

Military Institute of Science and Technology

Department of Computer Science and Engineering

Digital System Design Sessional

Group- 10B



Assignment Name: 3-Bit Right Shift Using Barrel Shifter

Course Code: CSE-364

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1. Barrel Shifter working procedure

A barrel shifter is a high-speed combinational digital circuit capable of shifting a binary data word by a specified number of bit positions in a single operation. Unlike regular shift registers, which shift data one bit per clock pulse, a barrel shifter can perform multi-bit shifts instantly because its structure is based entirely on combinational logic. It is typically implemented using multiple 2×1 multiplexers connected in cascaded stages. Each stage corresponds to a specific shift distance (such as 1-bit or 2-bit shift), and the appropriate output path is selected through control signals provided to the multiplexers.

In this project, a 4-bit barrel shifter was implemented using only 2×1 multiplexers, specifically the **74LS157 quad multiplexer ICs**. The design consists of two shifting stages, where the first stage performs a conditional 1-bit shift and the second stage performs a conditional 2-bit shift. The input bits (D3–D0) from the trainer board are routed through these two stages depending on the selected shift amount, which is controlled using toggle switches. Logical right shifting is performed, meaning that bits shifted out of the least significant positions are discarded, and the newly created higher-order positions are filled with 0.

The output of the circuit is displayed using LEDs on the trainer board, allowing the shifted result to be observed clearly in real time. The design demonstrates the efficiency of a barrel-shifting mechanism and highlights how multiplexers can be used to implement fast, multi-bit shifting operations without the need for sequential logic.

2. Description of Components Used

The following components were used in the project:

- $2 \times$ 74LS157 Quad 2×1 Multiplexer ICs: Used to implement the shifting stages.
- $4 \times$ Red LEDs: Connected to the output bits to visualize the shifted result.
- $6 \times$ Switches: Used for data input (D3–D0) and shift control signals (S1, S0).
- Trainer Board: Provided built-in LEDs and switches.
- Jumper Wires & Copper Wires: Used to make connections between IC pins, switches, and LEDs.

3. Discussion, Limitations, Challenges & Applications

The project successfully demonstrates the implementation of a 3-bit right shift operation using a barrel shifter designed entirely with 2×1 multiplexers (74LS157 ICs). The use of cascaded multiplexer stages allows the circuit to perform multi-bit shifting instantaneously without the need for a clock signal. This highlights the primary advantage of a barrel shifter—its ability to provide fast and efficient data manipulation using combinational logic.

The outputs observed on LEDs matched the expected truth table values, confirming that the design was logically correct and functionally accurate.

Limitations

- The design performs only **logical shifting**, not arithmetic shifting or rotation.
- The circuit is limited to **4-bit input data**, as required by the project.
- Manual switches may introduce **bouncing issues**, which can temporarily affect output stability.
- The use of discrete ICs and jumper wires increases the chance of **loose connections**.
- Only a fixed number of shift distances (3-bit right shift) is supported in this design.

Challenges

- Ensuring correct wiring of multiple 74LS157 ICs without short circuits was challenging because the IC has a dense pin layout.
- Understanding which input line of each multiplexer corresponds to shifted vs non-shifted data required careful planning.
- Maintaining clean and organized wiring on the trainer board was difficult due to the number of connections.
- Debugging faulty outputs caused by loose jumper wires required repeated testing with the logic probe.
- Managing the cascading stages correctly so that the final output matches the expected 3-bit right-shift operation took time and verification.

Applications

- **Arithmetic Logic Units (ALUs)** – Fast shifting operations inside processors.
- **Digital Signal Processing (DSP)** – Efficient bit manipulations and scaling.
- **Data Serialization/ Deserialization** – Rearranging bits during communication.
- **Floating-Point Unit (FPU)** – Normalization and alignment of mantissa.
- **Graphics & Game Engines** – Quick multiply/divide operations using bit shifts.
- **Cryptography** – Bit rotation and permutation units.
- **Embedded Systems** – High-speed data manipulation without extra cycles.