ZeBu® UART Transactor

User Manual

Version Q-2020.12, December 2020

Contents

List of Figures

List of Tables

Preface

About This Book

The ZeBu®UART Transactor User Manual describes how to use the ZeBu UART Transactor while emulating your design in ZeBu.

Related Documentation

For more information about the ZeBu supported features and limitations, see ZeBu Release Notes in the ZeBu documentation package corresponding to your software version.

For more information about the usage of the present transactor, see Using Transactors in the training material.

Typographical Conventions

This document uses the following typographical conventions:

To indicate	Convention Used
Program code	`OUT <= IN;`
Object names	`OUT`
Variables representing objects names	*<sig-name>*
Message	Active low signal name '<sig-name>' must end with _X.
Message location	OUT <= IN;
Reworked example with message removed	OUT_X <= IN;
Important Information	**NOTE:** This rule...

The following table describes the syntax used in this document:

Syntax	Description
[ ] (Square brackets)	An optional entry
{ } (Curly braces)	An entry that can be specified once or multiple times
| (Vertical bar)	A list of choices out of which you can choose one
. . . (Horizontal ellipsis)	Other options that you can specify

1 Introduction

This chapter gives an introduction to ZeBu UART transactor, its features, performance, and limitations.

This section describes the following sub-topics.

- *Overview*
- *Features*
- *FLEXlm License*
- *Performance*
- *Limitations*

1.1 Overview

The ZeBu UART transactor implements a serial RS232 interface. It contains the TXD/RXD data signals and CTS/RTS control signals as described in the EIA-232 (RS-232) standard at the logical level. This transactor is configurable to support the various operation modes of the RS232 protocol.

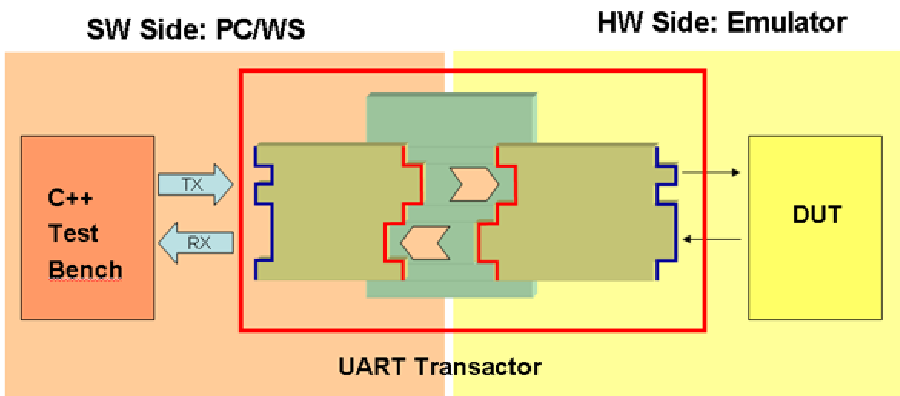


FIGURE 1. ZeBu Transactor Overview

This UART implementation supports, according to its configuration, 5-bit to 8-bit data with or without parity (odd or even) and 1 or 2 stop bits. The baud rate can be set as a fraction of the reference clock frequency (1 – 1/16777215).

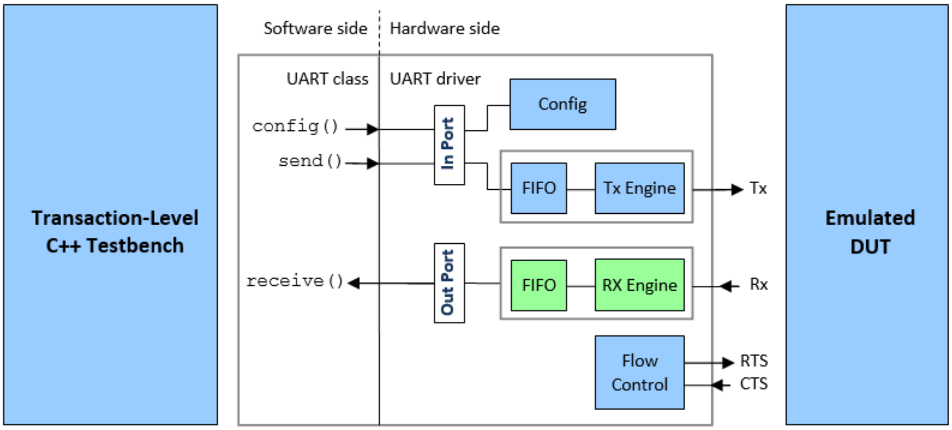


FIGURE 2. ZeBu UART Transactor Detailed Architecture

The ZeBu UART transactor proposes different operating modes:

- An application mode where the application testbench running on the ZeBu workstation reads/writes characters from/to the RS232 DUT interface.
- A server mode with remote connection via a TCP socket. This interface mechanism supports remote user application drivers running on Linux or Windows® operating systems.
- A ZeBu UART transactor with an interactive terminal interface. This feature launches an xterm terminal that communicates with the UART transactor. The data exchange between the UART interface and the terminal are automatically handled by the transactor.

1.2 Features

The UART transactor supports the following features:

- Data width of 5 – 8 bits.
- One or two stop bits.
- Parity bit.
- RTS/CTS handshaking in full duplex mode.

1.3 FLEXlm License

You need the hw_xtormm_uart FLEXnet license feature.

1.4 Performance

The hardware synthesized BFM part of the UART transactor uses:

- 751 registers and 706 LUTs in the Virtex 7 technology
- 751 registers and 809 LUTs in the Virtex 8 technology.

This transactor supports baud rates up to 10 Mbps full duplex for user application.

1.5 Limitations

The current version of this transactor has the following limitations:

- The ZeBu UART transactor is only a Data Terminal Equipment (DTE) device.
- The software flow control (XON/XOFF) is not implemented.
- RTS/CTS handshaking in half-duplex mode is not supported.

2 Installation

This section describes the following sub-topics.

- *Installing the ZeBu UART Transactor Package*
- *Package Structure and Content*

2.1 Installing the ZeBu UART Transactor Package

The ZeBu UART transactor should be installed under the ZEBU_IP_ROOT directory. You must have WRITE permission to the IP directory and current directory.

To install the UART transactor, perform the following steps:

1. Download the transactor compressed shell archive (.sh).
2. Install the UART transactor as follows:

```
$ sh xtor_uart_svs.<version>.sh install [options] [ZEBU_IP_ROOT]
```

where,

- [options] defines the working environment:

For:	...with Linux OS:	...Specify:
ZeBu-Server environment	32- or 64-bit	nothing
Any ZeBu machine	32-bit only	32b

- [ZEBU_IP_ROOT] is the path to your ZeBu IP root directory:
  - If no path is specified, the ZEBU_IP_ROOT environment variable is used automatically.
  - If the path is specified and a ZEBU_IP_ROOT environment variable is also set, the transactor is installed at the defined path, and the environment variable is ignored.

When the installation process is complete and successful, the following message is displayed:

```
xtor_uart_svs v.<version> has been successfully installed.
```

The transactor is installed under the `ZEBU_IP_ROOT/XTOR` sub-directory. This sub-directory is automatically created when necessary.

If an error occurred during the installation, a message is displayed to point out the error. The following is an example error message:

```
ERROR: /auto/path/directory is not a valid directory.
```

2.2 Package Structure and Content

Once the ZeBu UART transactor is installed, it provides the following elements under ZEBU_IP_ROOT/XTOR/xtor_uart_svs.<version>:

`lib` directory	.so libraries of the transactor.
vlog/vcs directory	protected verilog source code for the transactor.
`example` directory	Testbench, DUT, and environment files with the makefile necessary to run the transactor examples described in the Tutorial chapter of this manual.
`include` directory	.hh header files of the transactor.

During installation, symbolic links are created in the following directories for an easy access from all ZeBu tools:

- `$ZEBU_IP_ROOT/vlog`
- `$ZEBU_IP_ROOT/include`
- `$ZEBU_IP_ROOT/lib`

3 Hardware Interface

3.1 Interface Description

3.1.1 xtor_uart_svs driver

The following figure shows the transactor hardware with a reference clock.

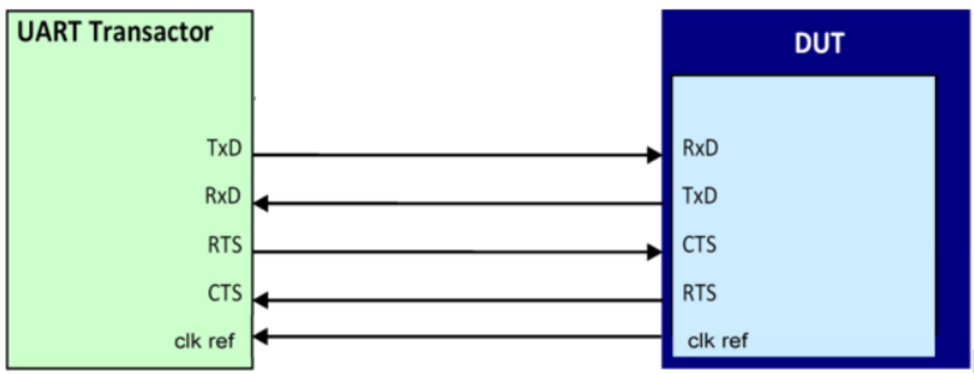


FIGURE 3. ZeBu UART Transactor Hardware Interface with Reference Clock

3.1.2 Signal List

TABLE 2 List of Signals for ZeBu UART Transactor Hardware Interface

Symbol	Size	Type (Transactor)	Type (DUT)	Description
`Clk_ref`	1	Input	Output	Reference clock to calculate the ratio.
`TxD`	1	Output	Input	Serial Transmit Data (from transactor).

TABLE 2 List of Signals for ZeBu UART Transactor Hardware Interface

Symbol	Size	Type (Transactor)	Type (DUT)	Description
`RxD`	1	Input	Output	Serial Receive Data (to transactor).
`RTS`	1	Output	Input	Ready To Send.
`CTS`	1	Input	Output	Clear To Send.

3.1.3 Verilog Source for the Transactor Driver

The vlog/vcs directory of the transactor package provides a Verilog source file that shows all signal connections and describes the UART transactor instance.

3.2 Instantiating the Transactor in the design wrapper

The design wrapper is the top level Verilog file in which the DUT and transactors are instantiated. The wrapper does not have any I/O ports.

An example wrapper is present in the `example/src/dut` directory of the transactor and can be used as a reference for creating a design wrapper.

The following example shows the instantiation of the ZeBu UART Transactor in the design wrapper. (Save and Restore feature is not used).

```
zceiClockPort clockPort0(
.cclock       (clk),
.cresetn      (rstn)
;

xtor_uart_svs uart_driver_0(
.CTS(DUT_RTS),
.RTS(DUT_CTS),
.TxD(DUT_RxD),
.RxD(DUT_TxD),
ref_clk(clk)

);
```

3.3 Connecting the Transactor's Clocks

The controlled clock can be one of the following:

- the UART controller DUT clock (if the clock is a primary clock).
- the DUT primary clock driving the UART controller clock.

4 Software Interface

This chapter describes the ZeBu UART transactor's software interface.

This section describes the following sub-topics.

- *Interface Description*
- *Class Description*
- *Common Interface*
- *Uart Class Specific Interface*

4.1 Interface Description

The ZeBu UART transactor can be instantiated and accessed through a C++ interface defined in the `$ZEBU_IP_ROOT/include/xtor_uart_svs.hh` file.

The ZeBu UART transactor's API provides the Uartxtor_uart_svs API class:

-

This API is included in the `ZEBU_IP::XTOR_UART_SVS` namespace for the three classes.

Note

Example:

A typical testbench starts with the following lines:

```
#include "xtor_uart_svs.hh"
using namespace ZEBU_IP
using namespace XTOR_UART_SVS
```

4.2 Class Description

The ZeBu UART transactor interface can be driven and implemented in the following C++ class:

TABLE 3 C++ Class for the ZeBu UART Transactor

Class	Description
`xtor_uart_svs`	class providing a low level interface (data send and receive).

You can choose to operate the transactor in different modes by configuring the API setOpMode().

The default mode is the Normal mode where you use the low level API (send/receive). You can set the operating mode to ServerMode or XtermMode as shown below:

4.3 Common Interface

The common interface is a set of methods common to `different modes, that is, normal, ServerMode, XtermMode` classes. The following table lists these common methods:

TABLE 4 List of Methods Common to all modes

Method	Description
Transactor Initialization and Configuration	see *Transactor Initialization and Configuration*
`init`	Connects the UART transactor to the ZeBu system.
`setWidth`	Sets the data word length.
`setParity`	Sets the parity.
`setStopBit`	Sets the number of stop bits.
`setRatio`	Sets the clock divider ratio.
`adjustRatio`	Adjusts the clock divider ratio to the value detected by the transactor.
`setBdRDetectWindow`	Sets the baud rate detect window.
`config`	Sends the configuration of the UART transactor communication mode.
`getWidth`	Obtains the data width.
`getParity`	Obtains the parity.
`getStopBit`	Obtains the number of stop bits.
`getRatio`	Obtains the clock divider ratio.
`getBdRDetectWindow`	Obtains the baud rate detect window.
`getDetectedRatio`	Obtains the clock divider ratio detected by UART transactor
Transactor Logging	see *Transactor Logging*
`setName`	Sets the transactor name shown in the messages.

