# PowerPro Signal Generator

inspire

- Frequency range: 1 Hz to 110 kHz in 5 decade ranges
- Waveforms: sine, triangular, square wave and TTL
- Output power: 4 W into 4 Ω load
- 4 digit LED frequency display
- Input impedance: 1 MΩ
- External input for microphone or music player (via 3.5 mm jack adapter)
- Amplitude and frequency modulation options
- Low impedance output: for driving vibration generators or loudspeakers
- High impedance output: attenuated by a factor of 10 or 100, for input to an oscilloscope or electronic circuits
- Internal loudspeaker (can be switched off)
- Output overload protection fuse on the back panel
- Shrouded sockets
- Designed specifically for use in school/college laboratories
- Stackable metal case with integrated ABS carry handles
- Detachable IEC mains cable
- **18 month manufacturer's warranty**

CE
to BSEN61010-2010
(EN 61010-1:2010 3rd Edition)


**TRIPLE PROTECTION:**

- Split bobbin transformer with internal resettable fuse
- Slow-blow fuse on mains input
- Separate fuse on low impedance output

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INDOSAW

## POWERPRO SIGNAL GENERATOR

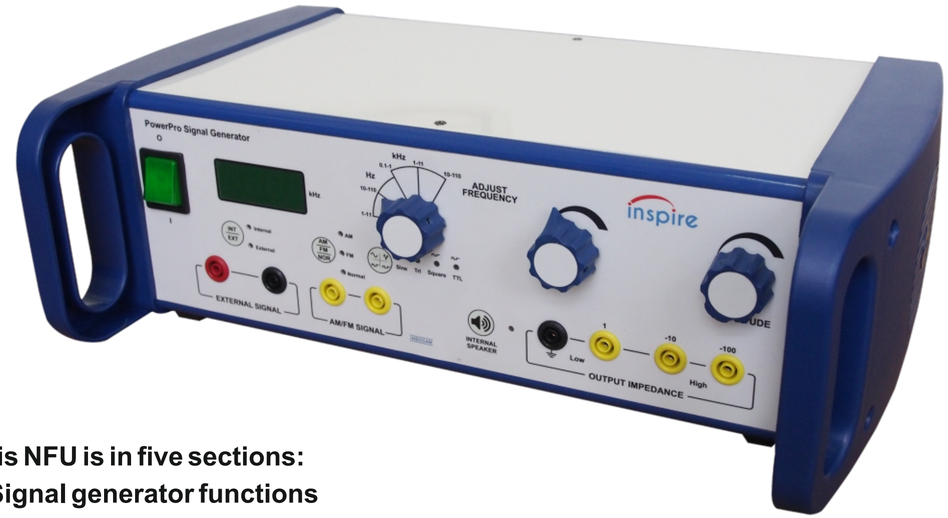
This advanced signal generator and amplifier is designed specifically for use in schools. The unit has both high and low impedance outputs:

low impedance for driving vibration generators and loudspeakers,
high impedance for input to oscilloscopes and electronic circuits.

An internal speaker (which can be turned on or off) makes the unit self-contained for simple experiments, e.g. exploring the range of human hearing.

The unit has an auxiliary input for amplifying external signals – this is ideal for amplifying signals from a microphone or music player for use with the SLS Rubens' Tube. A separate headphone socket lead and 4 mm adapter is available to connect a music player, e.g. an iPod, to the auxiliary input.

The unit also offers amplitude and frequency modulation. A second signal generator or suitable signal source is required.

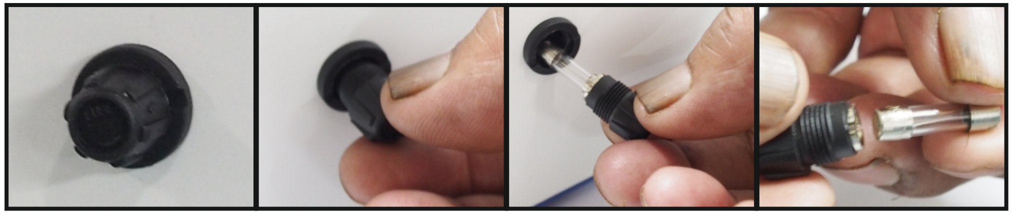



**This NFU is in five sections:**

- **Signal generator functions**
- **Output controls**
- **External signal input**
- **AM/FM modulation**
- **Applications**

### Output fuse replacement

The low impedance output is protected by an internal fuse, located in the back panel of the unit. The fuse is a 3 amp "slow-blow" or time delay T3A 250V 5 x 20 mm cartridge.



