GLOSSARY for REVISION

0

- **0:** Logic zero is any voltage below half the power supply voltage, often close to zero Volts.

1

- **1:** Logic one is any voltage above half the power supply voltage, often close to the power supply voltage.

2

- **2^N:** How many values can a five bit number represent? 2^5 = 32. There are many more problems similar to this one.

3

- **386:** This is a useful audio amplifier chip giving at least 0.25 Watts output.

4

- **4013:** D Type Flip Flop chip.
  - On the rising edge of the clock pulse, D is copied to Q.
  - At any time a high signal on S or R can be used to Set or Reset the chip.
  - Unused inputs must be held low or high and must not be left floating to pick up any random signal.
- **4017:** A counter chip with ten outputs numbered from 0 to 9.
  - Only one output is high at any time.
  - On the rising edge of the clock pulse, the output increases by one and the next output becomes high.
  - A high voltage on the reset pin resets the counter back to zero.
  - Unused inputs must be held low or high and must not be left floating to pick up any random signal.

5

- **555:** The timer chip used to make Monostable and Astable circuits.
  - If the trigger voltage drops below 1/3 of the power supply, the output goes high and the discharge transistor turns off.
  - The capacitor charges through the resistor/s.
  - If the threshold voltage rises above 2/3 of the power supply, the output goes low and the discharge transistor turns on.
  - The capacitor discharges.

7

- **741:** A cheap, low performance but well behaved operational amplifier chip. It has a very high open loop gain and input resistance close to infinity.

A

- **Absolute Position:** The position is fully known. See Relative Position.
- **AC:** Alternating Current. The voltage alternates positive and negative 50 times per second in Europe and 60 time per second in the USA. It's used because, unlike DC, it works with transformers and the voltage can be stepped up or down. High voltage, low current power distribution is more efficient and transformers are needed to make this work. Mains power is AC.
- **Accuracy:** Resistors are manufactured with precisions of +/- 1, 2, 5 or 10%. Capacitors are commonly accurate to +/- 5%. When calculating, electronic engineers mostly quote answers to two or three significant figures. More digits are pointless because the circuit can't be built to that level of precision. An exception is with the design and manufacture of precision measuring instruments.
- **Active:** Components, usually semiconductors, with high frequency voltage or current gain.
- **Active High:** A high voltage or logic ONE is needed to turn on a circuit or device. Example: Transistor Switch.
- **Active Low:** A low voltage or logic ZERO is needed to turn on a circuit or device. Example: Bistable Latch.
- **Active Filter:** Resistor/s, Capacitor/s and an Op Amp. See Filters.
- **Actuator:** An output transducer that provides mechanical movement. Examples include solenoids, motors and servos.
- **ADC:** See Analogue to Digital Converter.
- **Address:** Addresses uniquely identify one and only one memory location or I/O Port. This guarantees that only one tristate device ever has access to the data bus at any time.
- **ADDW:** AQA Assembler: Add K to W.
- **Aerial:** See Antenna.
- **AF:** Audio Frequency. 20 to 20000 Hz or 300 to 3000 Hz for telephone quality.
- **ACG:** See Automatic Gain Control.
- **Aliasing:** Unwanted patterns in still images. Unwanted frequencies in audio. Strange visual effects in motion video. The sampling frequency must be at least double the highest information signal frequency. If this is not the case, aliasing occurs.
- **Alternating Current:** Cells and batteries produce a steady flow of electrons called Direct Current. Alternating current flows backwards and forwards 50 times per second (Europe) or 60 times (USA). Alternating current is useful because the voltage can be stepped up or down using a transformer. This makes high voltage power distribution possible.
- **AM:** Amplitude modulation. The carrier amplitude is modified proportional to the information signal amplitude. AM is used in the LF, MF and HF broadcast bands. The AM bandwidth is double the highest frequency in the information signal.
- **Amp (Ampere):** Current is measured in Amps. One amp is 6.24 x 10^{18} electrons passing a point each second.
- **Amplifier:** This increases the magnitude of the input signal.
  - Voltage Amplification: Voltage Gain = V_{out} / V_{in}
  - Current Amplification: Current Gain = I_{out} / I_{in}
  - Power Amplification: Power Gain = P_{out} / P_{in}
- **Amplitude:** A measurement of the height of a wave.
- **Amplitude Modulation:** See AM.
- **Ammeter:** Break the circuit. Put the ammeter into the break so the current now flows through it. An ideal ammeter has no resistance. The voltage across an ideal ammeter is zero.
- **Analogue Signals:** Smoothly varying signals that occur in nature. The signals have an infinite range of values unlike digital where there are only two values.
- **Analogue to Digital Converter:** This converts smoothly varying signals that occur in nature into the two digital levels used by computers and other digital signal processing systems like phones and personal stereos. The analogue levels are often represented by binary numbers.
- **AND:** AND Gate. The output is ONE if all the inputs are ONE. ZERO otherwise.
- **ANDW:** AQA Assembler: AND W with K. The result goes into W.
- **Angular resolution:** The smallest angular rotation that can be detected. A 360°disc is divided into four tracks giving a 16 value Gray code. The angular resolution is 360 / 16 = 22.5^{o}.
- **ANN:** See Neural Network.
- **Antenna:** A receiving antenna is a transducer that converts electromagnetic radiation (radio waves) into an alternating voltage or current. A transmitting antenna does the same conversion in reverse. The most common antenna is a wire or rod, half a wavelength long, called a half wave dipole.
- **Architecture:** This describes the design and layout of the inner workings of microprocessors and microcontrollers.
- **Armature:** Usually the moving part of a motor. It's complex. Check out Wikipedia.
- **Assembler:** The Assembler program translates human-readable assembly code into binary numbers or machine code understood by the microcontroller. It automatically calculates the addresses of labels, jumps and subroutines saving the programmer a lot of time and preventing mistakes.
- **Astable:** An oscillator with zero stable states. It produces a square wave alternating output. The 555 chip is commonly used but op amp and logic gate astables are possible too.

- **Asynchronous:** Signalling where the sender and receiver have separate clocks and it's impossible to predict when a signal will start arriving.
- **Atom:** Matter is made of atoms. The atom is the smallest indivisible piece of an element.
  - Atoms contain a nucleus with neutral neutrons and positive protons. The nucleus is surrounded by cloud of negative electrons.
  - An uncharged atom has equal numbers of electrons and protons so the positive and negative charges cancel out or balance.
- **Attenuation:** This is the signal becoming weaker as it travels further from the transmitter. Sometimes a very large signal needs to be attenuated before it can be processed.
- **Audio Frequency/Amplifier:** This is the range of frequencies people can hear. It runs from 20 Hz to 20000 Hz. For telephone quality voice, the range of frequencies is from 300 Hz to 3000 Hz. An audio amplifier increases the magnitude of audio signals.
- **Automatic Gain Control (AGC):** uses negative feedback to control the gain of a receiver to maintain a constant audio output at the loudspeaker, even if the received signal strength varies.
- **Autonomous:** Robots with artificial intelligence that enables them to function without much human intervention.
- **AVR:** A family of microcontrollers made by Atmel.

B

- **Back EMF:** When the current in an inductor (coil) changes, a back EMF is produced. Sudden current changes cause large and possibly damaging back EMFs. To prevent damage, the current must be allowed to change more slowly. Correctly positioned diodes can achieve this.
- **Bandwidth:** A measure of the capacity of a channel to carry information.
  - Digital Bandwidth is measured in bits/second.
  - Analogue Bandwidth is measured in Hertz.
  - AM Radio Bandwidth = 2 x Fmax (the highest frequency in the information signal).
  - FM Radio Bandwidth = 2 x (deviation + Fmax) (the highest frequency in the information signal).
- **Bandwidth (Amplifiers):** The range of frequencies over which
  - the output voltage is at least 0.7 of the maximum voltage. Measured in Hz.
  - the output power is at least 0.5 of the maximum power. Measured in Hz.
- **Baseband:** This is the low frequency information signal such as Audio or Keyed DC. Baseband signals are often multiplexed using time division multiplexing. See Broadband.
- **Base Station:** Mobile phones connect by radio to the nearest Base Station or Cell.
- **Battery:** Chemical storage of electrical energy. Batteries provide an EMF. Compare types of battery. A battery contains two or more cells.
- **Baud Rate:** The number of bits per second sent or received in a communications system. Baud rate includes all the bits, some of which are data and some used to manage the data flow.
- **Bias:**
  - A DC Voltage needed for the correct working of a circuit. This is separate from the AC signals in the circuit.
  - Forward Bias - Current will flow - For example a lit LED.
  - Reverse Bias - Current might not flow. Normal diodes are a good example. Zener diodes do allow a current to flow and at the same time, produce a useful reference voltage.
- **Binary:** The base 2 number system. There are 10 kinds of people. Those that understand binary and those that don't.
- **Bistable Latch:** Made from two NAND gates.
  - The two inputs are NOT S (set) and NOT R (reset)
  - These must go low to set or reset.
  - The outputs are Q and NOT Q.
  - It is a one bit memory.
  - It can be used to de-bounce a switch.
- **Bit:** A binary digit. A Zero or a One.
  - A Zero is a low voltage less than half the power supply, often close to zero Volts.
  - A One is high voltage more than half the power supply, often close to the power supply voltage.
- **Bit Mask:** A binary pattern used to keep or discard bits usually using the AND operation. If the mask bits are 1, the data is kept. If the mask bits are 0, the data is cleared.
- **Bit Rate:** The number of bits per second sent or received in a communications system. Baud rate includes all the bits, some of which are data and some used to manage the data flow. Bit rate counts the data bits per second excluding the management bits.
- **BJT:** Bipolar Junction Transistor. A small base current controls a much larger emitter / collector current. The current gain is calculated from Ic / Ib.
- **Breakdown:** Breakdown voltage is the largest voltage a component can stand before it breaks down. When a component breaks down, it is usually destroyed by the large current that flows. A few components such as Zener Diodes are designed to be used in the broken down state and it's important to limit the current to a safe level with a suitable resistor.

