skip adjustments for all open channel overcurrent trip options.

B. However, check that trip will not occur for open channel by testing the "LC-BLK" link. Set "T-Set" dial to 580 and apply single phase 6 amps B to neutral. LCB Trip Indication should remain off even though the channel connection is opened.

10. DIRECT TRANSFER TRIP will be done on the LCB Channels so test of the DTT function both of the relays and as a field test including cables and external breaker trip signal.

A. On the MD Module set the link to "OCCC-TTI" and simulate transfer trip with the DTT switch contact wired into Terminal 7 (Figure 16). Check "RFO" test point for square wave direct transfer trip signal.

B. Open DTT switch and check that "RFD" signal relays to 1700 CPS unmodulated.

11. TEST THE TRIP OUTPUT MODULE (ARTM MODULE)

A. Set all conditions to normal with the channel cable connected between transmit and receive.

B. Set T-Set" dial to 580.

C. Apply 6 amps from Phase B to neutral input. Close trip control switch.

D. "LCB-Trip-1" and "LCB-Trip-2" indicator lamps should light.

E. Remove input current and press "System Indicator Reset". The LCB Trip 1 and 2 Indicators should remain on and AR-1 Relay remain picked up. The "LCB Trip" indicator on the Relay Module should turn off.

F. Open Trip Control Switch and AR-1 should drop out but the 1 and 2 LCB Trip Lights should remain on.

G. Press "System Indicator Reset" button again and the Trip 1 and 2 Indicators should reset.

12. CHECK THE DIRECT TRANSFER TRIP MODULE.

A. With the channel set for normal and no A.C. input applied, close DTT switch (Figure 16). "DTT Key" and "DTT Trip" lights on the DTT Module come on and AR-2 Relay on ARTM-2 Module operates.

B. Close trip control switch and "DTT Trip-1" and "DTT Trip-2" come on.

C. Open DTT Switch and all indicators remain lit.

D. Push "System Indicator Reset". The DTT Trip Indicators 1 and 2 remain on. "DTT Key and Trip" Indicators turn off. AR-2 relay should stay picked up.

E. Open Trip Control Switch and push "System Indicator Reset". All indicators should turn off and AR-2 drop out.

F. To check both direct transfer trip and LCB Trip, apply single phase 6 amps B to neutral with T-Set dial at 580. "LCB Trip" Indicator should light..

G. Close DTT switch and "DTT Key and Trip" Indicators should light.

H. Press "System Indicator Reset" and "LCB Trip" Light should turn off. "DTT Key and Trip" lights stay on.

I. Remove the A.C. current and open the DTT switch. Press the "System Indicator Reset" to turn the "DTT Key and Trip" indicators off.

13. TEST EXTERNAL TARGET RESET FUNCTION OF AUXILIARY AXLM

MODULE.

A. Perform the LCB Trip and DTT Trip functions as done in Section 12. Remove the trip current and open the DTT switch and trip control switch.

B. Close the Target Reset (TR) Switch (Figure 16) and all indicators reset and remain reset after TR is opened.

14. CHECK POWER UP RETURN OF INDICATOR OF ARTM MODULE.

A. Perform LCB Trip and DTT Trips as previously done, leaving all indicators on after current is gone and trip switches are open.

B. Turn off the D.C. power Switch and the trip relays drop out and indicators turn off.

C. Turn on the D.C. power. The trip AR relays should pick up and all trip indicators return in 2.5 to 4.5 seconds.

This completes the acceptance tests that can be done using the cable connection between the input and output of a stand alone relay. The relay was calibrated at the factory, and if all of the acceptance tests could not be done, the calibration section of the book would need to be used.

FIELD SET UP AND VERIFICATION

Some field tests must be made to insure correct operation of all equipment external to the relays. For convenience, I will call the line terminal relays Relay 1 and Relay 2.

Connect the first fiber optic cable from the transmit terminal of Relay 1 to the receive terminal of Relay 2. Connect the other cable from the receive terminal of Relay 1 to the transmit terminal of Relay 2.

Since the power system is not a three terminal line, only one fiber optic channel exists and the modules for three terminal lines do not exist. Tone control options also do not exist.

The settings provided by the owner are T-SET 20, link positions are: P = P1, N = N1, Z = Z1. These are the recommended link positions for about 90% of the jobs for the positive, negative, and zero sequence links. The CTs are 1200/5 so the 20 amp pick up represents 4800 amps three phase short circuit. The 20 amp setting requires a dial setting of

982.5 which is very near to maximum capability of the relay. From the pick up points (Table 4) the sensitivities are:

3 phase fault = 20 amps
A-B or C-A fault = 0.861 (20) = 17.22 amps
B-C fault = 0.523 (20) = 10.46 amps
A-B fault = 0.117 (20) = 2.34 amps
B-N or C-N = 0.126 (20) = 2.252 amps

Theoretically, these sensitivities should provide pickup for both relays from a single end FED fault. Time to trip is about 10 to 20 ms.

Some of these values should be verified but a look at the power system would determine whether three phase or phase-to-phase fault are likely or even possible. Without knowing the thermal limits of the relays I would be hesitant about testing the higher fault currents unless it was absolutely necessary. Obviously it must be capable of handling the faults but the risks of high current testing might not be justified.

1. In addition to the pickup tests, some system verifications are needed as follows:

   A. With normal unmodulated carrier on check that the "LO" light is not on.

   B. Check the automatic gain control voltage (AGC) on the IFO Module is between -10 and - 14 volts D.C.

   C. Disconnect the receiver input cable and see that the "LO" light comes on.

2. Carrier Frequency Verification

   A. Carrier frequency is checked for 1700 CPS +/- 5 CPS at "RFO" at the MD Module, but if it needs adjusting the module must be put on the extender and the adjustment made with P1 which is not front accessible.

3. Demodulated Signal Verifying

   A. Put AC current into the relay at the remote end and check the demodulated signal at "VRI" on the MD Module at the receiving end. This should be a clean sine wave.

   B. If a distorted or separate wave is seen, the MD

Module should be put on the extender and the distortion adjusted out with P4 Pot.

4. Signal Level Equalization

   A. Leave A.C. input off at both terminals.

   B. Connect a jumper from "Set-up" Terminal on the Relay Module to "Set-up" Terminal on the MD Module on both relays.

   C. At both terminals use an A.C. Voltmeter to read "VLD" on the Relay Module and "VRIF" on the MD Module. Both should read about 3.4 volts.

   D. If necessary adjust "DM Gain" on the DM Module to make "VRIF" voltage the same as "VLD".

   (Note: For these tests J (MS) is on J1 (2 MS). Unless there is a problem, this should be the correct setting for J (MS).

5. Channel Delay Equalization Adjustment

   This test is difficult to run since it requires the protected line to be energized at one end and voltage to current transformers at each terminal to develop the A.C. current from line PTs at one end and line or bus PTs at the other. The test currents must be exactly in phase in order to adjust "VRIF" (MD Module) to exactly match "VLD" in the Relay Module.

   Since the optional UCTB test boxes have been supplied with this job, the test boxes can be used for this test. There is no drawing of the VCTB test box in the book, but indications are that they operate directly from PT voltages with the CTs disconnected from the LCB Relays.

   This test is to make sure external faults do not cause trip so this test can be made under Functional Test Procedures, IV. Current Differential Test, or VI Desensitized Trip Test. If no problem occurs here, it can be assumed channel delay is okay.