### Mains fuse replacement

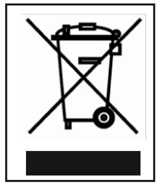
The mains socket on the back panel has a compartment for two fuses. It can be opened using a flat bladed screwdriver as shown.

The front fuse is a spare. It is a 5x20mm time delay or "slow blow" T500mA 250V fuse.


**IEC Mains Lead**
This is protected by a standard 3A 250V fuse in the mains plug.

**Power input** : 60 VA
**Dimensions** : 410 x 265 x 135 mm
**Weight** : 6.3 kg

**WEEE directive**
This symbol indicates that the electronic equipment should not be disposed of in the normal waste. It should be recycled in accordance with the WEEE directive.



**Operating temperature range:** 5°C to 40°C
**Operating humidity range:** 80% RH
**For Indoor use**

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## Signal generator functions

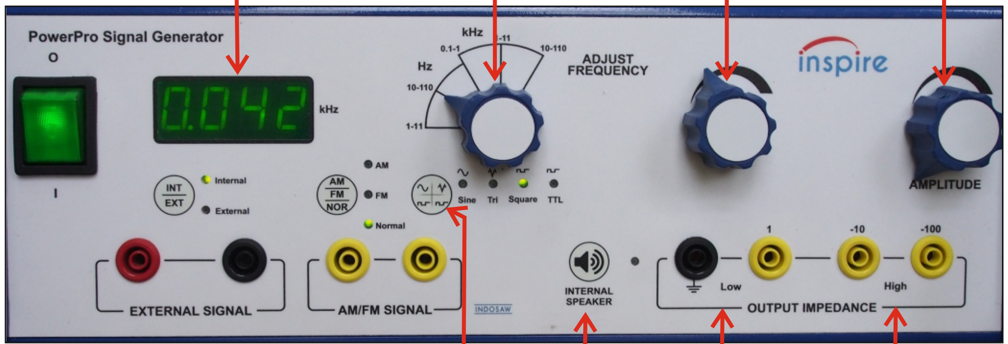
The signal generator provides sine, triangular and square waveforms at up to 10 V peak to peak, and TTL output fixed at 5 V. All waveforms are available from 1 Hz to 110 kHz. The frequency is always displayed in kHz, so 25 Hz is shown as 0.025 kHz and 440 Hz is shown as 0.440 kHz

The frequency **range** is from 1 Hz to 110 kHz in 5 switch selected ranges

**Amplitude** Control

Continuous frequency **sweep** in selected range

4 digit LED display showing the **frequency** in kHz




**Waveform** selection: sine, triangular, square and TTL

Internal Speaker ON/OFF

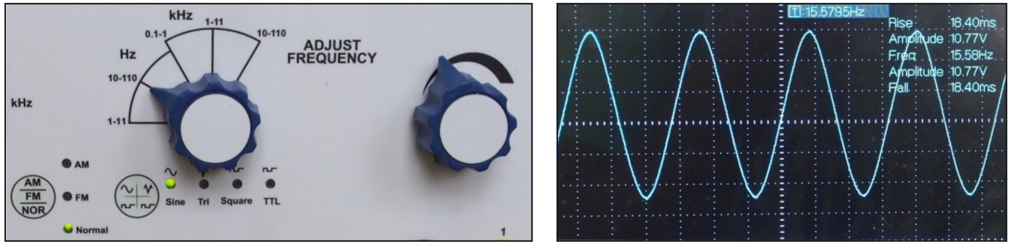
Output sockets

The default settings when the unit is switched on are:

