Overview

- Spartan-6 MultiBoot Capability
- Xilinx SP601 Board
- Software Requirements
- SP601 Setup
- Compiling the MultiBoot Design
- Run MultiBoot Design
- Spartan-6 MultiBoot Details
- References

Note: This presentation applies to the SP601
Spartan-6 MultiBoot Capability

- **MultiBoot Capability**
  - FPGA Application controlled configuration
  - Bitstream selection of multiple applications

- **Safe Update**
  - Golden bitstream
  - Upgradeable bitstream
  - Failure recovery
    - Possible Triggers (CRC error, IDCODE error, WDT timeout)

*Note: Presentation applies to the SP601*
Description

- Reconfiguration of FPGA based on error condition or command from user logic. Spartan-6 MultiBoot logic used to clear configuration memory and restart the configuration process (REBOOT) from an external non-volatile memory (e.g. SPI Flash). Location of new bitstream is determined by dedicated Spartan-6 address registers (General_1 to General_4)

Reference Design IP

- RTL state machine utilizing ICAP primitive and IPROG command to initiate REBOOT
- RTL counter
- RTL logic for Pushbutton inputs and LED outputs

Reference Design Source and Application

- rdf0006.zip

Note: Presentation applies to the SP601
**MultiBoot**: Process by which the FPGA selectively reprograms and reloads its bitstream from an attached external memory.

**Safe update**: Field updating bitstream storage with a new bitstream in such a manner to prevent any failure due to a failure in the update process. This is accomplished with the enhanced MultiBoot available in Spartan-6.

Can a multi-boot system be implemented without safe update design considerations?
Yes – If there are no potential for disruptions during flash loading

**How is a system upgraded?**
1. New multi-boot image is created
2. System setup to receive the new image
3. User application erases section of Flash
4. The new image is delivered into the system’s Flash
5. User application resets system

Note: Presentation applies to the SP601
Xilinx SP601 Board

Note: Presentation applies to the SP601
ISE Software Requirement

- **Xilinx ISE 11.4 software**
  - Install the Webpack for the Spartan-6 LX16 devices
  - Run XilinxUpdate and download the Webpack devices

*Note: Presentation applies to the SP601*
SP601 Setup

- Set the mode pins for SPI Flash
  - M0 = 1
  - M1 = 0

- Connect a USB Mini-B Cable to the USB JTAG connector on the SP601 board
  - Connect this cable to your PC
Compile MultiBoot Design

- Unzip the rdf0006.zip file

Note: Presentation applies to the SP601
Compile MultiBoot Design

- At a command prompt, type:
  
  `cd sp601_multiboot`
  
  `run_all_build_script.bat`

**Note:** Takes about five minutes
Program SPI MultiBoot Design

- Open iMPACT
  - impact

Note: Presentation applies to the SP601
Program SPI MultiBoot Design

- **Select**
  - Create a new project
  - Configure devices using Boundary Scan (JTAG)

**Note:** Presentation applies to the SP601
Program SPI MultiBoot Design

- Right click on the “SPI/BPI ?” box and select Add SPI/BPI Flash...
  - Select the <Design path>\PROM_files\header_golden_multiboot.mcs

Note: Presentation applies to the SP601
In the Select Attached SPI/BPI GUI, select
- SPI PROM
- W25Q64BV
- Data Width: 1

Note: Presentation applies to the SP601
Program SPI MultiBoot Design

- Program the SPI Flash:
  - Right-click on the Flash and select Program

Note: Programming takes about five minutes
Run MultiBoot Design

- **Cycle board power**
  - The multiboot_image design boots

- **The LED pattern will show a double flash of the four LEDs**

- **Press SW4**
  - This issues a REBOOT command to Spartan-6 configuration logic
  - The DONE led (DS9) will go out momentarily
  - The SP601 will reboot into the double flash design