- **Breakpoint Frequency:** At the breakpoint frequency of a filter the output voltage drops to 0.7 of the maximum output voltage. The reactance of the capacitor is equal to the resistance of the resistor.
- **Bridge Rectifier:** Four diodes used to convert AC into DC. Sometimes all four diodes are wired into one plastic moulding with four pins.
- **Broadband:** More than one and often hundreds of high frequency carriers are modulated with the the low frequency information signal such as Audio or Keyed DC. Broadband signals are multiplexed using frequency division multiplexing. See Baseband.
- **Broadcasting:** A one way transmission intended for one or a large number of recipients. Radio and TV are well known examples.
- **BS 1852:** A British Standard notation for labelling components. 4K7 means 4.7 kΩ
- **Buffer:** Buffer circuits isolate the input device from the buffer output by having a very high input impedance. Buffers can often provide quite large output currents making them the same as drivers. Tristate buffers can disconnect their output from a shared bus, allowing other devices to use the bus.
- **Bulb:** An output transducer that converts electric current into heat and light. White hot tungsten filaments are common but not very efficient.
- **Bus:** A collection of wires shared between multiple devices. This arrangement simplifies the interconnection of the devices.
  - Data Bus: This carries data in both directions (bidirectional, read, write).
  - Address Bus: This uniquely identifies and activates a single tristate device to connect to the data bus.
  - Control Bus: It contains a wire which selects Read or Write (the direction of the data on the data bus). It contains a wire which selects whether Memory or I/O ports are identified and activated by the address bus.
  - Instruction Bus: (Harvard Architecture Only) speeds up processing by allowing the instruction and data to be fetched at the same time.
- **Buzzer:** This transducer produces a buzzing sound and it needs a DC power source. It generates its own alternating signal to make the buzz. See **Sounder**.
- **Byte:** A group of eight bits.
  - The least significant (Bit_0) is worth 1.
  - The most significant (Bit_7) is worth 128.
  - The bits are worth 128, 64, 32, 16, 8, 4, 2 and 1.
  - If all the bits are set to One it's worth 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 = 255.
  - See Nybble.

C

- **CALL:** AQA Assembler: Call a subroutine.
  - Save the return address (PC + 1) onto the stack and add one to SP.
  - Jump to the subroutine address.
  - When finished, subtract one from SP and retrieve the return address from the stack.
  - Jump to the return address by setting PC to the return address value.
- **Capacitor:** Two metal plates separated by an insulator. The plates can be made from thin foil and rolled up into the common tubular capacitor shape. Capacitors store energy in the form of electronic charge. The biggest high voltage capacitors can store enough energy to deliver fatal a electric shock. $X_C = 1 / (2 \pi f C)$
  - Coupling and DC blocking
  - Decoupling
  - Smoothing
  - Tuning
  - Timing: The Time Constant $T = R C$ $T_{50\%} = 0.69 R C$ $T_{100\%} = 5 R C$.
- **Carrier:** This is a high frequency signal, usually for radio transmission. The carrier is modulated (modified) to include the information signal to be transmitted. It's needed because the frequency of the information signal is usually far too low to be transmitted by radio without the help of the carrier.
- **Cell:** Chemical storage of electrical energy. Two or more cells make a battery.
- **Cell:** Mobile phone networks rely on overlapping cells covering the entire country. If a phone moves from one cell to another, the call is automatically transferred to the new cell. Each cell has its own transmitters, receivers and antenna mast.
- **Centi:** S.I. Units Prefix: 1 / 100 10^{-2}
- **Charge:** Charge is measured in coulombs.
  - A negative charge is a zone where there more than the usual number of electrons.
  - A positive charge is a zone where there are fewer than the usual number of electrons.
- **Circuit:** A collection of electronic components performing a useful task. Current will not flow until the circuit is complete (without gaps).
- **Circuit Diagram:** A diagram showing the electronic component symbols and how they are connected. These diagrams are often confused with system diagrams, layout diagrams and flow charts.
- **Circuit Switched Network:** The original telephone network was circuit switched. It's being replaced by the more efficient and cheaper Packet Switched networks.

- **CISC:** Complete Instruction Set Chip. The chip has a large number of complex instructions built into it. It uses hardware to do most computations. The simpler RISC chips rely on software to solve similar problems. RISC chips are simpler and use much less power.
- **Clear:** The output goes low, becomes zero.
- **Clipping:** The amplifier is trying to generate an output greater than the power supply voltage so the top/bottom of the signal is flattened or clipped. This happens at high volumes. It's also called limiting or saturation.
- **Clock:** A square wave signal used to synchronize all operations in a logic, computer or communications system.
- **Closed Loop:** A control system with negative feedback. The output is measured and fed back to the input in order to correct errors in the output. See Open Loop.
- **Co-axial Cable:** This is a screened cable with a centre conductor and a woven braid screening layer. The screening layer keeps the wanted signal inside the cable and prevents outside noise or crosstalk signals getting in.
- **Common:** In a switch this connection is always connected to the circuit. The NO and NC connections are made by opperating the switch.
- **Common Anode:** In LED bars and arrays and Seven Segment displays, all the LED anodes are connected together and wired to a single pin.
- **Common Cathode:** In LED bars and arrays and Seven Segment displays, all the LED cathodes are connected together and wired to a single pin.
- **Codec:** Digital en**co**der and **dec**oder to modulate and demodulate digital transmissions.
- **Coil:** Wire wound into a spring shape. Coils act as electromagnets and are useful in filters and tuned circuits. Larger coils with an iron core are used in Solenoids and Electromagnetic Relays.
- **Combinational Logic:** Logic gates without a memory or a clock. The output changes as soon as the input changes.
- **Communication:** The transfer of meaningful information from the sender to the receiver.
- **Comparator:** Operational amplifiers have a very high open loop gain. The comparator op-amp compares its two input voltages. The output is always either low or high because the op-amp voltage gain is so high. If the non inverting input is greater than the inverting input, the output will be high and vice versa. The comparator is a one bit A to D converter.
- **Components:** Resistors, Capacitors, Transistors, MOSFETs and all the other devices that can't be broken up into smaller sub-systems.
- **Conductor:** A material in which the outer electrons are free to wander away from their parent atoms. If a potential difference is applied to this material, there will be a net flow of electrons and a current will flow.
- **Control System:** Input sensor/s processes and output devices, sometimes with negative feedback.
- **Coulomb:** The measurement unit of electronic charge. One coulomb = 6.25×10^{18} electrons.
- **Coupling:** Getting a signal from one subsystem into another. Coupling capacitors are commonly used.
- **Cross-Over Distortion:** The input signal is too small to turn on either MOSFET (or Bipolar Junction Transistor). The output disappears when the input voltage crosses over the zero line. This sounds harsh and unpleasant. It is cured by biasing the MOSFETs (or transistors) with diodes and resistors and also by including the MOSFETs (or transistors) in the negative feedback path.
- **Crosstalk:** Crosstalk is unwanted leakage of a signal from one channel to another. It can be caused by capacitative or magnetic coupling of the signal. More rarely it could be caused by leakage through poor insulation. It is greatly reduced by the twists in twisted pair cables and the screening layer in co-axial cable.
- **CTCSS:** Continuous Tone Coded Squelch System. A tone below 300 Hz. The receiver will not operate unless the correct tone is present. The tone is filtered out before audio is sent to the speaker. This allows multiple organisations to share the same radio channels without having to listen to each other's transmissions. Each uses a different tone.
- **Current:** This is a flow of charge (usually electrons) measured in Amps. One amp = One Coulomb passing a point per second.

D

- **D Type Flip Flop:** On the rising edge of the clock pulse, the input D is copied to the output Q.
    - At any time, Q can be set by toggling S high, otherwise it must be held low.
    - At any time, Q can be cleared by toggling R high, otherwise it must be held low.
    - Latch: Each input D is copied to the corresponding output Q and the data is stored until the next clock pulse.
    - Shift Register: Each Q is connected to the next D input so on the rising edge, the data moves one place to the right.
    - Frequency Divider: Since NOT Q is connected back to D, Q changes state on each rising edge.
    - Up Counter: The frequency dividers are connected with NOT Q wired to the next clock each of which counts at half the rate of the previous.
    - Down Counter: The frequency dividers are connected with Q wired to the next clock each of which counts at half the rate of the previous.
- **DAB:** Digital Audio Broadcasting using 1536 carriers for each multiplex with each carrier modulated at a low data rate with digital information.
- **DAC:** See Digital to Analogue Converter.
- **Damping:** How quickly a machine or signal reaches its final setting.
    - Over damped: It takes too long for the system to settle.
    - Critically damped: It settles in the fastest possible time without overshooting.

