

Introduction

This document outlines the usage cases for the error-injection capabilities of the LIN Tester. In order to test the robustness of a LIN implementation and the conformance to the LIN specification, it is essential that the LIN setup is tested with a controlled, programmable error injection to verify a correct node implementation.

All errors defined within the LIN specification document can be generated and detected using the Agilent LIN tester.

Agilent LIN Tester software

The Agilent LIN Tester software allows the user to control the J8115A LIN Tester in a basic and advanced emulation mode.

The advanced emulation capabilities of the Agilent LIN Tester make it possible to create real-time behavior in the LIN Tester's node emulation. This includes modification of emulated signals, switching of schedule tables in real-time, and the introduction of errors in the LIN communication (e.g. incorrectly calculated checksum bytes). The user describes the functionality in a separate control file, the LIN Emulation Control file (LEC file).

This capability is critical to make sure that thorough conformance testing of a LIN network or node can be performed. This application note demonstrates how the J8115A LIN Tester can be used to insert different errors to test LIN networks for robustness.

Set transfer parameters

Using the advanced emulation capabilities of the LIN Tester it is possible to inject errors in a frame by setting the number of different transfer parameters in the LEC file.

The parameters listed in the section below describe the different errors that the LIN Tester can produce, and also how the LIN Tester detects the caused errors.

The intention of this reference is to understand which requirements can be tested by using error-injection in the LIN Tester.

Errors detected

The LIN Tester can detect the following errors:

ECS	Checksum Error	Wrong checksum
EFR	Byte Framing Error	Stop bit not detected
ENA	No Answer	No response on header of a frame
ESA	Short Answer	Less bytes received than expected
E55	Synchronization byte Error	Synch byte is not 0x55
EID	Frame ID Error	An ID that is not found in the LDF
ETB	Break High Time Error	Wrong Break delimiter time
ETH	Header Time Error	Header time too long
ETF	Frame Time Error	Frame too long
EUB	Unidentified Byte(s)	Byte received that was not expected
IDL	Bus Idle Time-out	No communication detected
BNZ	Bus Error	Physical bus error (e.g. shortcut to ground)

These errors are detected and can be used in the trigger of the LIN Tester software. These are shown as errors in the trace window in the error code column.

Understanding the LIN Frame

The LIN Frame consists of four key elements:

- Synch Break – The Synch Break is used to identify the beginning of a packet.
- Synch Field – The Synch Field is used for clock synchronization.
- Identifier Field – The Identifier Field is sent by the master node to all LIN nodes and contains one of 64 different values and 2 parity bits in the 8 bit data. The identifier is normally associated with a collection of signals that are subsequently transmitted on the LIN bus.
- Data Field / Message response – The Data Field response is either sent out by the master or by one of the slaves.

Figure 1 shows a sample LIN Frame taken by an oscilloscope with 4 Data Bytes and a checksum at the end. To illustrate the byte boundaries, different colors per byte are used.

Depending on the role as master or slave a different list of errors can be inserted. The master always issues the synch break, the synch byte and the ID. The following data bytes can either be inserted from a slave on the bus (that is responsible to fulfill this ID) or by the slave node within the master itself.

The master also controls the schedule and possible alternative schedules. All schedule related tests have to be performed by the master node.

