The 4017 Decade Counter

A decade counter is a circuit which can count up to ten, a common IC which performs this function is a CMOS 4017. The IC has three inputs and eleven outputs. The IC counts the number of pulses applied to the clock input and produces an output representing this.

The IC can be used to count the number of times a specific action has occurred. For example it can be used to count the number of times a switch has been pressed.

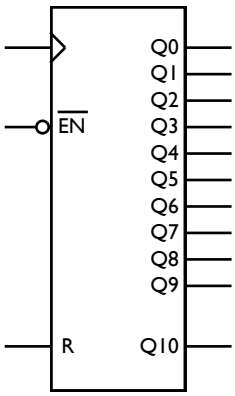

Fig 18.1: 4017 Decade counter symbol.

Pin label	Name	Function
Q0 to Q9	Counter outputs	The state of these outputs represent the count value. Only one of these outputs can be on at a time depending on the current state of the counter.
Q10	Output	Between the counts zero to four this input is high and between counts five to nine it is low. This output can be used to interface the counter to other circuits.
>	Clock input	Every time the clock input is pulsed high the counter is incremented. The > symbol is the method of indicating a clock input on a circuit symbol. The counter resets on a clock pulse after the Q9 has been high and starts from the beginning.
$\overline{EN}$	Enable input	The output will only increase with every clock pulse provided the EN input is low. If this EN is not low then the output will remain in its current state irrespective of whether a clock pulse is received or not. The circle on the input indicates that it is an *active low* input, ie. the IC is only enabled when EN is low.
R	Reset input	When this input is high the counter value is reset to zero.

Fig 18.2: 4017 Decade counter input and output pin functions.

The truthtable below shows what happens to the state of the outputs depending what happens to its inputs. The X in the table means *don't care*, for example if the $\overline{EN}$ input is not low then it doesn't matter whether or not a clock pulse is received since it will ignore it anyway.

$\overline{EN}$	R	>	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	X	X	When EN is low the output will remain in previous state										
0	1	X	1	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0	0	0	0	1
0	0	⎍	0	1	0	0	0	0	0	0	0	0	1
0	0	⎍	0	0	1	0	0	0	0	0	0	0	1
0	0	⎍	0	0	0	1	0	0	0	0	0	0	1
0	0	⎍	0	0	0	0	1	0	0	0	0	0	1
0	0	⎍	0	0	0	0	0	1	0	0	0	0	0
0	0	⎍	0	0	0	0	0	0	1	0	0	0	0
0	0	⎍	0	0	0	0	0	0	0	1	0	0	0
0	0	⎍	0	0	0	0	0	0	0	0	1	0	0
0	0	⎍	0	0	0	0	0	0	0	0	0	1	0

Fig 18.3: 4017 Decade counter truthtable.

The ⎍ symbol indicates that an input has been pulsed high (taken from low to high and then back low). In this case the counter is incremented every on the *rising edge* of the clock pulse. This means that it increments its output as soon as the clock input goes high. Some circuits have *falling edge* triggered inputs which means that they don't react until the input has gone from low, to high, and then back to low.

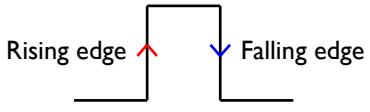

Fig 18.4: Signal rising and falling edges.

The 4026 decade counter/decoder and driver

Like the 4017 the 4026 is a decade counter. The 4026 is special though because it contains a decoder which converts the counter value into the correct signals required to drive an LED 7-segment display. The IC also contains a driver circuit which allows its outputs to supply sufficient currents to power the LEDs directly.

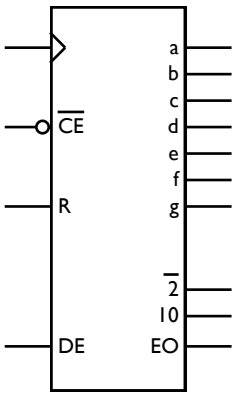

Fig 19.1: 4026 7-segment counter symbol.

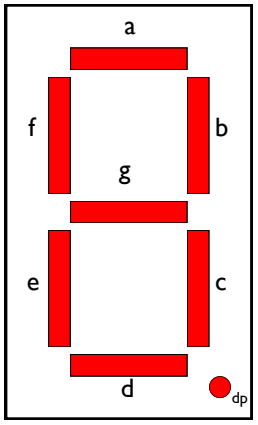

Fig 19.2: A LED 7-segment display.

Pin label	Name	Function
a to b	Coded outputs	Outputs to anodes of LED display.
>	Clock input	Every time the clock input is pulsed high the counter is incremented. Once the counter has reached nine the next clock pulse returns the count to zero.
$\overline{CE}$	Clock enable	If this input is not low then the IC will ignore any clock pulses.
DE	Display enable	In order for the display to be lit then this input must be high.
EO	Enable output	This output mimics the DE input but with a short delay.
R	Reset input	When this input is high the counter value is reset to zero.
$\overline{2}$		This output is high unless the count value is 2.
÷10	Output	This output is high for counts zero to four and high for counts five to nine. It divides the clock frequency by ten and can be connected to the clock input of an other 4026 to increase the count value to 99. Multiple 4026 ICs and LED displays can be cascaded in this way to display larger values.

Fig 19.3: 4026 counter input and output pin functions.

The truthtable below shows how the 4026 operates. Fig 19.5 shows how a 7-segment counter is wired up inside. The type the 4026 interfaces with is of the *common cathode* type, this means that all of the cathodes are connected together. There are also *common anode* LED displays available.

CE	R	>	a	b	c	d	e	f	g	Display	2	÷10
0	X	X	When CE is low the output will remain in previous state									
1	1	X	1	1	1	1	1	1	0	0	1	1
1	0	0	1	1	1	1	1	1	0	0	1	1
1	0	⎍	0	1	1	0	0	0	0	1	1	1
1	0	⎍	1	1	0	1	1	0	1	2	0	1
1	0	⎍	1	1	1	1	0	0	1	3	1	1
1	0	⎍	0	1	1	0	0	1	1	4	1	1
1	0	⎍	1	0	1	1	0	1	1	5	1	0
1	0	⎍	1	0	1	1	1	1	1	6	1	0
1	0	⎍	1	1	1	0	0	0	0	7	1	0
1	0	⎍	1	1	1	1	1	1	1	8	1	0
1	0	⎍	1	1	1	1	0	1	1	9	0	0

Fig 19.4: 4026 Truthtable (DE and EO omitted for clarity).

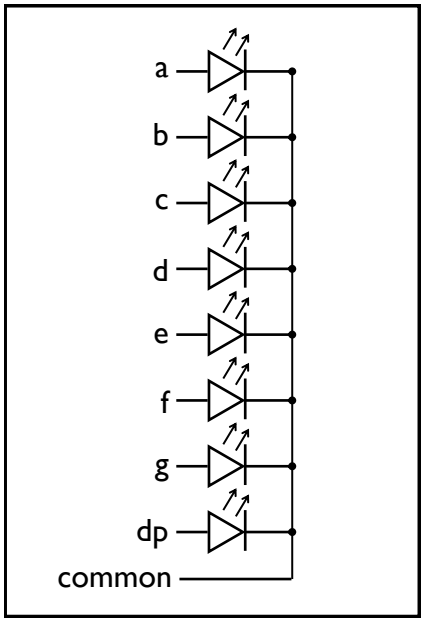

Fig 19.5: Common cathode 7-segment display wiring diagram.