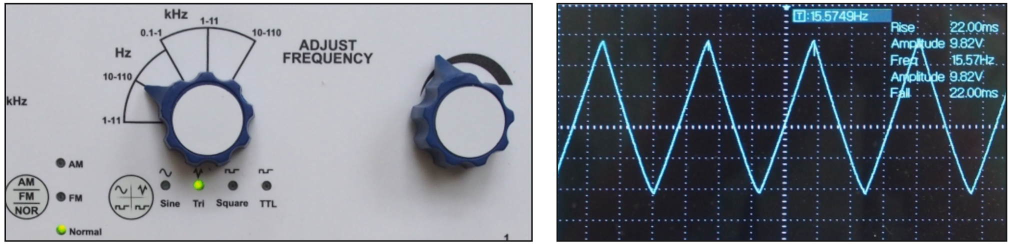
INTERNAL signal i.e. variable frequency tones
NORmal i.e. no modulation
Sine wave
INTERNAL SPEAKER Off

These settings are indicated by the LEDs next to each control.

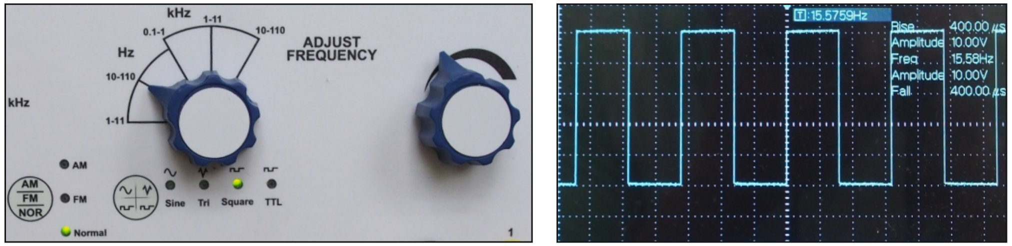
## Sample waveforms at 15Hz and 10V peak to peak (5V TTL)



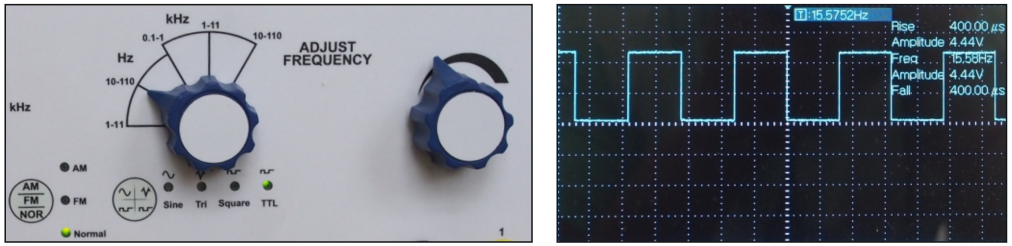

Sine wave




Triangular wave




Square wave

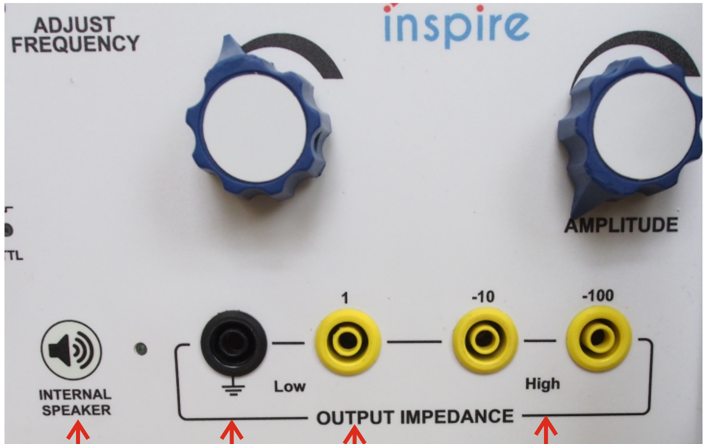



TTL (fixed 5V)

### Output Control

The output of the signal generator amplifier can be heard (at suitable frequencies) through the internal speaker, which can be turned on and off. The output can also be connected to an external loudspeaker with minimum impedance of 4 ohms, capable of handling at least 4 watts. The volume or loudness of the output can be controlled using the Amplitude control.