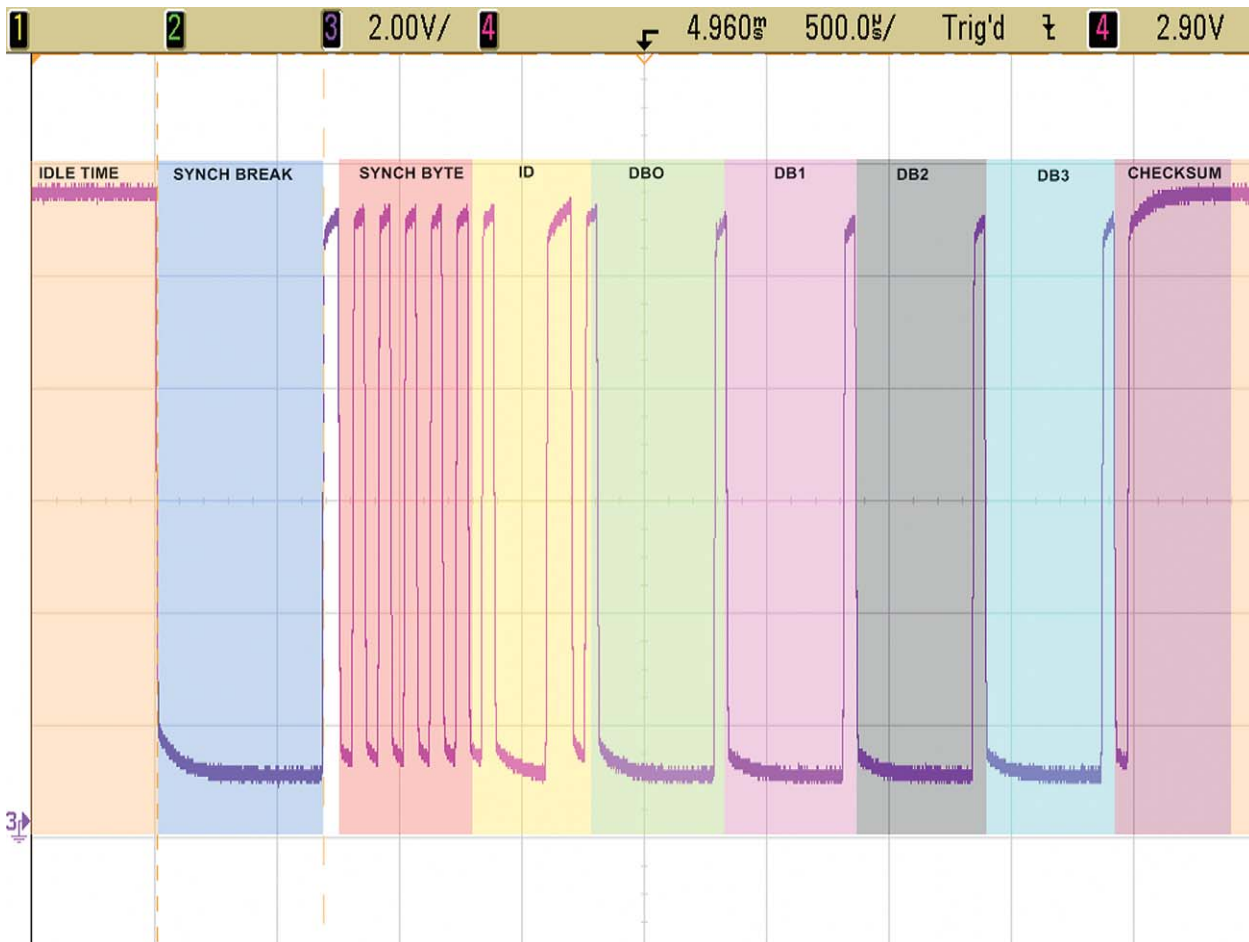


Figure 1.

Master only errors

The following list of error codes demonstrates the capability of the J8115A LIN Tester to insert errors and test the robustness of a LIN communication network.

SET_BREAK_DOMINANT_TIME

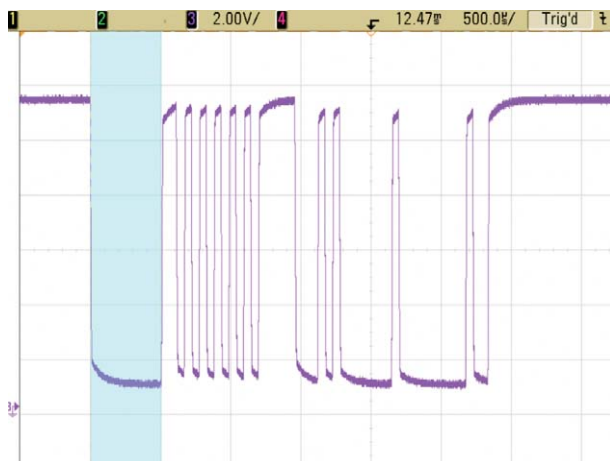
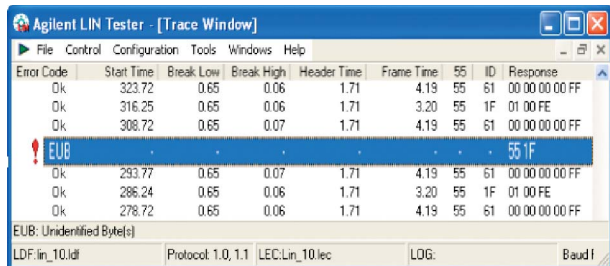
With this command, you can set the break dominant time (Break Low) through the LEC.

```
Set_Transfer_Param (Frame_name, SET_BREAK_DOMINANT_TIME, ); //time in ms (d.dd)
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Header) Set Break Dominant Time and the line above will be inserted with the appropriate frame name to the text. Write the time (in ms) you would like to set, as the last parameter (after the last comma).

The break dominant time will be rounded to 10 microseconds resolution. If the set parameter is too low, you will see the EUB Error Code in the trace window, if too high, the ETH and EUB or if more high the E55 error code.

The results are shown as an oscilloscope capture along with



SET_BREAK_DOMINANT_TIME

corresponding trace window display from LIN Tester. This continues throughout the application note.

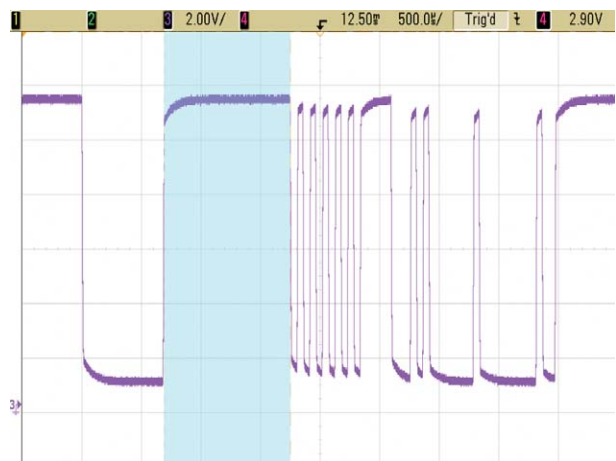
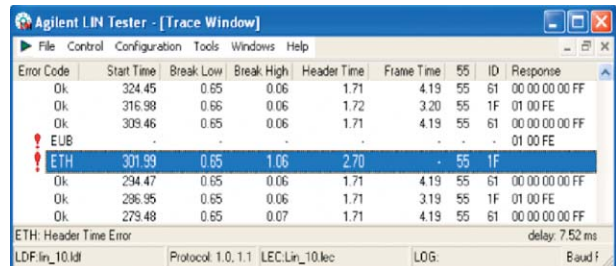
SET_BREAK_DELIMITER_TIME

With this command, you can set the break delimiter time (Break High) through the LEC.

