L90 Line Differential Relay: G.703 Communications Specification

Executive Summary

The purpose of this test is to verify the L90 Communication Specifications, for the G.703 Interface, with respect to; system end to end delay tolerance (balanced and asymmetrical), random error performance, phase re-lock for channel losses, and burst error performance.

The results of this experiment are as follows:

Maximum tolerated **Balanced Time Delay = 30ms** > Loop delay 62.0ms with UR settings near threshold.
Maximum tolerated **Asymmetrical Time Delay = 2ms** with UR settings near threshold.
Maximum tolerated **Random Error Rate = $8x10^{-4}$** with UR setting near threshold.
Maximum tolerated **Burst Error Performance = 1 sec @ $3x10^{-3}$**.
Average time to **Re-Lock for Channel Losses = 109 seconds**.

L90 COMMUNICATIONS TEST

Purpose:
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Definitions:
Random Error Rate: Random Error Rate (RER) is defined in units of error per bit. These errors have the same distribution as errors caused by Gaussian noise. The RER is settable from $1x10^{-0}$ to $1x10^{-9}$ error/bit. Setting the RER is generally done to achieve one of two effects:

- The desired effect is an error occurring on the average, every n bits in the error stream. The solution is to set the RER to 1/n (or as near as it can be).

  Example: We want on the average 20,000 bits between errors.
  Set RER to 1/n = 1/20,000 = $5e^{-5}$.

- It is desired to have errors occur at random intervals with a mean of T seconds between errors. The solution is to set the RER to 1/(fT) where f is the data rate in bits/sec and T is the desired time between errors in sec/error.

  Example: The data rate is $1.544x10^{6}$ bits/sec.
  We want errors to occur at approximately 3 millisecond intervals.
  Set RER to 1/(fT) = $2.159x10^{-4} \approx 2e^{-4}$.

Burst Errors: The burst error feature offers the user more control over errors than random error features do. Burst error functions allow the user to:

- Achieve lower effective random error rates than by using the Random Error Rate parameter alone.
- Generate consecutive bit errors to test effectiveness of error-correction schemes.
- Generate errors at fixed time intervals to simulate periodic error sources.
- Manually trigger errors, singly or in bursts.

The parameters for setting up burst error effects include burst length (bits or milliseconds), burst density (errors/bit), and gap length (msec). These effects are programmed separately for each channel and operate independently on each channel.

Burst Length: Burst length is measured in bits or in ms. A burst can be thought of as a "window" during which the burst error generator becomes active. The burst density parameter determines the error rate of the bits between the starting and ending bits of this 'window.' Burst length can be a constant length (fixed) or can be made to vary (random). In random burst mode, the distribution of burst lengths is geometric with the mean being the entered burst length.

Burst Density: The burst density parameter defines the random error rate during the burst error 'window.' Functionally, burst error densities operate the same as Random Error Rates, except that they are active only during bursts.

Gap Length: The gap length parameter defines the time between bursts in milliseconds. Gap length can be constant (fixed) or made to vary (random). The distribution of random gap lengths is geometric with the mean being the number entered.

Material:

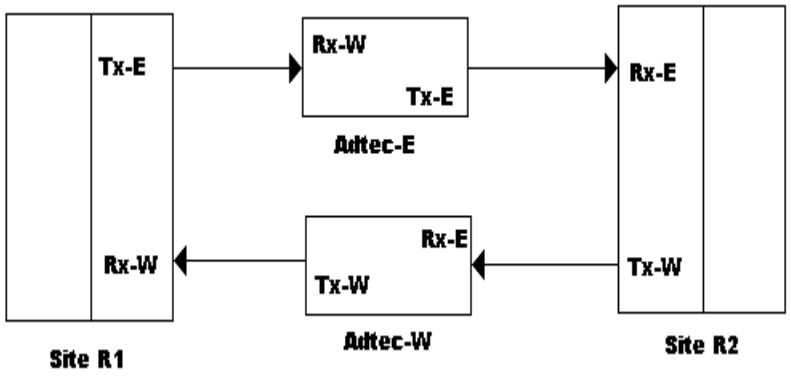
- Communication Link Simulator
- 2 UR relays equipped with the latest version of L90 firmware and G.703 comm. Modules
- 4 channel oscilloscope
- L90 Functional Test Rig equipped with Manta

Procedure:

Step 1: Configure the Communications Link Simulator (CLS) to operate the RS422 Interface. A copy of the setup is included in Appendix A.

