



ELECTRICAL COURSES

INSTRUMENTATION COURSES

MECHANICAL COURSES

PRACTICAL ELECTRONICS

COURSE 565: 5 DAYS: Max 8 Candidates

A basic electronics course for candidates who wish to explore the fundamental building blocks of electronics. The course employs a practical approach based on simple explanations and hands-on exercises. A good precursor to the electronics fault finding (570) course.

PARTICIPANTS

The course is intended for anyone interested in the electronics field and assumes no prior knowledge or for those that have studied the theory of electronic components and circuitry but have little experience of the practical application of that knowledge. Academic students of, for example ONC, HNC or HND electronics often find that this course provides the perfect complement to their studies.

COURSE PRESENTATION

The course provides participants with an understanding of the various commonly-used electronic components and how they would be employed in practical electronic circuits. Participants then build circuits incorporating these components and explore the functionality of them. We then make modifications to the circuit parameters by changing component values and measuring the effects. The course progresses from basic discrete electronic components like transistors and by the end of the course reaches components like analogue to digital converters (ADCs).

COURSE OBJECTIVES

On completion of the course, participants will be able to

- read electronic circuit diagrams and build small circuits
- understand the operation of electronic components within circuits
- determine the optimum / required values of circuit components
- use electronic test equipment to analyse circuits (oscilloscopes, logic probes, function generators etc)
- design and build an electronic circuit that incorporates ADCs, digital logic, analogue operational amplifiers and associated discrete components.

Successful completion of the course leads to the award of the Technical Training Solutions Certificate of Competence 565: Practical Electronics.

What do candidates on the Practical Electronics course actually do?

We begin with a recap of electrical principles. We remind the candidates about ohm's law, the power law, series and parallel networks, etc. Some of the candidates will have studied these before but we need to make sure everyone has the basic understanding before we proceed.

Then we look at capacitors and inductors, how they work and how they can be used, then look at low and high pass filter networks. We build some of these networks then test them with the function generators to see what sort of frequency response they have. We finish the first day by looking at semiconductors and LEDs.

INSTRUCTOR'S NOTES

Power

When individual components (respectively resistors), have a current passed through them they will consume heat as a by product.

To ensure that the component can withstand the heat they must be the right "size". The unit of power is the Watt (W) and with resistors not only is the ohmic value important, so is the power rating of the resistor that gets increased in a resistor is the product of current flowing through it and voltage across it and the heat it can dissipate. When a current flows through it it needs to be rated at least $40\text{W} - \text{so it will be physically quite large in order for it to handle the heat generated}$.

Power is additive so across the total power consumed by the circuit is the sum of all the individual components in that circuit.

The relationship of voltage, current, resistance and power is shown below:

Scientific Notation

In electronic circuits the amounts of current flowing, for example, can be very small, e.g. 0.001A , or very large, e.g. 1000A . To make handling this is to use scientific notation - using ten, raised to powers of 3, 6, or 9 etc., or reduced to powers of -3, -6, -9 etc.

$10^3 =$	$\text{Giga} =$	$G =$	$1,000,000,000$
$10^6 =$	$\text{Mega} =$	$M =$	$1,000,000$
$10^9 =$	$\text{Kilo} =$	$k =$	$1,000$
$10^{-3} =$	$\text{milli} =$	$m =$	0.001
$10^{-6} =$	$\text{micro} =$	$\mu =$	0.000001
$10^{-9} =$	$\text{nano} =$	$n =$	0.000000001
$10^{-12} =$	$\text{pico} =$	$p =$	0.00000000001

This would then allow 0.001A to be rewritten as 1mA . Other measurements in electronic circuits would be denoted in a similar way. Measurements of 1mV (0.00001V), 12mV (0.00012V), or 25mV (0.0025V) may be encountered.

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INSTRUCTOR'S NOTES

Practical 2: Differentiator

Build the following circuit:

INSTRUCTOR'S NOTES

Using a waveform generator with a square wave output set to 30ms of 1V pp, observe the output on the oscilloscope. By inputting different frequencies and observe how the output changes.

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INSTRUCTOR'S NOTES

The junction of the n -type and p -type material would be electrically neutral and would have no free electrons or holes. The region is known as the depletion layer. When the depletion layer gets thick enough the attraction of the holes to the anode side would not be strong enough to hold them there. When this happens a hole would be formed there - it would be a positive quasi-hole on one side of the depletion layer and electrons on the other. The junction thus formed is known as a PN junction.

If a voltage was applied across the ends of the PN junction then it is possible to偏轉 the electrons from the n -type side and holes from the p -type side and biasing the junction. The ends of the PN junction are known as the cathode and anode.

The voltage required to forward bias a PN junction is typically that's with the positive voltage being applied to the anode and the negative side to the cathode. If the voltage polarity was reversed then the depletion layer would get larger and no current would flow. This is known as reverse biasing the junction.