TABLE 4 List of Methods Common to all modes

Method	Description
`getName`	Obtains the transactor name shown in the messages.
`setDebugLevel`	Sets the messages debug level.
`setLog`	Sets the messages log file or stream.
Transactor Dumping	see *Transactor Dumping*
`dumpSetRxPrefix`	Sets the received data prefix in the dump file.
`dumpSetTxPrefix`	Sets the transmitted data prefix in the dump file.
`dumpSetDisplayErrors`	Enables dumping of the received erroneous data.
`dumpSetFormat`	Sets the dump format.
`dumpSetDisplay`	Sets the dump display.
`dumpSetMaxLineWidth`	Sets the maximum line width in the dump file.
`dumpGetRxPrefix`	Obtains the dump file received data prefix.
`dumpGetTxPrefix`	Obtains the dump file transmitted data prefix.
`dumpGetDisplayErrors`	Obtains the erroneous data handling configuration.
`dumpGetFormat`	Obtains the dump format.
`dumpGetDisplay`	Obtains the dump display.
`dumpGetMaxLineWidth`	Obtains the dump file maximum line width.
`openDumpFile`	Opens the dump file.
`closeDumpFile`	Closes the dump file.
`Runtime clock control`	
`runClk`	advanced transactor clock and also service the Tx Callbacks
runUntilReset ()	Wait for reset de-assertion

TABLE 4 List of Methods Common to all modes

Method	Description

4.3.1 Transactor Initialization and Configuration

This section describes the methods used to initialize and configure the transactor.

4.3.1.1 setOpMode ( ) Method

This method sets the operating mode for the ZEBU UART transactor. By default, mode is defaultMode, which uses low level APIs. However, you can also select ServerMode or XtermMode. Ensure to configure this API before the init () call as shown below:

```
bool   setOpMode (UartOperationMode_t mode) ;
```

4.3.1.2 init() Method

This method connects the Zebu UART transactor to the ZeBu system. After calling the `Board::open()` method, `init()` method must be called first before performing any configuration or operation on the ZeBu UART transactor.

```
void init (Board *zebu, const char *driverName);
```

where:

- `zebu` is the Zebu system identifier.
- `driverName` is the driver instance name in the design wrapper file.

4.3.1.3 setWidth() Method

This method sets the data word length, that is, the numbers of bits per data. The `config()` method must be called to make the setting effective in the hardware.

```
bool setWidth   (uint8_t width);
```

where, `width` is the data word length in number of bits. It can range from 5 through 8 (default).

The method returns:

- `true`, if successful.
- `false`, if the value is an invalid parameter.

4.3.1.4 setParity() Method

This method sets the parity bit generation and check. The `config()` method must be called to make the setting effective in the hardware.

```
bool setParity   (Parity_t parity);
```

where, `parity` is of `Parity_t` enumeration type as follows:

- `NoParity` (default): No parity bit is generated.
- `OddParity`: A parity bit is generated and set to one if the data contains an odd number of one bits; the incoming data parity bit is checked.
- `EvenParity`: A parity bit is generated and set to one if the data contains an even number of one bits; the incoming data parity bit is checked.

The method returns:

- `true`, if successful.
- `False`, if the parity value is an invalid parameter.

4.3.1.5 setStopBit() Method

This method sets the number of stop bits. The `config()` method must be called to make the setting effective in the hardware.

```
bool setStopBit (StopBit_t stop);
```

where, `stop` is of `StopBit_t` enumeration type and defined as follows:

- `OneStopBit`: the transactor generates one stop bit at the end of each data.
- `TwoStopBit` (default): the transactor generates two stop bits at the end of each data.

The configuration does not have any impact on incoming data, because only one stop bit is needed and then two stop bits are also supported.

The method returns:

- `true` if successful.
- `false` if the stop value is an invalid parameter.

4.3.1.6 setRatio() Method

This method sets the clock divider ratio. The clock divider ratio defines the baud rate. For details on the baud rate calculation, see *Baud Rate Calculation*.

The `config()` method must be called to make the setting effective in the hardware.

```
bool setRatio  (uint ratio);
```

where, `ratio` is the clock divider ratio. It can range from `1` (default) through `0xFFFFFF`.

The method returns:

- `true`, if successful.
- `false`, if the ratio value is an invalid parameter.

4.3.1.7 adjustRatio() Method

This method adjusts the clock divider ratio to the value detected by the ZeBu UART transactor.

```
uint adjustRatio (void);
```

The method returns the current clock divider ratio.

4.3.1.8 setBdRDetectWindow() Method

This method sets the minimum number of Rx edges of the baud rate detect window to validate the new upward ratio detected in the transactor.

The `config()` method must be called to make the setting effective in the hardware.

```
bool setBdRDetectWindow   (uint8_t n);
```

where, `n` defines the minimum number of `Rx` edges as follows:

number of Rx edges = n x 16.

`n` can range from 1 through 15.

By default, the baud rate detect window is set to 16 (n = 1).

The method returns:

- `true`, if successful.
- `false`, if the n value is an invalid parameter.

4.3.1.9 config() Method

This method sends the configuration parameters (defined with `setWidth()`, `setParity()`, `setStopBit()`, `setRatio()`, and `setBdRDetectWindow()`) to the UART transactor and starts the transactor BFM clock. This method applies these parameters to the hardware.

```
bool config  (void);
```

The method returns `true` if successful; otherwise, `false`.

4.3.1.10 getWidth() Method

This method returns the current data word length setting.

```
uint8_t getWidth  (void);
```

4.3.1.11 getParity() Method

This method returns the current parity setting.

```
Parity_t getParity  (void);
```

Possible returned values are:

- `NoParity`: No parity bit.
- `OddParity`: Odd parity.
- `EvenParity`: Even parity.

4.3.1.12 getStopBit() Method

This method returns the current number of stop bits.

```
StopBit_t getStopBit  (void);
```

Possible returned values are:

- `OneStopBit`: 1 stop bit.
- `TwoStopBit`: 2 stop bits.

4.3.1.13 getRatio() Method

This method returns the clock divider ratio setting corresponding to the current baud rate.

```
uint getRatio (void);
```

4.3.1.14 getBdRDetectWindow() Method

This method returns the number of Rx edges to validate the new upward ratio detected in the transactor:

```
uint getBdRDetectWindow  (void);
```

4.3.1.15 getDetectedRatio() Method

This method returns the clock divider ratio detected by the ZeBu UART transactor.

```
uint getDetectedRatio  (void);
```

This may be useful when integrating the ZeBu UART transactor to avoid calculation of the right value. To detect the value, the transactor needs to receive at least one data. For more details on how to use this method, see *Using the UART Transactor Baud Rate Detector*.

The method returns the following values:

- `Zero`: no ratio is detected.
- greater than zero: ratio value detected by the transactor.

4.3.2 Transactor Logging

4.3.2.1 setName() Method

This method sets the transactor name shown in the message prefixes.

```
void setName  (const char *name);
```

where, `name` is the pointer to the name string.

4.3.2.2 getName() Method

This method returns the transactor name shown in the message prefixes.

```
const char* getName  (void);
```

The method returns the following values:

- `Zero`: no name was defined.
- Non-zero values: pointer to the name string.

4.3.2.3 setDebugLevel() Method

This method sets the maximum information level for messages. The higher the level, the more detailed the messages.

```
void setDebugLevel  (uint lvl);
```

where, `lvl` is the information level. Its values are:

- 0: no messages.
- 1: main steps of the testbench (settings, connections, and so on).

- 2: level 1 messages with internal high-level information about the transactor (status, data, transmission/reception, and so on).
- 3: level 2 messages with low-level information (message contents, callbacks, and so on).

4.3.2.4 setLog() Method

This method activates and sets parameters for the transactor's log generation.

The log contains transactor's debug and information messages, which can be output into a log file. The log file can be defined with a file descriptor or by a filename.

The log file is closed upon ZeBu UART transactor object destruction.

Log File Assigned through a File Descriptor:

The log file where output messages are assigned through a file descriptor.

```
void setLog  (FILE *stream, bool stdoutDup = false);
```

where:

- `stream` is the output stream (file descriptor).
- `stdoutDup` is the output mode:
  - `true`: messages are output both to the file and the standard output.
  - `false` (default): messages are only output to the file.

Log File defined by a Filename:

The log file where to output messages is defined by its filename.

If the log file you specify already exists, it is overwritten. If it does not exist, the method creates it automatically.

```
bool setLog (char *fname, bool stdoutDup);
```

where:

- `fname` is the log file name.
- `stdoutDup` is the output mode:
  - `true`: messages are output both to the file and the standard output.
  - `false` (default): messages are only output to the file.

The method returns:

- `true` upon success.
- `false` if the specified log file cannot be overwritten or if the method failed in creating the file.

4.3.3 Transactor Dumping

4.3.3.1 dumpSetRxPrefix() Method

This method sets the “received data” prefix in the dump file. This prefix is added at the beginning of each received data sequence in the output file.

```
void dumpSetRxPrefix  (const char *str);
```

where, `str` is the “received data” prefix. By default, this prefix is “`RX>`”.

4.3.3.2 dumpSetTxPrefix() Method

This method sets the “transmitted data” prefix in the dump file. This prefix is added at the beginning of each sent data sequence in the output file.

```
void dumpSetTxPrefix  (const char *str);
```

where, `str` is the “transmitted data” prefix. By default, this prefix is “`TX>`”.

4.3.3.3 dumpSetDisplayErrors() Method

This method enables dumping of received erroneous data.

```
void dumpSetDisplayErrors  (bool enable);
```

where, `enable` enables or disables dumping:

- `true`: dumping is enabled; an error message is generated in the dump file for all the received data, which is corrupted.
- `false` (default): dumping is disabled.

When enabled, an error message is generated in the dump file for all the received data, which is corrupted.

When disabled, the error is ignored and the erroneous data is discarded.

4.3.3.4 dumpSetFormat() Method

This method sets the dump file format.

```
void dumpSetFormat  (DumpFormat_t format);
```

where, `format` is of `DumpFormat_t` enumeration type and it values are as follows:

- `DumpRaw`: All data are written out directly in the output file.
- `DumpASCII`: Only data value between 32 and 127 are written out directly. All other values are dumped in following decimal format: `\ddd` (default setting).

For instance, the following data sequence:

TX	0x54	0x65	0x73	0x74	0x20	0x31	0x32	0x33	0x0a
RX	0x31	0x32	0x33	0x0a					

It results in the following in the dump file in Raw Format (and sequential display):

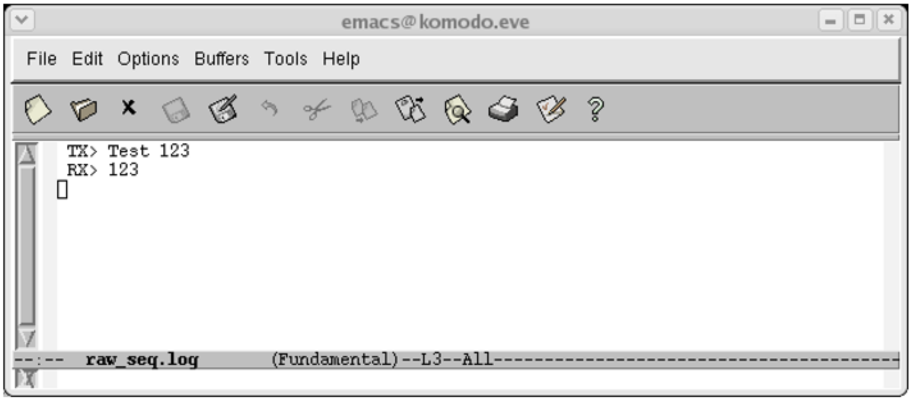


FIGURE 4. Dump File in Raw Format

or the following in the dump file in ASCII format (and sequential display):

