Engineering Note 42

A method of measuring speaker load impedance without an impedance meter

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Introduction

You may be asked to do some service or installation work on a music or paging system, it may be necessary to find out the load impedance of the system, perhaps with the view to adding some additional speakers, to do some fault finding, or to fit a new amplifier, if you do not have an impedance meter to hand this can present a problem.

The following method describes a practical way of measuring the speaker load impedance for 100v/70v line installations, using a test frequency of 1 kHz, it can also be used to measure low impedance systems as well but with less accuracy*, maths has been kept to a bare minimum and it is assumed that the reader has a basic knowledge of electronics, using hand tools and multi-meters. (For a detailed explanation of speaker impedance please refer to Engineering note 11.3) ***

Tools required

1. Smart phone
2. 3.5 mm Stereo Mini jack to phono plugs lead (or other plugs to suit the amplifier input)
3. A good quality digital multi-meter with AC Volts and AC milliamps/micro amps ranges, check that meter specification will allow good readings at 1kHz (and preferably higher frequencies). Most will be ok but some will not!
4. Terminal block (5 amp should do)
5. 1 ft of spare speaker cable (300 mm for the younger generation)
6. Cable cutters
7. Screwdrivers

It is a good idea to seek permission to carry out the test as on some sites people object to the noise of the test tone

First with your smart phone go to my you tube channel https://youtu.be/VuE-bdEsGqM where you will find a good quality 1 kHz test tone.

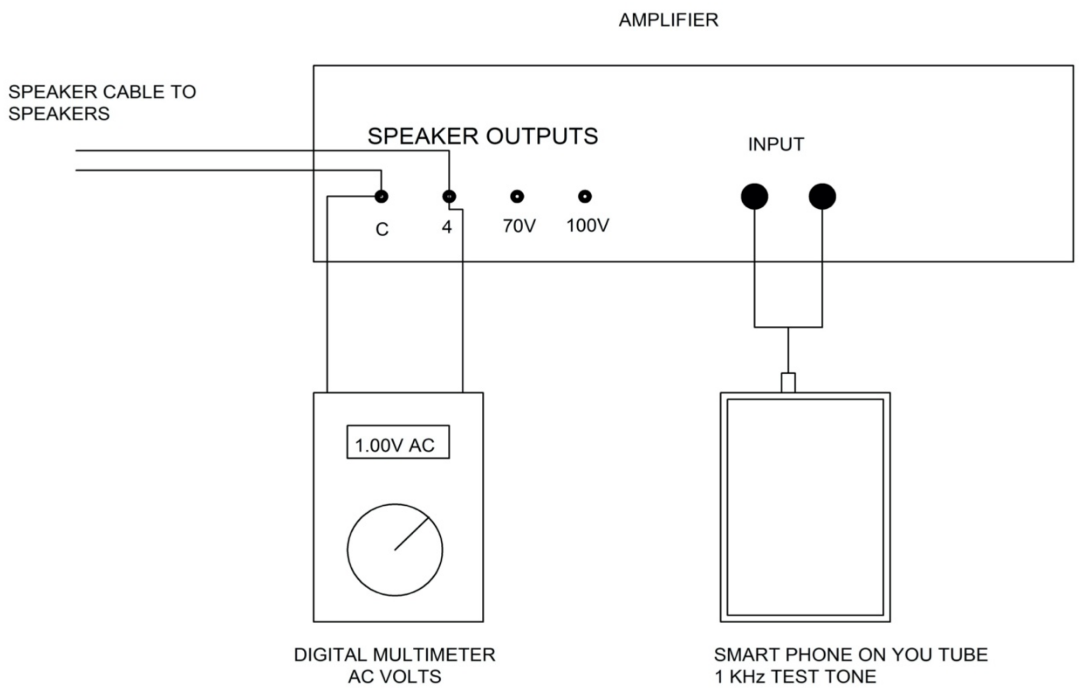
(Others are available)

With the systems amplifier switched off, plug the mini jack lead into the smart phone and the 2 phono plugs into the amplifier input, with the 1khz test tone applied at about half volume on the phone, this should ensure a distortion free output.