```
Set_Transfer_Param (Frame_name, SET_BREAK_DELIMITER_TIME, ); //time in ms (d.dd)
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and select Set Transfer Param (Header) Set Break Delimiter Time and the line above will be inserted with the appropriate frame name to the text. Write the time (in ms) you would like to set, as the last parameter (after the last comma).

The break delimiter time will be rounded to bit time resolution according to the actual Baud rate.



SET_BREAK_DELIMITER_TIME

Master only errors

SET_HEADER_INTERBYTE_TIME

With this command, you can set the header interbyte time through the LEC.

```
Set_Transfer_Param(Frame_name, SET_HEADER_INTERBYTE_TIME, ); //time in ms (d.dd)
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Header) Set Header Interbyte Time and the line above will be inserted with the appropriate frame name to the text. Write the time (in ms) you would like to set, as the last parameter (after the last comma).

The header interbyte time will be rounded to bit time resolution according to the actual Baud rate.

If the set parameter is too high, you will see the ETH and EUB or if more high the EID Error Code in the Trace window.

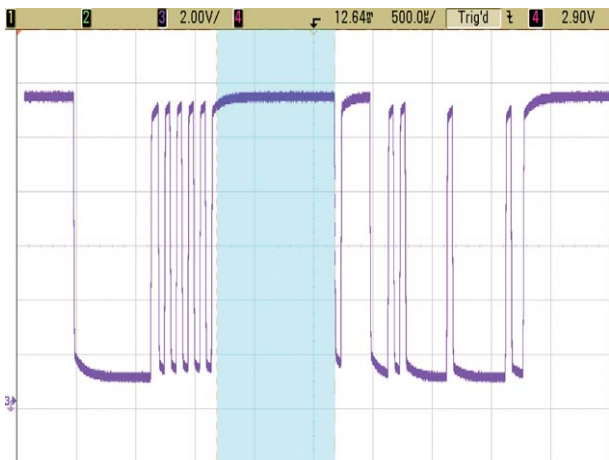
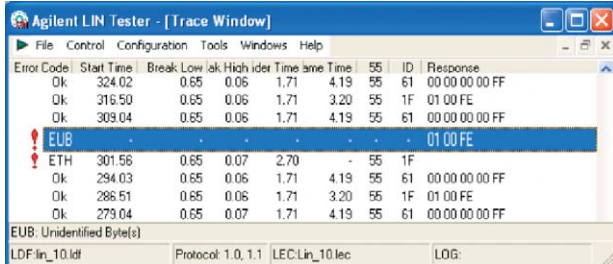
CHANGE_SYNCHRON_BYTE

With this command, you can set the synchron byte (Sync Field) value through the LEC.

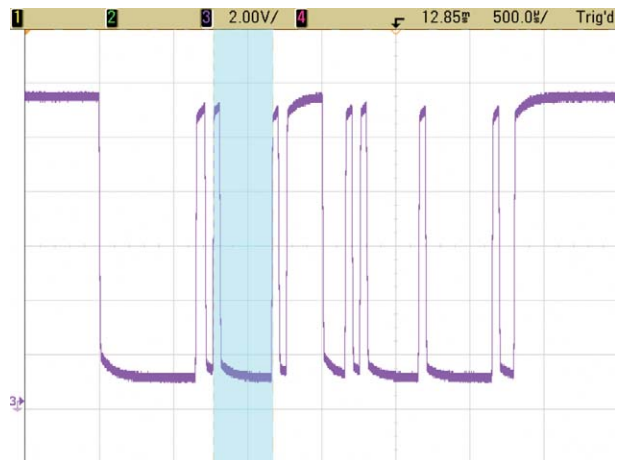
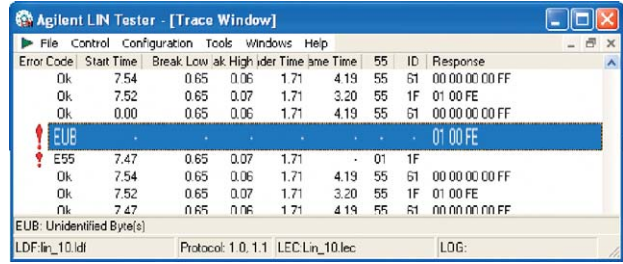
```
Set_Transfer_Param(Frame Name, CHANGE_SYNCHRON_BYTE, ); //new value of byte
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Header) Change Synchron Byte and the line above will be inserted with the appropriate frame name to the text. Write the new synchron byte value you would like to set, as the last parameter (after the last comma).

If the Synchron byte is not equal with 55, you will be see the E55 and EUB Error Code in the Trace window.