In effect see how a diode that will only allow current to flow in one direction only (and it is called a DIODE).

There are many different types of diode depending on the application. The most common are Zener, Zener Diodes - have a low forward voltage drop and a very fast switching action.

- Constant Current Diodes
- Schottky Diodes - has a low forward voltage drop and a very fast switching action.
- Shockley Diodes - has a negative resistance characteristic.
- Step Recovery Diodes - used to generate very short pulses.
- Tunnel Diodes - used in microwave oscillators and microwave amplifiers.
- Vincent Diodes - Variable capacitance used in reverse bias mode.
- Laser Diodes - produces light, wavelengths in the 375–2000 nm range.

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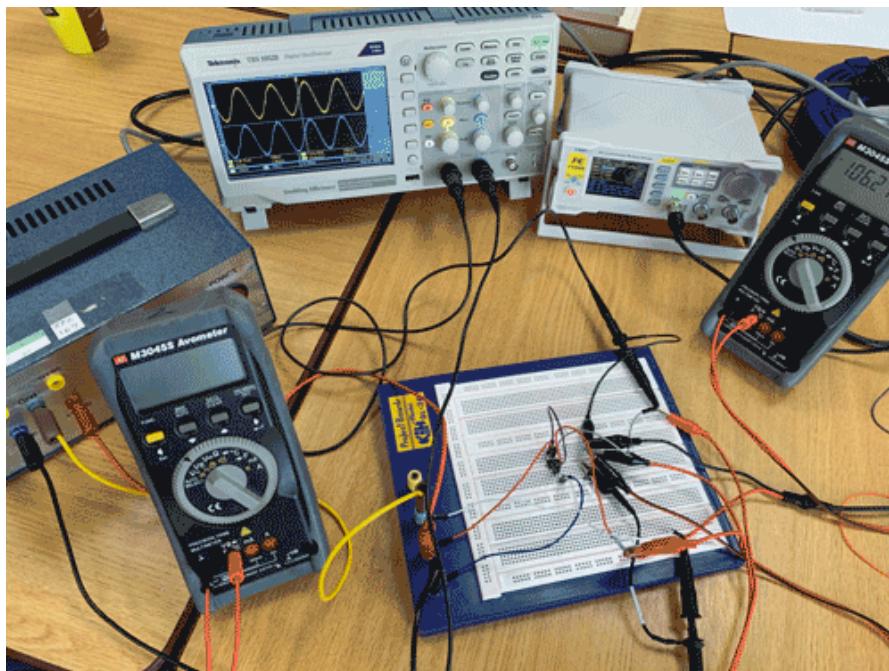
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Page 11 of the Practical Electronics course notes, discussing the complex forms of Ohm's law

Page 19 of the Practical Electronics course notes, exploring how integrators and differentiators work

Page 21 of the Practical Electronics course notes, where we look at the various types of LEDs in common use

At strategic points on the course we do practical exercises that reinforce or explore the technical issues. These circuits are built on our breadboards and each candidate has their own test equipment including oscilloscope, multimeter, function generator and power supply, etc.



The test gear that each candidate uses

Next we look at rectification, voltage regulators and transistors. We look at how these circuits might be integrated to form a full power supply unit. We build various circuits to explore and prove the operation of these circuits.

INSTRUCTOR'S NOTES

Regulator Circuits

Rectifiers are used to convert AC-to-DC. To do this a large signal diode is used which can pass high currents.

Single Diode Rectifier

Full Wave Rectifier

The use of a single diode can produce only half of the AC supplied voltage waveform and is therefore known as half wave rectification. For full wave rectification normally 4 diodes are used in the form of a bridge.

Required Power Supply

Most electronics require a stabilized DC power supply for the circuit to operate correctly. This can be achieved in many ways, one of the simplest uses the zener diode.

INSTRUCTOR'S NOTES
and derive steady state current through R_L

A disadvantage of this form of regulation is that the load can effect the voltage regulation. As the resistance of the zener diode is not zero and it changes in the current flowing through the diode it will affect the voltage output. However the zener can be used as reference for unbalance control circuit.

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INSTRUCTOR'S NOTES

Transistors

There are many types of transistors available today. The most common are the bipolar junction transistor or BJT and the Field Effect Transistor (FET). They work on different principles.

Bipolar Transistors

A bipolar junction transistor is a 3 layered device which can be NPN or PNP. Each layer of doped silicon is called the **emitter**, **base** and **collector**. This means that inside a bipolar junction transistor are 2 PN junctions, the base-emitter junction and the base-collector junction.

The name bipolar means that the current that flows inside the transistor is due to electrons moving in both directions (as an electron moves from left to right way then the hole it leaves behind moves in the opposite direction).