Step 2: Setup the CLS to enable impairments in both directions via the BNC connectors located on the front of the CLS (MULTIPLEX-COMM CHANNEL ACCESS), as shown in Figure 1; thus, enabling us to test the balanced end to end delay tolerance.

Figure 1



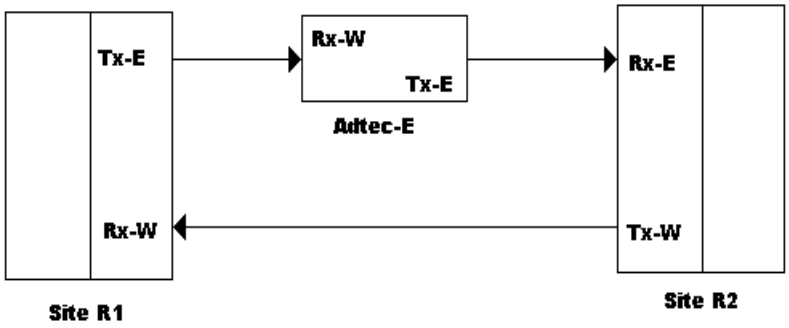
NOTE: This option enables impairments to be added to the paths R1–R2-EAST / R1–R2-WEST.

Step 3: Configure the Differential Element of the UR, so that the differential trip pickup levels are near threshold. Using the L9087L Program, we established the following settings:
For Local Relay we injected .53A
For Remote relay we injected 1.306A
A copy of the UR setup is included in Appendix B.

Step 4: Begin at 0ms delay and inject delay into the system until a differential trip is observed on the Universal Relays. Also, observe the PFLL signal to verify if the status is OK or fail. Record the results.

Step 5: Setup the CLS to enable impairments in one direction via the BNC connectors located on the front of the CLS (MULTIPLEX-COMM. CHANNEL ACCESS), as shown in Figure 2; thus, enabling us to test the asymmetrical delay tolerance.

Figure 2



NOTE: This option enables impairments to be added to the paths R1-R2-EAST but not R2-R1-WEST.

Step 6: Begin at 0ms delay and inject delay into the system until a differential trip is observed on the Universal Relays. Also, observe the PFLL signal to verify if the status is OK or fail. Record the results.

Step 7: Once again, setup the CLS to allow impairments to be added in both directions, as shown in Figure 1, to allow us to test the random error performance.

Step 8: Setup the Adtec to inject the following impairments: Random Error Rate East = $1x10e^{-6}$ and West = $1x10e^{-7}$, these values reflect normal operating conditions and should be the factory default. Next, increase the random error rate on the East channel until a differential trip is observed on the Universal Relays. Also, observe the PFLL signal to verify if the status is OK or fail. Record the results.

Step 9: To test re-lock for channel losses, add impairment, either delay or random error, until the PFLL status fails. Next remove all impairments and time how long it takes for the Relays to re-establish, status OK, PFLL. Repeat this test a few times and average the result.

Step 10: To test Burst error performance of the UR, a random error rate of $1x10e^{-4}$ in the east channel is desired for a 1-second pulse.

Settings: Set east random error rate to 0
Set east burst length to 1000F
Set east burst density to $1e^{-4}$
Set east gap length to 2500

These settings allow for 0 RER, with a burst length of 1second, a burst density of $1x10^{-4}$, with a 2.5-second delay between bursts. Also, adjust the burst length and burst density until the unit fails and record the results.