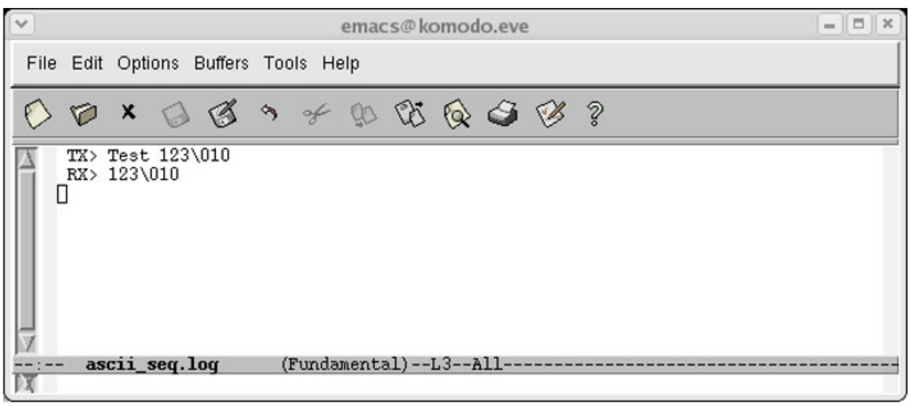


FIGURE 5. Dump File in ASCII Format

4.3.3.5 dumpSetDisplay() Method

This method sets the way transmitted and received data are displayed in the dump file.

```
void dumpSetDisplay  (DumpDisplay_t disp);
```

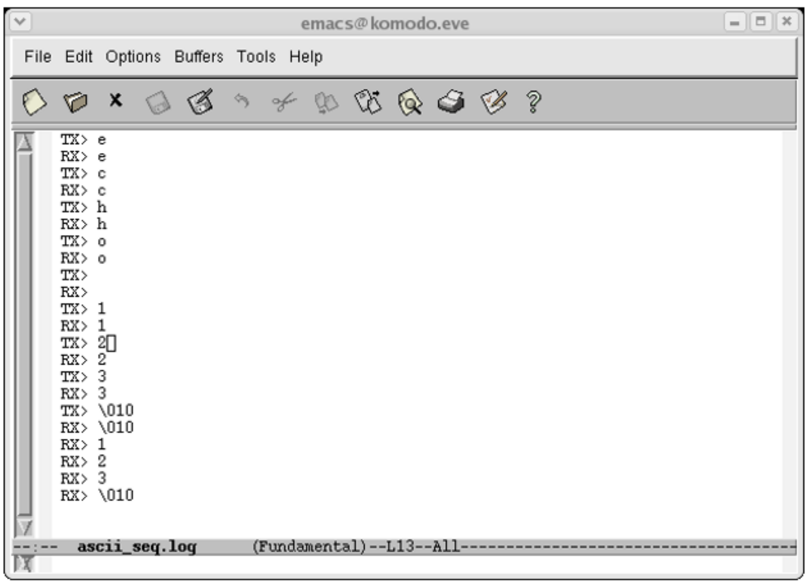
where, disp is of DumpDisplay_t enumeration type and its values are as follows:

- DumpSequential (default): Transmitted and received data sequences are dumped sequentially. Each received or sent data sequence is dumped in a new line beginning with relevant prefix.
- DumpSplit: Received and transmitted data are displayed side by side (transmitted data on the left, received data on the right).

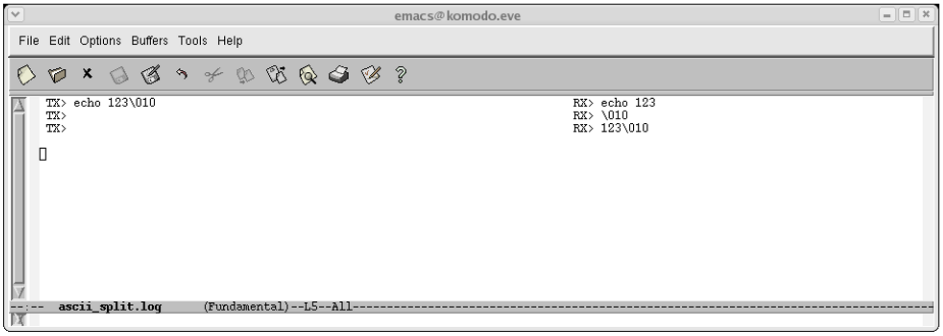
Example:

For instance, if the testbench sends a command “echo 123” followed by a line feed (0x0a), the DUT echoes all the characters and sends the results of the command execution “123” followed by a line feed (0x0a).

- Results using the DumpSequential setting (and DumpASCII format):



- Results using the `DumpSplit` setting (and `DumpASCII` format):



4.3.3.6 dumpSetMaxLineWidth() Method

This method sets the maximum line width in the dump file.

```
void dumpSetMaxLineWidth  (uint maxwidth);
```

where, `maxwidth` is the maximum line width in number of characters.

If set to `0`, the line width is unlimited.

By default, the maximum line width is `80`.

4.3.3.7 dumpGetRxPrefix() Method

This method returns the prefix dumped at the beginning of each received data sequence.

```
const char* dumpGetRxPrefix  (void);
```

4.3.3.8 dumpGetTxPrefix() Method

This method returns the prefix dumped at the beginning of each transmitted data sequence.

```
const char* dumpGetTxPrefix  (void);
```

4.3.3.9 dumpGetDisplayErrors() Method

This method returns the current error display setting.

```
bool dumpGetDisplayErrors  (void);
```

The method returns `true` when an error message is generated on erroneous data reception. It returns `false` when erroneous received data are ignored.

4.3.3.10 dumpGetFormat() Method

This method returns the current dump format setting.

```
DumpFormat_t dumpGetFormat (void);
```

The returned value can be:

- `DumpASCII`: the current dump format is ASCII.
- `DumpRaw`: the current dump format is Raw.

4.3.3.11 dumpGetDisplay() Method

This method returns the current dump display configuration.

```
DumpDisplay_t dumpGetDisplay  (void);
```

The returned value can be:

- `DumpSplit`: the current dump display configuration is the split display.
- `DumpSequential`: the current dump display configuration is the sequential dump display.

4.3.3.12 dumpGetMaxLineWidth() Method

This method returns the maximum line width in the dump file.

```
uint dumpGetMaxLineWidth  (void);
```

4.3.3.13 openDumpFile() Method

This method opens the dump file and starts dumping UART traffic.

```
bool openDumpFile  (const char *fname);
```

This method returns `true` when the operation is successful; otherwise, `false`.

4.3.3.14 closeDumpFile() Method

This method stops dumping UART traffic and closes the dump file.

```
bool closeDumpFile  (void);
```

This method returns `true` when the operation is successful; otherwise, `false`.

4.4 Uart Class Specific Interface

This section provides information about Uart class methods.

The Uart class provides a set of methods to send and receive data over the UART interface.

TABLE 5 Uart Class Specific Methods

Method	Description
`getNewXtor`	Static method for transactor constructor. DO NOT use the default constructor.
`~xtor_uart_svs`	Transactor destructor.
`setReceiveCB`	Registers the data reception callbacks.
`setSendCB`	Registers the data transmission callbacks.
`setTimeout`	Sets a timeout.
`send`	Sends the data over a serial link.
`sendBreak`	Sends a break condition over a serial link.
`receive`	Returns the received data over a serial link, if any.
`txQueueFlush`	Sends data remaining in the queue to the transactor hardware.
`txQueueLength`	Returns the number of data present in the transmission queue.
`rxQueueLength`	Returns the number of data present in the reception queue.

4.4.1 Description

4.4.1.1 getNewXtor () and ~xtor_uart_svs Methods

For xtor_uart_svs class constructor, it is recommended to use the unified API-based constructor method. For this use the Xtor::getNewXtor() method as shown below:

```
static Xtor * getNewXtor(ZEBU::Board * board,
                                    const char * xtorTypeName,
  XtorScheduler * sched,
  const char * driverName = NULL,
                           svt_c_runtime_cfg* runtime = NULL
                           ) ;
```

Here,

- board helps you handle ZEBU::Board
- xtorTypeName signifies the name that is used to register the class
- sched signifies handle to XtorScheduler
- driverName is the path to the transactor instance in HW. Can be left NULL, API can automatically detect it.
- runtime is the handle to global runtime configuration for testbench.
-

Example:

The following is the testbench example for constructing the UART transactor object.

The following is the testbench example for destructing the UART transactor object:

```
    svt_c_threading* threading = new svt_pthread_threading();
    XtorSchedParams->useVcsSimulation   = false;
    XtorSchedParams->useZemiManager     = true;
    XtorSchedParams->noParams           = true;
    XtorSchedParams->zebuInitCb         = NULL;
    XtorSchedParams->zebuInitCbParams   = NULL;
    xsched->configure(XtorSchedParams) ;
    zemi3 = ZEMI3Manager::open(zebuWork,designFeatures);
    board = zemi3->getBoard();
    zemi3->buildXtorList(); // manually add the xtor or use buildXtorList
    zemi3->init();

    runtime->set_threading_api(threading);
```

```
    runtime->set_platform(new svt_zebu_platform(board, false));
    svt_c_runtime_cfg::set_default(runtime);

    cerr << "#TB : Register UART Transactor..." << board << endl;
    xtor_uart_svs::Register("xtor_uart_svs");

    test = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(), "xtor_uart_svs",  xsched, NULL,runtime)) ;
```

```
~xtor_uart_svs
```

4.4.1.2 setReceiveCB() Method

This method registers the data reception callback. The callback function is called each time a data is received by the UART transactor.

```
void setReceiveCB  (rxFunc_typ rxcb, void *userData = NULL);
```

where:

- `rxcb` is the reception callback.
- `userData` is the pointer to the user data passed to the callback. By default, it is set to NULL.

The reception callback must have the following prototype:

```
void rcvCB (uint8_t data, bool valid, void *userData);
```

where:

- `data` is the received data.
- `valid` is:
  - `true`, if no error is detected during transmission.
  - `False`, if an error is detected during transmission.

- `userData` is the pointer specified when the callback is registered.

The reception callback can be disabled by setting `rxcb` to `NULL`.

4.4.1.3 setSendCB() Method

This method registers the data transmission callback. The callback function is called each time the UART transactor is ready to send data.

```
void setSendCB  (rxFunc_typ txcb, void *userData = NULL);
```

where:

- `txcb` is the transmission callback.
- `userData` is the pointer to the user data passed to callback. By default, it is set to `NULL`.

The transmission callback must have the following prototype:

```
bool tmitCB (uint char *data, void *userData);
```

where:

- `data` is a pointer to the data to be transmitted.
- `userData` is the pointer specified when registering the callback.

The callback must return `true`, if the data is ready to be sent; otherwise, `false`.

The reception callback can be disabled by setting `txcb` to `NULL`. Note that to service the TxCallback, you must call the runClk () cycle from the testbench regularly.

4.4.1.4 setTimeout() Method

This method sets the timeout in seconds. When called in blocking mode, and to avoid locking the testbench, the `send()` and `receive()` methods are forced to return when the timeout is reached.

```
void setTimeout  (uint sec);
```

where, `sec` is the timeout value in seconds.

4.4.1.5 send() Method

This method sends a single data byte over the UART interface in blocking or non-blocking mode in the following way:

- In non-blocking mode (default), it tries to send data and almost immediately returns control to your program (returns false if data not sent).
- In blocking mode, control is not returned to your program until data is sent to the transactor or the timeout is reached (see *setTimeout() Method*).

```
bool send (uint8_t data, bool blocking = false);
```

where:

- `data` is the data to be sent.
- `blocking` enables or disables the blocking mode:
  - `true`: blocking mode is activated.
  - `false`: non-blocking mode is activated.

  NOTE: *If hardware FIFO is full, the data might not be actually sent to the transactor hardware part and it is stored in a transmission queue (see txQueueLength() Method and txQueueLength() Method).*

The `send()` method returns `true` when the data is sent or stored in transmission queue; otherwise, `false`.

4.4.1.6 sendBreak() Method

This method sends a break condition (sending continuous 0 values with no Start and no Stop bits) over the UART interface in blocking or non-blocking mode in the following way:

- In non-blocking mode (default), it tries to send the break condition and almost immediately returns control to your program (returns false if the data is not sent).
- In blocking mode, control is not returned to your program until the break condition is sent to the transactor or the timeout is reached (see *setTimeout() Method*).

```
bool sendBreak  (bool blocking = false);
```

NOTE: *IIf hardware FIFO is full, the break condition might not be sent to the transactor hardware part and it is stored in a transmission queue (see txQueueFlush() Method and "txQueueLength() Method").*

The `sendBreak()` method returns `true` when the break condition is sent or stored in transmission queue; otherwise, `false`.

4.4.1.7 receive() Method

This method returns a single data received from the UART interface in blocking or non-blocking mode in the following way:

- In non-blocking mode (default), it returns the data received over the serial link, if any, and immediately returns control to the program.
- In blocking mode, control is not returned to your program until received data is available or the timeout is reached (see *setTimeout() Method*).

```
int receive (uint8_t *data, bool blocking = false);
```

where:

- `data` is the data to be received.
- `blocking` enables or disables the blocking mode:
  - `true`: blocking mode is activated.
  - `false`: non-blocking mode is activated.