(Many installations these days use small networked players, so will conveniently already have a mini jack lead connected to the amplifier)

Hook up the multi-meter in parallel with the low impedance speaker output, (the 70v/100v output can also be used but with less accuracy) ** also be aware that a 70v/100v line output is considered to be an electrical hazard these days.

With the speakers connected in circuit, set the multi-meter for AC volts.



Having got permission to carry out the test (as on some sites people object to the noise of the test tone)

Make sure the tone controls are set to the mid position (flat) and the master volume control fully down

Switch the amplifier on

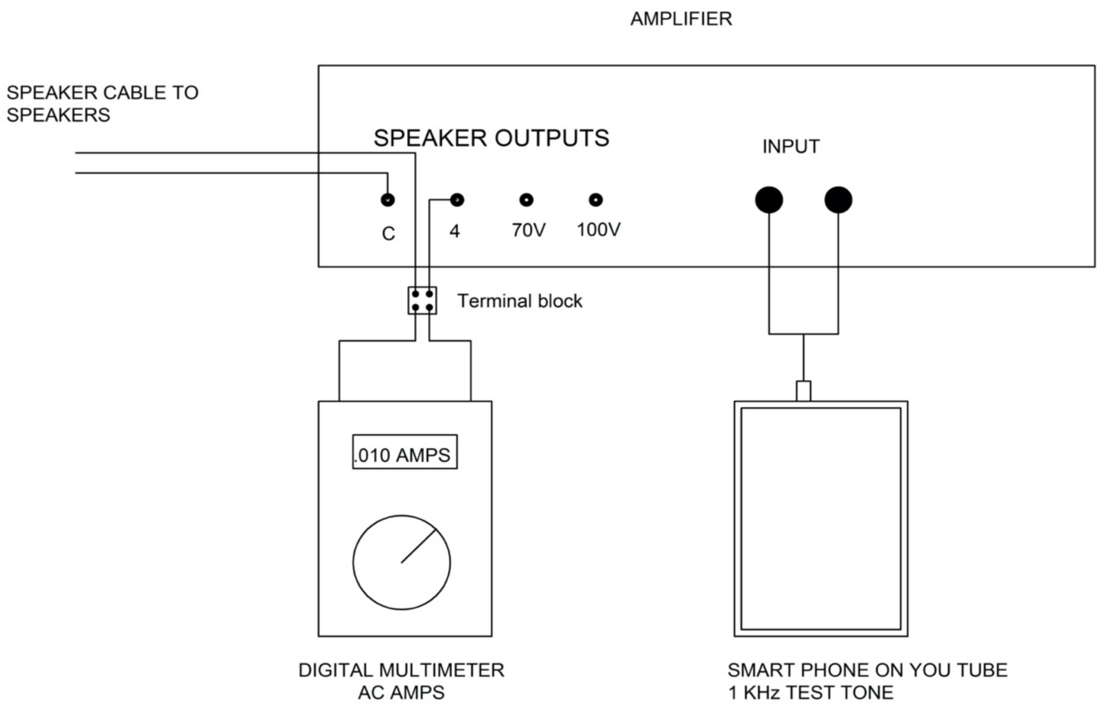
Slowly turn the volume up, looking at the meter until a reading of 1 volt is achieved. (I chose 1 volt as it makes the calculations for impedance very easy, it does not have to be this exact voltage, as everyone has access to a calculator these days)

At this point you should hear a low level 1 kHz tone from the speakers.

Turn the amplifier off, wait a few seconds and then turn the amplifier back on, checking that the meter reading has returned to 1 volt, usually the amplifier will switch back on and maintain the same output voltage level.

Turn the amplifier off again and do not touch the volume control this must be left in the same position for the test.

Disconnect the multi-meter, change the setting to AC milliamps; not forgetting to re-configure the meter probe leads for current, using the terminal blocks and spare cable, hook up the meter in series with the speaker cable.



