Mostek
CMOS digital integrated circuits (IC's).

This page contains a guide to the functions and utilization of the 4000 series of CMOS digital integrated circuits (IC's). This information will be of use to average electronics hobbyists starting out in digital electronics, and also to those who know the 'basics' but have never used an IC before and wonder what all those pins do!

Introduction

Digital (or logic) circuits can only have one of two states; logical 1 or 'high' and logical 0 or 'low'. In a digital circuit these are represented by two voltages, 'high' being close to the positive supply rail and 'low' being close to the negative supply rail (or ground). This should be contrasted to analogue circuits such as amplifiers where any voltage between these values is valid. The simplicity of logic circuits, having only two states, allows them to be used in a wide variety of applications such as, computing circuits, logic functions and counter circuits. The CMOS 4000 series provides a wide range of integrated circuits covering a variety of useful digital functions and have the advantages of a wide power supply range (3 to 15 Vdc) and low power consumption.

Fortunately the IC's themselves are inexpensive and with a solderless breadboard, some LED's, resistors and switches you can be well on your way to building your own circuits using these versatile components! This page shows the pin-outs and the functionality of each IC and what the various inputs and outputs do. Before describing each IC, first a note about input and output connections and handling precautions.

Interfacing to CMOS logic IC's

A logic *input* pin can be set to a logical 'low' by connecting it to the ground (Gnd) rail (usually battery negative), similarly a logic 'high' is set by connecting it to Vcc (or the positive battery terminal). An input should not be allowed to 'float' between these two states as this can cause unpredicable operation.

All the CMOS IC's require two of their pins to be *always* connected to a power supply for proper operation (Vcc = +, Gnd = -), logic diagrams often omit these connections!

CMOS *output* pins can drive an LED connected to Gnd *via a suitable resistor* (680 ohms is OK for 9 volt operation). A lit LED then indicates a 'high' output whereas an unlit LED indicates a 'low' output state. That LED could also be a segment of a 7 segment display and some of the CMOS counters provides outputs that do just that, each segment will require its own resistor. External transistors should be used to drive higher current loads (e.g. filament lamps).

The counter IC's require a 'clock', this is just a series of positive and negative pulses (a square-wave signal) and *can* be provided by a switch (although most switches suffer from contact 'bounce' and give multiple pulses with one press!) or an 'oscillator' circuit (e.g. the 4047 IC) which provides a constant clock frequency. The CMOS counter IC's advance (increment) on negative to positive clock transitions thus the counting rate is the same as that of the clock frequency.

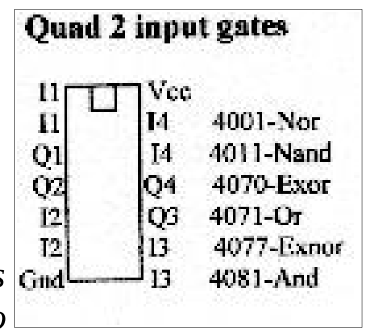
Handling precautions

Anti-static precautions should be taken when handling and storing CMOS IC's, store unused IC's in anti-static conductive foam, ground yourself (i.e. to a radiator pipe) before handling the IC's, finally, when soldering always use a socket and do not solder to the pins directly. Usually more elaborate precautions such as anti-static mats, wrist straps etc are not required unless your local humidity is exceptionally dry.

CMOS IC's by number/function

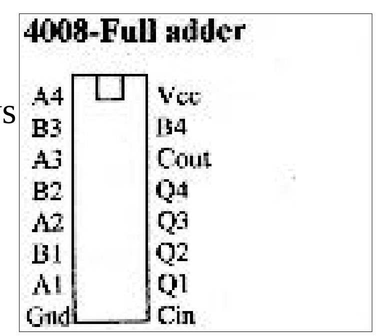
The pin out diagrams provided assume that the IC is the usual way round with the notch at the top and the pins sticking downwards (i.e. as they would be inserted into a PCB or breadboard). No circuit diagrams have been provided however the function of each IC pin is described so that you can connect switches/LED's to the various input/outputs and try out the different functions in your own circuits. I have also suggested possible applications for each IC, but complete systems can easily be built by interconnecting the various functions.