To drive a vibration generator or large loudspeaker (minimum 4 Ω impedance), use the black earth (0 V) socket and the Low output, the yellow socket labelled **1**.
Switch off the internal speaker.




Output & speaker amplitude control

Internal Speaker ON/OFF switch

Low Impedance output

High impedance
Use either of these sockets and the black (0V) socket

To provide lower level signals e.g. for input to an oscilloscope or electronic circuit, use the black earth (0 V) socket and one of the High impedance outputs, the yellow sockets labelled -10 or -100.

These outputs give a maximum of 1 V (peak to peak) or 0.1 V (p-p) respectively.

The internal speaker can be used to monitor the output signal. It can be switched off, when an external loudspeaker or vibration generator is connected.

### External signal input

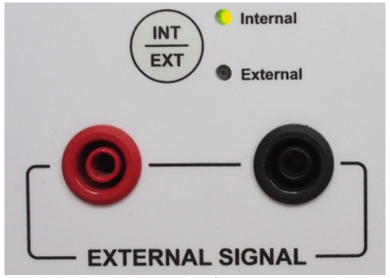
The amplifier section of the signal generator can be used to amplify the output from a microphone or other low level audio signal. Pressing the INT/EXT switch selects the EXTERNAL input and disables the internal tone generation.

A microphone can be connected using 4 mm plugs or a 3.5 mm jack plug, in which case the external adaptor module (shown below) will be needed.

The adaptor can also be used with a suitable 3.5 mm jack plug lead, to input music from an mp3 player, mobile phone or tablet.

The maximum input is 500 mV p-p to avoid distortion of the output sound. Output volume can be adjusted using the Amplitude control.

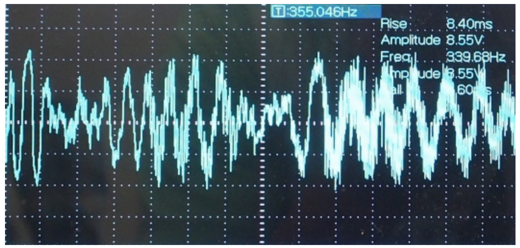
Maximum gain is 100, so an input of 10 mV could become 1 V at the output.




**External Input for 4mm leads**


**External adaptor module with 3.5 mm jack for audio input**

A typical oscilloscope trace of an amplified audio signal.



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## AM/FM Modulation

Modulation is the use of one signal to alter another signal (usually of higher frequency) for the purpose of transmitting information, e.g. by radio.

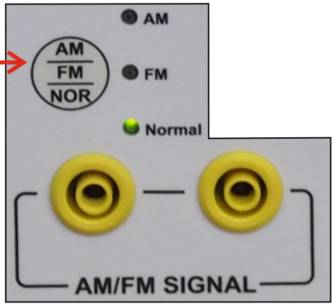
Amplitude modulation (AM) is a common method for broadcasting radio programmes. When a radio is tuned to 900 kHz, that is the CARRIER frequency of a particular radio station. You do not hear the carrier, it is not an audible signal. When music is played or the announcer speaks, those sounds are varying signals. They are combined with the carrier making the amplitude of the carrier increase and decrease. The pattern of increase and decrease matches the changes in the music or voice. The radio receives the modulated carrier and separates the audio signal from the high frequency. The listener hears the music or voice. >> See Experiment 7 below.

Frequency modulation (FM) is used for higher quality radio transmissions. It uses higher carrier frequencies, typically around 80 to 100 MHz.
The music or voice signal is used to shift the frequency up and down. The pattern of increase and decrease matches the changes in the music or voice. The radio receives the frequency modulated carrier and separates the audio signal from the high frequency.

## Modulation function

The signal generator has a modulation function, which allows the user to connect a second signal generator or microphone so that the effects of amplitude and frequency modulation can be explored and demonstrated.

The switch selects NORmal (no modulation), FM or AM, indicated by the LEDs.




For AM, the input signal should be limited to +/- 250 mV which can be provided by a crystal microphone.

