Counting Circuit: 4-Bit Design, Construction

Jitesh Kumar
Department of Electronics and Communication Engineering
Faculty of Engineering, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

ABSTRACT: 4 Bit Count Down. A 4-bit down counter is a digital counter circuit which provides a binary 1111 to 0000 countdown. This circuit uses four flip-flops of form D, which are activated with positive edge. The flip-flop feeds its inversed output (/Q) back into its own data input (D) at each stage. A binary four-bit counting circuit has been designed and developed. The materials used were: PIC Microcontroller, Seven Segment LED, Printed Circuit Board, LEDs, Transistors, 9 V DC power source (Battery), and other passive components. The method adopted for this counter uses a microcontroller as the backbone of the system that holds the command for every action that is to take place during an operation. Four Light Emitting Diodes (LEDs) with counts showed the output (results) of the circuit; 0000, 0001, 0010, 0011, 0100, 1010, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110 and 1111. These binary outputs were further converted via a reprogrammable microcontroller to decimal equivalent and then displayed using a dual seven-segment display device.

KEYWORDS: Counting circuit, PIC microcontroller, seven-segment display, logic systems.

INTRODUCTION

A 4-bit down counter is a digital counter circuit which provides a binary 1111 to 0000 countdown. This circuit uses four flip-flops of form D, which are activated with positive edge. The flip-flop feeds its inversed output (/Q) back into its own data input (D) at each stage. However it feeds its non-inverted output (Q) to the following stage's clock input (CK). This type of circuit operates in an erratic (ripple) manner since timing is not dependent on a standard clock pulse by the flip-flop stages. The counter operating speed depends on the propagation of the signal through successive phases, rather than on a-clock pulse as in synchronous circuits. When RESET is applied simultaneously on all the flip-flops, their Q outputs become the state of logic 0, and /Q outputs become the state of logic 1. The /Q outputs are fed back into their own data inputs (D) and so all they need is the rising edge of a clock pulse to pass the data to output Q at input (D).

An instrument that provides an output in its simplest form, corresponding to the number of pulses. The digital counter added to its input is named. In digital logic a counter is a system that stores (and often even sells) displays the number of occurrences of a particular event or operation, often in relation to a clock signal. The circuit performing this function and having certain features is commonly referred to as a digital counter. The counting circuits belong to a different sequential circuit class. Everyone has a unique input and a Number of outputs that meets those digital codes. The counter itself is a J-K flip-flop.

Digital counters work in the system of binary numbers. That is because the binary principle is simple and quick performed with electronic circuits. Computer information is provided in binary (bits) form due to the convenience of handling two clearly-defined states. Each bit is either a ZERO or a ONE, OFF or ON, LOW or High, and so on. Figure 1 and table 1 display a 4–bit binary counter which can count from 0 to 15. The 16th input count returns the counter to the 0 output, and produces a carrying pulse. This counter action to get back to the 0 condition. The 4–bit binary renders a modulo-16 (mod 16) counter with a performed output on every 16th pulse. Modulus counter means predetermined state operates. For example, it only counts 10 states in mod-10 counter [1].