- o **Under damped:** It overshoots and oscillates before settling.
  - o **Hunting:** It overshoots and never settles.
- **Darlington Driver:** A bipolar transistor switch using two transistors instead of one. It has an extremely high current gain.
- **Data:** Meaningful information.
  - o Analogue data consists of voltages or currents which are proportional to the meaningful information.
  - o Digital data consists of well organised binary numbers which represent the meaningful information.
- **DC:** Direct Current. This is a steady unvarying voltage. Batteries produce DC.
- **Debouncing:** Switch bounce is a problem if the switch operations are being counted. The problem is caused by mechanical bouncing of the switch contacts. It is cured with a debouncing circuit.
- **DEC:** AQA Assembler Instruction - Subtract one from the specified register.
- **Decibel:** Decibels **dB** are a measurement scale where the numbering multiplies instead of adding. 1, 10, 100, 1000. This allows the scale to cover a vast range of values. Decibels compare a signal with a reference level or compare the signal level with the noise level.
- **Decimal:** The base 10 number system used in every day life.
- **Decision:** For example: A comparator sensing if a voltage is above or below a set level. Depending on the result, different actions are taken. In flowcharts, a decision is shown as a diamond shaped box containing a question with YES or NO answers. Microcontrollers make decisions based on status flags and commands like JPZ and JPC.
- **Decoder:** Binary numbers can be decoded. For example a four bit binary input causes one of sixteen outputs to become high. The 4017 counter chip decodes a binary number between 0 and 9 and activates the correct single output, also numbered from 0 to 9. Digitally modulated signals are decoded to retrieve the Information Signal.
- **Decoupling:** Getting rid of unwanted AC signals by coupling them to ground through a capacitor.
- **Decrypting:** Decode and encrypted signal. This is impossible unless you possess the key to decrypt.
- **Demodulator:** A circuit the separates the information signal from the modulated carrier signal. The output might be music, speech or control signals as in radio control. Also known as a detector or decoder.
- **Detector:** This is another name for a demodulator.
- **Digital:** Signals with only two levels ZERO/ONE or LOW/HIGH. Digital signals perform well because unwanted noise can usually be removed resulting in error free signals.
- **Digital Ramp ADC:** Slow, cheap, OK for audio and human manual interaction.
- **Digital to Analogue Converter:** Computers only store digital data as ONEs and ZEROs. For a computer to play back audio or video, the digital data has to be converted back into analogue.
  - o **Digital ramp ADC:** Slow, cheap, OK for audio and human manual interaction.
  - o **Flash ADC:** Fast, expensive, needed for digitising video signals and also MF and HF radio receiver signals.
- **Digitise:** Convert an analogue signal into digital.
- **Diode:** Passes current in one direction only.
  - o used for polarity protection
  - o convert AC into DC in a Power Supply
  - o eliminate damaging Back EMFs
  - o demodulate AM
  - o combined with resistors, they bias MOSFETS and Transistors to reduce cross-over distortion
  - o a typical forward biased silicon diode has about 0.7 Volts across it.
- **Dipole:** The dipole antenna is half a wavelength long. It is usually connected to a transmitter or receiver with 50 Ω co-axial cable. If the dipole length is wrong, it will be less efficient and there will be an impedance mismatch - no longer 50 Ω.
- **Direct Current:** This is the steady flow of current from cells, batteries and DC power supplies. See Alternating Current.
- **Dispersion:** Pulses spread out in time becoming less square. If the dispersion is excessive, pulses merge into each other and can no longer be decoded. Dispersion in optical fibres is caused by light travelling on multiple paths with more of fewer zigzags so the distance travelled varies. Different frequencies also travel at slightly different speeds. This causes different part of the transmission spectrum to arrive at different times. Higher frequency light (blue) travels slower the the lower frequencies (red).
- **Distortion:** Amplifiers should be linear. The output should be exactly proportional to the input. In real life this is hard to achieve so the output is distorted. Two common types of distortion are cross-over distortion with small signal inputs and clipping or limiting with large signal inputs.
- **Dope:** Tiny amounts of impurities added to intrinsic semiconductors. The impurities control the electronic properties of the semiconductors. Boron and Phosphorus are commonly used dope materials diffused into the intrinsic Silicon.
- **Downlink:** A radio signal from a satellite down to the Earth such as satellite TV reception. Also a signal from the cell base station to a mobile phone. See Uplink.
- **Driver:** This is a switch or follower circuit with a tiny current input and a much larger current output. They drive relays, motors, lamps and many other higher power devices. The circuit is needed because the microcontroller, comparator or other process circuit can not drive the load on its own.
- **Duplex:** The capabilities of a communications channel.
  - o **Simplex:** One way communication like radio broadcasting.
  - o **Half Duplex:** Two way communication but only one direction at a time. Walkie Talkies are like this.
  - o **Full Duplex:** Two way simultaneous communication. Frequency or Time Division Multiplexing is needed to achieve this.

- **Dynamic Range:** Systems that can handle a wide range of signal levels without noise or distortion have a good dynamic range. Digital systems often have extremely good performance.

E

- **E24:** These resistors are available in catalogues for purchase. There are 24 values per decade. For example between 1kOhm and 9.1kOhm, there are 24 values available.
- **Earth / Ground:** This is a zero volt reference level. It's important for electrical safety. By definition the whole planet is at zero volts although locally this might not be true. The earth wire in a mains plug is very close to the zero volts earth potential unless there is a fault.
- **Electromagnetic Spectrum:** The radio spectrum ranging from VLF up to UHF, EHF, Infra-Red, Visible, Ultra-Violet, X-Rays and beyond.
- **Electromagnetic Waves:** These are radio waves. They travel in straight lines through air or a vacuum at the speed of light, 300 million metres per second.
- **Electrons:** Electrons are tiny negatively charged subatomic particles. Each atom is surrounded by a cloud of electrons. Normally the negative charge of the electrons is exactly balanced by the positive charge of the atomic nucleus. Electronic circuits rely on the behaviour of electrons in different materials.
- **EMF:** This is electromotive force or electron moving force measured in Volts. The term EMF is applied to cells, batteries, dynamos, alternators, photovoltaic cells and any other power sources that create their own volts.
- **Encapsulation:** One example is the wrapping data into IP packets, adding origin and destination addresses, the packet type and an error checksum.
- **Encoding:** The process of producing a digitally modulated signal.
- **Encrypting:** Encode a signal so it can not be read unless you also possess the key to decrypt.
- **Ethernet:** The most widely used LAN protocol with fairly simple rules.
  - Only transmit if the cable is silent or idle / not in use.
  - If, by chance, more than one transmission happens, (a collision), stop transmitting and wait for a random time delay.
  - If there are multiple collisions, back off by increasing the random time delay. This reduces the pressure on the network.

F

- **Fading:** Variations in the signal strength of received radio signals. This often happens if the signals arrive by more than one path due to reflections off terrain, buildings, vehicles or the ionosphere. If the signals arrive out of phase, they cancel out. If they arrive in phase, the signals add and appear stronger.
- **Farad:** The measurement unit of capacitance.
- **Feedback:** The output is measured and fed back to the input.
  - Negative feedback corrects errors in the output. It also controls the gain of amplifiers.
  - Positive feedback allows for different on and off switching levels and guarantees fast switching between on and off. It's also used in astable and oscillator circuits.
- **Feeder:** The co-axial cable, open wire feeder used to connect an antenna to a transmitter or receiver.
- **Ferrite:** A non-conducting magnetic material. One type of ferrite is made with iron dust and non-conducting resin. Ferrite is useful in RF Tuned Circuits and Filters. Adding ferrite to a coil greatly increases its inductance.
- **Fibre Optics:** See optical fibre.
- **Filter:** Circuits used to block or pass signals at particular frequencies or over a range of frequencies. See Bandwidth.
  - Low Pass / Treble Cut: Pass low frequencies and block high ones.
  - High Pass / Bass Cut: Pass high frequencies and block low ones.
  - Band Pass: Pass only middling frequencies. Block low and high ones.
  - Bass Boost: Pass all frequencies but selectively increase low ones.
  - Treble Boost: Pass all frequencies but selectively increase high ones.
- **Flags:** Microcontrollers contain a STATUS Register. This contains FLAGS. The flags are set to ONE under certain conditions.
  - **C** (bit 0), the carry flag is set if a calculation gives a result too big to store in 8 bits (an overflow)
  - **T** (bit 1), the timer interrupt flag is set when the TMR register reaches zero.
  - **Z** (bit 2), the zero flag is set if there is a zero result in "W" after a calculation or move
- **Flash ADC:** A high speed, complex, more expensive ADC useful for converting video and radio frequency signals into a digital format. See Digital Ramp ADC.
- **Flow Charts:** These diagrams show the sequence and timing of inputs, processes, decisions and outputs in an electronic process. These diagrams are often confused with system diagrams, circuit diagrams and layout diagrams.
- **FM:** Frequency Modulation.
  - The frequency of a carrier signal is modified in proportion to the displacement of the information signal before transmission (usually by radio).
  - The FM bandwidth = 2(Deviation + Fmax) where Fmax is the highest frequency in the information signal.

- **Follower Circuits:**
  - Emitter Follower (Transistor)
  - Source Follower (MOSFET)
  - Voltage Follower (op-amp)
    - have a voltage gain of ONE.
    - have high current / power gain.
    - have a high input resistance.
    - isolate the output so it has no effect on the input.
    - make useful buffer circuits.
- **Forward Voltage:** This applies to diodes, LEDs and the base emitter junction of a transistor. When current is flowing, there is a typical voltage across the device which does not depend greatly on the size of the current.
  - Silicon diodes: About 0.7V. Not all diodes are the same. Check the data sheet for the diode.
  - LED: About 2V. It depends on the LED colour.
  - Transistor base emitter junction: About 0.7V
- **Free Space:** Electromagnetic radiation can travel through free space. This is a vacuum. Air comes really close to free space. The opposite of free space is cables and optical fibres.
- **Frequency:** This is the number of complete cycles of a wave in one second. It is measured in Hertz.
- **Frequency Divider:** The digital output frequency is half the input clock frequency. The output mark space ration is 1:1. D Type Flip Flops are commonly used for this.
- **Frequency Modulation:** The carrier frequency is altered or modulated in proportion to the information signal.
- **Full Wave Rectifier:** Power supplies with two of four diodes rectify both halves of the AC cycle.
- **Fuse:** A very thin wire designed to melt if the current is larger than some safe value. When the wire melts, the circuit is turned off for safety. If the wrong fuse is used and too much current flows there is a serious fire risk.