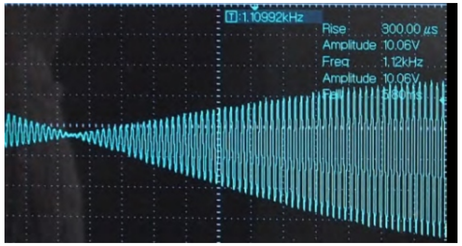
For FM, the input signal should be limited to +/- 3V which can be provided by a second signal generator.

## Amplitude modulation (AM)

During amplitude modulation, the frequency display shows the frequency selected using the range and sweep controls. Note *1 Set the carrier frequency to 5 kHz and display the output on an oscilloscope. Adjust the display to show a large amplitude and several complete waves. Select AM, by pressing the AM/FM/NOR switch to enable the AM/FM input sockets. The signal generator is providing the CARRIER frequency.

Modulating inputs (+/- 250 mV) can be provided by a crystal microphone or a separate signal generator, using its high impedance, attenuated output (÷100).
Connect the modulating signal and observe the effect of:
whistling into the microphone OR
starting at 500 Hz, vary the amplitude and frequency of the modulating signal.

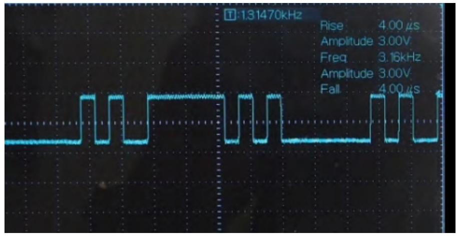
In this example, the amplitude of a 1 kHz carrier frequency, has been modulated by a much lower frequency, around 4 Hz.



## Frequency modulation (FM)

Use a similar arrangement of two signal generators, one providing a carrier frequency, the other providing a modulating signal. Select FM. When FM is selected, the sweep frequency control is disabled and the output frequency is approximately centred within the selected decade, e.g. at 5 kHz in the 1 to 11 kHz decade.
The modulating signal should be in the range +/-3 V and at a lower frequency than the carrier. 10 times lower is recommended.

A signal swing from +3 V to -3 V will change the frequency up and down by approximately 70% of the centre frequency. E.g. 5 kHz would rise and fall between 9.5 kHz and 1.6 kHz.



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## Applications

Typical experiments include:
1. Exploring the frequency range that is audible to humans
2. Comparing the different waveforms with musical instruments
3. Creating standing waves to explore frequency and wavelength
4. Measuring the speed of sound using a microphone, speaker and dual beam oscilloscope - **Edexcel Core Practical 6**
5. Investigating the effects of length, tension, and mass per unit length on the frequency of a vibrating string or wire - **Edexcel Core Practical 7**, **AQA Required Practical 1**
6. Amplitude modulation - audio frequencies
7. Amplitude modulation - radio frequencies
8. Frequency modulation - audio frequencies

**1. Exploring the audible frequency range**

Use the signal generator with its internal speaker ON, or connect the LOW impedance output to a good quality hifi speaker (minimum impedance 4 Ω).
Set the amplitude at a comfortable level.
Using the range selector and the sweep control, find the lowest and highest frequencies that people can hear. Do we all have the same range?

**2. Comparing the different waveforms with musical instruments**

We recognise different musical instruments by the quality or 'timbre' of their sound.
First of all, set the signal generator at 440 Hz (0.440 kHz) with the internal speaker ON.
The waveform is a sine wave, by default. Change it to a triangular wave (Tri) and to a square wave. Ignore TTL, it is a special square wave for use in electronics.
Now listen to some musical instruments playing the note A above middle C. A flute, a violin and a piano are good examples. Do any of them sound like the signal generator waveforms?
If possible, connect a microphone to an oscilloscope and look at the waveforms produced by those instruments. Does any instrument produce a square wave?