Results:

BALANCED			ASYMMETRICAL		
Time Delay		**Pass/Fail**	**Time Delay**		**Pass/Fail**
Injected Delay	**Loop Delay**		**Injected Delay**	**Loop Delay**	
10ms	21.8ms	Pass	0ms	1.7ms	Pass
15ms	31.8ms	Pass	1ms	2.7ms	Pass
20ms	41.8ms	Pass	2ms	3.6ms	Pass
25ms	52.0ms	Pass	3ms	4.8ms	Threshold/Fail
30ms	62.0ms	Threshold/Fail			

Random Error Rate

Random Error Rate	Pass/Fail
$1x10e^{-4}$	Pass
$2x10e^{-4}$	Pass
$3x10e^{-4}$	Pass
$4x10e^{-4}$	Pass
$5x10e^{-4}$	Pass
$6x10e^{-4}$	Pass
$7x10e^{-4}$	Pass
$8x10e^{-4}$	Threshold/Fail

Re-Lock for Channel Losses

Sample #	Measured Time
1	1:50 min
2	1:46 min
3	1:31 min
4	2:07 min
5	1:52 min

Burst Error Performance

Burst Length	Burst Density	Gap Length	Pass/Fail
1 sec	$1x10e^{-4}$	2.5 sec	Pass
1 sec	$2x10e^{-4}$	2.5 sec	Pass
1 sec	$3x10e^{-4}$	2.5 sec	Pass
1 sec	$4x10e^{-4}$	2.5 sec	Pass
1 sec	$5x10e^{-4}$	2.5 sec	Pass
1 sec	$6x10e^{-4}$	2.5 sec	Pass
1 sec	$7x10e^{-4}$	2.5 sec	Pass
1 sec	$8x10e^{-4}$	2.5 sec	Pass
1 sec	$9x10e^{-4}$	2.5 sec	Pass
1 sec	$1x10e^{-3}$	2.5 sec	Pass
1 sec	$2x10e^{-3}$	2.5 sec	Pass
1 sec	$3x10e^{-3}$	2.5 sec	Threshold/Fail

Conclusions:

Maximum tolerated Balanced Time Delay = 30ms > Loop delay 62.0ms with UR settings near threshold.
Maximum tolerated Asymmetrical Time Delay = 2ms with UR settings near threshold.
Maximum tolerated Random Error Rate = $8x10^{-4}$ with UR setting near threshold.
Maximum tolerated Burst Error Performance = 1 sec @ $3x10^{-3}$.
Average time to Re-Lock for Channel Losses = 109 seconds.

Appendix A

CLS Settings

Port Assignments

Port Overview

```
Bayly Communications Inc.                                    Omniplexer

                    RACS II [CLS] Current Configuration

Local Port Data Rate = 9600 baud, Password = GEM

          Port Number      Port Name      Module Type      Connection

          E1/T1            E1/T1          E1/T1 IM         fixed
          Exp.             Expand          - - -           fixed
          1                R1Voice        4W               logon
          2                R1G703         G703             logon
          3                R1RS422        RS422            logon
          4                R2Voice        4W               logon
          5                R2G703W        G703W            logon
          6                R2RS422W       RS422W           logon
          7                R3VOice        4W               logon
          8                R3G703         G703             logon
          9                R3RS422        RS422            logon

Press any key to continue....
```

Port 1

```
          4 Channel TCM Current Configuration

The E-Lead Status is Normal, & all Channels are Transmitting East.

          Channel A                          Channel B

          Channel =          07              Channel =          11
          Loopback =         Off             Loopback =         Off
          Rx Level =         0.0             Rx Level =         0.0
          Tx Level =         0.0             Tx Level =         0.0
          Signalling Type =  5               Signalling Type =  5
          Interface Type =   4-W             Interface Type =   4-W

          Channel C                          Channel D

          Channel =          Disabled        Channel =          08
          Loopback =         Off             Loopback =         Off
          Rx Level =         0.0             Rx Level =         0.0
          Tx Level =         0.0             Tx Level =         0.0
          Signalling Type =  5               Signalling Type =  5
          Interface Type =   4-W             Interface Type =   4-W

Press any key to continue...
```