SET_HEADER_INTERBYTE_TIME



CHANGE_SYNCHRON_BYTE

Master only errors

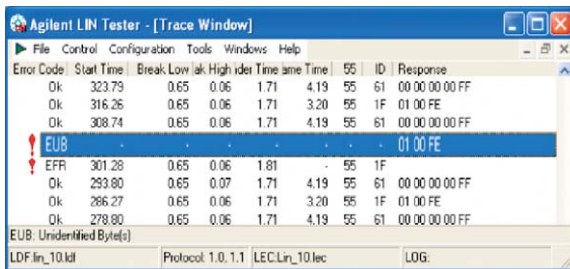
FRAMING_ERROR_SYNCHRON

This command will cause a framing error, by sending a wrong stop bit in the synchron byte.

```
Set_Transfer_Param(Frame_name, FRAMING_ERROR_SYNCHRON, 0); //no parameter
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Header) Framing Error Synchron Byte and the line above will be inserted with the appropriate frame name to the text.

You will see the EFR and EUB Error Codes in the Trace window.



FRAMING_ERROR_SYNCHRON

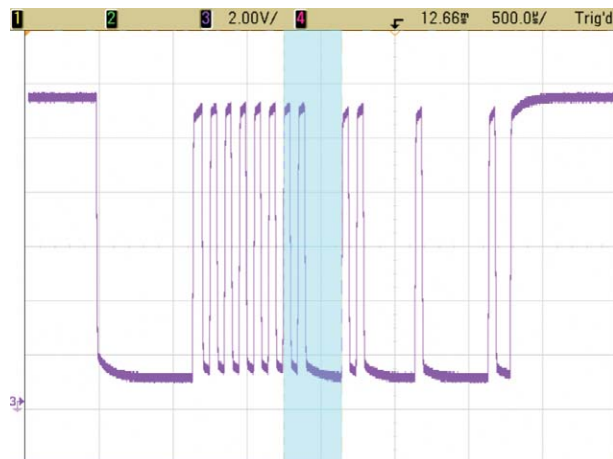
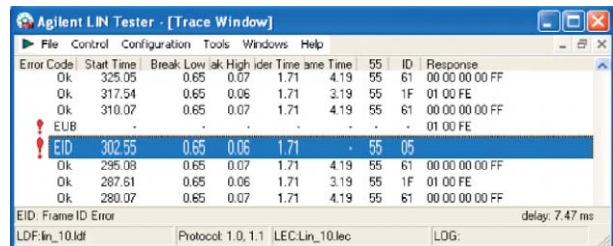
CHANGE_ID_BYTE

With this command, you can set the ID byte (Ident Field) value through the LEC.

```
Set_Transfer_Param(Frame_name, CHANGE_ID_BYTE, ); //new value of byte
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Header) Change ID Byte. The line above will be inserted with the appropriate frame name to the text. Write the new ID byte value, you would like to set, as the last parameter (after the last comma).

If the ID is not appropriate, you will be see the EID and EUB Error Codes in the Trace window.



CHANGE_ID_BYTE

Master only errors

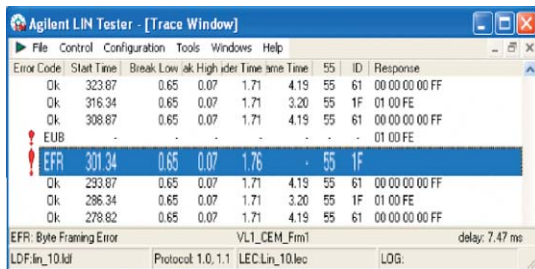
FRAMING_ERROR_ID

This command causes a framing error; in fact send a wrong stop bit in the ID byte.

Set_Transfer_Param (Frame_name, FRAMING_ERROR_ID, 0); //no parameter

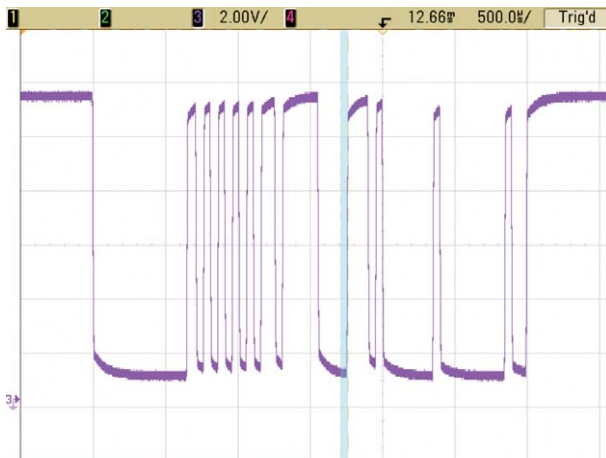
Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Header) Framing Error ID. The line above will be inserted with the appropriate frame name to the text.

You will see the EFR and EUB Error Codes in the Trace window.



The screenshot shows the 'Agilent LIN Tester - [Trace Window]' interface. It features a menu bar (File, Control, Configuration, Tools, Windows, Help) and a table of error logs. The table has columns for Error Code, Start Time, Break, Low ak, High ider, Time, Time, SS, ID, and Response. The error log shows several 'Ok' entries followed by an 'EUB' (Byte Framing Error) entry at 301.34, which is highlighted in blue. Below the table, there is a status bar with the text 'EFR: Byte Framing Error', 'VL1_CEM_Frm1', 'delay: 7.47 ms', 'LDF:lin_10.kdf', 'Protocol: 1.0.1.1', 'LEC:Lin_10.lec', and 'LOG:'.

Error Code	Start Time	Break	Low ak	High ider	Time	Time	SS	ID	Response
Ok	323.87	0.65	0.07	1.71	4.19	55	61	00 00 00 00 FF	
Ok	316.34	0.65	0.07	1.71	3.20	55	1F	01 00 FE	
Ok	308.87	0.65	0.07	1.71	4.19	55	61	00 00 00 00 FF	
EUB	301.34	0.65	0.07	1.76	-	55	1F	-	01 00 FE
Ok	293.87	0.65	0.07	1.71	4.19	55	61	00 00 00 00 FF	
Ok	286.34	0.65	0.07	1.71	3.20	55	1F	01 00 FE	
Ok	278.82	0.65	0.07	1.71	4.19	55	61	00 00 00 00 FF	



