UART Loopback Project Documentation

1. Study of the Existing Code

The uart_loopback project from the VSDSquadron_FM repository implements a basic UART loopback system. The Verilog code provided consists of several key components:

Key Components:

1. **top.v (Top-Level Module)**:
   - Connects input UART RX (uartrx) directly to output UART TX (uarttx).
   - Includes an internal oscillator using the SB_HFOSC primitive.
   - Implements an RGB LED driver (SB_RGBA_DRV) to provide visual feedback using received UART data.
   - Uses a simple counter for internal timing.
2. **uart_tx_8n1.v (UART Transmitter)**:
   - Implements an 8N1 (8 data bits, no parity, 1 stop bit) UART transmission protocol.
   - Contains a finite state machine (FSM) to manage the transmission process.

- Includes states for idle, start bit, data transmission, and stop bit.

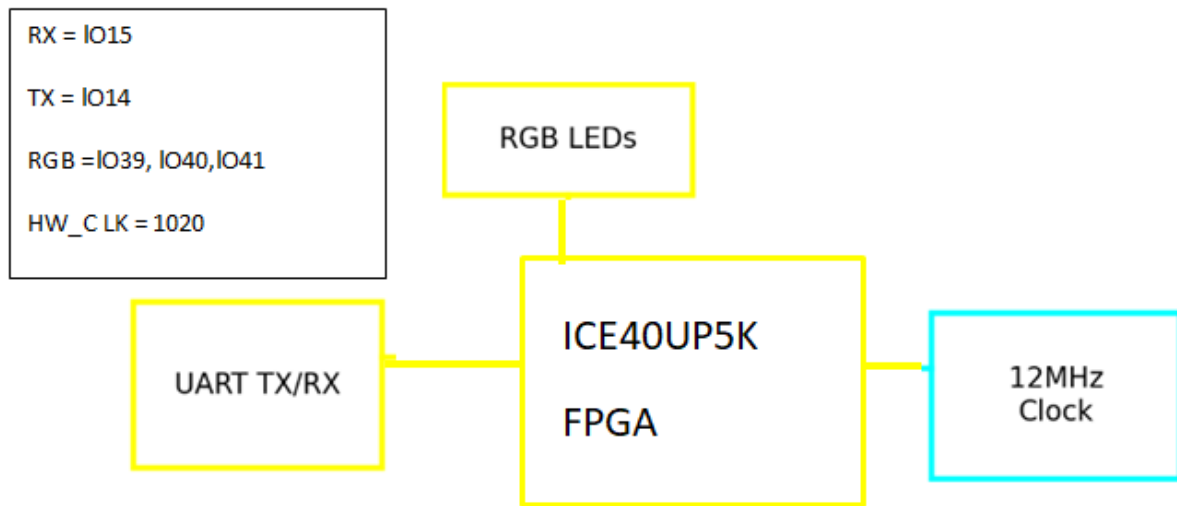3. **VSDSquadronFM.pcf (Pin Constraint File)**:
   - Defines FPGA pin assignments:
     - UART TX: Pin 14
     - UART RX: Pin 15
     - RGB LED pins: 39, 40, 41
     - Clock input: Pin 20

4. **Makefile (Build System)**:
   - Automates synthesis, place & route, timing analysis, and FPGA programming.
   - Uses yosys, nextpnr-ice40, icepack, and iceprog tools.
   - Provides a UART terminal setup using picocom for communication.

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2. Design Documentation

Block Diagram

RX = IO15

TX = IO14

RGB =IO39, IO40,IO41

HW_C LK = 1020

RGB LEDs

ICE40UP5K

FPGA

UART TX/RX

12MHz
Clock

Circuit Diagram

- The FPGA receives data from a serial terminal via the RX pin.
- The received data is directly assigned to the TX pin, ensuring a loopback mechanism.
- RGB LEDs are controlled based on received data for debugging purposes.

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3. Implementation Steps

Hardware Setup

1. Connect the FPGA board to the PC via USB.

2. Ensure that the correct FPGA pins are connected to the UART device.
3. Use picocom or a similar serial terminal to send data to the FPGA.

Synthesis & Upload

1. Run make to synthesize and generate the FPGA bitstream.
2. Flash the FPGA using sudo make flash.

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4. Testing & Verification

Test Procedure

1. Open a serial terminal using:
2. sudo picocom -b 9600 /dev/ttyUSB0
3. Send test characters via the terminal.
4. Observe if the same characters are received back.
5. Check if RGB LEDs respond to received data.

Expected Outcome

- Sent characters should be echoed back in the terminal.
- RGB LEDs should show changes based on received data.

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5. Documentation Summary

The final documentation includes:

- **Block Diagram**
- **Circuit Diagram**
- **Code Explanation**
- **Testing Results**

This ensures a comprehensive understanding of the UART loopback project and its implementation on the VSDSquadron FPGA Mini.