Port 2

```
Bayly Communications Inc.

            64 kBits DCM [CODIRECTIONAL] Current Configuration

All Channels are Transmitting East

       Channel A                              Channel B

       Channel =          04                  Channel =          12
       Loopback =         Off                 Loopback =         Off
       Timing Status =    xx                  Timing Status =    xx

       Channel C                              Channel D

       Channel =          Disabled            Channel =          05
       Loopback =         Off                 Loopback =         Off
       Timing Status =    xx                  Timing Status =    xx

Press any key to continue...._
```

Port 3

```
Bayly Communications Inc.

              NX56/64 kBits DCM [RS-422] Current Configuration

All Channels are Transmitting East

    Channel A           Channel B           Channel C           Channel D

Oper. Mode = NX64   Oper. Mode = NX64   Oper. Mode = NX56   Oper. Mode = NX64
Start Ch.  = 01     Start Ch.  = 10     Start Ch.  = Dis.   Start Ch.  = 02
Value of N = 01     Value of N = 01     Value of N = 01     Value of N = 01
Loopback   = Off    Loopback   = Off    Loopback   = Off    Loopback   = Off
Clock      = Int.   Clock      = Int.   Clock      = Int.   Clock      = Int.
Timing     = OK     Timing     = OK     Timing     = OK     Timing     = OK




Press any key to continue....
```

Port 4

```
              4 Channel TCM Current Configuration

The E-Lead Status is Normal, & all Channels are Transmitting West.

         Channel A                          Channel B

         Channel =          07              Channel =          11
         Loopback =         Off             Loopback =         Off
         Rx Level =         0.0             Rx Level =         0.0
         Tx Level =         0.0             Tx Level =         0.0
         Signalling Type =  5               Signalling Type =  5
         Interface Type =   4-W             Interface Type =   4-W

         Channel C                          Channel D

         Channel =          09              Channel =          Disabled
         Loopback =         Off             Loopback =         Off
         Rx Level =         0.0             Rx Level =         0.0
         Tx Level =         0.0             Tx Level =         0.0
         Signalling Type =  5               Signalling Type =  5
         Interface Type =   4-W             Interface Type =   4-W

Press any key to continue...
```

Port 5

```
Bayly Communications Inc.

            64 kBits DCM [CODIRECTIONAL] Current Configuration

All Channels are Transmitting West

       Channel A                          Channel B

       Channel =          04              Channel =          12
       Loopback =         Off             Loopback =         Off
       Timing Status =    xx              Timing Status =    xx

       Channel C                          Channel D

       Channel =          Disabled        Channel =          Disabled
       Loopback =         Off             Loopback =         Off
       Timing Status =    xx              Timing Status =    xx

Press any key to continue....
```

Port 6

```
Bayly Communications Inc.

          NX56/64 kBits DCM [RS-422] Current Configuration

All Channels are Transmitting West

    Channel A           Channel B           Channel C           Channel D

Oper. Mode = NX64   Oper. Mode = NX64   Oper. Mode = NX56   Oper. Mode = NX56
Start Ch.  = 01     Start Ch.  = 10     Start Ch.  = Dis.   Start Ch.  = Dis.
Value of N = 01     Value of N = 01     Value of N = 01     Value of N = 01
Loopback   = Off    Loopback   = Remote Loopback   = Off    Loopback   = Off
Clock      = Int.   Clock      = Int.   Clock      = Int.   Clock      = Int.
Timing     = OK     Timing     = OK     Timing     = OK     Timing     = OK




Press any key to continue...._
```