FRAMING_ERROR_ID

Master and Slave errors

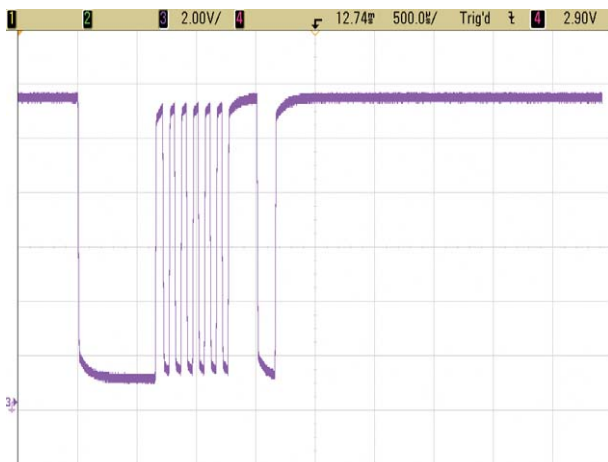
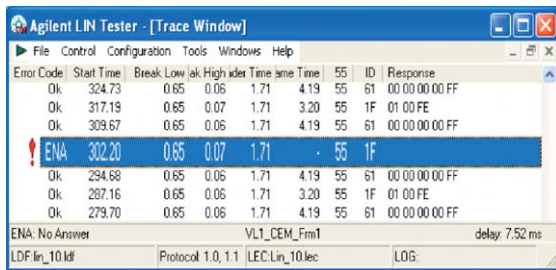
SEND_NO_ANSWER

This command sends no answer with the frame.

```
Set_Transfer_Param (Frame_name, SEND_NO_ANSWER, 0);
//no parameter
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Send No Answer and the line above will be inserted with the appropriate frame name to the text.

You will see the ENA Error Code in the Trace window.



SEND_NO_ANSWER

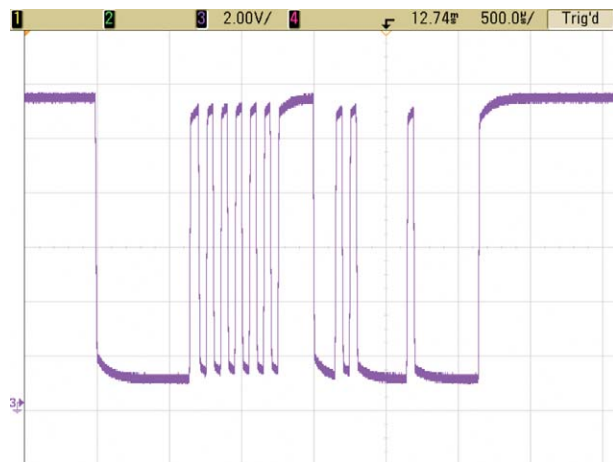
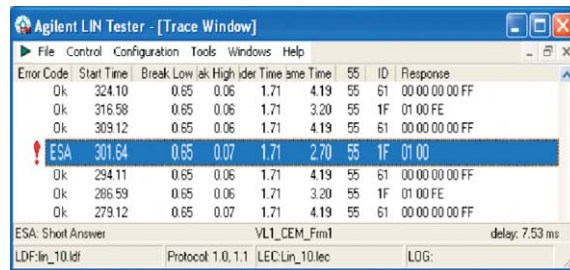
SEND_NO_CHECKSUM

This command sends no checksum with the frame.

```
Set_Transfer_Param(Frame_name, SEND_NO_CHKSUM, 0);
//no parameter
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Send No Checksum and the line above will be inserted with the appropriate frame name to the text.

You will see the ESA Error Code in the Trace window.



SEND_NO_CHECKSUM

Master and Slave errors

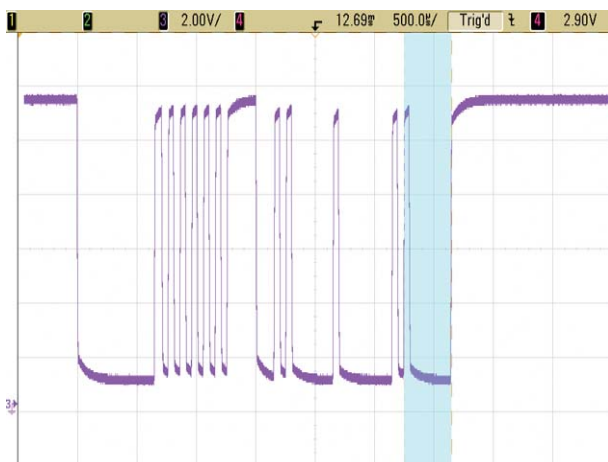
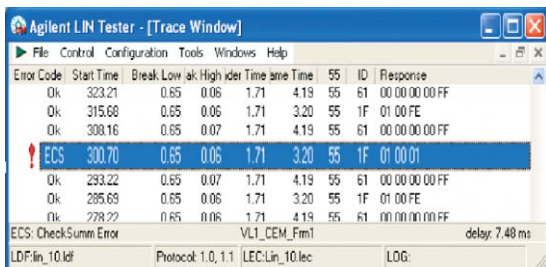
SEND_WRONG_CHKSUM