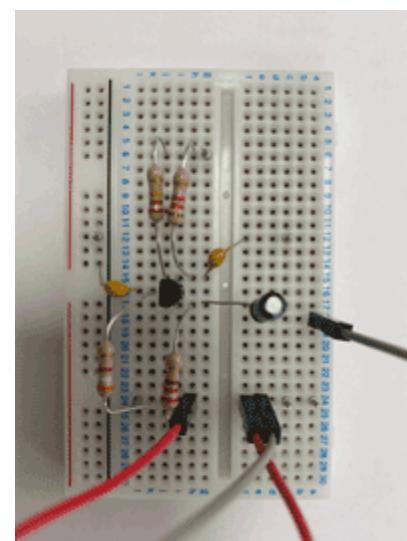
Transistors can be used as amplifiers and there are 3 basic configurations:

- Common emitter
- Common collector
- Common base

Each has an advantage - see below:

Transistor Configuration Summary Table			
	Common Base	Common Collector (Base Follower)	Common Emitter
Voltage Gain	High	Low	Medium
Current Gain	Low	High	Medium
Power Gain	Low	Medium	High
Phase Relationship	180°	180°	180°
Input Resistance	Low	High	Medium
Output Resistance	High	Low	Medium

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Page 24 of the Practical Electronics course notes, exploring rectification and shunt regulation

Page 30 of the Practical Electronics course notes, discussing how transistors are biased and what modes they are used in

One of the practical exercises where our candidates build a single stage Class A transistor amplifier

Op-amps are used in many electronics circuits, hence it's important that our candidates gain a proper insight into their uses, configurations, limitations and applications. We look at op-amp circuits like comparators, inverting amplifiers, summing amplifiers, buffers, ac amplifiers, schmitt triggers, oscillators and integrators.

Practical 8: Voltage Follower

Procedure

- 1) Connect the signal generator and scope as shown.
- 2) Set the signal generator to 1kHz, 300mV peak to peak and connect CH1 of the scope to 0.2mV/div and 200µs/div.
- 3) Now connect the 100k resistor across the output of the op-amp, as shown and record the voltage reading.
- 4) Now connect the 100k resistor across the output of the op-amp, using the Pcb to provide the supply requirements.
- 5) Connect the signal generator to the input of the op-amp and the oscilloscope to the output of the op-amp and observe the waveform, now connect the 100k resistor across the output of the op-amp and note the effect on the waveform.

When switching off the 12V power supply the Pcb needs to also charge

Practical 10: Schmitt Trigger

Components

- 1 - 741 op-amp
- 2 - 10k resistors
- 1 - 100k resistor
- 1 - Univeral potentiometer 100k
- 1 - 0.01uf disc ceramic capacitor.

Procedure

- 1) Connect the circuit as shown.
- 2) With Channel 1 of the scope connected to Vout and channel 2 of the scope to Vref, set the initial switches to the 0.2mV dc position and the timebase control to 50µs.
- 3) Connect one of the variable dc voltages (provided on the power supply) to Input A and connect the GND to the output, set to the 20V dc range.
- 4) Set the earth references of both scope channels to the centre line of the grid and switch both channels to dc input.
- 5) Switch on the supply and adjust the variable dc voltage so that channel 1 (the input voltage) is more positive than the voltage of point B (channel 2).
- 6) Measure Vout using the DMM
- Vout_____V
- 7) Measure Vref (Channel 2)
- Vref_____V
- 8) Reduce the variable voltage until it is more negative than the voltage of point B.
- 9) Measure Vout using the DMM
- Vout_____V

Practical 11: Oscillator

Components

- 1 - 741 op-amp
- 2 - 10k resistors
- 1 - 100k resistor
- 1 - 0.01uf disc ceramic capacitor.

Procedure

- 1) Connect the circuit shown.
- 2) Connect channel 1 of the oscilloscope across the output of the circuit.
- 3) Adjust VBI to give a maximum frequency. Adjust the timebase control of the scope and measure the frequency.
- Maximum frequency = _____Hz
- 4) Adjust VBI to give a minimum frequency. Re-adjust the timebase control and measure the frequency.
- Minimum frequency = _____Hz
- 5) Connect channel 1 of the oscilloscope to the inverting input and channel 2 to the non-inverting input. Set the timebase control to 1ms/div and measure 2 cycles of the waveform (one on top of the other).
- 6) Vary VBI and observe the effect on the two waveforms displayed on the scope.

Page 49 of the Practical Electronics course notes, where we do a practical exercise building a voltage follower circuit

Page 55 of the Practical Electronics course notes, where we do a practical exercise building a schmitt trigger

Page 58 of the Practical Electronics course notes, where we do a practical exercise building an oscillator

Then we look at digital logic circuits. We look at the main logic families (TTL and CMOS), studying their input and output stages, the common gates that are available, and the more complex functions that are used.