This method returns:

- `0`: no data is received.
- `1`: data is received.
- `-1`: data is received, but a parity error is detected.

4.4.1.8 txQueueFlush() Method

This method sends remaining data from transmission queue to the hardware part of the transactor.

```
bool txQueueFlush  (void);
```

The method returns:

- `true` when the transmission queue is empty.
- `false` when data is remaining in the transmission queue.

4.4.1.9 txQueueLength() Method

This method returns the data length present in the transmission queue. If a data cannot be sent immediately in non-blocking mode or if the timeout is elapsed in blocking mode, the `send()` method stores the data in a transmission queue for later transmission.

The data stored in the transmission queue is consumed, the runClk() cycle or next send() non-blocking command, is called, by the `txQueueFlush()` method or each time the `send()` method is called. This method can then be used to ensure that all the data is sent.

```
uint txQueueLength  (void);
```

4.4.1.10 rxQueueLength() Method

This method returns the data length present in the reception queue.

The data stored in the reception queue can be consumed using the `receive()` method. Use this method to check if all the received data is consumed.

```
uint rxQueueLength  (void);
```

4.4.1.11 runClk () Method

This method advances the clock for specified number of clocks when the transactor is operating in controlled the clock mode. Also this method services the Tx Callbacks registered. Therefore, you must call this method if the testbench is registering a TX callback using setSendCB ().

The following is the syntax of the runClk() Method

```
void runClk  (uint32_t numClks) ;
```

4.5 Server Mode Specific Interface

This section provides information about the class methods applicable when the operating mode is set as ServerMode.

The UART server uses the UART transactor and the TCP/IP protocol to relay data from the UART transactor to the TCP socket. It allows the user to send and receive data from a remote PC, running on the Linux or the Windows operating system.

TABLE 6 Server Mode Specific Methods

Method	Description
`startServer`	Starts the TCP server.
`startClient`	Connects to the remote TCP server.
`isConnected`	Returns the TCP connection status.
`closeConnection`	Closes the TCP connection.
`setDisplayErrors`	Enables the generation of an error message on erroneous data reception.
`getDisplayErrors`	Obtains the error display setting.

4.5.1 Description

4.5.1.1 startServer() Method

This method opens a TCP connection in server mode. The method starts the server and returns immediately without waiting for an incoming connection.

```
bool startServer (uint16_t tcpPort, uint frameSize = 1534);
```

where:

- `tcpPort` is the TCP port number. It ranges from `0` through `65553`, generally 1024 through 65553 are used.
- `frameSize` is the maximum size of TCP frames. Default value is `1534` (optional parameter).

The method returns `true` when the server was launched successfully; otherwise, `false`.

4.5.1.2 startClient() Method

This method opens a TCP connection in the client mode to an existing server. The method tries to establish a connection with the server and returns immediately.

```
bool startClient (const char *host,
                  uint16_t tcpPort,
                  uint frameSize = 1534 );
```

where,

- `host` is the host name.
- `tcpPort` is the TCP port number. It can range from `0` through `65553`, generally `1024` through `65553` are used.
- `frameSize` is the maximum size of TCP frames. Default value is `1534` (optional parameter).

The method returns `true` when the connection is successful; otherwise, `false`.

4.5.1.3 isConnected() Method

This method returns the TCP connection status.

```
bool isConnected (void);
```

The method returns `true` if the TCP is connected, `false` if it is disconnected.

4.5.1.4 closeConnection() Method

This method closes the TCP connection in client or server mode.

```
bool closeConnection  (void);
```

The method returns `true` when the TCP connection is closed, `false` if an error occurs while closing connection.

4.5.1.5 setDisplayErrors() Method

This method enables the generation of an error message when erroneous data is received.

```
void setDisplayErrors (bool enable);
```

where, `enable` activates or deactivates the error message generation in the following way:

- `true`: an error message is generated in the terminal.
- `false` (default): the error is ignored and erroneous data is discarded.

4.5.1.6 getDisplayErrors() Method

This method returns the error display setting.

```
bool getDisplayErrors  (void);
```

It returns:

- `true`: Transmission errors are monitored and displayed.
- `false`: Data with transmission errors is not displayed.

4.6 XtermMode Specific Interface

This section provides information about the `UartTerm` class methods.

The UART terminal provides a graphical terminal (`xterm`).

TABLE 7 UartTerm Class Specific Methods

Method	Description
`setConvMode`	Sets the conversion mode for xterm
`setTermName`	Sets the terminal name.
`getTermName`	Obtains the terminal name.
`isAlive`	Obtains the terminal status.
`printTermString`	Converts, formats, and prints its arguments to the xterm terminal
`setDisplayErrors`	Enables the generation of an error message on erroneous data reception
`getDisplayErrors`	Obtains the error display setting
`setInputCharCB`	Defines the conversion callback function for the input characters
`setOutputCharCB`	Defines the conversion callback function for the output characters
`setFilterIn`	Enables or disables filtering on input characters
`setFilterOut`	Enables or disables filtering on output characters
`isFilterInEnabled`	Obtains the filtering status on input characters
`isFilterOutEnabled`	Obtains the filtering status on output characters

4.6.1 Description

4.6.1.1 setConvMode() Method

This method accepts a parameter that is used to apply some character translation to special OS-dependent characters such as CR, NL, LF, and so on.

```
setConvMode (ConvMode_t char_conversion_mode);
```

Where, char_conversion_mode defines the type of predefined conversion algorithm already defined in the transactor:

- Conv_None: No conversion.
- Conv_DOS: DOS conversion.
- Conv_DOS_BSR: DOS conversion with BSR (0x13) only for CRLF.
- Conv_ISO: ISO conversion.
- Conv_MAC: MAC character conversion.
- Conv_7bits: Conversion to 7-bit ASCII code.

4.6.1.2 setTermName() Method

This method sets the terminal name (xterm window title).

```
bool setTermName  (const char *name);
```

where, name is the pointer to the terminal name string.

The method returns true when the operation is successful; otherwise, false.

4.6.1.3 getTermName() Method

This method returns the terminal name (xterm window title).

```
const char *name getTermName  (void);
```

4.6.1.4 isAlive() Method

This method returns the terminal status.

```
bool isAlive  (void);
```

The method returns:

- `true` when the terminal is active.
- `false` when the terminal is inactive.

The terminal can be closed by terminating the `xterm` window.

4.6.1.5 printTermString() Method

This method converts, formats, and prints its arguments to the xterm terminal.

```
void printTermString (const char *format, ... );
```

The `printTermString()` method works like the standard `printf`.

4.6.1.6 setDisplayErrors() Method

This method enables the generation of an error message when an erroneous data is received.

```
void setDisplayErrors (bool enable);
```

where, enable activates or deactivates the error message generation in the following way:

- `true`: an error message is generated in the terminal.
- `false` (default): the error is ignored and erroneous data is discarded.

4.6.1.7 getDisplayErrors() Method

This method returns the error display setting.

```
bool getDisplayErrors  (void);
```

It returns:

- `true`: Transmission errors are monitored and displayed.
- `false`: Data with transmission errors is not displayed.

4.6.1.8 setInputCharCB() Method

This method defines the callback function that translates all input characters from the terminal before sending them to the DUT interface.

`ConvMode_t` must be set to `Conv_None` in the `UartTerm` constructor.

```
void setInputCharCB (ConvFunct_t cb, void *user_data);
```

where:

- `cb` is the pointer to the callback translation function. The function type must be `bool fconv(char ichar, char &ochar, void *user_data)`. where, `ochar` is the result of `ichar` conversion.
- `user_data` is the user-defined data.

4.6.1.9 setOutputCharCB() Method

This method defines the callback function that translates all output characters from the DUT before sending them to the terminal.

`ConvMode_t` must be set to `Conv_None` in the `UartTerm` constructor.

```
void setOutputCharCB (ConvFunct_t cb, void *user_data);
```

where:

- `cb` is the pointer to the callback translation function. The function type must be `bool fconv (char ichar, char &ochar, void *user_data)`. Where, `ochar` is the result of `ichar` conversion.
- `user_data` is the user-defined data.

4.6.1.10 setFilterIn() Method

This method enables or disables the filtering on the input characters.

```
void setFilterIn (bool enable);
```

where enable activates or deactivates the filtering in the following way:

- `true`: filtering is enabled.
- `false`: filtering is disabled.

4.6.1.11 setFilterOut() Method

This method enables or disables filtering on output characters.

```
void setFilterOut (bool enable);
```

where enable activates or deactivates the filtering in following way:

- `true`: filtering is enabled.
- `false`: filtering is disabled.

4.6.1.12 isFilterInEnabled() Method

This method gets the filtering status on input characters.

```
bool isFilterInEnabled ();
```

The method returns:

- `true`: filtering is enabled.
- `false`: filtering is disabled.

4.6.1.13 isFilterOutEnabled() Method

This method gets the filtering status on the output characters.

```
bool isFilterOutEnabled ();
```

The method returns:

- `true`: filtering is enabled.
- `false`: filtering is disabled.

4.6.2 Key Combinations Supported by xterm Terminal

The xterm runs a tool that connects to the UART transactor and automatically exchanges data between the xterm terminal and the UART transactor.

The following combinations are not filtered out by the terminal and are transmitted to the DUT:

- `Ctrl-[A-Z]`
- `Ctrl-\`

5 Typical Implementation

This chapter provides typical testbench implementation using three UART modes.

This section describes the following sub-topics.

- *Using the xtor_uart_svs class for default mode*
- *Using the Server Mode*
- *Using the XtermMode*

5.1 Using the xtor_uart_svs class for default mode

This section provides the following three typical testbench implementations using the `Uart` class:

- *Testbench Using the Uart Class With Non-Blocking Send and Receive*
- *Testbench Using the Uart Class With Blocking Send and Receive*
- *Testbench Using the Uart Class With Callbacks*

5.1.1 Testbench Using the Uart Class With Non-Blocking Send and Receive

```
#include <stdexcept>
#include <exception>
#include <queue>
#include <libZebu.hh>
#include "xtor_uart_svs.hh"

#include "svt_report.hh"
#include "svt_pthread_threading.hh"
#include "svt_cr_threading.hh"
#include "svt_c_threading.hh"
#include "svt_zebu_platform.hh"
#include "TopScheduler.hh"
#include "XtorScheduler.hh"

#include "libZebuZEMI3.hh"
#include "svt_systemverilog_threading.hh"
#include "svt_simulator_platform.hh"
#define THREADING svt_systemverilog_threading

using namespace ZEBU;
```