Quad 2 input logic gates (4001, 4011, 4070 etc)



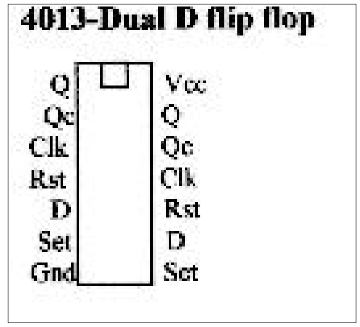
A range of 6 CMOS IC's providing 4 totally independent logic gates having the same function in one package. Logic functions available are AND, OR (the normal inclusive OR function), NAND (NOT-AND), NOR (not OR), EXOR (exclusive OR) and EXNOR (NOT exclusive OR). For each gate in the package there are two input pins labeled 'I' followed by the gate number 1-4 in the package and one output 'Q' followed by the gate number. *The output state depends on the logical states at the two inputs obeying normal logic function rules, thus these IC's are ideal for detecting a certain binary value and taking appropriate action (i.e. to reset a counter).*

4 bit full adder 4008



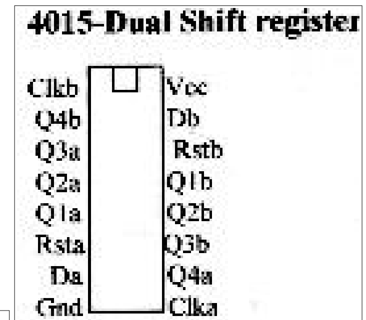
An IC which adds two 4 bit binary numbers presented at port A (A1-A4) and port B (B1-B4) with bit 4 being the most significant bit (msb). The result is output from port Q (Q4 is msb) and, if required, the Cout pin. A carry in (Cin) pin allows devices to be cascaded (e.g. for adding 8 bit binary numbers) but if not used this pin should be connected to Gnd. *This IC is useful in simple computing circuits.*

Dual D type flip flop 4013



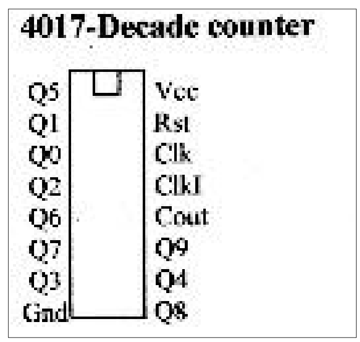
Two identical but independent D type (data) flip flops in one IC, the pins for the first flip flop are arranged down the left side of the IC and the remaining flip flop uses the pins down the right hand side of the chip. The state of the normal (Q) and complement (Qc) outputs reflects the binary state of the D (data pin) after the next negative-positive transition on the clock (Clk) pin, this state is then latched until the next clock transition. Taking reset (Rst) 'high' forces output Q 'low' (and Qc high) and Set forces Q 'high' regardless of the status of the clock or D pins, when this function is not required both pins should be connected to logical 'low' (Gnd). *This IC is useful in latch circuits and for counters.*

Dual shift register 4015



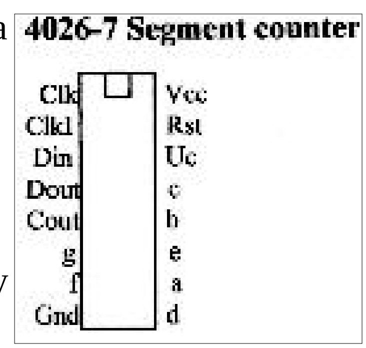
Two completely independent 4 bit shift registers (a and b) sharing common power supply on one IC. Data is applied to pin D, the state of pin D appears on pins Q1, Q2, Q3 and Q4 in succession on successive negative-positive transitions on the clock pin (Clk), taking reset (Rst) 'high' resets all the bits to 0 'low' states. *This IC is useful for programmable light chasers, toys, games, displays etc.*