Port 7

```
               4 Channel TCM Current Configuration

The E-Lead Status is Normal, & all Channels are Transmitting West.

          Channel A                          Channel B

          Channel =          Disabled        Channel =          11
          Loopback =         Off             Loopback =         Off
          Rx Level =         0.0             Rx Level =         0.0
          Tx Level =         0.0             Tx Level =         0.0
          Signalling Type =  5               Signalling Type =  5
          Interface Type =   4-W             Interface Type =   4-W

          Channel C                          Channel D

          Channel =          09              Channel =          08
          Loopback =         Off             Loopback =         Remote
          Rx Level =         0.0             Rx Level =         0.0
          Tx Level =         0.0             Tx Level =         0.0
          Signalling Type =  5               Signalling Type =  5
          Interface Type =   4-W             Interface Type =   4-W

Press any key to continue...
```

Port 8

```
Bayly Communications Inc.

            64 kBits DCM [CODIRECTIONAL] Current Configuration

All Channels are Transmitting West

       Channel A                              Channel B

       Channel =          Disabled            Channel =          12
       Loopback =         Off                 Loopback =         Off
       Timing Status =    xx                  Timing Status =    xx

       Channel C                              Channel D

       Channel =          06                  Channel =          05
       Loopback =         Off                 Loopback =         Off
       Timing Status =    xx                  Timing Status =    xx

Press any key to continue....
```

Port 9

```
Bayly Communications Inc.

              NX56/64 kBits DCM [RS-422] Current Configuration

All Channels are Transmitting West

    Channel A          Channel B          Channel C          Channel D

Oper. Mode = NX56  Oper. Mode = NX64  Oper. Mode = NX64  Oper. Mode = NX64
Start Ch.  = Dis.  Start Ch.  = 10    Start Ch.  = 03    Start Ch.  = 02
Value of N = 01    Value of N = 01    Value of N = 01    Value of N = 01
Loopback   = Off   Loopback   = Off   Loopback   = Off   Loopback   = Off
Clock      = Int.  Clock      = Int.  Clock      = Int.  Clock      = Int.
Timing     = OK    Timing     = OK    Timing     = OK    Timing     = OK




Press any key to continue....
```

Appendix B

UR Settings

Current Differential

Current Differential // Settings List: C:...

SETTING	PARAMETER
Function	Enabled
Tap	1.0
Phase Pickup	0.20 A
Ground Pickup	4.00 A
Phase Restraint1	30 %
Phase Restraint2	50 %
Phase Breakpoint	1.0
Ground Restraint1	30 %
Ground Restraint2	50 %
Ground Breakpoint	1.0
Key DTT	Disabled
Ext Key DTT	OFF
Target	Self-reset
Events	Disabled

Current Sensing

Current Sensing // Settin...

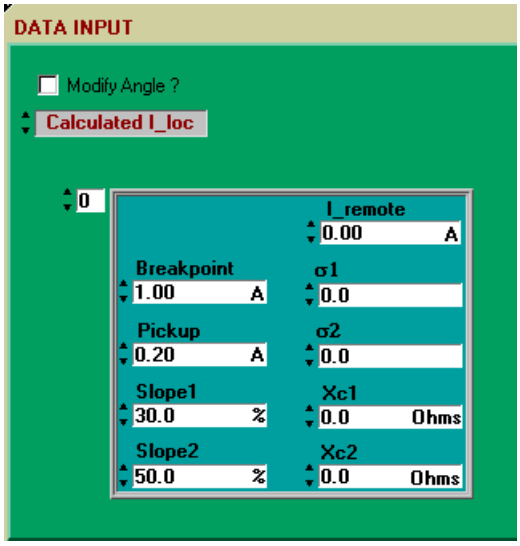
SETTING	PARAMETER
Phase CT Primary	5 A
Phase CT Secondary	5 A
Ground CT Primary	5 A
Ground CT Secondary	5 A

