AN-1700 LMX9838 Cable Replacement

ABSTRACT

This application report describes the main features and configurations required to implement the LMX9838 as a cable replacement into a system.

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1 Introduction

Bluetooth® technology offers a wide range of features and profiles in order to support many different applications. Even though Bluetooth is very flexible, it still keeps the advantage of having a standardized wireless transmission.

The growing success and wide distribution of Bluetooth in many different devices and applications make Bluetooth an attractive solution to be used as a general data interface such as simple cable replacement applications.

Texas Instruments SimplyBlue module products include the complete Bluetooth stack and profile together with a great selection of features to provide an easy-to-use solution with minimal integration effort.

2 Cable Replacement as "Waiting Device"

Implementing a cable replacement solution with a LMX9838 device only requires minimal efforts in software and hardware. The following details the hardware implementation, software implementation, and a specific part on how to configure the device for production lines, in this specific scenario.

2.1 Hardware Implementation

To connect a LMX9838 device in a system for a serial cable replacement application, you should pay attention to the following points:

- All UART lines (TX, RX, RTS, CTS) should be connected to the host device. Omitting the flow control can bring up some corruption issues if the module works in transparent mode. In transparent mode the module forwards the data without interpreting and has therefore no way to control the flow. For more details on transparent mode, refer to the software user's guide (reference [1]).
- 1K pull ups should be applied to the OP pins that should be at high level. Table 1 gives the possible OP pins configuration and their respective UART settings.

Table 1. General Baudrate

OP3	OP4	OP5	UART Speed Selection
1	0	0	UART speed read from NVS
1	0	1	UART speed 9600 bps
1	1	0	UART speed 115200 bps
1	1	1	UART speed 921600 bps

For more details and other configurations, refer to the datasheet (reference [3]) and the design guide (reference [4]).

- The module should be powered according to the datasheet values. The datasheet also gives system schematics example to give some guidance.
- PG6 pin can be connected to one of the host IO as event trigger for the application. The PG6 pin goes high when a Bluetooth link is established on the module.

Figure 1 shows a connection diagram example of a typical serial replacement application.

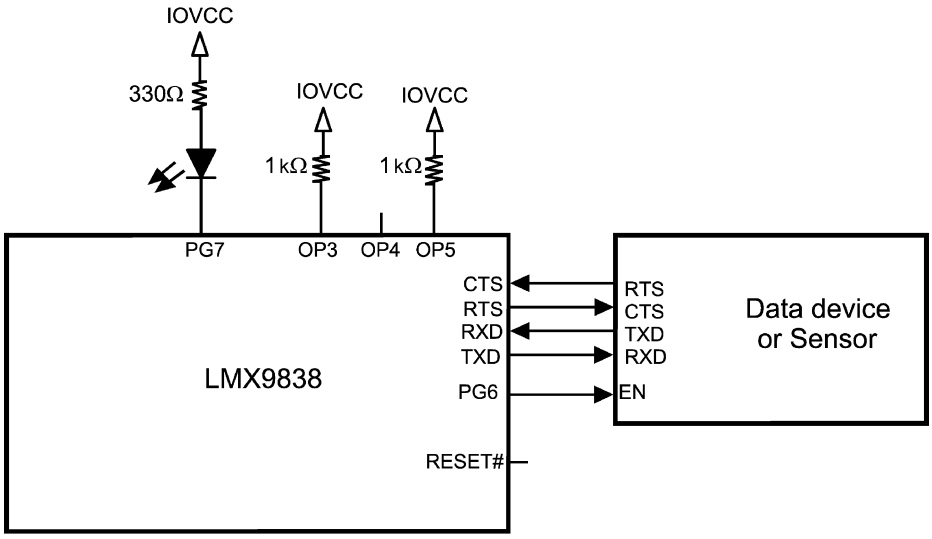

Figure 1. System Diagram Example For Cable Replacement Application

NOTE: The UART selection in this example is set up to 115200 bps. PG7 acts as RF traffic indicator.

2.2 Firmware Implementation

The firmware implementation is reduced to a minimum due to the simplicity of SimplyBlue and its orientation towards cable replacement applications.