This command sends wrong checksum with the frame.

```
Set_Transfer_Param(Frame_name, SEND_WRONG_CHKSUM, 0); //no parameter
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Send Wrong Checksum and the line above will be inserted with the appropriate frame name to the text.

You will see the ECS Error Code in the Trace window.



SEND_WRONG_CHKSUM

SEND_EXTRA_BYTE

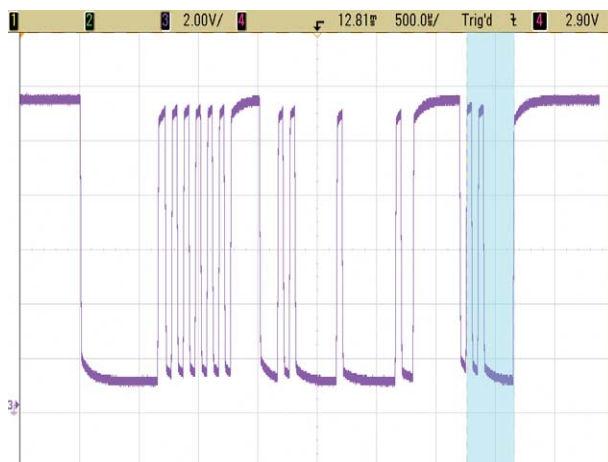
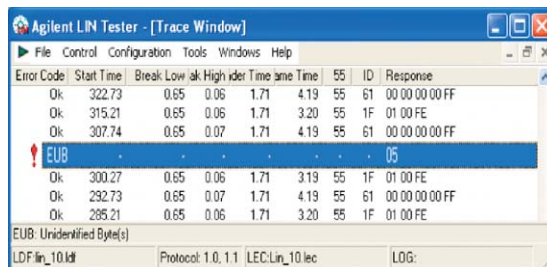
This command sends extra byte with the frame.

```
Set_Transfer_Param(Frame_name, SEND_EXTRA_BYTE, ); // value of byte
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Send Extra Byte and the line above will be inserted with the appropriate frame name to the text.

Write the new byte value you would like to set, as the last parameter (after the last comma).

You will see the EUB Error Code in the Trace window.



SEND_EXTRA_BYTE

Master and Slave errors

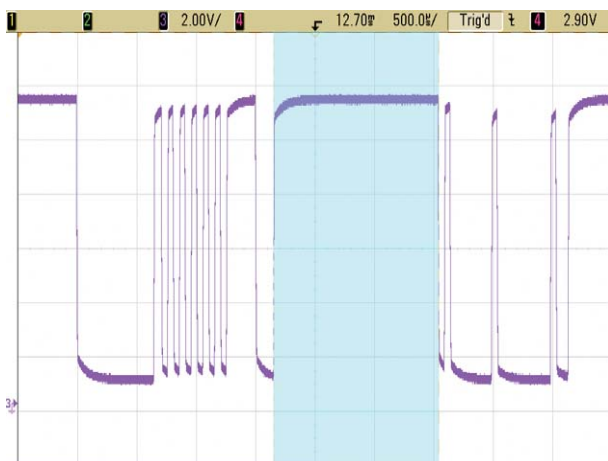
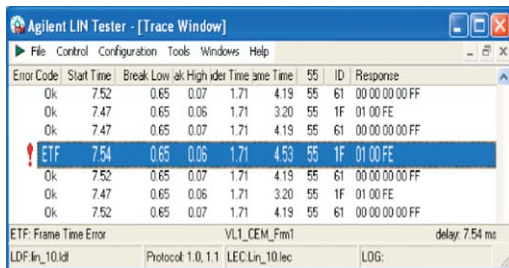
SET_INFRAME_RESPONSE_TIME

With this command, you can influence the Inframe response time (Inframe Response Space) time through the LEC.

```
Set_Transfer_Param(Frame_name, SET_INFRAME_RESPONSE_TIME, ); //time in ms (d.dd)
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Set Inframe Response Time and the line above will be inserted with the appropriate frame name to the text. Write the time (in ms) you would like to set, as the last parameter (after the last comma).

If the set time is too high you will see one of the following Error Codes in the Trace window: ETF, ESA, ENA, depending on the length of the Inframe response time.



SET_INFRAME_RESPONSE_TIME

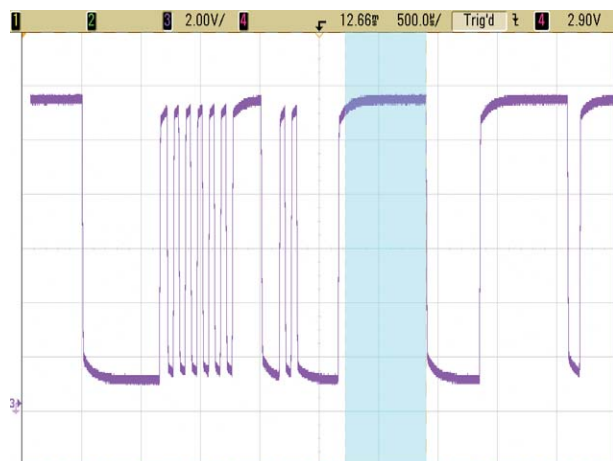
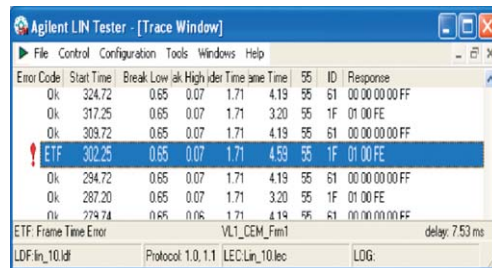
SET_SLAVE_INTERBYTE_TIME

With this command, you can set the response interbyte time through the LEC.

```
Set_Transfer_Param(Frame_name, SET_SLAVE_INTERBYTE_TIME, ); //time in ms (d.dd)
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Set Slave Interbyte Time and the line above will be inserted with the appropriate frame name to the text. Write the time (in ms) you would like to set, as the last parameter (after the last comma).

If the set parameter is too high, you will see the ETF or ESA Error Code in the Trace window, depends on the length of the response interbyte time.