Practical 13: Logic Gates 1

Decide which TTL IC part numbers from the parts available to you have the required gates in them to build the circuit below.

AND	OR	NAND	NOR	EXOR	EXNOR
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Build a circuit using one of the logic gates from the TTL family to confirm that the truth table shown earlier is correct.

Decide which CMOS IC part numbers from the parts available to you have the required gates in them to build the circuit below.

AND	OR	NAND	NOR	EXOR	EXNOR
-----	----	------	-----	------	-------

Now do the same with the CMOS equivalent IC

TTL

CMOS

Practical 14: Logic Gates 2

Build the circuit below using one of the AND gates from the TTL family. Confirm that the pulsation allows circuit to reach the output when it's pressed.

Gates can be combined in larger arrays.

In the circuit determine some examples of the combination of inputs that would produce a 1 or 0 of the output.

Note that the functionality of the above combinational logic circuit could be described using Boolean algebra. In this case it would be:

Qn

Build this circuit and confirm that your definitions are correct.

Practical 16: Counters

Build the circuit below. Confirm that the pulse train advances or reverses the binary count each time that they're pressed.

By removing the bias from the clear and load inputs, does that make any difference? Does the output code change after just one movement? Why might it do? What 741 IC has two parallel load functions. What should be done with the data inputs that are not being used in the circuit above? If that is on it will code be produced? How would you connect another counter so that on it will code be produced?

Build the circuit below. Ensure that the function generator's output is set so that it is crossing within valid logic (around 0.5V). Meanwhile, your instructor will help you with this.

Function Generator

Don't let the counter reset if the function generator goes up. Use the switch to calculate in this case they short out its output.

Use an oscilloscope to test the outputs of the counter. What is the relationship in frequency between the input clock and Q18? What is the relationship in frequency between Q18 and Q17? What is the output frequency of Q14?

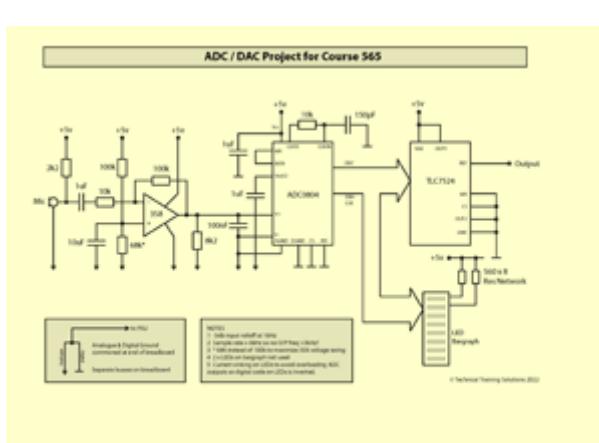
Show that the binary sequence can be used to produce frequency. This sequence might not certainly be used for counting of all.

Page 65 of the Practical Electronics course notes, where we do a practical exercise exploring the worst-case logic levels of TTL and CMOS

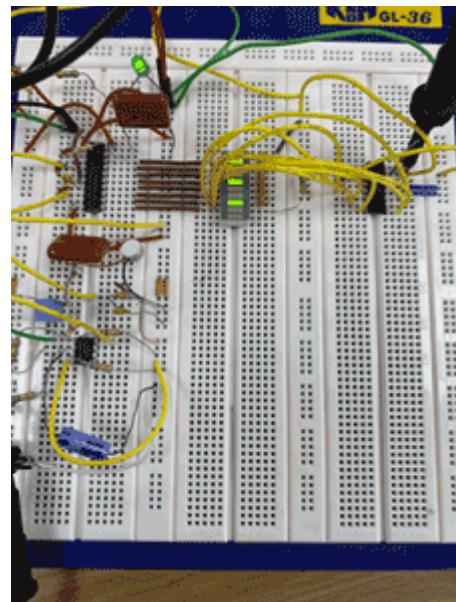
Page 66 of the Practical Electronics course notes, where we do a practical exercise looking at how logic gates can be combined to produce complex functions

Page 70 of the Practical Electronics course notes, where we do a practical exercise getting a digital counter to increment and decrement its values

The last part of our course sets the candidates the task of bringing all of the above experience together when they design and build a circuit that incorporates an analogue front end to amplify a microphone, an analogue to digital converter (ADC) to convert this into a digital data stream and a digital to analogue converter (DAC) that converts this data back into a signal that we can amplify to drive a speaker. In order to do this the candidates need to study the data sheets for the devices that we want them to use. Each candidate will progress differently in this exercise but we expect all of them to get a basic circuit working - with the help of our instructor of course. The following is an example of what they might produce:



An example of the circuit that candidates might design



An example of the circuit on its breadboard

If you would like to see some of the equipment used on the Practical Electronics training course for yourself, then please call us to arrange a visit to our offices in Kent. Alternatively, we can visit you anywhere in the British Isles.