G

- **Gain:** Voltage Gain = V_{OUT} / V_{IN} Current Gain = I_{OUT} / I_{IN} Power Gain = P_{OUT} / P_{IN}
- **Gain Bandwidth Product (GBP):** This parameter tells you how well an amplifier might perform at higher frequencies. The GBP of an amplifier might be 1000000. At 5000Hz, the maximum possible gain would be 1000000 / 5000 = 200.
- **Gates:** These logic gates perform electronic switching according to well defined rules. The gates ...
  - AND - Two ones give a one. Anything else gives zero.
  - NAND - Two ones give a zero. Anything else gives one.
  - OR - Two zeros give a zero. Anything else gives one.
  - NOR - Two zeros give a one. Anything else gives zero.
  - XOR - Equal inputs give zero. Non-equal inputs give one.
  - XNOR - Equal inputs give one. Non-equal inputs give zero.
  - NOT - the input is inverted.
- **Gateway Router:** The router that connects your own local network to the cloud or internet.
- **Giga:** S.I. Units Prefix: 1000000000 10^9
- **Gray Code:** A scale used in robotics for absolute position sensing. It is better than a binary scale because there is never ambiguity because only ever one bit changes at a time with the Gray code.

H

- **H Bridge:** A motor controller using four MOSFETS or Transistors.
- **Half-wave Dipole:** The dipole antenna is half a wavelength long. C = F λ
- **Half-wave Rectifier:** Power supplies with only one diode rectify only half the AC cycle.
- **Hardware:** This is the physical stuff that computers are made of. It breaks if you drop it or spill your drink over it. See Software.
- **Hardwired:** Permanently soldered circuits with a single function. Compare these with programmable circuits which can be altered by re-programming.
- **Harvard:** A microcontroller architecture with an extra instruction bus. Processing is faster because the instruction can be fetched at the same time as the data.
- **Heat-Sinks:** are used to remove waste heat from a circuit.
  - **Conduction:** Use a metal like aluminium or copper.
  - **Convection:** Use a large surface area to heat lots of air which then rises.
  - **Radiation:** Matte black surfaces radiate best and a large surface area helps too.
  - The thermal resistance is defined as the temperature rise of the heat-sink if one watt of heat is being dissipated.
- **Henry:** The measurement unit of Inductance.
- **Hertz:** The measurement unit of frequency. One Hertz means one complete cycle per second.

- **Heterodyne:** The sum and difference beat frequencies produced when two signals on different frequencies are mixed. Heterodynes can be audible as a whistling tone. In a superhet receiver, they are outside the range of human hearing.
- **Hexadecimal:** The base 16 number system. It's used because it makes a neat shorthand for binary nybbles. F = 1111   C = 1100.
- **HF:** The HF radio band is from 3 to 30MHz. It's also known as Short Wave.
- **High:** Logic one. A voltage more than half the power supply often close to the power supply voltage.
- **Host:** Any networked computing device, including computers, printers and devices connected to the "Internet of Things".
- **Hum:** Mains circuits work at high voltages and with high currents. Sensitive amplifiers can easily pick up stray, unwanted hum from the mains. This is a low pitched 50 Hz tone often with other noise included because the mains is rarely a clean sine wave. Co-axial cables and screening help to reduce hum.

I

- **IC:** Integrated Circuit. This is one wafer of silicon containing multiple devices manufactured into the silicon. ICs perform many useful functions and make modern electronics possible. Simple ICs contain dozens of components. Complex ICs are close to the 1000 million devices mark. (Written in 2012).
- **IF:** Intermediate Frequency. This is used in the superhet receiver to provide efficient, low cost, fixed frequency filtering for selectivity. AM radios often use 455kHz for the IF. FM radios often use 10.7 mHz for the IF.
- **Image Frequency:** This is the same as the second channel. The mixer in a superhet receiver converts two input frequencies to the intermediate frequency. The inputs are the wanted signal and the unwanted image frequency.
- **Impedance:** This is the alternating current equivalent of resistance in a DC circuit. It is measured in Ohms and the letter **Z** often represents it. The maths is more complex because the current and voltage are often not in phase with each other. Impedance depends on the signal frequency. Antennas have the correct impedance, only at the design frequency.
- **Impedance Matching:** The antenna impedance and the feeder cable impedance must be the same. Common values are 50 and 75 Ohms.
- **INC:** AQA Assembler: Add one to the register R.
- **Inductor/Inductance:** Energy is stored in an inductor in the form of a magnetic field. Inductors are coils of wire that act as electromagnets. $X_L = 2 \pi f L$. Inductors create a Back EMF which opposes changes of current in the coil. Sudden current changes can create destructively large Back EMF voltages.
- **Information Signal:** This signal contains meaningful information. Voice, music and control data are three examples.
- **Input:** Most electronic systems have an input transducer used to measure a real-world parameter and convert the measurement into an electronic signal. The real world parameters include temperature, humidity, air pressure and many many more. In flowcharts, an input is shown with a slanting box.
- **Input resistance:** MOSFETs and non-inverting amplifiers have a very high input resistance. This property is most useful if the connected input device is not able to provide much current.
- **Insulator:** Electrons are tightly bound to their parent atoms and they are not free to move.
- **Interference:** Two signals or waves adding together. Often one signal is unwanted. Constructive interference causes the waves to add. Destructive interference causes waves to cancel out partially or fully. This causes the fading of radio signals.
- **Interfacing:** This is the circuitry needed to connect one subsystem to another. The simplest interface circuit is a piece of wire. Coupling capacitors are often needed to pass AC signals while blocking DC voltages. Interfacing can get quite complex.
- **Interrupts:** A signal to the processor suspends the current task, the return address and processor state are saved onto the stack, the interrupt code is executed and finally the processor resumes its previous state and task at the address retrieved from the stack.
- **Intrinsic:** Intrinsic semiconductors are almost completely pure. Adding dope gives the useful properties needed to manufacture semiconductor devices or chips.
- **Inverting:** The output is upside down relative to the input. Positive inputs become negative outputs. Logic ONE input gives logic ZERO output.
- **I/O:** Shorthand for Input / Output. Usually an I/O Port.
- **I/O Mapped:** Input/output using an I/O port. The correct port is selected using the address bus. A control bus line is set in order to access I/O ports instead of memory addresses.
- **IP:** Internet Protocol. A set of rules allowing packets to be routed to their destination. The IP rules ignore lost or damaged data. TCP deals with re-transmitting lost or damaged data.

J

- **Jitter:** Pulses arriving too soon or late due to noise on the channel. Use a regenerator to clean up the noise and timing.
- **JMP:** AQA Assembler: Jump to address K. The program counter is set to K.

- **JPC:** AQA Assembler: Jump to address K if the CARRY Flag is set. The program counter is set to K if the CARRY Flag is set.
- **JPZ:** AQA Assembler: Jump to address K if the ZERO Flag is set. The program counter is set to K if the ZERO Flag is set.

K

- **Karnaugh Map:** Useful for simplifying logic expressions.
- **Kilo:** S.I. Units Prefix: 1000 10^3. Examples: Kilometres, kilogrammes, kilohms **(NOT killer Ohms!)**
- **Kirchoff's Laws:**
  - **Voltage Law:** If all the voltages in a loop of a circuit are added up, the total is equal to the battery or power supply voltage.
  - **Current Law:** At a junction, the sum of all the currents entering the junction is equal to the sum of all the currents leaving the junction. This idea is quite simple as it also applies to vehicles at road junctions.