Using the xtor_uart_svs class for default mode

```
using namespace ZEBU_IP;
using namespace XTOR_UART_SVS;
using namespace std;


uint8_t convertData ( uint8_t data )
{
    uint8_t ret = data;
    if (ret > 'a' && ret < 'Z') {
        ret = (ret < 'z')?(ret+0x20):(ret-0x20);
    }
    return ret;
}


//#################################
//  main
//#################################
int main ( ) {
    int ret = 0;
    xtor_uart_svs  *test    = NULL;
    xtor_uart_svs  *replier = NULL;
    Board *board   = NULL;
    ZEMI3Manager *zemi3 = NULL ;
    bool ok;
    TbCtxt context;

    uint8_t data         = 0;
    bool    dataSent     = false;
    uint8_t tmpData      = 0;
    queue<uint8_t> dQueue;
    bool    end          = false;
    unsigned int    errors       = 0;
```

```
    try {
        //open ZeBu
        XtorScheduler     * xsched = XtorScheduler::get();
        XtorSchedParams_t * XtorSchedParams = xsched->getDefaultParams();
        svt_c_runtime_cfg * runtime   = new svt_c_runtime_cfg();


        char *zebuWork       = ZEBUWORK;
        char *designFeatures = DFFILE;
        svt_c_threading *threading = new svt_pthread_threading();

        XtorSchedParams->useVcsSimulation   = false;
        XtorSchedParams->useZemiManager     = true;
        XtorSchedParams->noParams           = true;
        XtorSchedParams->zebuInitCb         = NULL;
        XtorSchedParams->zebuInitCbParams   = NULL;
        xsched->configure(XtorSchedParams) ;
        zemi3 = ZEMI3Manager::open(zebuWork,designFeatures);
        board = zemi3->getBoard();
        zemi3->buildXtorList(); // manually add the xtor or use
buildXtorList
        zemi3->init();

        runtime->set_threading_api(threading);
        runtime->set_platform(new svt_zebu_platform(board, false));
        svt_c_runtime_cfg::set_default(runtime);


        cerr << "#TB : Register UART Transactor..." << board << endl;
        xtor_uart_svs::Register("xtor_uart_svs");
```

```
        test = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(), "xtor_uart_svs",  xsched, NULL,runtime)) ;
        fprintf (stderr, "Found - Drivers [%s][%s] ...\n", test-
>getDriverModelName (),test->getDriverInstanceName ());
        replier = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(),  "xtor_uart_svs",  xsched, NULL,runtime)) ;
        fprintf (stderr, "Found - Drivers [%s][%s] ...\n", replier-
>getDriverModelName (),replier->getDriverInstanceName ());

        //open ZeBu
        test->init(board,"uart_device_wrapper.uart_driver_0");
        replier->init(board,"uart_device_wrapper.uart_driver_1");

        cerr <<"--------------------------Zemi3 Start---------------------
-------" << endl;
        zemi3->start();   //This will start the Zemi3 service loop


        cerr <<"--------------------------Wait for Reset -----------------
-----------" << endl;
        test->runUntilReset() ;
        ok = test->setWidth(8);
        ok &= test->setParity(NoParity);
        ok &= test->setStopBit(TwoStopBit);
        ok &= test->setRatio(16);
        ok &= test->config();
        if (!ok ){ throw ("UART config failed");}

        ok = replier->setWidth(8);
        ok &= replier->setParity(NoParity);
        ok &= replier->setStopBit(TwoStopBit);
        ok &= replier->setRatio(16);
        ok &= replier->config();
        if (!ok ){ throw ("UART config failed");}
```

```
        test->dumpSetDisplayErrors(true);
        test->dumpSetFormat(DumpASCII);
        test->dumpSetDisplay(DumpSplit);
        test->dumpSetMaxLineWidth(5);
        test->openDumpFile("test_dump.log");

        replier->dumpSetDisplayErrors(true);
        replier->dumpSetFormat(DumpASCII);
        replier->dumpSetDisplay(DumpSplit);
        replier->dumpSetMaxLineWidth(5);
        replier->openDumpFile("test_dump.log");

        context.TX = test;
        context.RX = replier;

        // TB Main loop
        while (!end) {

            // Tester data sending
            if (!dataSent) {
                if (test->send(data)) {
                    dataSent = true;
                    printf("Tester  -- Sending data 0x%02x\n",data);
                }
            }

            // Tester data receiving
            if (test->receive(&tmpData)) {
                if (!dataSent) {
                    printf("Tester  -- Received unexpected data 0x%02x
!!!\n",tmpData); ++errors;
                } else {
```

```
                    printf("Tester  -- Received data 0x%02x\n",tmpData);
                    dataSent = false;
                    if (tmpData != convertData(data)) {
                      printf("Wrong data '0x%02x' instead of '0x%02x'\n",
                                tmpData, convertData(data));
                        ++errors;
                    }

                    if (data == 0xff) {
                        end = true;
                        test->sendBreak(true);
                    } else {
                        ++data;
                    }
                }
            }
            // Replier data receiving
            if (replier->receive(&tmpData)) {
                printf("Replier -- Received data 0x%02x\n",tmpData);
                // push processed received data in tx queue
                dQueue.push(convertData(data));
            }

            // Replier data sending
            // If TX queue not empty, try to send next data
            if (!dQueue.empty()) {
                if (replier->send(dQueue.front())) {
                    printf("Replier -- Sending data
0x%02x\n",dQueue.front());
                    // data sent, remove it from tx queue
                    dQueue.pop();
                } else {
```

```
                    printf("REPLIER - Could not send data\n");
fflush(stdout);
                }
            }
        }

        test->closeDumpFile();
        replier->closeDumpFile();

        if (errors != 0) {
            printf("Detected %d errors during test\n",errors);
            ret = 1;
        }
    } catch (const char *err) {
        ret = 1; fprintf(stderr,"Testbench error: %s\n", err);
    }
    if (test != NULL)  { delete test; }
    if (replier != NULL) { delete replier; }

    zemi3->terminate();
    zemi3->close();

    printf("Test %s\n",(ret==0)?"OK":"KO");

    return ret;
}
```

5.1.2 Testbench Using the Uart Class With Blocking Send and Receive

```
#include <stdexcept>
#include <exception>
#include <queue>
#include <libZebu.hh>
#include "xtor_uart_svs.hh"
#include "svt_report.hh"
#include "svt_pthread_threading.hh"
#include "svt_cr_threading.hh"
#include "svt_c_threading.hh"
#include "svt_zebu_platform.hh"
#include "TopScheduler.hh"
#include "XtorScheduler.hh"

#include "libZebuZEMI3.hh"
#include "svt_systemverilog_threading.hh"
#include "svt_simulator_platform.hh"
#define THREADING svt_systemverilog_threading

using namespace ZEBU;
using namespace ZEBU_IP;
using namespace XTOR_UART_SVS;
using namespace std;


typedef struct {
  xtor_uart_svs* rep;
  queue<uint8_t> dQueue;
} UsrCtxt_t;
```

```
uint8_t convertData ( uint8_t data )
{
  uint8_t ret = data;
  if (ret > 'a' && ret < 'Z') {
    ret = (ret < 'z')?(ret+0x20):(ret-0x20);
  }
  return ret;
}


void usercb ( void * context )
{
  UsrCtxt_t* ctxt = (UsrCtxt_t*)context;
  uint8_t data;


  // Check if data received on uart
  if (ctxt->rep->receive(&data)) {
    printf("Replier -- Received data 0x%02x\n",data);
    // push processed received data in tx queue
    ctxt->dQueue.push(convertData(data));
  }

  // If TX queue not empty, try to send next data
  if (!(ctxt->dQueue.empty())) {
    if (ctxt->rep->send(ctxt->dQueue.front())) {
      printf("Replier -- Sending data 0x%02x\n",ctxt->dQueue.front());
      // data sent, remove it from tx queue
      ctxt->dQueue.pop();
    }
  }
```

```
}



//#################################
//  main
//#################################
int main () {
  int ret = 0 ;
  xtor_uart_svs  *test    = NULL;
  xtor_uart_svs  *replier = NULL;
  Board *board   = NULL;
  ZEMI3Manager *zemi3 = NULL ;
  bool ok;

  UsrCtxt_t usrCtxt;
  uint8_t data         = 0;
  uint8_t tmpData      = 0;
  bool    end          = false;
  unsigned int    errors       = 0;


  try {
    //open ZeBu
    XtorScheduler     * xsched = XtorScheduler::get();
    XtorSchedParams_t * XtorSchedParams = xsched->getDefaultParams();
    svt_c_runtime_cfg * runtime   = new svt_c_runtime_cfg();

    char *zebuWork       = ZEBUWORK;
    char *designFeatures = DFFILE;
    svt_c_threading* threading = new svt_pthread_threading();

    XtorSchedParams->useVcsSimulation   = false;
    XtorSchedParams->useZemiManager     = true;
```

```
    XtorSchedParams->noParams            = true;
    XtorSchedParams->zebuInitCb          = NULL;
    XtorSchedParams->zebuInitCbParams    = NULL;
    xsched->configure(XtorSchedParams) ;
    zemi3 = ZEMI3Manager::open(zebuWork,designFeatures);
    board = zemi3->getBoard();
    zemi3->buildXtorList(); // manually add the xtor or use buildXtorList
    zemi3->init();

    runtime->set_threading_api(threading);
    runtime->set_platform(new svt_zebu_platform(board, false));
    svt_c_runtime_cfg::set_default(runtime);



    cerr << "#TB : Register UART Transactor..." << board << endl;
    xtor_uart_svs::Register("xtor_uart_svs");

    test = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(), "xtor_uart_svs",  xsched, NULL,runtime)) ;
    fprintf (stderr, "Found - Drivers [%s][%s] ...\n", test-
>getDriverModelName (),test->getDriverInstanceName ());
    replier = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(), "xtor_uart_svs",  xsched, NULL,runtime)) ;
    fprintf (stderr, "Found - Drivers [%s][%s] ...\n", replier-
>getDriverModelName (),replier->getDriverInstanceName ());



    test->init(board,"uart_device_wrapper.uart_driver_0");
    replier->init(board,"uart_device_wrapper.uart_driver_1");
```

Using the xtor_uart_svs class for default mode

```
    cerr <<"--------------------------Zemi3 Start-------------------------
---" << endl;
    zemi3->start();   //This will start the Zemi3 service loop


    test->setLog ("tester.log") ;
    test->setDebugLevel(4) ;

    cerr <<"--------------------------Wait for Reset ---------------------
-------" << endl;
    test->runUntilReset() ;

    ok = test->setWidth(8);
    ok &= test->setParity(NoParity);
    ok &= test->setStopBit(TwoStopBit);
    ok &= test->setRatio(16);
    ok &= test->config();
    if (!ok ){ throw ("UART config failed");}

    replier->setLog ("replier.log") ;
    replier->setDebugLevel(4) ;
    ok = replier->setWidth(8);
    ok &= replier->setParity(NoParity);
    ok &= replier->setStopBit(TwoStopBit);
    ok &= replier->setRatio(16);
    ok &= replier->config();
    if (!ok ){ throw ("UART config failed");}

    test->dumpSetDisplayErrors(true);
    test->dumpSetFormat(DumpASCII);
    test->dumpSetDisplay(DumpSplit);
    test->dumpSetMaxLineWidth(40);
    test->openDumpFile("test_dump.log");
```

```
    replier->dumpSetDisplayErrors(true);
    replier->dumpSetFormat(DumpASCII);
    replier->dumpSetDisplay(DumpSplit);
    replier->dumpSetMaxLineWidth(40);
    replier->openDumpFile("test_dump.log");

    usrCtxt.rep = replier;
    //test->registerUserCB(usercb, &usrCtxt);

    // TB Main loop
    while (!end) {
      // Tester sends data
      if (!test->send(data,true)) {
        throw("Tester could not send data");
      } else {
        printf("Tester  -- Sending data 0x%02x\n",data);
      }
      uint8_t rdata ;
      if (replier -> receive(&rdata, true)) {
         printf("Replier -- Received data 0x%02x\n",rdata);
         // push processed received data in tx queue
         usrCtxt.dQueue.push(convertData(rdata));
      }
      // If TX queue not empty, try to send next data
      if (!(usrCtxt.dQueue.empty())) {
        if (replier->send(usrCtxt.dQueue.front())) {
          printf("Replier -- Sending data
0x%02x\n",usrCtxt.dQueue.front());
          // data sent, remove it from tx queue
          usrCtxt.dQueue.pop();
        }
      }
```

```
    // Tester receives and check received data
    if (test->receive(&tmpData,true)) {
      printf("Tester  -- Received data 0x%02x\n",tmpData);
      if (tmpData != convertData(data)) {
        printf("Wrong data '0x%02x' instead of '0x%02x'\n",
               tmpData, convertData(data));
        ++errors;
      }
    } else { throw("Tester could not receive data"); }
    if (data == 0xff) {
      end = true;
    } else {
      ++data;
    }
  }

  test->closeDumpFile();
  replier->closeDumpFile();

  if (errors != 0) {
    printf("Detected %d errors during test\n",errors);
    ret = 1;
  }
} catch (const char *err) {
  ret = 1; fprintf(stderr,"Testbench error: %s\n", err);
}
if (test != NULL)  { delete test; }
if (replier != NULL) { delete replier; }

zemi3->terminate();
zemi3->close();
```

```
  return 0;
}
```

5.1.3 Testbench Using the Uart Class With Callbacks

```
#include <stdexcept>
#include <exception>
#include <queue>
#include <libZebu.hh>
#include <sys/resource.h>
#include <sys/time.h>
#include "xtor_uart_svs.hh"
#include "svt_report.hh"
#include "svt_pthread_threading.hh"
#include "svt_cr_threading.hh"
#include "svt_c_threading.hh"
#include "svt_zebu_platform.hh"
#include "TopScheduler.hh"
#include "XtorScheduler.hh"

#include "libZebuZEMI3.hh"
#include "svt_systemverilog_threading.hh"
#include "svt_simulator_platform.hh"
#define THREADING svt_systemverilog_threading
svt_c_threading * threading = NULL ;

using namespace ZEBU;
```

```
using namespace ZEBU_IP;
using namespace XTOR_UART_SVS;
using namespace std;


uint8_t convertData ( uint8_t data )
{
  uint8_t ret = data;
  if (ret > 'a' && ret < 'Z') {
    ret = (ret < 'z')?(ret+0x20):(ret-0x20);
  }
  return ret;
}

typedef struct {
  uint8_t sentData;
  bool    dataExpected;
  unsigned int    error;
  bool    end;
} TbCtxt;

// TX Callback
bool txCB ( uint8_t* data, void* ctxt )
{
  bool send = false;
  TbCtxt* tbCtxt = (TbCtxt*)ctxt;
  if (!tbCtxt->dataExpected) {
    if (tbCtxt->sentData == 0xFF) {
      tbCtxt->end = true; // All data have been sent and received
      //if (threading -> is_blocked()) {
      //  threading -> unblock() ;
      //}
    } else {
```

```
      *data = ++(tbCtxt->sentData);
      tbCtxt->dataExpected = true;
      send = true; // send next data
      printf("Tester  -- Sending data 0x%02x\n",*data);
    }
  }
  return send;
}

// RX Callback
void rxCB ( uint8_t data, bool valid, void* ctxt )
{
  TbCtxt* tbCtxt = (TbCtxt*)ctxt;

  printf("Tester  -- Received data 0x%02x %s\n",data,valid?"":"-- parity 
error detected !!! )");

  if (!tbCtxt->dataExpected) {
     printf("Received unexpected data '%02x'\n", data);
     ++(tbCtxt->error);
  } else {
     tbCtxt->dataExpected = false;
     if (!valid) {
       printf("Parity error detected on received data '%02x'\n", data);
       ++(tbCtxt->error);
     } else if (data != convertData(tbCtxt->sentData)) {
       printf("Wrong data '0x%02x' instead of '0x%02x'\n",
              data, convertData(tbCtxt->sentData));
       ++(tbCtxt->error);
     }
  }
}
```