Decade counter 4017



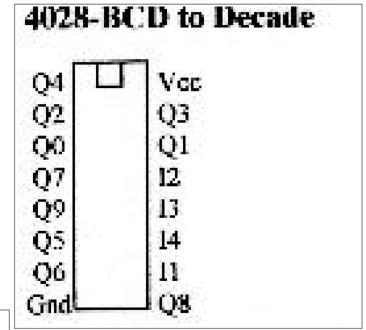
A 'one of ten' counter whose outputs Q0 to Q9 successively (and in turn) go 'high' on successive negative to positive transitions on the clock pin (Clk). Only one output pin is 'high' at any one time. A clock inhibit pin (ClkI) when taken 'high' inhibits the counting action, a carry out (Cout) pin goes 'high' every 10 clock cycles and thus allows devices to be cascaded. Taking reset (Rst) 'high' resets the count (i.e. pin Q0 'high', other outputs 'low') but for normal operation tie this pin to Gnd. *This IC is particularly useful in a light chaser application and could be used to good effect with 10 multicoloured LED's in toys, displays and games.*

7 segment counter 4026



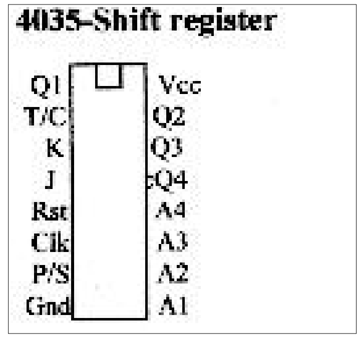
An IC whose function is identical to a 4017 but instead of '1 of 10 output' offers a fully decoded output suitable for driving segments a-g of a normal *common cathode* 7 segment LED display. Output pins a-f connect to the corresponding terminals on the 7 segment display (via series current limiting resistors), the clock (Clk) and clock inhibit (ClkI) pins function as above, Din must be 'high' to illuminate the display, output Dout follows the state of Din and allows devices to be cascaded or, with additional logic, provides for leading zero suppression. Carry out (Cout) goes 'high' once every 10 clock cycles and allows counters to be cascaded (i.e. connect Cout to the Clk pin on a 'tens' chip). The reset (Rst) pin when taken 'high' resets the count so that '0' is displayed, this pin is connected to Gnd for normal counting. *This IC is ideal for any application where an 'up' counter is required with 7 segment output e.g. timers and clocks.*

BCD to decade decoder 4028



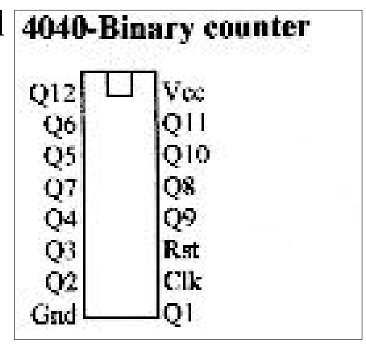
A 4 bit binary number applied to inputs I1-I4, (I4 being the most significant bit) is decoded to a '1 of 10' output on terminals Q1 to Q9, only one output is 'high'. Binary inputs of greater than 9 (1001) are ignored and all inputs are held low if this input data is presented at the input terminals. *This IC in conjunction with a 4 bit BCD counter (4510) is ideal for light chasers and display, toys applications.*