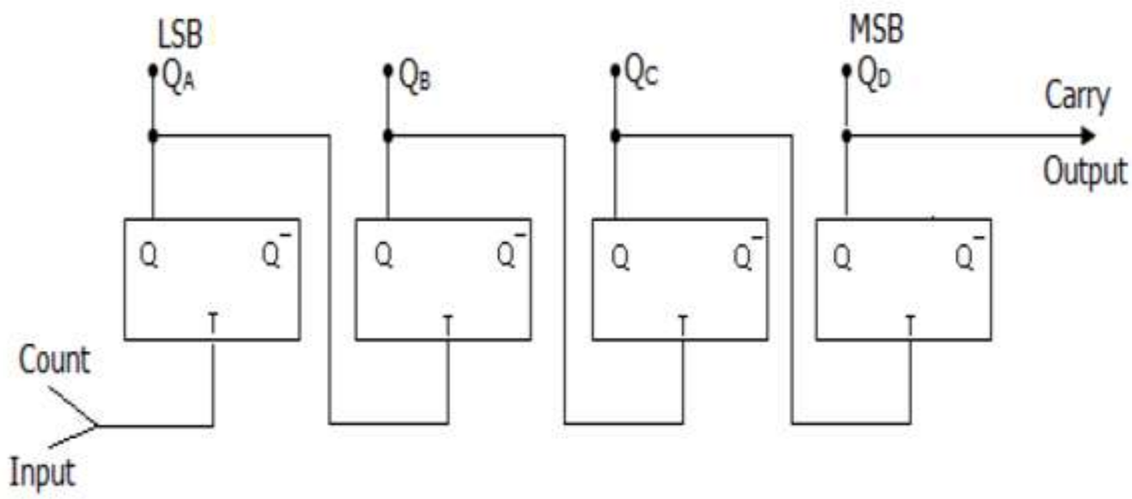

Fig. 1: Schematic Symbol Of A Counter.

The four binary outputs in figure.1: QD, QC, QB and QA are said to have a weighting of 8-4-2-1 because if QD through QA are all 1s, then the binary counter output would be;

$1111_2 = (1x2^3) + (1x2^2) + (1x2^1) + (1x2^0) = 8 + 4 + 2 + 1 = 15_{10}$

The subscripts indicate the device basis.

No. of count pulse	Binary output	Octal (Base 8)	Decimal (Base 10)	Hexadecimal (Base 16)
0	0000	0	0	0
1	0011	1	1	1
2	0010	2	2	2
3	0011	3	3	3
4	0100	4	4	4
5	0101	5	5	5
6	0110	6	6	6
7	0111	7	7	7
8	1000	10	8	8
9	1001	11	9	9
10	1010	12	10	A
11	1011	13	11	B
12	1100	14	12	C
13	1101	15	13	D
14	1110	16	14	E
15	1111	17	15	F
16	0000	0	0	0

Table 1: Counter output in various number systems

THEORY

Every counting circuit is made up of four basic units-the sensing unit, the signal conditioning unit, Unit counter and output unit. Typically, the sensing unit consists of a photoelectric device or a switch or a pick-up capability or an interruptible jet. Its role is to detect what to rely on. The signaling unit is usually a interfacing tool such as R-C Circuit [2] Discriminator. The role of the "sensed" signal or entity is to be arranged in a countable type. The clock, which is normally a J-K flip-flop's shift register, time-wise records the event or entity. The output device can be a visual meter indicator or an audible beep producer. In this work however, a instead of the standard J-K flip-flop PIC microcontroller will be used.

A	B	P
0	0	0
0	1	1
1	0	1
1	1	0

Table 2: Truth table for XOR Gate

The materials used during the circuit construction include: soldering iron, soldering lead, soldering pump, side trimmer, digital multi-meter, sandpaper and electrical knife, as well as Perspex plastic for the case. The binary counting circuit consists of four separate parts [3]. The Hardware is a Small set of emitting diodes, Seven Segment display unit and other resistors that restrict the current of both the light emitting diodes and a view of the seven segments. Such components are interfaced with the microcontroller to give the output the result expected would be a more interpretable format. The system used for this counter uses a microcontroller as the backbone of the design. Holds the command for every action that is to take place during the process. The reason for this approach is to raising the amount of components, and improve circuit functionality. Figure 2 displays counting block diagram of counter circuit [4].