*Note: Presentation applies to the SP601*
Run MultiBoot Design

- **Press SW5**
  - This will simulate a failed programming of the multiboot_image design
  - SW5 erases the first block of the Multiboot_image in Flash

**Note:** Presentation applies to the SP601
Run MultiBoot Design

- Press SW4
  - This issues a REBOOT command to Spartan-6 configuration logic
  - The DONE led (DS9) will go out momentarily
  - The SP601 will reboot into the golden_image, a single flash design

- **This shows the loading of the golden original file in case of a programming failure**

Note: Presentation applies to the SP601
Spartan-6 MultiBoot Details
MultiBoot Register Setup & Command

- **General Configuration Registers**
  - Sticky 16-bit registers that are maintained after reboot
    - General 1, 2 - Set to hold address of Multi-boot bitstream
    - General 3, 4 - Set to hold address of Golden bitstream
    - General 5 - User Data
  - All registers loaded at base address of Flash (SPI or BPI) and constant
  - Bitfiles and designs (ICAP commands) are independent of addressing

- **REBOOT command – Loads multi-boot image directly**
  - Issued via ICAP to reload multi-boot address space
  - Jumps to address based on Strike Count, which increments on a failure
    - Load Multi-boot (Gen 1,2) when Strike Count < 3
    - Load Golden (Gen 3,4) when Strike Count < 6

- **See UG380 for MultiBoot details**

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Note: Presentation applies to the SP601
MultiBoot Register Setup & Command

- Below is a sample of the boot header HEX file, boot_header_only_SPI_x1.hex
- To change the Golden image and MultiBoot image address locations to a different location in the SPI Flash
  - Edit the boot_header_only_SPI_x1.hex. See the highlighted numbers below.
  - Edit the promgen command in the run_all_build_script.bat. Specifically the promgen "-u <address>" values need to match the boot header HEX value locations.

```
FFFFFFFE // DUMMYWORD, DUMMYWORD
AA995566 // SYNCWORD
31E1FFFF
32610000 // 32A1=GENERAL1 0x0000=address[15:0] MultiBoot image location
32810340 // 32B1=GENERAL2 0x03=SPIx1 read command, 0x40=address[23:16] MultiBoot image address
32A10000 // 32A1=GENERAL3 0x0000=address[15:0] Golden image address location
32C10301 // 32C1=GENERAL4 0x03=SPIx1 read command, 0x01=address[23:16] of Golden image address
32E10000
30A10000
33012100
3201001F
30A1000E
20002000 // NOOP, NOOP
20002000 // NOOP, NOOP
```

Note: Presentation applies to the SP601
MultiBoot Register Setup & Command

- IPROG command issued via the logic in ICAP_SP601_reboot.v

```vhdl
if (MBT_REBOOT) begin
    next_state = SYNC_H;
    icap_ce = 0;
    icap_wr = 0;
    icap_din = 16'hAA99;  // Sync word
    part 1
end
else begin
    next_state = IDLE;
    icap_ce = 1;
    icap_wr = 1;
    icap_din = 16'hFFFF;  // Null data
end

SYNC_H:
begin
    next_state = SYNC_L;
    icap_ce = 0;
    icap_wr = 0;
    icap_din = 16'h5566;  // Sync word part 2
end

SYNC_L:
begin
    next_state = NULL_H;
    icap_ce = 0;
    icap_wr = 0;
    icap_din = 16'h30A1;  // Write to Command Register....
end
```