Using the xtor_uart_svs class for default mode

```
typedef struct {
  queue<uint8_t> dataQueue;
} RpCtxt;

// TX Callback
bool rpTxCB ( uint8_t* data, void* ctxt )
{
  bool send = false;
  RpCtxt* rpCtxt = (RpCtxt*)ctxt;

  if (!((rpCtxt->dataQueue).empty())) {
    *data =  convertData((rpCtxt->dataQueue).front());
    (rpCtxt->dataQueue).pop();
    send = true; // send next data
    printf("Replier -- Sending data 0x%02x\n",*data);
  }
  return send;
}

// RX Callback
void rpRxCB ( uint8_t data, bool valid, void* ctxt )
{
  RpCtxt* rpCtxt = (RpCtxt*)ctxt;
  printf("Replier -- Received data 0x%02x %s\n",data,valid?"":"-- parity
error detected !!! )");
  if (valid) {
    (rpCtxt->dataQueue).push(data);
  } else {
    (rpCtxt->dataQueue).push(0x0);
  }
}
```

```
//##################################
//  main
//##################################
int main () {
  int ret = 0;
  xtor_uart_svs  *test    = NULL;
  xtor_uart_svs  *replier = NULL;
  Board *board   = NULL;
  ZEMI3Manager *zemi3 = NULL ;
  bool ok;
  TbCtxt tbenchCtxt;
  RpCtxt replierCtxt;

  char *zebuWork       = ZEBUWORK;
  char *designFeatures = DFFILE;

  tbenchCtxt.sentData     = 0;
  tbenchCtxt.dataExpected = false;
  tbenchCtxt.error        = 0;
  tbenchCtxt.end          = false;

  try {
    //open ZeBu
    XtorScheduler     * xsched = XtorScheduler::get();
    XtorSchedParams_t * XtorSchedParams = xsched->getDefaultParams();
    svt_c_runtime_cfg * runtime   = new svt_c_runtime_cfg();

    char *zebuWork       = ZEBUWORK;
    char *designFeatures = DFFILE;
    threading = new svt_pthread_threading();
```

```
    XtorSchedParams->useVcsSimulation   = false;
    XtorSchedParams->useZemiManager     = true;
    XtorSchedParams->noParams           = true;
    XtorSchedParams->zebuInitCb         = NULL;
    XtorSchedParams->zebuInitCbParams   = NULL;
    xsched->configure(XtorSchedParams) ;
    zemi3 = ZEMI3Manager::open(zebuWork,designFeatures);
    board = zemi3->getBoard();
    zemi3->buildXtorList(); // manually add the xtor or use buildXtorList
    zemi3->init();

    runtime->set_threading_api(threading);
    runtime->set_platform(new svt_zebu_platform(board, false));
    svt_c_runtime_cfg::set_default(runtime);

    cerr << "#TB : Register UART Transactor..." << board << endl;
    xtor_uart_svs::Register("xtor_uart_svs");

    test = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(), "xtor_uart_svs",  xsched, NULL,runtime)) ;
    fprintf (stderr, "Found - Drivers [%s][%s] ...\n", test-
>getDriverModelName (),test->getDriverInstanceName ());
    replier = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(),  "xtor_uart_svs",  xsched, NULL,runtime)) ;
    fprintf (stderr, "Found - Drivers [%s][%s] ...\n", replier-
>getDriverModelName (),replier->getDriverInstanceName ());

    //open ZeBu
    printf("opening ZEBU...\n");

    test->init(board,"uart_device_wrapper.uart_driver_0");
    replier->init(board,"uart_device_wrapper.uart_driver_1");
```

```
    cerr <<"--------------------------Zemi3 Start-------------------------
---" << endl;
    zemi3->start();   //This will start the Zemi3 service loop



    cerr <<"--------------------------Wait for Reset ---------------------
-------" << endl;
    test->runUntilReset() ;
    cerr <<"--------------------------Configuring XTOR--------------------
-------" << endl;
    ok = test->setWidth(8);
    ok &= test->setParity(NoParity);
    ok &= test->setStopBit(TwoStopBit);
    ok &= test->setRatio(16);
    ok &= test->config();
    if (!ok ){ throw ("UART config failed");}

    ok = replier->setWidth(8);
    ok &= replier->setParity(NoParity);
    ok &= replier->setStopBit(TwoStopBit);
    ok &= replier->setRatio(16);
    ok &= replier->config();
    if (!ok ){ throw ("UART config failed");}

    test->dumpSetDisplayErrors(true);
    test->dumpSetFormat(DumpASCII);
    test->dumpSetDisplay(DumpSplit);
    test->dumpSetMaxLineWidth(40);
    test->openDumpFile("test_dump.log");

    replier->dumpSetDisplayErrors(true);
    replier->dumpSetFormat(DumpASCII);
    replier->dumpSetDisplay(DumpSplit);
```

Using the xtor_uart_svs class for default mode

```
    replier->dumpSetMaxLineWidth(40);
    replier->openDumpFile("test_dump.log");

    test->setReceiveCB(rxCB,&tbenchCtxt);
    test->setSendCB(txCB,&tbenchCtxt);

    replier->setReceiveCB(rpRxCB,&replierCtxt);
    replier->setSendCB(rpTxCB,&replierCtxt);

    // TB Main loop
    while (!tbenchCtxt.end) {
      test    -> runClk (10) ;
      replier -> runClk (10) ;
    }

    test->closeDumpFile();
    replier->closeDumpFile();

    if (tbenchCtxt.error != 0) {
      printf("Detected %d errors during test\n",tbenchCtxt.error);
      ret = 1;
    }
  } catch (const char *err) {
    ret = 1; fprintf(stderr,"Testbench error: %s\n", err);
  }
  if (test != NULL)   { delete test; }
  if (replier != NULL) { delete replier; }

  zemi3->terminate();
  zemi3->close();

  printf("Test %s\n",(ret==0)?"OK":"KO");
```

```
  return ret;
}
```

5.1.4 Using DMTCP with the UART class

You can use the DMTCP save and restore utility with the UART class. To test the DMTCP capability, use the non-blocking testbench in the example directory of the transactor. This example presents a non-GUI mode of operation.

You can run the example using the corresponding make target. For more information, see the README in the example directory.

5.2 Using the Server Mode

This section explains the following topics:

- *Implementing xtor_uart_svs class Using the Client Mode*
-

5.2.1 Implementing xtor_uart_svs class Using the Client Mode

Following are the typical testbench implementations using the `xtor_uart_svs` class in the client mode:

- The testbench starts a UART transactor server on TCP port 10000 of the test machine with an IP address in the following format: `ddd.ccc.bbb.aaa`.
- With the server started, any TCP client can connect to
  - the UART transactor server.
  - The testbench ends when the client disconnects.

```
#include <stdexcept>
#include <exception>
#include <queue>
#include <sys/time.h>
#include <libZebu.hh>
#include "xtor_uart_svs.hh"
#include <string.h>


using namespace ZEBU;
using namespace ZEBU_IP;
using namespace XTOR_UART_SVS;
using namespace std;

#include "svt_report.hh"
#include "svt_pthread_threading.hh"
#include "svt_cr_threading.hh"
#include "svt_c_threading.hh"
#include "svt_zebu_platform.hh"
#include "TopScheduler.hh"
#include "XtorScheduler.hh"

#include "libZebuZEMI3.hh"
#include "svt_systemverilog_threading.hh"
#include "svt_simulator_platform.hh"
#define THREADING svt_systemverilog_threading
svt_c_threading * threading = NULL ;

#define xstr(s) str(s)
#define str(s) #s
```

```
#ifndef TCP_PORT
#define TCP_PORT    10000
#endif

#ifndef TCP_SERVER
#define TCP_SERVER "localhost"
#endif

#ifndef TCP_MODE
#define SERVER_MODE  true
#else
#define SERVER_MODE  ( strncmp( "client" , TCP_MODE ,6) != 0 )
#endif

uint8_t convertData ( uint8_t data )
{
  uint8_t ret = data;
  if (!((ret < 'A') || (ret > 'z'))) {
    ret = (ret < 'a')?(ret+0x20):(ret-0x20);
  }
  return ret;
}


typedef struct {
  queue<uint8_t> dataQueue;
} RpCtxt;

// Replier TX Callback
bool rpTxCB ( uint8_t* data, void* ctxt )
{
  bool send = false;
  RpCtxt* rpCtxt = (RpCtxt*)ctxt;
```

```
  if (!((rpCtxt->dataQueue).empty())) {
    *data =  convertData((rpCtxt->dataQueue).front());
    (rpCtxt->dataQueue).pop();
    send = true; // send next data
  }
  return send;
}

// Replier RX Callback
void rpRxCB ( uint8_t data, bool valid, void* ctxt )
{
  RpCtxt* rpCtxt = (RpCtxt*)ctxt;
  if (valid) {
    (rpCtxt->dataQueue).push(data);
  } else {
    (rpCtxt->dataQueue).push(0x0);
  }
}



//#################################
//  main
//#################################
int main ( ) {
  int ret = 0;
  Board       *board   = NULL;
  xtor_uart_svs*        test    = NULL;
  xtor_uart_svs*        replier = NULL;
  ZEMI3Manager *zemi3  = NULL ;
  bool ok;
  RpCtxt replierCtxt;
```

```
uint16_t tcpPort     = TCP_PORT;
char*    tcpServer   = TCP_SERVER;
bool     serverMode  = SERVER_MODE;


try {
  //open ZeBu
  printf("opening ZEBU...\n");
  //open ZeBu
  XtorScheduler     * xsched = XtorScheduler::get();
  XtorSchedParams_t * XtorSchedParams = xsched->getDefaultParams();
  svt_c_runtime_cfg * runtime   = new svt_c_runtime_cfg();

  char *zebuWork       = ZEBUWORK;
  char *designFeatures = DFFILE;
  threading = new svt_pthread_threading();

  XtorSchedParams->useVcsSimulation   = false;
  XtorSchedParams->useZemiManager     = true;
  XtorSchedParams->noParams           = true;
  XtorSchedParams->zebuInitCb         = NULL;
  XtorSchedParams->zebuInitCbParams   = NULL;
  xsched->configure(XtorSchedParams) ;
  zemi3 = ZEMI3Manager::open(zebuWork,designFeatures);
  board = zemi3->getBoard();
  zemi3->buildXtorList(); // manually add the xtor or use buildXtorList
  zemi3->init();

  runtime->set_threading_api(threading);
  runtime->set_platform(new svt_zebu_platform(board, false));
  svt_c_runtime_cfg::set_default(runtime);

  cerr << "#TB : Register UART Transactor..." << board << endl;
```

```
    xtor_uart_svs::Register("xtor_uart_svs");

    test = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(), "xtor_uart_svs"  ,  xsched, NULL,runtime)) ;
    fprintf (stderr, "Found - Drivers [%s][%s] ...\n", test-
>getDriverModelName (),test->getDriverInstanceName ());
    replier = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(),"xtor_uart_svs" ,  xsched, NULL,runtime)) ;
    fprintf (stderr, "Found - Drivers [%s][%s] ...\n", replier-
>getDriverModelName (),replier->getDriverInstanceName ());




    printf("Going through UART drivers...\n"); fflush(stdout);

    test->setOpMode (ServerMode) ;
    test->init(board,"uart_device_wrapper.uart_driver_0");
    replier->init(board,"uart_device_wrapper.uart_driver_1");

    cerr <<"--------------------------Zemi3 Start-------------------------
---" << endl;
    zemi3->start();   //This will start the Zemi3 service loop



    cerr <<"--------------------------Wait for Reset ---------------------
-------" << endl;
    test->runUntilReset() ;
    cerr <<"--------------------------Configuring XTOR--------------------
-------" << endl;
    ok =  test->setWidth(8);
    ok &= test->setParity(NoParity);
    ok &= test->setStopBit(TwoStopBit);
    ok &= test->setRatio(16);
    ok &= test->config();
```

```
    if(!ok) { throw ("Could not configure UART"); }

    ok =  replier->setWidth(8);
    ok &= replier->setParity(NoParity);
    ok &= replier->setStopBit(TwoStopBit);
    ok &= replier->setRatio(16);
    ok &= replier->config();
    if(!ok) { throw ("Could not configure UART"); }

    test->dumpSetDisplayErrors(true);
    test->dumpSetFormat(DumpASCII);
    test->dumpSetDisplay(DumpSplit);
    test->dumpSetMaxLineWidth(40);
    test->openDumpFile("test_dump.log");

    replier->dumpSetDisplayErrors(true);
    replier->dumpSetFormat(DumpASCII);
    replier->dumpSetDisplay(DumpSplit);
    replier->dumpSetMaxLineWidth(40);
    replier->openDumpFile("replier_dump.log");

    replier->setReceiveCB(rpRxCB,&replierCtxt);
    replier->setSendCB(rpTxCB,&replierCtxt);

    if (serverMode) {
      char hostName[1024];
      printf("\n\n  -- Start TCP server  -- \n");
      if (!test->startServer(tcpPort)) {throw ("Could not start UART
Server."); }
      if (gethostname(hostName, 1024) == 0) {
        printf("\nTCP server is up, TCP client may now be connected to
%s:%u\n\n",hostName,tcpPort);
      }
```

```
      while (!test->isConnected()) {}
      printf("\nTCP client is now connected\n\n");
    } else {
      printf("\n\n  -- Starting TCP connection  -- \n");
     if (!test->startClient( tcpServer, tcpPort)) {throw ("Could not start
UART Server."); }
    }

    printf("\n\n  -- Starting testbench  -- \n"); fflush(stdout);
    while (test->isConnected()) {
      test    -> runClk (10) ;
      replier -> runClk (10) ;
    }

    test->closeDumpFile();
    replier->closeDumpFile();

  } catch (const char *err) {
    ret = 1; fprintf(stderr,"Testbench error: %s\n", err);
  }

  if (replier != NULL) { delete replier; replier = NULL;}
  if (test != NULL)    { delete test; test = NULL;}

  zemi3->terminate();
  zemi3->close();

  printf("Test %s\n",(ret==0)?"OK":"KO");

  return ret;
}
```