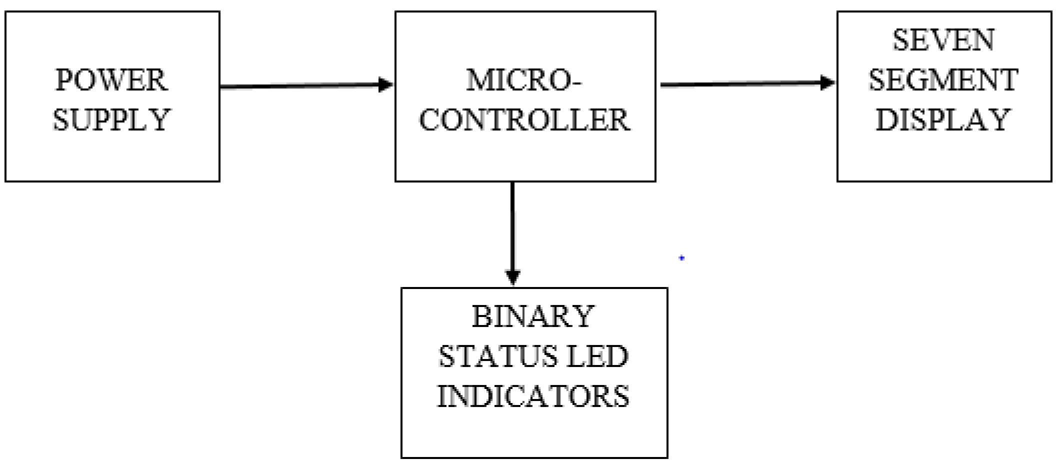

Fig. 2: Block Diagram Of A 4-Bit Binary Counting Ciruit

The design phases for the 4-bit binary counter include the sequential power supply relation, the seven segment display unit, Microcontroller and binary status LED indicators. The different units which make up this system would be mounted on a Printed Circuit Board, tested and ultimately interconnected. Because of specialized integrated circuit like microcontroller can be used for operational efficiency, durability, and reproducibility. The microcontroller forms the foundation of the entire system. The binary information is processed and shown on the display unit. At the same time, the four binary status LED indicators [5] convert the produced binary value to decimal. Displays it in seven pieces. In addition, the microcontroller controls the dual seven segment display unit that help to reduce complex diagram wiring.