L

- **Label:** In a microcontroller program, labels represent addresses. The addresses are calculated automatically by the Assembler program. Labels are used with JMP, JPC, JPZ and CALL. In each case, the program counter is set to the address represented by the label.
- **LAN:** A local area network on a single site for a single organisation. Hosts are interconnected using switches.
- **LASER Diode:** These are used in fibre optic communications. The LASER can be switched extremely fast to encode high data rates onto a bright light beam.
- **Latch:** Use D Type Flip Flops. On the rising edge of the clock pulse, each D is copied to the corresponding Q and the output data is stored until the next clock pulse.
- **Latency:** The time delay sending a signal through the transmitter, media, regenerators or routers and the receiver. This can often be heard when two TV sets are tuned into the same channel. There is an audio echo effect due to the different latency in the TV receivers. Latency is very noticeable on satellite links due to the huge distances the signal has to travel.
- **Layout Diagram:** This diagram shows the positioning of components on a circuit board. Circuit diagram symbols are often NOT used as the physical shape of the component is more important. These are often confused with circuit diagrams, system diagrams and flow charts.
- **LCD:** Liquid Crystal Display. Very low power consumption. Needs a back-light in the dark. Easy to see in bright light. Most can display graphical shapes. Needs a microcontroller to drive it.
- **LDR:** Light dependent resistor.
  - Brighter light makes the resistance drop.
  - Use the LDR in a voltage divider circuit.
  - Use the voltage divider circuit in a comparator circuit.
  - LDRs are slow and not suitable for detecting high speed optical data pulses. They are OK at lower audio frequencies.
- **Leakage Current:** Ideal reverse biased diodes and capacitors have an infinite resistance. In real life they leak. Mostly this leakage current is so small it can be forgotten. Timing capacitors take longer to charge or might never fully charge if there is too much leakage.
- **LED:** Light emitting diode. A red LED has about 1.9 Volts across it. A blue LED might have 3.6 Volts across it. This is due to quantum physics. Blue photons are more energetic than red photons so a higher voltage is needed to make them.
- **LED Matrix Display:** 7 x 5 array of LEDs. Any character can be displayed with limited resolution. Easy to see in the dark. Poor visibility in bright sunlight. High power consumption. A microcontroller is needed to drive it.
- **LF:** The Low Frequency radio band is from 30 to 300kHz. It's also called Long Wave.
- **Light Waves:** These are identical to radio waves but they have a much smaller wavelength. They travel through air or a vacuum at about 300 million metres per second.
- **Limiting:** See Clipping.
- **Linear:** Direct proportion. If you plotted a graph, the line would be straight.
- **Litz Wire:** See Skin Effect.
- **LM386:** This is a widely used audio power amplifier integrated circuit giving over 0.25 Watts output.
- **LNB:** The low noise block on a satellite dish. This uses a local oscillator and mixer to reduce the received satellite signals to a frequency low enough to be sent to the satellite TV using co-axial cable. Without this, expensive waveguide would have to be used to connect the dish to the TV.
- **Load:** Loads have a resistance. Loudspeakers, motors and lamps are simple examples. A more complex example is the inverting amplifier which might have an input resistance of 10kΩ This input resistance acts as the load for the previous sub-system which must be designed to drive this.

- **Local Oscillator:** In the superhet receiver, the local oscillator is MIXED with the wanted RF signal to produce a heterodyne at the Intermediate Frequency (IF). Changing the local oscillator frequency will "tune in" different stations.
- **Logic:** Electronic circuits that process zero and one digital signals.
- **Logic Diagram:** A circuit diagram showing how the logic gates are connected.
- **Logic Gates:** See Gates.
- **Loop:** This is a repeated electronic process. For example the temperature might be measured once per minute and different actions taken depending on the measurement. In flow charts, a loop is shown when the arrows double back to an earlier point in the flow chart.
- **Loudspeaker:** An output transducer which converts alternating audio currents into sound pressure waves in air. The most common speakers have an 8 Ohm resistance.
- **Low:** Logic zero. A voltage less than half the power supply often close to zero.

M

- **Magnitude:** The size of a signal (ignoring polarity or direction). Amplifiers increase the magnitude of signals.
- **Mains:** This is the 230 Volt alternating power available from sockets across Europe. In the USA it's 110 Volts.
- **Mains Plug:** Brown Live - Blue Neutral - Green/Yellow Stripes Earth - Fuse.
- **Mark Space Ratio:** The On to OFF time of a square wave signal expressed as a ratio like 3:2 or 1.5.
- **Medium:**This is what the signal travels through. **Examples:** Free space (air or vacuum), copper cable, optical fibre.
- **Mega:** S.I. Units Prefix: 1000000 10^6. **Examples:** Megahertz, Megabytes, Megohms. **(NOT mega ohms !)**
- **Memory:** Memory types include ROM, RAM, Flash, Disk and Tape.
- **Memory Mapped:** A memory location is used for input/output to an external peripheral device. Compare this with I/O mapping.
- **MF:** The MF radio band is from 300 to 3MHz. It's also known as Medium Wave.
- **Micro:** S.I. Units Prefix: 1 / 1000000 10^{-6}
- **Microphone:** An input transducer that converts pressure waves in air into a proportional alternating voltage.
- **Microcontroller:** A system on a chip with the clock, processor, memory and I/O all on the same silicon wafer.
  - Low cost.
  - Re-programmable so it can be used in different control applications.
  - Reliable as there are no moving parts.
  - Better for the user as it can interface to text displays making products easier to use.
- **Microprocessor:** A low cost computer central processing unit. It reads data, carries out arithmetic and logic and writes results.
- **Microswitch:** Small reliable switches found in mice, game controllers and machinery.
- **Milli:** S.I. Units Prefix: 1 / 1000 10^{-3}
- **Mixer:** This sub-system has two input frequencies. The output contains the sum and the difference of the two input frequencies. The mixer outputs are called heterodynes. Mostly they are outside the range of human hearing so they are supersonic heterodynes (superhet). The Dalek sound effect is created by mixing a voice signal with a 30Hz local oscillator signal.
- **Modulation:** This is the modification of a radio frequency carrier signal by the information signal. Analogue: See AM and FM. Digital: See PAM, PWM, PPM and PCM.
- **Modulator:** The circuit the carries out modulation.
- **Monostable:** The 555 circuit has one stable state and one unstable state. When triggered, it produces a single accurately timed pulse. T = 1.1 RC
- **MOSFET:** Metal Oxide Semiconductor, Field Effect Transistor.
  - Pins: Gate, Drain, Source.
  - Fast switching.
  - Very high current gain.
  - Low Source Drain Voltage when saturated. Less waste heat generated.
  - Very high input resistance.
  - Low resistance between the Drain and Source when saturated.
  - Able to switch large currents.
  - High mutual conductance (a small input voltage change produces a large output current change).
- **Motor:** An output transducer or actuator that converts electric power into rotational movement.
  - Conventional Motors have simple control circuits. Large and fast motors can be made.
  - Stepper motors allow accurate angular position control which is difficult to achieve with conventional motors.
  - Large stepper motors are too expensive and impractical to use.
- **MOVRW:** AQA Assembler: Copy the data from R into W.
- **MOVW:** AQA Assembler: Copy K into W.
- **MOVWR:** AQA Assembler: Copy the data in W into R.
- **Multimeter:** A meter which can be set to measure Volts, Amps, Ohms and sometimes other values depending on the model of meter.
- **Multiplexing:** Sending many signals along one channel simultaneously.

- o **Time division** multiplexing (TDM) allocates short time slices to each user of the channel at regular time intervals.
- o **Frequency division** multiplexing (FDM) allocates a different frequency to each data stream in the channel. The frequencies are separated by filtering at the receiving end. Digital signal processing is used to encode and decode the signals (codec).
- o **Space division** multiplexing. A nice example is satellite TV where horizontally and vertically polarised signals re-use the same frequencies. The signals are separated at the receiver dish antenna by horizontal and vertical antennas.

N

- **NAND:** NAND Gate. The output is ZERO if all the inputs are ONE.
- **Nano:** S.I. Units Prefix: 1 / 1000000000 10^{-9}
- **Negative:** Electrons are negatively charged. Any material with more than the usual number of electrons is negatively charged.
- **Neural Network:**
  - o Many simple processors.
  - o Many inputs and there are hidden layers.
  - o Information is stored in the link weightings between the processors.
  - o It must be "trained" and it learns. Although useful, there is only a probability it will get the right answer. It can't do accurate maths.
  - o There is no separate memory and it is not programmed like a conventional computer.
  - o It's good at language processing, image recognition and fuzzy, ill defined problem solving.
- **Neutron:** These are uncharged particles in the atomic nucleus. They have no known effect on electronic circuits.
- **Noise:** Unwanted signals. It can be a background hiss or cracks and bangs caused by lightning or the switching of industrial machinery. This is impulsive noise. Radio signals often suffer from noise due to unwanted signals leaking into the receiver. FM demodulators ignore the signal amplitude and therefore have better noise immunity then AM receivers.
- **NOP:** AQA Assembler: Do nothing for one clock cycle.
- **NOR:** NOR Gate. The output is ONE if all the inputs are ZERO.
- **NOT:** NOT Gate. The output is INVERTED.
- **NPN:** A type of bipolar junction transistor with two layers of N type silicon and a middle layer of P type. See PNP.
- **NVRAM:** Non Volatile RAM. The data is retained when the power is off. The data can be erased and new data recorded.
- **Nybble or Nibble:** This is half a byte. The low nybble has values between 0 and 15. The high nybble has values like 16, 32, 64, 128, 48, 80, etc.
- **Nyquist:** When digitising, the sampling rate needs to be double the highest frequency being sampled. See Aliasing.

O

- **Ohm:** Ω - Resistance is measured in Ohms. More resistance results in less current. Resistance opposes the free flow of charge, usually electrons.
- **Ohm's Law:** $R = V / I$ $V = I R$ $I = V / R$ where R is the resistance, I is the current flowing and V is the potential difference across the device.
- **ONE:** Logic one is any voltage above half the power supply voltage, often close to the power supply voltage.
- **Open Loop:** A control system without negative feedback. See Closed Loop.
- **Open Wire Feeder:** Parallel wires used to connect a transmitter or receiver to an antenna. The wires are close together and the equal and opposite currents cancel out so the feeder does not pick up or radiate electromagnetic energy.
- **Operational Amplifier:** Operational amplifiers have a very high open loop gain and near infinite input resistance. These properties make them useful in many circuits.
  - o Comparator   Gain is very large
  - o Inverting Amplifier $G_v = - R_f / R_1$
  - o Summing Amplifier $V_{out} = - R_f (V_1/R_1 + V_2/R_2 + V_3/R_3)$
  - o Summing DAC $V_{out} = - R_f (V_1/R_1 + V_2/R_2 + V_3/R_3)$
  - o Non-inverting Amplifier $G_v = 1 + R_f / R_1$
  - o Voltage Follower   Gain = 1
  - o Difference Amplifier $V_{out} = (V_+ - V_-) \times (R_f / R_1)$
  - o Inverting Schmitt Trigger.
- **Optical Fibre:** A two layer glass fibre used for communications by means of modulated light beams. The inner layer of glass has a high refractive index. The outer layer of glass has a lower refractive index. Light is trapped in the inner layer by total internal reflection. Optical fibres have a very high data bandwidth and they are more secure because they are so hard to tap.