<table>
<thead>
<tr>
<th>Configuration Data (hex)</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFFF</td>
<td>Dummy Word</td>
</tr>
<tr>
<td>AA99</td>
<td>Sync Word</td>
</tr>
<tr>
<td>5566</td>
<td>Sync Word</td>
</tr>
<tr>
<td>32B1</td>
<td>Type 1 Write 1 Words to GENERAL_1</td>
</tr>
<tr>
<td>XXXX</td>
<td>Warm Boot Start Address [15:0]</td>
</tr>
<tr>
<td>3281</td>
<td>Type 1 Write 1 Word to GENERAL2</td>
</tr>
<tr>
<td>XXXX</td>
<td>OPCODE and Address [23:16]</td>
</tr>
<tr>
<td>32A1</td>
<td>Type 1 Write 1 Word to GENERAL3</td>
</tr>
<tr>
<td>XXXX</td>
<td>Fallback Start Address [15:0]</td>
</tr>
<tr>
<td>32C1</td>
<td>Type 1 Write 1 Word to GENERAL4</td>
</tr>
<tr>
<td>XXXX</td>
<td>OPCODE and Fallback Address [23:16]</td>
</tr>
<tr>
<td>30A1</td>
<td>Type 1 Write 1 Word to CMD</td>
</tr>
<tr>
<td>000E</td>
<td>IPROG Command</td>
</tr>
<tr>
<td>2000</td>
<td>Type 1 NO OP</td>
</tr>
</tbody>
</table>
**Spartan-6 Memory Map & Flow Diagram**

### Memory Map
- **Multi-boot**
  - Sector 16
- **User Data**
  - Sector 14
- **Golden**
  - Sector 1
- **Protected Sectors**
  - Sector 0
- **Start**

### Flow Diagram
- **Multi-boot**
  - 3 – Configure
  - 4 – Run design
  - 5 – Re-image flash
  - 6 – Issue Reboot
- **Configuration Fails**
  - Attempt up to 3 times and increment Strike Count
- **Golden**
  - 7 – Configure
  - 8 – Run design
  - 9 – Re-image Flash
  - 10 – Pulse PROG or Power Cycle

**Baseline**
- 1 – Set General 1,2,3,4,5 and other registers
- 2 – Issue Reboot
Spartan-6 Multi-boot and Golden Designs

**Data Link**
Send and receive application data and new images

**Multi-boot controller w/ ICAP**
- Track multi-boot attempts via General 5 and BOOT_STS for Strike Count
- Issue REBOOT (Multi-boot Only)
- Power cycle or Pulse Prog (Golden Only)

**Flash access**
Read and write application data and new images

**BitGen Options**
-g register_write_disable:yes
-g reset_on_error:yes

**Baseline**
Manually created with SYNC, General Registers, and REBOOT command
BitGen will auto create in 11.4 as part of Golden image

**Note:** Presentation applies to the SP601
Upgrading Flash

- **Steps in the multi-boot and safe update process:**
  - **Erase:** What if the power goes down?
    - Erased flash will contain all F’s in erased locations starting from bottom up
    - Partial erasing will erase SYNC word and config attempts will time out
    - CFG_TIMER will trigger reboot of “Golden Image”
    - CFG_TIMER value can be adjusted
  - **Program:** What if the power or data link goes down?
    - Loading bitfile in top down method will write the SYNC word last
    - The flash will be in the same condition as a partially erased flash
    - Error management is now the same as Erased condition
  - **Verify:** Problems during this phase?
    - Any CRC error will trigger a reload of the Golden image
  - **Re-start system**
    - Issue REBOOT via ICAP from multi-boot application
    - Pulse PROG or cycle power to reset system after Golden load

**Flash Memory States**

- **Half Erased**
  - FF: End of .bit
  - 00: All F’s

- **Erased**
  - FF: All F’s

- **Half Programmed**
  - FF: End of .bit
  - 00: All F’s

- **Programmed**
  - FF: .bit
  - 00: SYNC word
References

- Spartan-6 Configuration
  - Spartan-6 FPGA Configuration User Guide – UG380
Documentation

- **Spartan-6**
  - Spartan-6 FPGA Family

- **SP601 Documentation**
  - Spartan-6 FPGA SP601 Evaluation Kit
  - SP601 Getting Started Guide
  - SP601 Hardware User Guide
  - SP601 Reference Design User Guide