The LMX9838 firmware by default is configured to automatically accept incoming links having the correct pin and switches the UART to the so called “transparent mode”, to directly forward the RAW data between the host and the Bluetooth link.

There are few events to keep in mind in such an application:

- **Incoming link established event:** After an incoming link has been successfully established, the Incoming link established event will be sent to the host by the module.
- **Link released event:** After a link has been released, the module sends the link released event to the host with the reason of the connection release.
- **Incoming UART break event:** When the device works in transparent mode, it sends a UART break event to the host on a link release just before the link released event is sent.
- **Event filter:** This optional setting can be used to “filter” the event messages to a certain degree. It can be set to stop reporting any events including UART break. The event filter can be programmed in production. See Section 2.3 for more details.

To configure a SimplyBlue Bluetooth module as pure cable replacement when receiving an incoming link, the event filter should be set to mode 02 or 03 to disable the event reporting.

For more details on the previous parameters, refer to the software user’s guide (reference [1]).

Example 1. Indicator Scenario Example for Event Filter Set to 01

Link establishment: the remote device initiates the link.

- RX Event: Incoming Link Established, BdAddr: 071501000000, Local Port 01
- RXHex: 02 69 0C 07 00 7C 07 15 01 00 00 00 01 03

The module automatically switches to transparent mode until the connection gets released.

Link release: On a link release, the device sends the incoming UART break event, switches back to command mode then sends the link released event.

- RX Event: Transparent mode, Local Port 01, Mode 00
- RXHex: 00 (UART Break event)
- RXHex: 02 69 11 02 00 7C 01 00 03 (Transparent mode left event)
- RX Event: Link Released, Reason: 01, Local Port 01
- RXHex: 02 69 0E 02 00 79 01 01 03

Example 2. Indicator Scenario Example for Event Filter Set to 02

Link establishment: the remote device initiates the link.

- RX Event: (=> Nothing as the event filter is set to 02)
- RXHex:

The module automatically switches to transparent mode until the connection gets released.

Link release: On a link release, the device sends the incoming UART break event, switches back to command mode then sends the link released event.

- RX Event: (=> Nothing except UART Break as the event filter is set to 02)
- RXHex: 00 (UART Break event)
- RXHex:
- RX Event: (=> Nothing as the event filter is set to 02)
- RXHex

Example 3. Indicator Scenario Example for Event Filter Set to 03

Link establishment: the remote device initiates the link.

- RX: (=> Nothing as the event filter is set to 03)
- TXHex:

The module automatically switches to transparent mode until the connection gets released.

Link release: On a link release, the device sends the incoming UART break event, switches back to command mode then sends the link released event.

- RX: (=> Nothing including UART Break as the event filter is set to 03)
- RXHex:
- RX Event: (=> Nothing as the event filter is set to 03)
- RXHex:

2.3 Production Line

The LMX9838 SimplyBlue module stores all functional parameters into the internal EEPROM. In most of the cases, the module can be used as is and do not need specific changes. But in some applications, the system requires the module to work slightly differently than default.

2.3.1 Baudrate is Different Than a Hardware Setting

The OP pins settings combination can select 3 different hardware UART settings as described in Table 1. If the UART speed to be used is different than the hardware selection available, the specific baudrate can be stored in NVS. In this case the OP pin settings must be configured to “UART speed read from NVS” and the baudrate must be programmed in EEPROM using the “Change NVS UART Speed” command. Table 2 gives the NVS baudrates available and their respective values to be stored.

Table 2. NVS UART Speed

UART Speed	NVS Value
2400	0
4800	1
7200	2
9600 (default)	3
19200	4
38400	5
57600	6
115200	7
230400	8
460800	9
921600	0A

2.3.2 The Local Name is Different Than Original

The module Local Name is set to “Serial Port Device” by default. The new chosen name can be programmed in NVS (EEPROM) using the “Write Local Name” command. For more details, refer to the software user’s guide (reference [1]).

2.3.3 The Pin is Different Than Default Value

The original factory PIN is set to 0000. It is of good usage to set the PIN to a different value to get a better security. The PIN can be stored in NVS (EEPROM) using the “set fixed PIN“ command. If the PIN value is empty, the module will ask the user for a dynamic PIN value. For more details, refer to the software user’s guide (reference [1]).