- **OR Gate:** Two ZEROS in give a ZERO out. All other inputs give ONE out.
- **ORW:** AQA Assembler: OR W with K. The result goes into W.
- **Oscillator:** This is an astable circuit producing an AC output at a designed frequency. The output wave shape might be sine, square or saw tooth.
- **Oscilloscope:** This measures voltage, period and wave shape. Frequencies can be calculated from F = 1 / P
- **Output:** Electronic systems have one or more outputs. Sub-system outputs are fed to the next sub-system. The final sub-system output is fed to a transducer. Transducers include indicator lights, displays, sounders, loudspeakers, motors, solenoids, relays and many more devices. In flowcharts, an output is shown with a slanting box.

P

- **Packet:** A packet contains...
  - The data.
  - Two IP Addresses (source and destination).
  - A check sum for error detection.
  - A sequence number (to reassemble packets into the correct order).
  - The Protocol (http for websites, ftp for file transfers, smtp for email, etc).
  - For TCP/IP purists, the above is an addressed packet encapsulated inside a sequence numbered segment.
- **Packet Switched Network:** Many networks joined together via **ROUTERS**.
  - There are usually alternative routes.
  - It's reliable because data can be re-routed to avoid congested or failed links.
  - It's cheaper because more people share the costs of the infrastructure.
  - It's less secure because untrustworthy people share the infrastructure. Use encryption.
- **PAM:** Pulse Amplitude Modulation. The amplitude of fixed width pulses is modified in proportion to the sampled level of the information signal.
- **Parallel:** Components wired side by side.
  - Resistors Rt = 1 / (1 / R1 + 1 / R2)
  - Capacitors Ct = C1 + C2
- **Parallel Data:** It travels on a multi-wire bus. The groups of bits travel side by side. Parallel data is faster than serial because of the multiple wires. In practice serial transmission has become so fast that nearly all data is serially transmitted apart from the parallel buses inside computers.
- **Parallel Ports:** PORTA, PORTB and PORTC are eight bit parallel ports. The eight lines can be configured as inputs or outputs by setting TRISA, TRISB or TRISC.
- **Passive:** Components like capacitors, resistors, switches and inductors. These are usually NOT semiconductor devices.
- **Passive Filter:** This uses only resistor/s and capacitor/s and less often inductor/s. See Filter.
- **PCM:** Pulse Code Modulation. The information signal is sampled and converted into binary numbers. The binary is transmitted as a stream up pulses.
- **Peak:** The highest voltage point on a wave. Peak Voltage = 1.4 x V_{RMS}
- **Period:** The duration of one complete cycle of a wave. Period = 1 / Frequency.
- **PIC:** Programmable Integrated Circuit. See Microcontroller.
- **Piezoelectric Effect:** Substances like quartz deform if a potential difference is applied across the surfaces. This can be used to make sounders, tweeters, crystals for accurate timing in oscillators and for high quality filters. This process also works in reverse, allowing movements to be converted into a voltage. Some mirophones and ultrasound sensors use this effect.
- **PIN Diode:** This is a very fast light sensing transducer used for fibre optic communication systems with high data rates.
- **Phase:** Compares the position of waves in space or time. Phase is measured in radians or degrees of angle.
- **Photodiode:** A diode that is sensitive to light. In the dark, a reverse biased diode passes very little current. Photons of light dislodge electrons and increase the leakage current.
- **Pico:** S.I. Units Prefix: 1 / 1000000000000 10^{-12}
- **Plug Wiring:**
  - Earth Wire: Green/Yellow stripes. This one is the most important to get right for safety. It carries Zero Volts and is connected to the outer case of appliances.
  - Live Wire: Brown. This carries 230 V_{rms}. If too much current flows, the fuse melts and shuts down the live wire. This prevents overheating and fires.
  - Neutral Wire: Blue. The live and neutral wires carry the current needed to operate the appliance. The earth wire only carries current if a fault has occurred.
- **PNP:** A type of bipolar junction transistor with two layers of P type silicon and a middle layer of N type. See NPN.
- **Polarisation:** Electromagnetic radiation is polarised. This is the angle at which the electric field is oriented. Mostly this is random, horizontal or vertical but circular polarisation is possible too.
- **Polarity:** Correctly identifying and connecting the + and - connections. For some components this is critical. For others, they can be connected either way round.
- **Polling:** Repeatedly reading a port whether the data has changed or not.
- **PORT, PORTA, PORTB, PORTC:** Ports are used for data input (reading) and output (writing).

- **Positive:** Atomic nuclei are positively charged. Normally this charge is exactly balanced by the correct number of electrons and the material is neutral or not charged. If some electrons are removed, a net positive charge remains.
- **Potential:** A voltage measured relative to Earth or Ground.
- **Potential Difference:** A voltage measured across a circuit or component ignoring Earth or Ground connections.
- **Potentiometer:** A variable resistor. A slider moves along a resistive track altering the resistance from 0 to 100% of the value of the component. It's often used as a volume control of for changing the timing in an RC circuit.
- **Power:** Power is measured in Watts.
  Power $= I\ V\quad =\quad I^2\ R\quad =\quad V^2\ /\ R$
  RMS Power $= I_{RMS}\ V_{RMS}\quad =\quad I_{RMS}^2\ R\quad =\quad V_{RMS}^2\ /\ R$
  $V_{RMS} = 0.7\ V_{Peak}\quad I_{RMS} = 0.7\ I_{Peak}$
- **Power Supply:** This usually refers to a 110V / 230V mains powered box that produces low voltage DC suitable for electronic circuits. The term is also used for cells, batteries, photocells and other power sources.
- **PPM:** Pulse Position Modulation. The position (in time) of pulses is modified in proportion to the sampled level of the information signal. The amplitude and width of the pulses is fixed.
- **Process:** Most electronic systems contain a process. This could be an amplifier, a comparator, a timer, an astable oscillator, one or more logic gates or a microcontroller chip capable of performing computations. In flowcharts, a process is shown as a rectangle.
- **Program:** A set of instructions to carry out a task understood by the processor.
- **Protocol:** A set of rules which allows successful communication to take place.
- **Proton:** A positively charged particle in the nucleus of an atom. In electrically neutral matter, the charge on each proton is cancelled out by a nearby negative electron.
- **Pulse:** This is usually a square wave toggling on and off again.
- **Push Pull:** A type of amplifier that uses two MOSFETs or Junction Transistors. One amplifies the positive half of the signal. The other amplifies the negative half.
- **PWM:** Pulse Width Modulation. The width of fixed amplitude pulses is modified in proportion to the sampled level of the information signal.

Q

- **Q Factor:** The quality factor of a tuned circuit. $Q = f\ /\ (\ \Delta F\ )$ where f is the resonant frequency and ΔF is the bandwidth of the tuned circuit.

R

- **Radio Frequency (RF):** Frequencies above about 50kHz are called radio frequencies because it's possible to transmit them if they are fed into a suitable antenna.
- **Radio Waves:** These are electromagnetic waves. They travel through air or a vacuum at 300 million metres per second.
- **RAM:** Random Access Memory. This is typical computer memory. The data is lost if the power is turned off. This is known as VOLATILE memory.
- **RCD Residual Current Device:** This acts like a fuse and shuts off the circuit if the current is too big. The second advantage is shutting off the circuit if the current is leaking on a fault path. This could include a person being electrocuted so the RCD is a really useful safety device.
- **Reactance:** The equivalent of resistance for capacitors and inductors in alternating current circuits. Measured in Ohms. It depends on frequency. $X_c = 1\ /\ (2\ \pi\ F\ C)\quad X_L = 2\ \pi\ F\ L$
- **Read:** Data is copied into the processor (from the memory or an input port) See Write.
- **Receiver:** Radio receiver. Its input is a small RF signal from the antenna. Its output is the wanted information signal. This could be voice, music or control data for radio controlled devices or machines.
- **Rectifier:** A diode used to convert AC into DC. This process is called rectification.
- **Redundancy:** Duplicated hardware to make it more reliable or fault tolerant. Multiple network links. Backup power supplies. RAID disks.
- **Reed Switch:** This is a magnetically operated switch enclosed inside a glass tube. If there is a magnet near the tube, the switch contacts are attracted and the switch turns on. A simple intruder alarm can be made by placing the magnet in a door and the switch in the door frame. When the door is opened, the switch turns off and the alarm sounds.
- **Regeneration:** Positive feedback used to increase the Q factor of tuned circuits. The fed back energy compensates for energy losses in the tuned circuit raising its performance.
- **Regenerator:** A Schmitt trigger circuit used restore logic levels and remove noise from a digital signal. It might use other techniques to remove timing errors or jitter.
- **Register:** A storage location, often inside a microcontroller or microprocessor. Microcontroller registers include ...
  - **W:** The working register where maths and logic are carried out.
  - **PC:** The program counter. This contains the address of the currently executing instruction. On completion, the address in PC is updated for the next instruction.