Shift register 4035



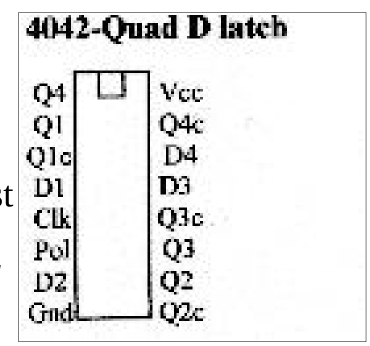
A 4 bit binary number applied to inputs I1 to I4 (I4 being the msb) appears at outputs Q1 to Q4 after the next negative-positive transition on the clock (Clk) input and is latched until the next clock cycle. Taking T/C 'high' allows a 'true' output, whereas if the T/C pin is 'low' the complement of the input data appears at the outputs after the clock cycle. The P/S pin allows such 'parallel' operation described above only when it is set 'high', when 'low' data can instead be applied to either the J or K pins (the K pin provides complementation of the input data) and is latched into the register after 4 successive clock cycles appearing at the outputs Q1 to Q4 in the order in which it was input. Taking reset (Rst) 'high' clears the register (all binary 0's). *This IC finds use in general latch and 'memory' circuits and in arithmetic circuits.*

12 bit binary counter 4040



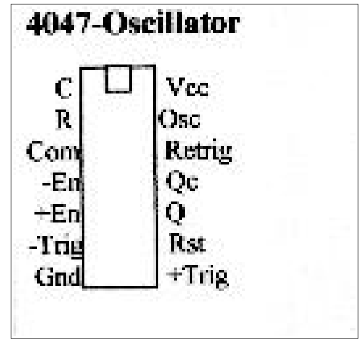
An IC that counts clock pulses (low to high transitions) on its clock pin (Clk) and outputs an incrementing binary number on outputs Q1 to Q12 (Q12 is msb). A reset pin (Rst) is provided which clears the count to binary 0 (all outputs low). This IC is also capable of divider functions (i.e. the frequency of the clock input is divided by 2^n where n is the pin where output is taken from). *This IC is useful in display applications or in divider circuits.*

Quad D latch 4042



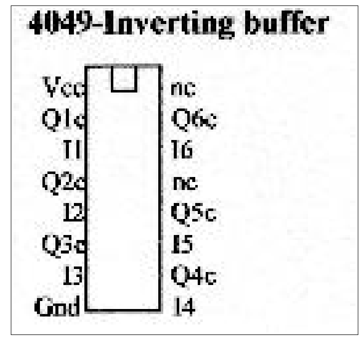
An IC that provides 4 separate D type latches (1-4) on one IC with common control inputs Clk and Pol. When Clk and Pol have the *same* logic state the latches provide 'straight through' operation (i.e. the logic level at a Q output follows the logic level input to the corresponding latches D pin) when the control pins have complementary logic levels the data at all the Q pins is latched at the last states of the D pins until the control logic states are identical again. Each latch also provides a complement output Qc. *An IC again useful in 'memory', latch and arithmetic circuits.*

Oscillator 4047



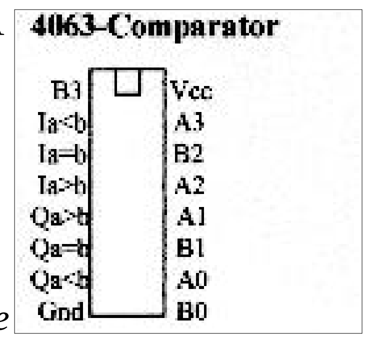
An IC that provides clock pulses at a frequency dependent on the values of the resistor connected across pins 2 (R) and 3 (Com) and capacitor (*which must not be electrolytic*) across pins 1 (C) and 3. The frequency in Hz (at pins Q and Qc) is approximately equal to 0.46/(RxC), and pin Osc provides an *unbuffered* output at twice this frequency. For normal oscillator operation connect pins -En, +En and -Trig to Vcc and pins Retrig, Rst and +Trig to Gnd. Using these extra pins it is possible to use the IC as a monostable, but we will not cover this operation. For ~1Hz operation (e.g. to drive the clock inputs of any of the counter IC's) use R=1.0Mohms and C=0.47uF (ceramic) and connect the Q output directly to the relevant IC's clock input pin. *Note that, unlike the 555 timer, this IC cannot drive a loudspeaker directly, additional amplification will need to be provided if this IC were to be used as an audio oscillator.*

Buffers (4049,4050)