SET_SLAVE_INTERBYTE_TIME

Master and Slave errors

FRAMING_ERROR_FIRSTBYTE

This command causes a framing error in the first response byte; in fact send a wrong stop bit in the first byte.

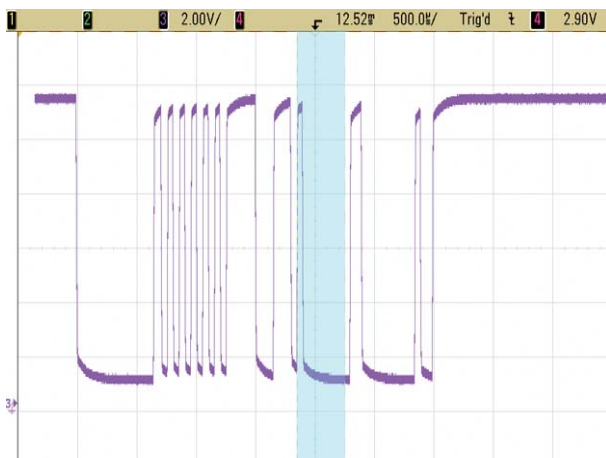
```
Set_Transfer_Param(Frame_name, FRAMING_ERROR_
FIRSTBYTE, 0); //no parameter
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Framing Error First Response Time and the line above will be inserted with the appropriate frame name to the text.

You will see the EFR Error Code in the Trace window.

Error Code	Start Time	Break	Low	ak	High	Id	Time	ame	Time	55	ID	Response
Ok	323.07	0.65	0.07	1.71	4.19	55	61	00	00	00	00	FF
Ok	315.54	0.65	0.07	1.71	3.20	55	1F	01	00	FE		
Ok	308.02	0.65	0.07	1.71	4.19	55	61	00	00	00	00	FF
EFR	300.56	0.65	0.06	1.71	3.40	55	1F	01	00	FE		
Ok	293.08	0.65	0.07	1.71	4.19	55	61	00	00	00	00	FF
Ok	285.55	0.65	0.06	1.71	3.20	55	1F	01	00	FE		
Ok	278.03	0.65	0.06	1.71	4.19	55	61	00	00	00	00	FF

EFR: Byte Framing Error VLI_CEM_Fim1 delay: 7.48 ms
LDF: lin_10.kid Protocol: 1.0,1.1 LEC:Lin_10.lec LOG:



FRAMING_ERROR_FIRSTBYTE

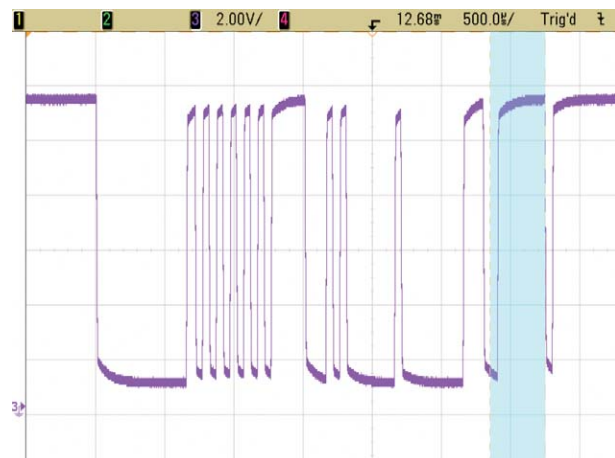
FRAMING_ERROR_LASTBYTE

This command causes a framing error in the last response byte.

The LIN Tester reports the EFR error code. [LIN Protocol Specification revision 2.0: 4.2.2 Frame processor] and [LIN Protocol Specification revision 2.0: 6 Status Management]

Error Code	Start Time	Break	Low	ak	High	Id	Time	ame	Time	55	ID	Response
Ok	323.08	0.65	0.06	1.71	4.19	55	61	00	00	00	00	FF
Ok	316.15	0.65	0.07	1.71	3.20	55	1F	01	00	FE		
Ok	308.63	0.65	0.06	1.71	4.19	55	61	00	00	00	00	FF
EFR	301.16	0.65	0.06	1.71	3.30	55	1F	01	00	FE		
Ok	293.64	0.65	0.06	1.71	4.19	55	61	00	00	00	00	FF
Ok	286.18	0.65	0.06	1.71	3.19	55	1F	01	00	FE		
Ok	278.65	0.65	0.07	1.71	4.19	55	61	00	00	00	00	FF

EFR: Byte Framing Error VLI_CEM_Fim1 delay: 7.52 ms
LDF: lin_10.kid Protocol: 1.0,1.1 LEC:Lin_10.lec LOG:



FRAMING_ERROR_LASTBYTE

Master and Slave errors

CHANGE_TRANSFER_SPEED

With this command, you can set the speed of the response through the LEC.

```
Set_Transfer_Param(Frame_name, CHANGE_TRANSFER_SPEED, ); //new speed in kbps (dd.ddd)
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Change Transfer Speed and the line above will be inserted with the appropriate frame name to the text.

Write the speed (in kbps) you would like to set, as the last parameter (after the last comma).

The minimum speed is 5 kbps and the maximum is 20.161 kbps.