For instance, to connect from a Windows-based machine using Microsoft's HyperTerminal:

1. Start the HyperTerminal from Windows XP.
2. Create a new connection, in the **Connection** dialog box:
   a. Set the host address to the host machine's name or to its IP address (`ddd.ccc.bbb.aaa`).
   b. Set the port number to 10000.
   c. Set the connection type to TCP/IP (`winsock`).
3. Click **OK** to connect the terminal.

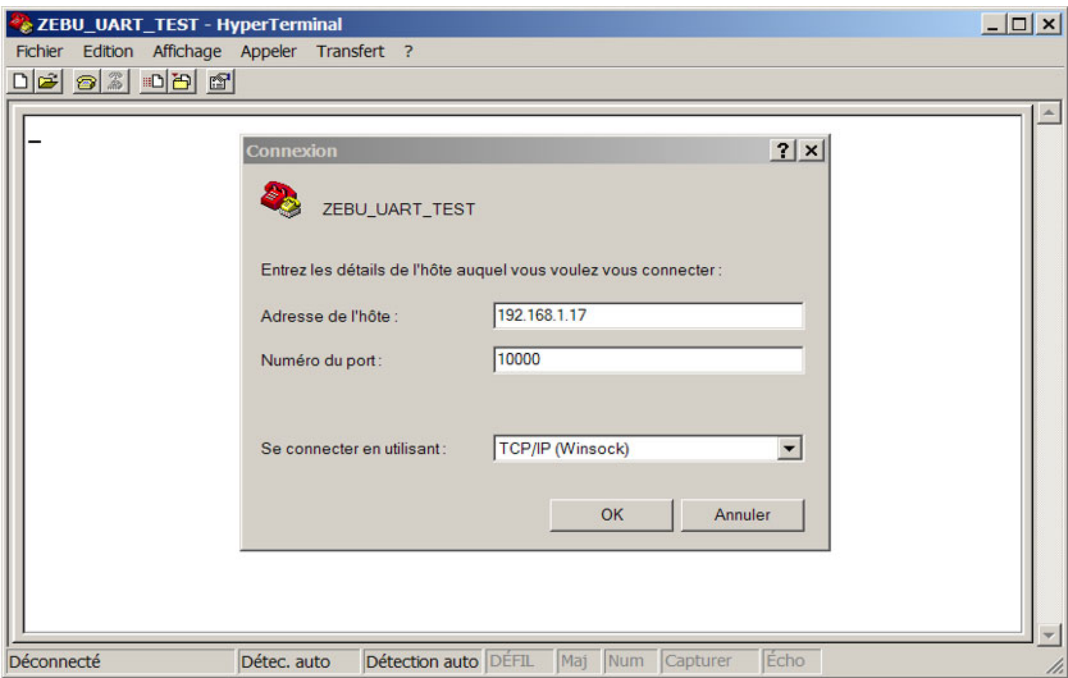


FIGURE 6. HyperTerminal Connection Configuration

5.2.2 Using DMTCP with the UART Server class

The UART server class enables you to use the DMTCP utility in the GUI mode.

See the example in the *example* directory of the transactor. The example uses the netcat utility to create a listening service to which the transactor connects. That is, the transactor works as a client.

To use the netcat utility the listening mode, specify the following command:

```
nc -lk <PORT>
```

You can run this command from a different terminal. For more information on the make targets, see the README file available in the Examples directory.

5.3 Using the XtermMode

The transactor is directly linked to a virtual console, sending commands and receiving results from the ZeBu DUT. Here is a typical implementation of a testbench using the xtor_uart_svs class operating in XtermMode :

```
#include <stdexcept>
#include <exception>
#include <queue>
#include <sys/time.h>
#include <libZebu.hh>
#include "xtor_uart_svs.hh"
#include <ctype.h>

#include "svt_report.hh"
#include "svt_pthread_threading.hh"
#include "svt_cr_threading.hh"
#include "svt_c_threading.hh"
#include "svt_zebu_platform.hh"
#include "TopScheduler.hh"
#include "XtorScheduler.hh"

#include "libZebuZEMI3.hh"
#include "svt_systemverilog_threading.hh"
#include "svt_simulator_platform.hh"
#define THREADING svt_systemverilog_threading


using namespace ZEBU;
using namespace ZEBU_IP;
using namespace XTOR_UART_SVS;
using namespace std;
```

```
uint8_t convertData ( uint8_t data )
{
  uint8_t ret = data;
  if (!((ret < 'A') || (ret > 'z'))) {
    ret = (ret < 'a')?(ret+0x20):(ret-0x20);
  }
  return ret;
}

typedef struct {
  queue<uint8_t> dataQueue;
} RpCtxt;

// Replier TX Callback
bool rpTxCB ( uint8_t* data, void* ctxt )
{
  bool send = false;
  RpCtxt* rpCtxt = (RpCtxt*)ctxt;

  if (!((rpCtxt->dataQueue).empty())) {
    *data =  convertData((rpCtxt->dataQueue).front());
    (rpCtxt->dataQueue).pop();
    send = true; // send next data
  }
  return send;
}

// Replier RX Callback
void rpRxCB ( uint8_t data, bool valid, void* ctxt )
{
  RpCtxt* rpCtxt = (RpCtxt*)ctxt;
  if (valid) {
```

```
    (rpCtxt->dataQueue).push(data);
    #if TEST_JMB==0
    if(isalnum(data)){
        (rpCtxt->dataQueue).push('[');(rpCtxt->dataQueue).push('{');
    (rpCtxt->dataQueue).push(data);
    (rpCtxt->dataQueue).push(toupper(data));
    (rpCtxt->dataQueue).push(tolower(data));
    if (isdigit(data)) {
    for (int i=(data-'0');i>=0;i--)  (rpCtxt->dataQueue).push(data);
    }
            (rpCtxt->dataQueue).push(']');         (rpCtxt-
>dataQueue).push('}');
    }
    #endif
  } else {
    (rpCtxt->dataQueue).push(0x0);
  }
}



//###################################
//  main
//###################################
int run_test (const char *testName) {
  int ret = 0;
  Board       *board = NULL;
  ZEMI3Manager *zemi3 = NULL ;
  const unsigned   nbxtor_uart_svsMax = 2;
  unsigned         nbxtor_uart_svs = 0;
  xtor_uart_svs           * uarts[nbxtor_uart_svsMax];
  const char     * uartInstNames[nbxtor_uart_svsMax];
  bool ok;
```

```
RpCtxt replierCtxt;

try {
  //open ZeBu
  printf("opening ZEBU...\n");
  //open ZeBu
  XtorScheduler      * xsched = XtorScheduler::get();
  XtorSchedParams_t * XtorSchedParams = xsched->getDefaultParams();
  svt_c_runtime_cfg * runtime    = new svt_c_runtime_cfg();

  char *zebuWork        = ZEBUWORK;
  char *designFeatures = DFFILE;
  svt_c_threading * threading = new svt_pthread_threading();

  XtorSchedParams->useVcsSimulation    = false;
  XtorSchedParams->useZemiManager      = true;
  XtorSchedParams->noParams            = true;
  XtorSchedParams->zebuInitCb          = NULL;
  XtorSchedParams->zebuInitCbParams    = NULL;
  xsched->configure(XtorSchedParams) ;
  zemi3 = ZEMI3Manager::open(zebuWork,designFeatures);
  board = zemi3->getBoard();
  zemi3->buildXtorList(); // manually add the xtor or use buildXtorList
  zemi3->init();

  runtime->set_threading_api(threading);
  runtime->set_platform(new svt_zebu_platform(board, false));
  svt_c_runtime_cfg::set_default(runtime);

  cerr << "#TB : Register UART Transactor..." << board << endl;
  xtor_uart_svs::Register("xtor_uart_svs");
```

```
    uarts[0] = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(),  "xtor_uart_svs" ,  xsched, NULL,runtime)) ;
    fprintf (stderr, "Found - Drivers [%s][%s] ...\n", uarts[0] -
>getDriverModelName (),uarts[0] ->getDriverInstanceName ());
    uarts[1] = static_cast<xtor_uart_svs*>(Xtor::getNewXtor(
Board::getBoard(), "xtor_uart_svs" ,  xsched, NULL,runtime)) ;
    fprintf (stderr, "Found - Drivers [%s][%s] ...\n", uarts[1]-
>getDriverModelName (),uarts[1]->getDriverInstanceName ());



    uartInstNames[0] = "uart_device_wrapper.uart_driver_0";
    uarts[0]->setOpMode (XtermMode) ;
    uarts[0]->init(board,uartInstNames[0]);
    uarts[0]->setDebugLevel(2);
    uarts[0]->setName("UART_XTERMINAL_0");
    uarts[0]->setConvMode(Conv_DOS_BSR) ; // Conv_None , Conv_ASCII (DOS)
: Conv_DOS_BSR



    uartInstNames[1] = "uart_device_wrapper.uart_driver_1";

    uarts[1]->init(board,uartInstNames[1]);
    uarts[1]->setDebugLevel(2);uarts[1]->setName("UART_STD_1");

    nbxtor_uart_svs = 2;



    cerr <<"--------------------------Zemi3 Start-------------------------
---" << endl;
    zemi3->start();   //This will start the Zemi3 service loop



    cerr <<"--------------------------Wait for Reset ---------------------
-------" << endl;
```

```
    uarts[0]->runUntilReset() ;
    cerr <<"-------------------------Configuring XTOR--------------------
-------" << endl;
    for (unsigned int i = 0; (i < nbxtor_uart_svs); ++i) {
      // Config UART interface
      ok =  uarts[i]->setWidth(8);
      ok &= uarts[i]->setParity(NoParity);
      ok &= uarts[i]->setStopBit(TwoStopBit);
      ok &= uarts[i]->setStopBit(TwoBitStop);
      ok &= uarts[i]->setRatio(16);
      ok &= uarts[i]->config();

      if (ok) {
        char logFname[1024];
        // Configure and open dump file
        uarts[i]->dumpSetDisplayErrors(true);
        uarts[i]->dumpSetFormat(DumpASCII);
        uarts[i]->dumpSetDisplay(DumpSplit);
        uarts[i]->dumpSetMaxLineWidth(80);
        sprintf(logFname,"%s_dump.log", uartInstNames[i]);
        uarts[i]->openDumpFile(logFname);
      }

      if(!ok) { throw ("Could not configure UART"); }
    }

    if (nbxtor_uart_svs > 1) {
      uarts[1]->setReceiveCB(rpRxCB,&replierCtxt);
      uarts[1]->setSendCB(rpTxCB,&replierCtxt);
    }

    printf("\n\n  -- Starting testbench  -- \n"); fflush(stdout);
    // Testbench main loop
```

```
    while (uarts[0]->isAlive()) {
      uarts[0]->runClk (10) ;
      uarts[1]->runClk (10) ;

    }



    for (unsigned int i = 0; (i < nbxtor_uart_svs); ++i) { uarts[i]-
>closeDumpFile(); }

  } catch (const char *err) {
    ret = 1; fprintf(stderr,"Testbench error: %s\n", err);
  }
  for (unsigned int i = 0; (i < nbxtor_uart_svs); ++i) { delete uarts[i]; }

  zemi3->terminate();
  zemi3->close();

  printf("Test %s\n",(ret==0)?"OK":"KO");

  return ret;
}
```

The testbench starts an xterm window. Every character typed in the xterm window is sent to the transactor interface without being echoed. All the data received by the UART transactor is displayed in the respective terminal.