- o **SP:** The stack pointer holds the stack address. The stack is used to keep track of subroutine return addresses.
- o **SR:** The status register contains flags. These are single bits are set to one if ...
    - "Z" (zero) the working register has become equal to zero.
    - "C" (carry) a calculation gave a result too big to fit inside the working register.
    - "T" (timer) the TMR or timer register has counted to zero so the timing interval is complete.
- **Relative Position:** The amount of movement is known but not the absolute or exact position.
- **Relay:** A small current in the coil of the electromagnetic relay creates a magnetic field which attracts a lever which switches over the relay switch contacts. In this way large currents can be switched. Relays lack reliability due to the moving parts. Relays can switch high voltages and alternating currents.
- **Repeater:** This amplifies the analogue or digital signal including any noise and passes the amplified signal on. No clean-up is attempted.
- **Reset:** Restore a circuit to its "Switch On State".
- **Resistance:** Resistance opposes the free flow of current or electrons. It can be calculated using Ohm's Law.
- **Resistor:** A component with a known amount of resistance which is constant over a wide range of temperatures and frequencies.
    - o Pull up
    - o Pull down
    - o Current limiting
    - o Voltage dividing
    - o Timing when combined with a capacitor: T = R C
    - o Temperature sensing (thermistor)
    - o Light level sensing (LDR)
    - o Position/angle sensing (Potentiometer).
    - o **Types:** Carbon Film, Metal Film, Wire Wound
- **Resolution:** The smallest measurable step or the step size. For example if an eight bit DAC (256 Levels) produces voltages between 0 and 5.12V, the resolution will be 5.12 / 256 = 0.02V or 20mV.
- **Resonance:** A natural frequency of oscillation where the amplitude becomes much larger than at other frequencies. Radio tuning relies on this effect in tuned circuits.
- **RET:** AQA Assembler: Return from a subroutine. See CALL.
- **Reverse Bias:** The current or voltage is in the opposite direction to that normally expected. For example Zener diodes are used in reverse bias and the current flows in the opposite direction to that in a normal diode.
- **RF:** See Radio Frequency.
- **RFID:** A radio technology where the RFID chip transmits data when activated by the energy from a nearby transmitter. The RFID chip does not normally have its own power source. Pets and farm animals are "chipped" for easier identification. Some retail organisations use RFID chips instead of barcodes.
- **RISC:** Reduced Instruction Set Computing (or chip). The microcontroller makes do with a few, very high performance instructions. See CISC.
- **RMS Power:** RMS power   =   Peak Power / 2
- **RMS voltage:** RMS voltage   =   Peak Voltage / $\sqrt{2}$ =   Peak Voltage x 0.7
- **Robot:** A robot is a machine but unlike a conventional machine, it can be re-programmed to perform new tasks.
- **ROM:** Read Only Memory. This is computer/microcontroller memory. The data can not be altered and is not lost if the power is turned off. This is known as NON-VOLATILE memory. It is used to store essential programs required for the operation of the chip.
- **Router:** Small local networks are interconnected via ROUTERS to make a wide area network such as the Internet.

S

- **Sample and Hold:** A circuit which accurately stores an analogue voltage for a short period. It's needed in A to D converters to maintain a steady value while the conversion is taking place.
- **Sampling:** Repeatedly measuring an analogue signal and converting it into digital. The sampling must occur at at least double the frequency of the highest frequency being sampled.
- **Saturation:** Once a transistor, MOSFET or amplifier is 100% switched on, increasing the input has no further effect. Also see clipping.
- **Schmitt Trigger:** A comparator with added positive feedback. This gives two different reference voltages for the switching levels. It also guarantees fast switching. It can be used to clean up a noisy signal, producing an error free digital output unless the noise is so bad that the clean-up stops working.
- **Screen/screening:** Metal or foil sheets or boxes are used to screen circuits to prevent wanted signals getting out and unwanted signals getting in. Poor screening is a common problem, most often noticed when a mobile phone interferes with an audio circuit. Co-axial cable is screened with an outer woven braid or foil layer.
- **Second Channel:** This is the same as the image frequency. The mixer in a superhet receiver converts two input frequencies to the intermediate frequency. The inputs are the wanted signal and the unwanted image frequency.
- **Selectivity:** This is a measure of the ability of a radio to select the wanted frequency or station and to reject all others.

- **Semiconductor:** Pure semiconductors like silicon do not conduct electricity at room temperature. By adding impurities like Boron or Phosphorus, the electronic properties can be controlled and the whole range of semiconductor devices can be manufactured.
- **Sensitivity:** This is a measure of the ability of a radio receiver to pick up weak signals.
- **Sensor:** An input transducer used for detecting signals from the environment and converting them into a proportional voltage or current.
- **Sequential Logic:** Logic circuits with a clock and memory. The outputs change in time with the clock.
- **Serial Data:** Bits are transmitted down one wire one after another. USB is a very common serial data interface. See Parallel.
  - Start Bits: One or more bits indicating the start of a serial data block.
  - Data Bits: The actual data being exchanged.
  - Stop Bits: One or more stop bits indicating the end of the serial data block.
  - Parity Bit: This is used to detect errors. With even parity, an even number of bits should always be received. If an odd number is received, an error has been detected.
  - Overheads: Start, stop and parity bits are used for managing the data link. To send a seven bit code, with one start bit, one stop bit and the parity bit, ten bits must be sent.
  - Baud Rate: The total number of bits sent per second including the management bits.
  - Bit Rate: The number of data bits sent per second excluding the data management bits.
- **Series:** Components connected end to end.
  - Resistors: Rt = R1 + R2
  - Capacitors: Ct = 1 / (1 / C1 + 1 / C2)
- **Servo:** A motor with 180° rotation. The angle is controlled with a stream of pulses between 1 and 2 ms wide.
- **Set:** The signal/output goes high, becomes one.
- **Seven Segment Display:** Higher power consumption than LCD. Hard to see in bright sunlight. It's only possible to display digits and a very few letters. Simple drive logic.
- **Shaft Encoder:** This is used to measure the rotation of a shaft.
  - Absolute position can be measured with a Binary or better still Gray Code disc.
  - Relative position can be measured with a slotted wheel.
- **Shift Register:** This uses D Type Flip Flops. On the rising edge of the clock pulse, D is copied to Q and all the data moves one place to the right in the shift register. This circuit is useful for converting serial data into parallel and also parallel data into serial. Pseudo-random numbers can be generated. Pulses can be delayed.
- **Shock (electric):** Muscular spasms, burns, difficulty breathing, heart stops. 1) Disconnect the victim. 2) Get help. 3) First aid, recovery position, resuscitation if necessary.
- **Short / Short Circuit:** A wiring error that causes the circuit to get hot and in extreme cases catch fire. Connecting a wire across the battery or power supply creates a short. A common circuit diagram howler is to short the power lines.
- **SI Units:** The International System of Units. When calculating always use whole SI units like Volts, Amps, or Ohms. When working with millivolts or kilohms, always do the right conversion before calculating.
- **Sidebands:** When a carrier is modulated, sidebands are always produced. The width of the sidebands is at least equal to the bandwidth of the information signal being transmitted and double for AM or even more for FM.
- **Signal:** This is an electric current or voltage or optical or audio pulses that represent useful information such as speech, music, measurement data or control data.
- **Signal to Noise Ratio:** Measured in dB. A big number indicates lots of signal and not much noise.
- **Signal Generator:** This produces an alternating signal at a known frequency and voltage. It is used for testing circuits. Most signal generators produce a choice or wave shapes including sine, square and saw tooth shapes.
- **Silicon:** The most widely used semiconductor material.
- **Silicone:** A widely used rubbery material used for water proofing, bath sealant and breast implants. Do not confuse with silicon!
- **Simplex:** One way / single direction communication such as radio broadcasting. See Duplex.
- **Sine Wave:** A pure signal containing only one frequency.
- **Skin Effect:** Radio frequency currents flow, only in the surface of the conductor. For better performance, conductors with a large surface area are a good idea. Tubes are good and and also special wire with a very large number of thin strands called Litz Wire.
- **Skin Resistance:** The resistance of wet human skin is much lower so electric shocks are more dangerous if your skin is wet. This makes bathrooms and kitchens more dangerous for electrical safety.
- **Smart Card:** It is the size of a credit card and it contains a microcontroller, ROM, RAM and NVRAM. It connects to a card reader using metallic pads printed onto the card.
- **Smoothing:** Large capacitors are used to smooth out variations in the DC power supply voltage.
- **SoC:** System of a Chip. Microcontrollers have all the required hardware on a single chip.
- **Software:** This is stored on computer disks, pen drives, CDs, DVDs etc. Software is the programs and data needed to make computers work. Software must be backed up in case there is a hardware failure that causes the software to be lost.
- **Solenoid:** An electromagnetic actuator providing linear movement. Turning on the magnet makes the mechanism move.
- **Soliton:** A special pulse shape that travels without dispersion. These are being researched because they could enable higher communications data rates.