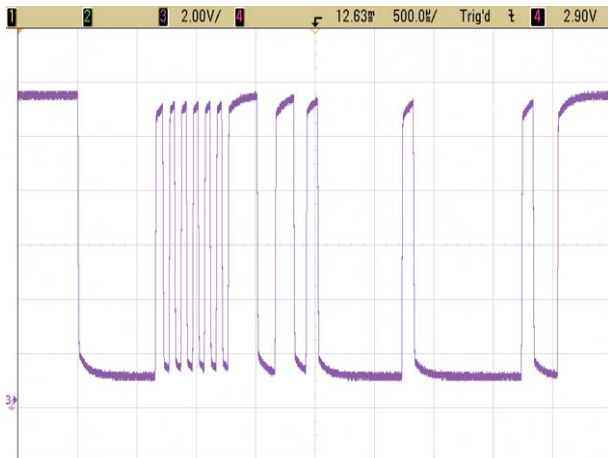
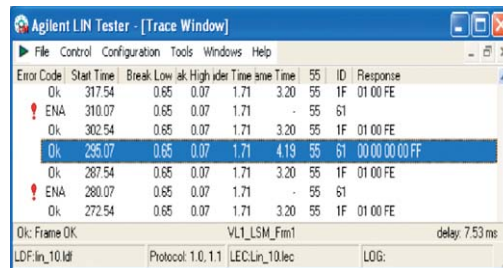
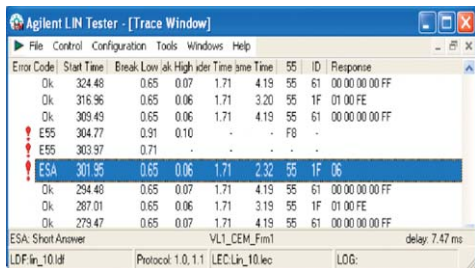
You will see errors in the Trace window, if the difference between the set transfer speed and the baud rate is more than approximately 5%.

SEND_ANSWER

This command sends an answer to the frame (defined by Frame_name). This command has importance, if the slave node, which has to respond to the frame, is not emulated.

```
Set_Transfer_Param(Frame_name, SEND_ANSWER, 0);  
//no parameter
```

Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Response) Send Answer and the line above will be inserted with the appropriate frame name to the text.



SEND_ANSWER

CHANGE_TRANSFER_SPEED

Master and Slave errors

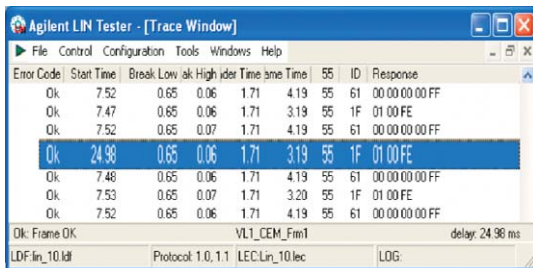
SET_FRAME_DELAY

With this command, you can set the Frame Delay time through the LEC.

```
Set_Transfer_Param(Frame_name, SET_FRAME_DELAY,20 );  
//delay in timebase
```

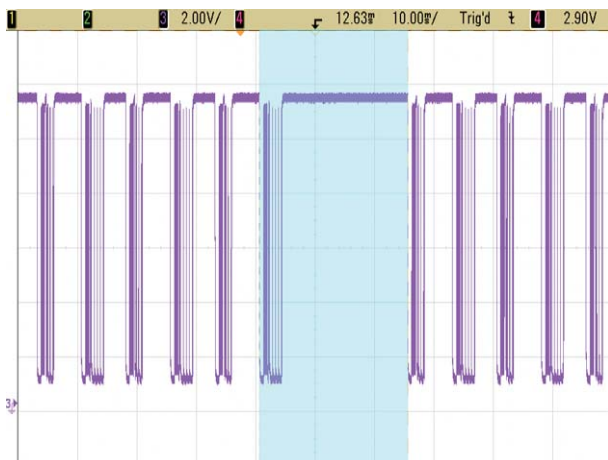
Use the pop-up menu in the LEC Editor Nodes-Frames-Signals section by right click on the frame, which behavior you would like to affect, and choose Set Transfer Param (Header) Set Delay and the line above will be inserted with the appropriate frame name to the text. Write the time (in timebase, defined in the LDF file, under the Node definition in the Master sub-class) you would like to set, as the last parameter (after the last comma).

If the frame becomes too short because of the set parameter, you will see the ESA Error Code in the Trace window, if it is too long, and the Bus IdleTimeOut is elapsed, the IDL error code appears in the Trace window.



Error Code	Start Time	Break	Low	ak	High	Idle	Time	Time	SS	ID	Response
Ok	7.52	0.65	0.06	1.71	4.19	55	61	00 00 00 00 FF			
Ok	7.47	0.65	0.06	1.71	3.19	55	1F	01 00 FE			
Ok	7.52	0.65	0.07	1.71	4.19	55	61	00 00 00 00 FF			
Ok	24.98	0.65	0.06	1.71	3.19	55	1F	01 00 FE			
Ok	7.48	0.65	0.06	1.71	4.19	55	61	00 00 00 00 FF			
Ok	7.53	0.65	0.07	1.71	3.20	55	1F	01 00 FE			
Ok	7.52	0.65	0.06	1.71	4.19	55	61	00 00 00 00 FF			

Ok: Frame OK
LDF:in_10.kdf Protocol: 1.0, 1.1 LEC:Lin_10.lec LOG: delay: 24.98 ms



SET_FRAME_DELAY

Summary

This extensive and detailed list shows how the user can use the LIN Tester to check the robustness of his LIN network / node implementation against various failures.

The error injection capabilities are very powerful and allow controlling most of the relevant parameters of the LIN protocol.

Related literature

Publication title	Publication type	Publication number
J8120A VPT 501	Data Sheet	5989-6818EN
J8115A LIN Tester	Data Sheet	5989-6817EN

Product Web site

For the most up-to-date and complete application and product information, please visit our product Web site at: www.agilent.com/find/automotive-network

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