2.3.4 The Event Filter Setting is Different Than Default Value

By default the event filter setting is set to 0x01. In this configuration all events except ACL indicators are reported back to the host device. If the event filter setting needs to be different in the final application, the value can be programmed in NVS (EEPROM) using the “Set Event Filter” command. Table 3 sums up the filters configuration and their respective values.

For more details on the event filter, refer to the software user’s guide (reference [1]).

Table 3. Event Filter Settings

Event Filter Level	NVS Value
All event reported	00
ACL events filtered	01
All events filtered except UART break	02
All events filtered including UART break	03

3 Bluetooth Link Versus Physical Cable

A Bluetooth link is from its characteristics different to a physical cable. The main differences are the throughput and latency, which are always fixed for a given cable, but depend on the link parameters, the actual link state and link quality in a Bluetooth link.

3.1 Throughput

The data throughput over a cable is constant for a given technology. The data throughput in a cable is reduced either if the cable gets broken, or if the other cable end is not able to sustain the flow.

In a Bluetooth link, the data throughput depends on:

- The transport layer speed setting: Speed setting selected between the host controller and the module.
- The link quality: If the link quality is bad, the Bluetooth radio will see more bit, frame errors and thus retransmissions that reduce the data throughput.
- The transport layer mode:
  - In command mode, the module interprets the data coming in which consumes more processing and requires more overhead. This reduces the overall data throughput.
  - In transparent mode, the module just forwards the data without processing to optimize the flow.

To get the best data transfer rate out of a Bluetooth link, the module needs to be configured in a way taking care of all the previous points written. To be sure having the highest throughput using a SimplyBlue module, you should:

- Set up the transport layer speed to 921600 bps.
- Use the module in transparent mode.
- Ensure the Bluetooth devices are placed at a reasonable distance to get a good link quality.

3.2 Latency

The latency of a physical cable can be considered insignificant compared to a Bluetooth link. The latency of a Bluetooth link is in ms range and depends essentially on the baseband buffer management, the RFCOMM layer buffer management, the type of packet used. With SimplyBlue modules the user does not have any direct influence on the packet type used as it is automatically selected to get the optimal transfer.

For the general buffer management, SimplyBlue handles data buffers depending on the module state and the transport layer mode. In command mode, the data bytes number is known from the command/data size field. Once all bytes are present in the data buffer, the command bytes will be forwarded to the upper layer. In transparent mode the data bytes number is unknown. Therefore there is a timeout mechanism allowing the data to be forwarded to the upper layer even if the buffer is not full. For more details on the UART buffer management, refer to the UART buffer application report (reference [2]).

In order to reduce the timeout latency and get the best results out of the module, you should:

- Use the module in transparent mode.
- Avoid slicing the data frames in small packets to improve the communication flow. (Send data packets above 330 Bytes if possible).

NOTE: Reducing the latency is an important factor as it contributes to increasing the average data throughput.

3.3 Power Management

Another specificity of a Bluetooth link is the power it consumes to get the data transmitted. This consumption depends mainly on the radio activity.

Bluetooth includes a specific low power mode called sniff mode that allows reducing the consumption of an active link. In this mode the module will periodically shut down the radio activity for a certain time.

But this low power sniff mode is a direct trade-off between latency and power consumption:

- If the sniff interval is low, the latency will be as low but the consumption will be the normal functional consumption
- If the sniff interval is high, the latency will be as high but the power consumption will be much reduced

It is then really important to know the exact requirement of the cable replacement application in term of latency and throughput to be able to decide the sniff interval to be applied.

For more information on sniff mode, refer to the software user's guide (reference [1]).

4 Bibliography

1. *AN-1699 LMX9838 Software Users Guide* (SNOA498)
2. *AN-1809 UART Buffer Application Report* (SNOA517)
3. *LMX9838 Bluetooth Serial Port Module* (SNOSAZ9).
4. *LMX9838 Application Notes, Software, and Tools* (SNWC002)

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