**3. Creating standing waves**

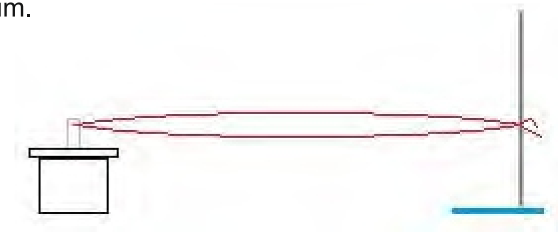
Apart from the signal generator, you will need a vibration generator, some rubber cord or string and a heavy retort stand. Connect the vibration generator to the LOW impedance output of the signal generator with long 4 mm plug leads.
Continued >>

## Amplitude modulation (AM)

3. continued

Attach the cord to the vibration generator's armature (moving part) and tie it to the retort stand, about 1 metre away. The cord should be level, slightly stretched, but not tight.
Select the frequency range 1 to 11 Hz and turn the sweep control to minimum.
Increase the amplitude to maximum.

Adjust the frequency slowly, until the rubber cord oscillates in a steady wave pattern. This is a standing wave and probably looks like this:



Make a note of the frequency, then set the signal generator to double that frequency. Again, adjust the frequency slowly to get a new standing wave. Discuss your result, then continue to change the frequency to find more standing waves. Look for a relationship between the frequency and wavelength.

Make a note of the frequency, then set the signal generator to double that frequency. Again, adjust the frequency slowly to get a new standing wave. Discuss your result, then continue to change the frequency to find more standing waves. Look for a relationship between the frequency and wavelength.

**4. Measuring the speed of sound - Edexcel Core Practical 6**

Using a signal generator, microphone, speaker and dual beam oscilloscope. The signal generator output to the speaker is also connected to one channel of the oscilloscope. The microphone is connected to the other channel. The time difference between the two signals depends on the separation between the source (speaker) and the microphone, which can be measured using the oscilloscope.
Detailed guidance is provided in the Teacher Resource Pack.

**5.** Investigating the effects of length, tension, and mass per unit length on the frequency of a vibrating string or wire
**Edexcel Core Practical 7, AQA Required Practical 1**
Using a signal generator, vibration generator, a heavy retort stand, a bench pulley, a mass hanger and a bridge, the above effects can be explored using an apparatus similar to that below:

Detailed guidance is provided in the Edexcel Teacher Resource Pack, or the AQA Required Practical Activity guide.

6. Amplitude modulation - audio frequencies
Two signal generators are required. One should be adjusted to give an output of 500 Hz, at a moderate amplitude, with the internal speaker ON. It should then be switched into AM mode.
The second signal generator provides the modulating signal, which must be taken from the -100 attenuated, high impedance output. This gives a modulating signal of up to 0.1 V or 100 mV. Select the 1 to 11 Hz decade and explore the effect of varying the frequency. Similar effects, called 'tremolo', are found on guitar amplifiers.

**7. Amplitude modulation - radio frequencies**
This demonstration requires: a crystal microphone, a signal generator, 2 metres of insulated wire with 4 mm plugs on each end, an AM/FM radio with a long wave band (LW).

Wind the insulated wire into a circular coil, approximately 100 mm in diameter, and sticky tape to hold it in shape. Connect the coil to the LOW impedance output of the signal generator.
Select the 10 to 110 kHz decade and set the sweep control to maximum.
Connect the microphone to the AM/FM signal input and select AM.
Set up the radio some distance away, say 5 metres and tune it to receive 220 kHz on the LW (long wave) band.
Increase the Amplitude on the signal generator and speak into the microphone.
Have someone listening to the radio. They might need to adjust the tuning to receive your AM radio broadcast.

**8. Frequency modulation - audio frequencies**
We cannot simulate FM radio transmission, because the signal generator's maximum frequency is 110 kHz - well below the 80 to 100 MHz of FM radio.
However, with a similar arrangement to experiment 6, you can frequency modulate audio sounds, some of which will be familiar as the sirens of emergency vehicles. Two signal generators are required, one in FM mode, set to the 0.1 to 1 kHz decade, with the internal speaker ON.
The other is set to the 1 to 11 Hz decade, and the output is taken from the LOW impedance sockets. The Amplitude control should be close to minimum.
Explore the effects of varying the modulating frequency, amplitude and waveform.

**Note *1** The frequency display is basically a counter, counting the output pulses of the signal generator. During amplitude modulation, when the carrier amplitude becomes small, the counter will not detect all the pulses and the frequency display will give low readings, even though the frequency has not changed.