- **Sound Waves:** These are pressure waves in air. They travel at about 330 metres per second. This is roughly one million times slower than light waves.
- **Sounder:** This transducer produces sound from an alternating signal such as the 555 astable output. See **Buzzer**.
- **Source Follower:** useful buffer circuit with
    - a voltage gain of one
    - a very high input resistance
    - a very high power or current gain.
- **Speaker:** See Loudspeaker.
- **Spectrum:** A range of frequencies. The audio spectrum is from 20 Hz to 20000 Hz. The radio spectrum is sub-divided into bands like LF, MF, HF and VHF.
- **Spectrum Plot:** A graphical representation of voltage or power plotted on the Y axis against frequency plotted on the X axis.
- **Speed:** Examples include the speed of light or the speed of sound. It is **WRONG** to refer to the speed of a data link. Use Bandwidth or Bit Rate instead. In a faster data link, the data takes just as long to arrive unless faster than light communication has just been invented. However more bits per second can be transmitted and received.
- **Square Waves:** These are produced by circuits like the 555 Astable. The signal switches suddenly between the high and low levels producing the square wave shape.
- **Step Index:** A type of optical fibre with two separate layers of glass with different refractive indexes. The more expensive single mode fibre is better.
- **Stepper Motor:** Moves in precise angular steps. Excellent for robotic position control. More complex driver circuits are needed. Large or fast stepper motors can't easily be made.
- **Sub-systems:** These are self contained electronic circuits that perform a useful function. An example is a voltage divider made from two resistors. This produces a known output voltage and the circuit can't be sub-divided any further. Another example is a 555 monostable. This sub-system can be sub-divided into smaller sub-systems like the R C timing circuit.
- **Subroutine:** A small re-usable block of code, often from a library of useful subroutines, within the larger program. It avoids writing the same code more than once.
- **SUBW:** AQA Assembler: Subtract K from W.
- **Summing DAC:** A summing amplifier with input resistors values in the 1, 2, 4, 8, 16, 32, 64 pattern. This circuit is used to convert a binary number digital value back into an equivalent analogue voltage.
- **Superhet Receiver:** This receiver has improved selectivity because of the fixed frequency IF amplifier and filter. To make tuning possible, a variable frequency local oscillator and mixer are used. The unwanted image frequency is filtered out by the RF tuned circuit and amplifier which also provides improved sensitivity. Automatic gain control provides a stable information signal output even if the received signal strength is varying.
- **Switch:** A resistive transducer with a resistance of zero or infinity Ohms. Switches are digital transducers.
    - NO - Normally Open
    - NC - Normally Closed
    - COM - The common connection in double throw switches.
- **Switch:** A device that learns the addresses of hosts on the local network and correctly forwards packets to the right device. They commonly have 4 up to 32 ports for local computers or hosts.
- **Synchronous:** Signalling where the sender and receiver use the same clock signal or the clock signal is included in the transmission.
- **System:** The complete electronic system built up from simpler sub-systems.
- **System Diagram:** Labelled rectangular boxes joined with arrows. The boxes show how a system is divided up into sub-systems. The arrows show the information signals between the sub-systems. These are often confused with circuit diagrams, layout diagrams and flow charts.
- **System Synthesis:** This is the idea of dividing large complex systems into smaller, easy to understand, easy to test, sub-systems. System diagrams are used to describe the sub-systems needed for a full system.

T

- **Telemetry:** Scientific or engineering measurement values transmitted, usually by radio.
- **Tera:** S.I. Units Prefix: 1000000000000 10^{12}
- **TCP:** Transmission Control Protocol. A set of rules allowing internet data to be acknowledged, put into the correct sequence and re-transmitted if necessary. TCP uses IP to send the actual packets.
- **Thermal Cut Out:** A safety device using a bimetal strip which bends when heated. If the circuit current is too big, the strip gets hot and bends so much that it shuts off the faulty circuit.
- **Thermistor:** A temperature dependent resistor.
    - As the temperature rises, the resistance decreases.
    - Use it in a voltage divider circuit.
    - Use the voltage divider circuit with a comparator circuit.
- **Tilt Switch:** The switch contains a bead of mercury. When tilted, the mercury flows and joins the switch contacts. Non-mercury tilt switches are available.
- **Time Slices:** Time is shared out between many devices using a single time division multiplexing channel.

- **Timing Circuit:** Resistor Capacitor Timing Circuits $T_{50\%}$ = 0.69 RC $T_{63\% \text{ charging}}$ = RC $T_{37\% \text{ discharging}}$ = RC $T_{100\%}$ = 5 RC.
- **Timing Diagram:** A diagram showing how the logic states (zero or one) of a circuit change with time.
- **Tolerance:** The manufacturing accuracy of components. Resistors come in 1, 2, 5 and 10% tolerance. Capacitors can be as poor as 20% tolerance.
- **Transducer:** This converts energy from one form into another. For example a microphone converts sound waves into an alternating voltage proportional to the air pressure of the sound wave. This is an input transducer. The loudspeaker is an output transducer and it converts an alternating current into pressure waves in the air.
- **Transformer:** A device used to step up or step down alternating voltages and currents. The transformer consists of two coils magnetically coupled together. Mains transformers have an iron core that greatly increases the magnetic coupling.
- **Transistor:** Base, Collector, Emitter
  - The small BASE current in a bipolar-junction-transistor controls a much larger EMITTER COLLECTOR current.
  - This makes it useful as a switch and current amplifier.
  - Low input resistance is a disadvantage.
- **Transmitter:** A transmitter sub-system is an amplifier used to increase the power of the signal from the modulator to a level high enough to feed to the antenna. The term is also used to include all the sub-systems including the carrier generator and modulator.
- **TRISA, TRISB and TRISC:** These are data direction registers. PORTA, B and C carry the data. TRISA, B and C are used to determine which port pins are inputs or outputs.
- **Tristate:** Tristate logic allows multiple devices to share one bus. All the devices except for one are disconnected. The one that is connected can set the bus lines to zero or one. The three logic states are Zero, One and Disconnected (or high impedance). The address bus is used to uniquely select a single tristate device.
- **Truth Table:** This table containing zeros and ones describes the inputs and outputs of a logic circuit.
- **Tuned Circuit:** A capacitor (often variable) and an inductor (coil) used to select a single frequency. This provides selectivity in a receiver and controls the transmission frequency in a transmitter.
- **Tuning:** Adjusting a tuned circuit or other filter to the wanted frequency.
- **Twisted Pair Cable:** This cable is widely used in computer networks. The twists in the pairs of conductors prevent crosstalk. The twists are not constant throughout the length of the cable and are carefully designed to allow the maximum data bandwidth.

U

- **UDP:** User Datagram Protocol is used for audio and video streaming. There are no acknowledgements and lost data shows up as gaps in the audio or momentarily frozen or poorer quality images.
- **UHF:** Ultra-high Frequency. The UHF radio band is from 300 to 3000 MHz. Broadcast TV, Mobile Phones, WiFi.
- **Uplink:** A radio signal from the Earth up to a satellite. Also a signal from a mobile phone up to the cell base station. See Downlink.
- **USB:** A half duplex serial data connecting cable used with computers. Ground, +5Volts, D+ and D-. The D lines are twisted together to reduce crosstalk and interference into or out of the cable. USB3 supports Full Duplex.

V

- **Vacuo or Vacuum:** The vacuum of free space. This is a transmission medium for electromagnetic radiation.
- **VHF:** Very High Frequency. The VHF radio band is from 30 to 300 MHz. FM is used in the 88 to 108 MHz broadcast band. DAB Radio uses frequencies around 220 MHz.
- **Virtual Earth:** Operational amplifiers have a very high open loop gain. If the output is a few volts, the inverting input will be a few microvolts. This is so close to zero, it's called a virtual earth.
- **Voltage:** This is the mysterious force that attracts or repels charge. If there are two voltages giving a potential difference and if there is a complete circuit, current will flow.
- **Voltage Divider:** The voltage is divided up in the same ratio as the resistors.
  - V1 / V2 = R1 / R2
  - Vout = Vs R2 / (R1 + R2)
- **Voltage Regulator:** A three pin device that provides a stable DC Voltage output from an unsteady DC supply.
- **Voltmeter:** Connect it in parallel with the component being measured. No current flows through an ideal voltmeter.
- **Von Neumann:** The three bus architecture of a microprocessor. Instructions are fetched and in a second step, the data is fetched.

W

- **WAN:** A wide area network between multiple LAN sites, interconnected via routers and via multiple routes. The Internet is the ultimate WAN.
- **Watt:** Power is measured in Watts. $P = I\,V$ $P = V^2 / R$ $P = I^2\,R$
- **Wave Band:**
  - LF: Low frequency. 30 to 300 kHz. AM is mostly used.
  - MF: Medium frequency. 300 to 3000 kHz. AM is mostly used.
  - HF: High frequency. 3 to 30 MHz. Many modulation methods are used, including some digital.
  - VHF: Very High frequency. 30 to 300 MHz. FM is used in the 88 to 108 MHz band. DAB digital radio uses 174 - 230 MHz.
  - UHF: Ultra High frequency. 300 to 3000 MHz. Digital TV uses this band.
- **Waveguide:** Expensive metal pipes used to carry radio waves with wavelengths measured in millimetres or a few centimetres. Normal cables don't work for such short wavelength signals.
- **Wavelength:** The length of a complete cycle of a wave wave. $\lambda = C / F$ where
  - λ is the wavelength.
  - C is the speed of light ($3 \times 10^8 \text{ms}^{-1}$).
  - F is the frequency.
- **WiFi:** A radio-wave wireless technology used to connect computing devices. No cables are needed. It's less secure than a wired connection.
- **Write:** Data is copied from the processor (to the memory or an output port) See Read.

X

- **XNOR:** XNOR Gate. Equal inputs give ONE. Non-equal inputs give ZERO.
- **XOR:** XOR Gate. Equal inputs give ZERO. Non-equal inputs give ONE.
- **XORW:** AQA Assembler: XOR W with K. The result goes into W.

Y

Z

- **Zener Diode:** This diode is used in reverse bias breakdown mode to provide an accurate reference voltage.
- **ZERO:** Logic zero is any voltage below half the power supply voltage, often close to zero Volts.