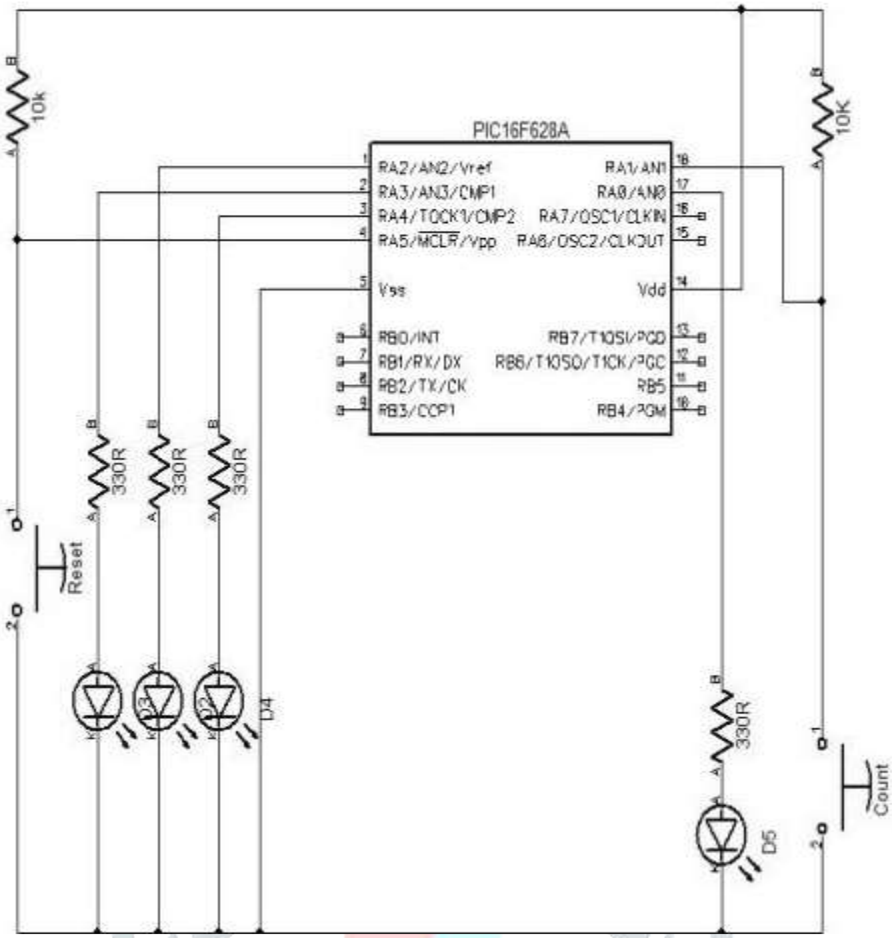

Fig. 3: Circuit For The Binary LED And The Microcontroller Stage

The drop in voltage over seven LED segments is 3V. Since a 5V supply is used to power both the LED display in seven segments and the LEDs that leaves 2V across their respective resistors. So the current LED show across the seven segments is:

$= /R = 2/150 = 0.013A.$ … (1)

For LED

$= /R = 2/330 = 0.0060A$ ... (2)

Equations 1 and 2 can be written as

$R = VS – VD / I$ … (3)

Where VS is the supply voltage, and where VD is the decrease in LED voltage. From equation 3 the resistor value for the seven segments LED display is

$= 5 – 3/0.02 = 145$ ohm

Switching transistor

Using transistor BC 548, Supply voltage, VS= 9V

The load driven by the transistor is the relay Load resistance, R_L = 145ohm

Load current LI = VS/RL = 9/145 = 62mA (4)

Since Load current L_I (max) must be greater than I_C and from the data sheet

Ic (max) = 100mA The Base Resistor, R_B

$$RB = Vcc \times hfe \quad 5 \times Ic \quad (5)$$

Where,

I_C = collector

Therefore R_B = 9 × 400/5 × 100 = 7.2 KΩ

Where the typical h_{fe} =-400 (from data sheet). Therefore, the closet value for the base resistor is selected to be 10KΩ.

Schematic

The effective and reliable schematic and PCB design and development produces improved efficiency and consistent outcomes. Dip Trace, which was downloaded from diptrace [6], is the program used in making the PCBs and schematic diagrams. Footprint cross checking and design procedures were required to ensure a favorable outcome. A laser jet printer was used in the printing of the converted template in a special material known as Press and Peel layer, a transparent film used in PCB production, after converting the schematics into PCBs.

RESULT

The binary to decimal and all the transformations and counting algorithms are implemented in the firmware of F628 PIC16. The result finally appears on the LED display of the Seven Segment dual. Compiled the script with micro C Pro for mikroElektronika PIC compiler. The firmware has been compiled into a machine code using the same editor and microcontroller programming. Simulation of the detector algorithm the device was rendered using Lab Center Electronics Proteus software.

Pulse No/ SSD	LED 1	LED 2	LED 3	LED 4
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

Table 3: Counter Output Obtained At Each Count Pulse.

CONCLUSION

Digital counting circuits are important in daily Electronics. They are used not only in counting, but in the conversion from one number base to another. Although counters can also be designed / constructed using multi-vibrators, this work has used the PIC microcontroller, demonstrating that it is the best method because it uses a firmware for its operation while minimizing the number of components in the circuit at the same time. Again, the chip could be reprogrammed to accomplish other counter types.

The designed and constructed 4-bits counter will find application in the following areas:

(1) It is used primarily in digital computers and other digital devices for memory storage and counting in different bases.

(2) The binary counting circuit may be modified and used in the Rate Meter of radioactivity for the count rate per record.

(3) It can be modified and implemented in operations of frequency-division.

(4) They can be used for counting events in digital clocks and timers.

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