



## How to exchange data buffers with the coprocessor



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A quality version of this page, approved on 7 January 2021, was based off this revision.

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## 1 Article purpose

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This article gives an example of high-rate transfers of data chunks from the Arm® Cortex®-M core to the Arm® Cortex®-A core.



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## 2 Introduction

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Relying on a logic analyzer sample, this article describes the mechanism and the software implemented to perform high-rate transfers. In this example, the Cortex-M core is used to perform continuously:

- real-time operations
- offload of a heavy data algorithm
- transfer of the resulting data flow to DDR buffers via DMA.

Such kind of implementation requires :

- contiguous memory allocation in DDR memory
- Cortex-M awareness of the physical address and size of the memory buffers
- mmaping of buffers to enable Linux® user land application access to them.

A specific Linux driver, `rpmsg_sdb` (shared data buffer), has been developed to take care of such constraints.

For details on the buffer exchange mechanisms, refer to the [how to exchange large data buffers with the coprocessor - principle](#) article.



### 3 Example of context description

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Let us implement a logic analyzer running on the STM32MP1 discovery kit.

From the user interface, press the START button to start the logic analyzer sampling. The logic analyzer samples GPIO PORT E bits 8 to 12, which are present on the Arduino connector. They correspond to 5 bits. The 3 remaining bits in each data byte are used to implement a packing algorithm.

After packing, the logic analyzer saves data in a binary file system named "date-time".dat, where date-time is the date and time of the system when the START button is pressed.



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## 4 Example of static architecture for exchanging large data buffers

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The example of large data buffer exchange includes:

- A Cortex-M firmware
- A Linux user land application
- A Linux rpmsg\_sdb (shared data buffer) driver
- A Linux rpmsg\_tty driver

File:How2ELDBArchi.jpg  
800px

In the figure above, the numbers indicate the chronological order of data flows.



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## 5 Cortex-M firmware

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The Cortex-M firmware is responsible for:

- receiving messages containing the physical address and size of DDR buffer(s), from the Linux `rpmsg_sdb` driver
- receiving a command Start/Stop sampling (including sampling frequency) through the TTY `RPMsg` channel, from the Linux application
- On start request:
  - sampling the data at the requested sampling frequency
  - filtering and packing data
  - transferring via DMA the packed data to the DDR buffer by packet of 1024 bytes
  - informing the Cortex-A user interface (through the TTY `RPMsg` channel) when a DDR buffer of 1 Mbyte is filled, and roll to next DDR buffer.





## 6 Linux user land application

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The Cortex-A Linux application includes a web user interface.

It allows controlling:

- the sampling frequency
- the start / stop of the sampling.

The user interface displays statistics, including:

- the number of packed data received by the user interface
- the number of unpacked data decompressed by the user interface
- the number of packed data written by the user interface in the file system.

The user interface saves the packed data in a binary file.



## 7 Linux drivers

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- The `rpmsg_sdb` Linux driver is responsible for the shared buffer management.
- The `rpmsg_tty` driver is used to communicate (transport commands and status/events) between the Cortex-M firmware and the Cortex-A user land application.



## 8 Dynamic view

At startup, the Linux application performs the following actions:

- It loads the `rpsmsg_sdb.ko` module.
- It loads the Cortex-M firmware, then starts it.
- It opens the `rpsmsg_tty` driver for Cortex-M firmware control.
- It opens the `rpsmsg_sdb` driver, then uses `rpsmsg_sdb` IOCTL interface to allocate and `mmap` 3 buffers of 1Mbyte in DDR memory.

When the START button is pressed, the application sends the sampling command to the Cortex-M firmware (including the sampling frequency), and creates a "date-time.dat" binary file that is used to store the data sample in mass storage.

When the STOP button is pressed, an overrun data error or a file system full error occurs, the application sends the stop command to the Cortex-M firmware and finalizes the "date-time.dat" binary file.

When the Cortex-M firmware sends a "buffer full" signal via the `rpsmsg_sdb` driver, the application unpacks data, writes the packed data in "date-time.dat" file, and updates the statistic information.

File:Howtobigdatamsc.jpg

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## 9 Results

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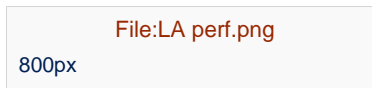
Depending on the type of data available on GPIOE, the transfer rate between the Cortex-M and the Cortex-A core varies from 1 Mbyte per second (repetition factor of 7) to 8 Mbytes per second (repetition factor of 0).

In the later use case, the Cortex-M CPU is able to compress data at a rate up to 64 Mbits per second (8 Mbytes per second). This corresponds to the maximum rate that can be achieved.



## 10 Limitation

The limitation is due to data packing, as shown in the figure below:



On this oscilloscope snapshot, a GPIO is set at the beginning of the packing algorithm, and reset at the end of the algorithm. So, 109.5  $\mu$ s are spent to pack 1024 bytes of data at a sampling frequency of 8 MHz. Increasing the frequency to 9 MHz would cross the limit : 9MHz => 111 $\mu$ s.



## 11 Source code

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The source code corresponding to this use case is available as a Yocto layer at:

<https://github.com/STMicroelectronics/meta-st-stm32mpu-app-logicanalyser.git>

The firmware is included in the Yocto layer as an .elf file.

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For firmware compilation, please have a look into: [Developer Package for STM32CubeMP1](#)



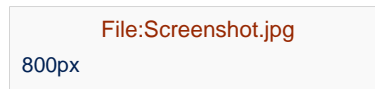
## 12 Usage

Please follow README.md of Yocto layer to perform installation.

The **logicanalyser application** is launched/stopped by pressing User2 button of the STM32MP1 Discovery board.

Select the sampling frequency and click on Start to start the use case.

Snapshot view of user interface :



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Such kind of implementation requires :

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A specific Linux driver, `rpmsg_sdb` (shared data buffer), has been developed to take care of such constraints.

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After packing, the logic analyzer saves data in a binary file system named "date-time".dat, where date-time is the date and time of the system when the START button is pressed.



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The example of large data buffer exchange includes:

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File:Howtobigdatamsc.jpg

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Depending on the type of data available on GPIOE, the transfer rate between the Cortex-M and the Cortex-A core varies from 1 Mbyte per second (repetition factor of 7) to 8 Mbytes per second (repetition factor of 0).

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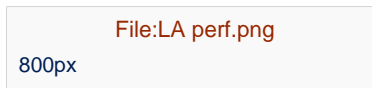


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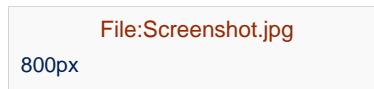
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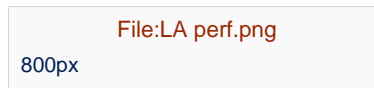
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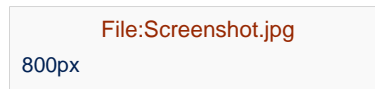
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