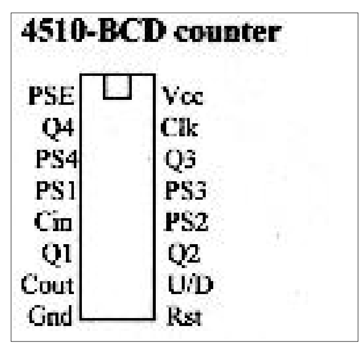
Two IC's having identical pin outs, the 4049 providing a complement (inverted) output and the 4050 providing a true output. Each IC contains 6 identical and independent buffers with a single input (I) and output (Q) each. Buffers provide a high input impedance and can drive low impedance loads, they are ideal for driving multiple LED displays or when an output is used to drive an LED and another logic input (where the loading from the LED would force the output too low in voltage to be recognized as a 'high' by the succeeding input). The maximum source/sink current per buffer is 30mA so each buffer can drive 30+ CMOS inputs or up to three LED's. *These IC's are useful to 'buffer' higher current loads than could normally be driven e.g. for a multi-LED display.*

Binary comparator 4063



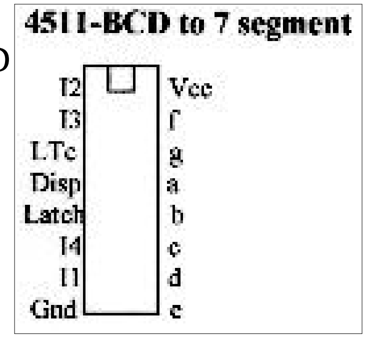
An IC that compares the magnitudes of two 4 bit binary numbers applied to port A (A1 to A4) and port B (B1-B4) with '4' being the msb. The corresponding output (Qa<b, Qa=b or Qa>b) goes 'high' depending on the relative magnitude of the two numbers. Inputs Ia<b, Ia=b and Ia>b are provided for cascading several IC's (for example for an 8 bit comparator) but if a single IC is used Ia=b should be connected to logic 'high' and the remaining two inputs held 'low'. *This IC finds uses in arithmetic and counting circuits and particularly where two binary numbers need to be compared (e.g. for an alarm clock where the preset alarm time is held in a latch and compared with a counter).*

Presettable BCD/binary counters 4510/4516



Two IC's that either provide Binary coded decimal (0-9) 4510, or binary (0-F) 4516, counting of low-high transitions on their clock (Clk) pins. BCD/Binary outputs are taken from pins Q1 through Q4 (Q4 is msb). For normal operation PSE is held 'low' but, if taken high, a 4 bit binary number applied to inputs PS1 through PS4 is loaded into the counter and when PSE is returned to a 'low' logic level the count resumes from this value. Cin is normally held 'low' and Cout goes 'high' every 10 clock cycles and thus provides for a 'tens' device (cascade operation). Count proceeds up when U/D is set 'high' and down when U/D is taken to logical 'low', finally a reset (Rst) pin when taken 'high' resets the counter (i.e. binary 0000 all outputs low) but for normal counting should be held 'low'. *These IC's provide up/down binary counts that are compatible with the arithmetic circuits and display drivers that take BCD inputs (e.g. 4028 and 4511).*

BCD to 7 segment decoder 4511



An IC that takes a 4 bit binary BCD (0-9) number on its inputs I1 through I4 (I4 is msb) and generates the familiar a-g segment outputs for a common cathode LED display on output pins a-g. When lamp test (LTc) is taken low, all LED segments are illuminated regardless of the number at the inputs, when Latch is taken 'high' the displayed value is latched regardless of the input value (the display only updates when this pin is 'low'). The display is blanked (all segments off) either when (a) an invalid code (i.e. A-F) is applied to the inputs or (b) the 'display' pin (Disp) is held at a logical 'low' (this pin with additional logic gates can provide leading zero suppression in multi-digit counters). *This IC is useful in any application where a binary number needs to be converted to a format to be displayed on a 7 segment display, e.g. clocks and timers, arithmetic circuits and counters.*

END