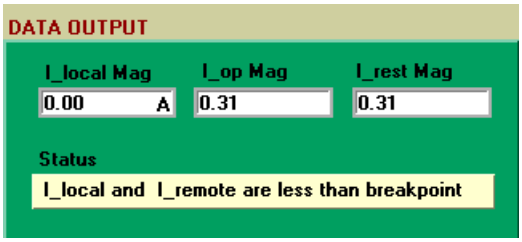
Voltage Sensing

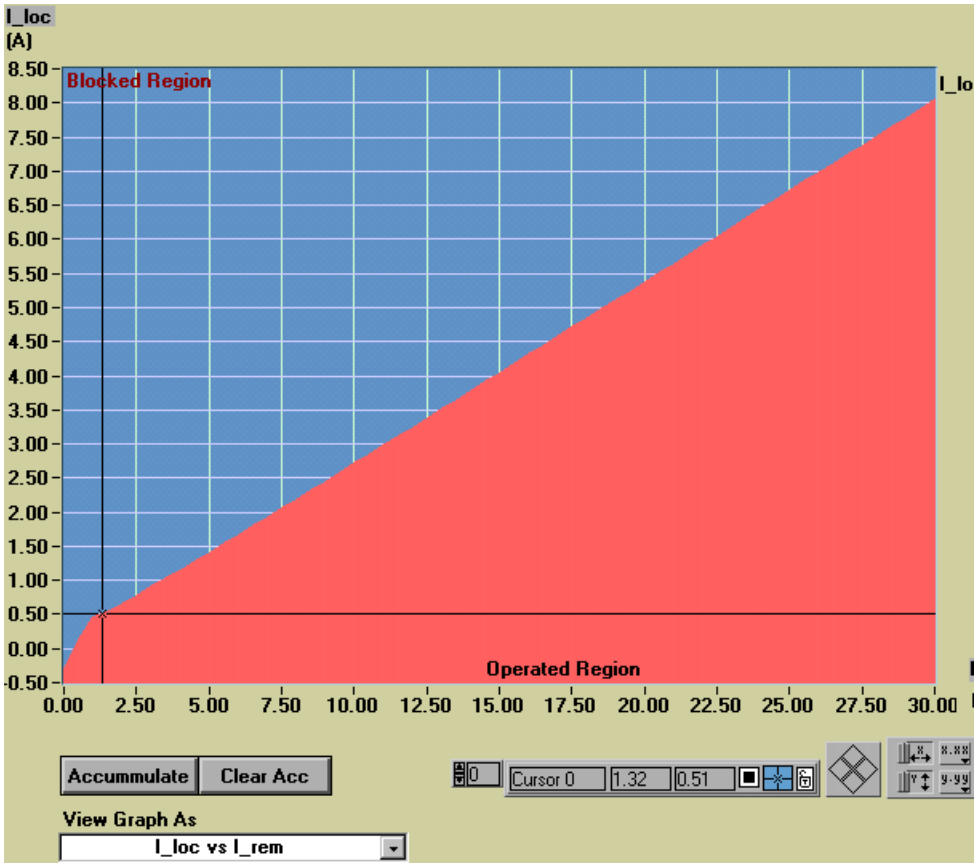
Voltage Sensing // Settings List: C...

SETTING	PARAMETER
VT Connection Type	None
Nominal VT Secondary Voltage	120.0 V
VT Ratio	120.0 :1

L9087L


DATA INPUT
Modify Angle ?
Calculated I_loc
0
I_remote
0.00 A
Breakpoint
1.00 A
σ1
0.0
Pickup
0.20 A
σ2
0.0
Slope1
30.0 %
Xc1
0.0 Ohms
Slope2
50.0 %
Xc2
0.0 Ohms


DATA OUTPUT
I_local Mag
0.00 A
I_op Mag
0.31
I_rest Mag
0.31
Status
I_local and I_remote are less than breakpoint


I_loc
(A)
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
Blocked Region
Operated Region
0.00
2.50
5.00
7.50
10.00
12.50
15.00
17.50
20.00
22.50
25.00
27.50
30.00
Accumulate
Clear Acc
Cursor 0
1.32
0.51
View Graph As
I_loc vs I_rem

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