Once the terminal is terminated (using CTRL+C or pressing the window's kill button), the testbench ends.

FIGURE 7. UART Terminal Window When the Testbench Ends

6 Baud Rate Calculation

This chapter describes how to calculate the baud rate in a ZeBu design.

This section describes the following sub-topics.

- *Definition*
- *Calculating the Baud Rate*

6.1 Definition

The baud rate in a ZeBu design is measured between the DUT and the UART transactor. As in actual designs, the UART baud rate is a division of the UART controller clock frequency, which is linked to the UART transactor controlled clock. For UART transactor with `clk_ref` input, the UART baud rate is a division of this reference clock.

The effective baud rate of the UART transactor is defined by the user using a ratio parameter. The ratio parameter of the UART matches the ratio between the UART transactor controlled clock frequency or the input `clk_ref` (DUT frequency) and the baud rate (`BaudRate`); it can be set using the `Uart::setRatio` method (see *setRatio() Method*):

$$BaudRate = \frac{DUTfrequency}{ratio} \Leftrightarrow ratio = \frac{DUTfrequency}{BaudRate}$$

Many times the same “UART controller clock/BaudRate” ratio in the ZeBu environment and the reference system environment (as specified in the UART controller DUT user setup), because all clocks and interface speeds are scaled down with the same factor:

$$\frac{DUTfrequency_{ZeBu}}{BaudRate_{ZeBu}} = \frac{DUTfrequency_{Ref}}{BaudRate_{Ref}}$$

However, it leads to an important slowdown of the effective UART baud rate in the verification environment.

The ratio parameter is an integer; you must therefore use the nearest value when the calculated value is a decimal number.

Reference System Environment		ZeBu Environment		
System Clock Frequency (MHz)	**Reference Baud rate (bps)**	**DUT Clock Frequency (MHz)**	**Ratio Parameter**	**Resulting ZeBu Baud Rate (bps)**
100	115,200	10	868	11,520
100	115,200	5	868	5,760
50	115,200	5	434	11,520

Reference System Environment		ZeBu Environment		
System Clock Frequency (MHz)	**Reference Baud rate (bps)**	**DUT Clock Frequency (MHz)**	**Ratio Parameter**	**Resulting ZeBu Baud Rate (bps)**
100	19,200	10	5,208	1,920
50	19,200	5	2,604	960

In the preceding table, notice how the resulting baud rate in the ZeBu environment is different from the system environment initial baud rate (in blue).

The other possible setup is to keep an identical baud rate in both the environments, regardless of the DUT clock frequency in ZeBu. The ratio parameter then varies differently according to the DUT clock frequency in ZeBu, as shown in the following table:

Reference System Environment		ZeBu Environment	
System Clock Frequency (MHz)	**Reference Baud Rate (bps)**	**DUT Clock Frequency (MHz)**	**Ratio Parameter**
100	115,200	10	87
100	115,200	5	43
50	115,200	5	43
100	19,200	10	520
50	19,200	5	260

In the preceding tables, notice how the ratio parameter in the ZeBu environment has evolved (in green).

6.2 Calculating the Baud Rate

This section describes the methods to calculate the baud rate.

6.2.1 Using the UART Transactor Baud Rate Detector

The UART transactor includes a baud rate detector that can be used to estimate the ratio parameter value from the real baud rate transmitted by the DUT. To provide accurate results, the UART transactor needs to receive at least one data word from the DUT. The process is as follows:

1. Write the testbench to set the ratio to an estimated value. The *getDetectedRatio() Method* can then be used in the testbench to obtain the ratio detected by the UART transactor. When releasing the transactor, if the detected ratio is different from the user-specified ratio, a warning message is displayed to signal the detected ratio value to the user.
2. Run the testbench and get the ratio value detected by the UART transactor:

```
UART Xactor  Warning    : Specified and detected clock ratio differs
                                 ( detected=16 / specified=64 )
```

3. Update the testbench with the UART ratio previously detected, if necessary.
4. Check again whether the data from the DUT is correctly received by the transactor.

6.2.2 Alternative Method

The ratio parameter description in the previous section may prove useless if you do not have all the necessary information about the UART controller setup. Here is a method based on the measurements for baud rate evaluation:

1. Determine which clock signal is your transactor controlled clock (see *Connecting the Transactor's Clocks*).
2. Create an RxD transactor port waveform with the controlled clock attached to the UART transactor, using driver clock sampling.
3. Count the number of cycles from the UART clock for a single bit transfer, like the minimum delay between two consecutive edges of the RxD transactor signal (for

example, a STOP to START transition).
This count is the “frequency/baud rate” Q quotient which may be equal to the ratio parameter:

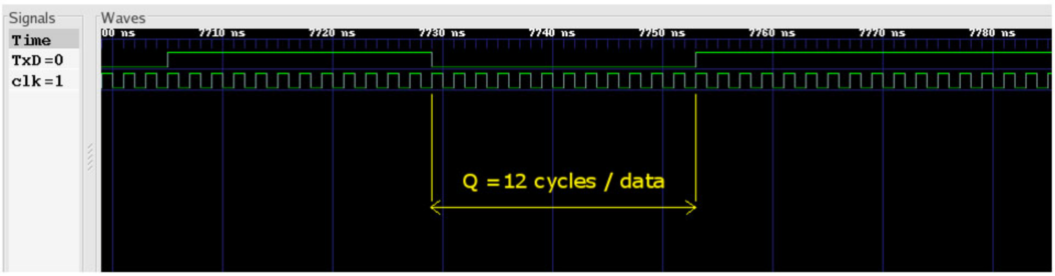


FIGURE 8. Frequency/Baud Rate

Note *The waveform above shows the RxD port on a transactor connected to the TxD output signal from the DUT.*

7 Tutorial

In this tutorial, the DUT instantiates two UART controllers connected to two UART transactors as described in the following figure:

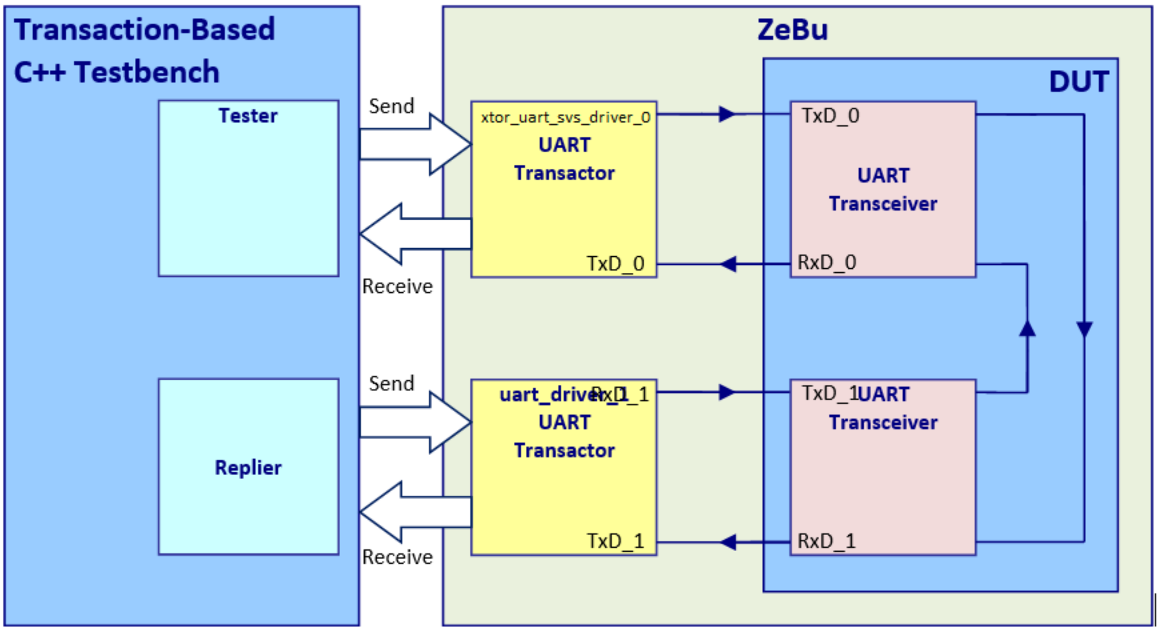


FIGURE 9. UART Transactor Tutorial Example

The testbench is a C++ program, which configures the UART transactors, has following two components:

- One transactor, called replier, is a xtor_uart_svs object. The replier receives data, processes it, and sends the processed data back.
- The other transactor, called tester, is a xtor_uart_svs object according to the selected testbench.

The data received by the replier is processed in the following way:

- Lower-case letters ? upper-case letters.
- Upper-case letter ? lower-case letters.

- No processing on other characters.

The testbenches using the xtor_uart_svs object (blocking send and receive; non-blocking send and receive; and callback testbenches), sends a set of data and check the value returned by the replier.

The testbench, when operating in XtermMode, starts a terminal. The data typed in the terminal is sent to the test interface and the data received on the test interface is displayed on the terminal.

The testbench, when operating in ServerMode, starts a TCP client or a TCP server according to the specified parameters. The user needs to launch a TCP client or server connection to connect the UART server. The data is transmitted between the TCP client or server and the UART transactor in the following way:

- When running the UART in server mode, the TCP client must be connected when the UART server starts. The testbench waits for the TCP client to be connected before it starts.
- When using the UART in client mode, the TCP server must be started before the testbench.

This example is available in the XTOR/xtor_uart_svs.<version>/example directory and the testbench source code is available in the example/src/bench subdirectory.

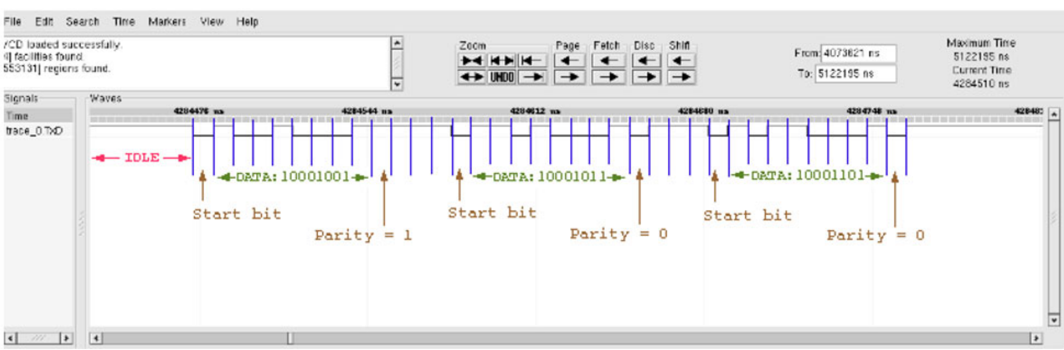


FIGURE 10. Tx Data Waveforms

7.1 DUT Implementation

The DUT is available in the example/src/dut directory.

7.2 Compiling and Running for ZeBu

The compilation flow is available in the Makefile provided in example/zebu.

The example has two compilation flows: the UC (available from ZeBu 2015.09) and legacy mode. From the appropriate directory:

1. Launch the compilation using the `compil` option:
2. For UC flow

```
make compil
```

3. Run one of the three testbenches using one of the following commands:

```
make run             with Uart object.
make run_xterm       with UartTerm object
make run_server      with UartServer object
```

A help message can be obtained by running make without any target:

```
##########################
# Available targets      #
##########################
#                        #
# ZeBu compilation:      #
#   -> compil            #
#                        #
#                        #
# Uart testbench:        #
#   -> run_cb            #
#   -> run_nonblocking   #
#   -> run_blocking      #
#                        #
# UartServer testbench:  #
#   -> run_server        #
#                        #
# UartTerm testbench:    #
#   -> run_xterm         #
#                        #
#                        #
# Clean                  #
#   -> clean_compil      #
#   -> clean_run         #
#   -> clean             #
##########################
For run_server target you can set the followingvariable:
```

```
TCP_PORT   : TCP port number (default: 10000)
TCP_MODE   : TCP mode (client or server, default: server)
TCP_SERVER : TCP server for client mode (default: localhost)
```