Introduction

This application note describes how to use LIN controllers of various Renesas microcontroller products.

Several different LIN controller types are available; so this application note is collecting frequently asked questions and hot topics for all of them. By using the index, the user may locate the answers in one or several chapters. Nevertheless, the content of this application note does not make any claim to be complete.

Due to this, the application note may be updated without further notice in shorter time intervals. Proposals for improvement are always highly welcome.

Target Device

earlier series:
V850/FK3:
V850/Xx4:
RL78/X1x:
RH850/X1x:

UART types A-D
LIN Controller types
LIN Controller types
LIN Controller types

Figure 1.1 State of the art LIN Controller RLIN3

Note: Subsequent pages may be partly blank or have interleaved chapter numbering. This is by intention, as this application note is continuously improved.
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2. LIN Applications

2.1 Using LMA, U(A)RTE or U(A)RTF as LIN Master and U(A)RTx as LIN Slave

The following applies to any NEC/Renesas UART types U(A)RTx to U(A)RTF, when used in conjunction with LMA, U(A)RTE and U(A)RTF.

Note: Nomenclature of function names has changed from formerly “UART” to “URT” in the applicable manuals.

The UART reports the completion of a reception, as soon as the last data bit of the current frame has been sampled. As the sampling point is located in the middle of the bit, the reception interrupt occurs just a few peripheral clocks later.

On the other hand, the bit consistency is checked (if enabled) by the LIN master at about 70% to 80% of the bit time. In order to be within the LIN specification, the bit consistency checking functionality of the LIN master must be enabled.

Consequently, if a LIN master based on LMA, U(A)RTE, U(A)RTF is combined with any U(A)RTx slave, the slave will report the reception at a time, where the master has not yet finished transmission of the same LIN byte, here, the PID.

Figure 2.1 LIN Master / Slave Coincidence

Therefore, the U(A)RTx slave must have implemented a delay function after LIN reception, which suppresses the transmission of data right after a reception. Otherwise, this transmission would coincide with the ongoing reception from the master; and the LIN master would detect this as a bit error.

Implementations of LIN slaves using RLIN3 are not affected by this issue, because RLIN3 considers this situation in its state engine.
2.2 Distinguishing between Framing Error and valid BREAK Condition

The following situation requires special attention for a LIN slave implementation, independent of any LIN controller hardware. It is addressing the “Response Error” reporting of a LIN slave, when having to distinguish between a frame error at the STOP bit of the first data field of a response or a new BREAK detection.

It is a feature of LIN, that the response of a frame can be omitted by just starting another frame, doing so by sending a new BREAK field. A LIN slave, which is waiting to receive the response of a frame in this case must stop its response waiting, and recognize the new frame.

The recognition of a BREAK field when waiting for a response usually causes a framing error in the LIN slave controller. At this point, the LIN slave has to take an action on this.

If already at least one byte of the response was received, this framing error can be easily categorized to be a real framing error, because the abortion of a response by a BREAK field is not allowed. To detect this, LIN slave controllers have the indication flag of the first response data byte in their register set.

If no response byte has been received yet, at the point in time when the BREAK is sent, then the LIN slave has two options to categorize the framing error:

1. A BREAK has occurred, and the framing error must not be reported as a Response Error.
2. In the first data byte, which has the value of 0x00, a frame error is detected, means, the STOP bit is inverted. Thus, a Response Error must be reported.

At the point of time, when the frame error occurs, the LIN slave cannot distinguish between these two cases. A distinction is possible at latest, after the new header (BREAK+SYNC+ID) has been received completely. So, if the LIN slave shall be able to distinguish the two cases, special delay circuitry of framing errors would be required in hardware, or an additional time condition must be checked in software by using a hardware timer.

In the figure below, the situation is shown with a BREAK length of 10 bits, which is the minimum to be detectable by LIN slaves.

