The 4-digit 7-segment display with 12 pins uses a **multiplexing technique** to control all the digits while sharing many of the same pins for the segments. Let's break this down:

1. Structure of the 4-Digit 7-Segment Display

A single 7-segment display typically has:

- **7 segment pins (a-g)**: These control the individual LEDs in the shape of numbers.
- **1 decimal point pin (p)**: Optional, controls the decimal point.
- **1 or 2 common pins**: These determine if the display is common anode or common cathode.

For a 4-digit display:

- All **segments (a, b, c, d, e, f, g, p)** of the four digits are **shared**.
- Each digit has its **own enable pin**, allowing only one digit to be active at a time.

This design reduces the total pin count significantly:

- **8 pins** for the shared segments (a, b, c, d, e, f, g, and possibly p).
- **4 pins** for the digit selection (d1, d2, d3, d4).

Thus, you only need **12 pins** for controlling the display.

2. How Multiplexing Works

Multiplexing means controlling the 4 digits by activating them one at a time, very quickly. Here's how it works:

1. **Activate one digit**: Enable a digit pin (e.g., d1) to turn on a single digit. The other digit pins are turned off.
2. **Set the segments**: Send the appropriate signals to the segment pins (a-g) to display the number for the active digit.
3. **Repeat for the other digits**: Quickly switch to the next digit, enable it (e.g., d2), and update the segments.

Because this switching happens very fast (hundreds of times per second), the human eye perceives all digits as being lit simultaneously.

3. Why It Works with Fewer Pins

Instead of having separate pins for every segment in every digit, multiplexing uses shared segment pins. For 4 digits:

- Instead of **4 × 8 = 32 pins** (8 for each digit), you only need:
    - **8 pins for segments**.
    - **4 pins for digit selection**.

This drastically reduces the number of pins.

4. How the Display Knows Which Digit to Light

The digit selection pins (`d1`, `d2`, `d3`, `d4`) act as switches:

- When a digit pin is activated (e.g., `d1` is LOW for common anode or HIGH for common cathode), current flows through that digit only.
- The segment pins (a-g, p) control the pattern to light up for that digit.
- By cycling through each digit quickly, the microcontroller creates the illusion of all digits being lit simultaneously.

5. Summary

- A 4-digit 7-segment display has shared segment pins and individual digit enable pins.
- Multiplexing allows it to control all four digits using only 12 pins.
- The display appears to light all digits at once because the microcontroller switches between digits at high speed.

This clever design reduces pin usage while maintaining full control over the display.

Learn How a 4-Digit 7-Segment LED Display Works and how to control it using an Arduino

Seven-segment display character representations

Visualizing Data with 7-Segment Displays