![Figure 2.2 Two cases of reception to decide on “Response Error” flagging](image)

Currently, the detection and distinction of these two cases is not available in the LIN controller hardware. Therefore, if required, the timing condition shown in the figure needs to be evaluated by software; it is recommended to use a hardware timer instance for this purpose.

At the framing error interrupt, the timer shall be started and set to a timeout condition, which is longer than SYNC and PID of the LIN header. If no LIN slave header reception interrupt occurs, before the timer indicates a timeout, then the last frame has had a framing error and the “Response Error” flag can be indicated to upper software layers and in the LIN response data stream to the LIN master.
3. Frequently Asked Questions

3.1 Interrupts

3.1.1 Interrupt Handling in RL78 RLIN3 Implementations

The interrupt controller in RL78 is triggered by edges of interrupt indications of peripherals, and so for RLIN3, too. On the other hand, the interrupt sources of RLIN3 are level based.

For this reason, when handling RLIN3 interrupts in RL78, all interrupt sources within RLIN3, which are sharing the same interrupt flag of RL78 must be handled and cleared, as soon as the interrupt is executed by RL78.

As an overview, the following interrupt sources of RLIN3 are grouped in RL78:

<table>
<thead>
<tr>
<th>Interrupt Source</th>
<th>Shared Interrupt Events</th>
<th>Operation Modes</th>
<th>Interrupt Event Flags to Clear</th>
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<tbody>
<tr>
<td>Common LIN</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Transmission</td>
<td>-</td>
<td>all</td>
<td></td>
</tr>
<tr>
<td>Reception</td>
<td>-</td>
<td>all</td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td>Bit Error</td>
<td>all</td>
<td>BER in LEST Register</td>
</tr>
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<td></td>
<td>Physical Bus Error</td>
<td>LIN Master</td>
<td>PBER in LEST Register</td>
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<tr>
<td></td>
<td>Frame / Response Timeout Error</td>
<td>LIN</td>
<td>(F)TER in LEST Register</td>
</tr>
<tr>
<td></td>
<td>Framing Error</td>
<td>ALL</td>
<td>FER in LEST Register</td>
</tr>
<tr>
<td></td>
<td>Checksum Error</td>
<td>LIN</td>
<td>CSER in LEST Register</td>
</tr>
<tr>
<td></td>
<td>Response Preparation Error</td>
<td>LIN</td>
<td>RPER in LEST Register</td>
</tr>
<tr>
<td></td>
<td>Sync Field Error</td>
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<td>SFER in LEST Register</td>
</tr>
<tr>
<td></td>
<td>ID Parity Error</td>
<td>LIN Slave</td>
<td>IPER in LEST Register</td>
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<tr>
<td></td>
<td>Overrun Error</td>
<td>UART</td>
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<td></td>
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<td>ID Match</td>
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<tr>
<td></td>
<td>Parity Error</td>
<td>UART</td>
<td>UPER in LEST Register</td>
</tr>
</tbody>
</table>

Note: As an example, when using the common LIN interrupt in LIN Slave mode, the flags BER, (F)TER, FER, CSER, RPER, SFER and IPER must always be checked and cleared if set, as soon as the common LIN interrupt has been handled. Otherwise, no further common LIN interrupt would be generated. The common LIN interrupt is not available in UART operation mode; therefore the flags OER, EXBT, IDMT and UPER need not to be checked in LIN Slave mode.

As a secondary example, when using the separated transmission interrupt in either operation mode, no additional flag needs to be cleared during interrupt handling.
Website and Support

Renesas Electronics Website
http://www.renesas.com/

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• http://www.renesas.com/contact/
<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
<th>Chapter</th>
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<tr>
<td>1.00</td>
<td>March 2015</td>
<td>First Edition issued</td>
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General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Handling of Unused Pins
   Handle unused pins in accordance with the directions given under Handling of Unused Pins in the manual.
   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on
   The state of the product is undefined at the moment when power is supplied.
   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals
   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.
   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

5. Differences between Products
   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.
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