Switch the amplifier back on and take a reading, as an example if you have a reading of 10 mA - using the following calculation Z = V \ I

Z = V / I or Impedance = Volts divided by Amps

1 volt divided by 0.01 amps = 100 ohms

If you have a reading of 1 mA - using the same calculation

Z = V / I or Impedance = Volts divided by Amps

1 volt divided by 0.001 amps = 1000 ohms

If you have a reading of 2 mA - using the same calculation

Z = V / I or Impedance = Volts divided by Amps

1 volt divided by 0.002 amps = 500 ohms

For low impedance systems

If you have a reading of 125 mA - using the same calculation

Z = V / I or Impedance = Volts divided by Amps

1 volt divided by 0.125 amps = 8 ohms

This method can be used with reasonable accuracy enabling an engineer on site to make an evaluation of the load impedance of the system.

Some actual readings I made for these Engineering notes are as follows:

I used an ADS 1015 15W mixer amplifier with 100V - 16-ohm - 8ohm - 4-ohm outputs,

For the test loads I used an Apart MASK 4TW Speaker, using the 10w, 5w, 2.5w settings, also 100 ohm and 4.7 ohm dummy loads.

With 1.05 volts on the 4 ohm output, the current reading was 10.05 mA = 100 ohms, using the 100-ohm dummy load - which is spot on.

With .999 volts on the 4 ohm output of the amplifier, the current reading was 70 mA = 14.2 ohms using the 4.7-ohm dummy load, as you will notice there is an error of 9.5 ohms, this error is due to the amplifier output not being a perfect voltage source, because the output transformer has its own impedance which is in series with the load, also the meter is probably only accurate to + or - 1.5%, however this error will start to become insignificant with loads above 100 ohms, even with the error, the readings should give a good rough indication with loads under 100 ohms.

(Because the value of the dummy load was known to be 4.7 ohms I was able to see the 9.5-ohm error, there is no reason why an engineer could not do a test reading with a known value resistor – say 10 ohms to find the error value)

With 1.004 volts on the 4 ohm output, and the MASK 4TW speaker set at 10w, the current reading was 623 uA = 1605 ohms (6.2w)

With 1.004 volts on the 4 ohm output, and the MASK 4TW speaker set at 5w, the current reading was 363 uA = 2754 ohms (3.65w)

With 1.004 volts on the 4 ohm output, and the MASK 4TW speaker set at 2.5w, the current reading was 201.5uA = 4962 ohms (2.0w)

These readings were made using my AVO Megger M5097 digital multi-meter, which can read AC current down to uA, most good quality multi--meters will give comparable results at 1 KHz, the readings also compared favourably with my TOA ZM104 impedance meter, which is a common impedance test meter used in the installation of 100v/70v systems.

It is not a problem to use a different voltage for the test, however using less than 1 volt will require a meter with a low mA and uA range, on the other hand using 10 volts would probably blast the entire site to pieces, I would recommend keeping things under 2 volts.

As an example, if you set the amplifier output to 1.5 volts and your current reading is 0.0015 amps

Using the same method of calculation

Z = V / I or Impedance = Volts divided by Amps

1.5 volts divided by 0.0015 amps = 1000 ohms

As another example, if the amplifier output was 1.9 volts and your current reading is 0.016 amps

Using the same method of calculation

Z = V / I or Impedance = Volts divided by Amps

1.9 volts divided by 0.016 amps = 118.75 ohms

From the impedance reading you can then calculate the load on the amplifier in watts as follows.

For 100v line systems

10000 / Z = watts or in the above example 10000 divided by 118.75 = 84.21 watts

For 70v line systems

4900/Z = watts or in the above example 4900 divided by 118.75 = 41.26 watts

Having evaluated the load of the speaker system, a decision can be made on whether the amplifier installed is powerful enough handle the load, in the above example a 50w amplifier would not be man enough for 118.75 ohms = 84.21 watts on the 100v output, but would be able to handle this load 118.75 ohms = 41.26 watts on the 70v output.

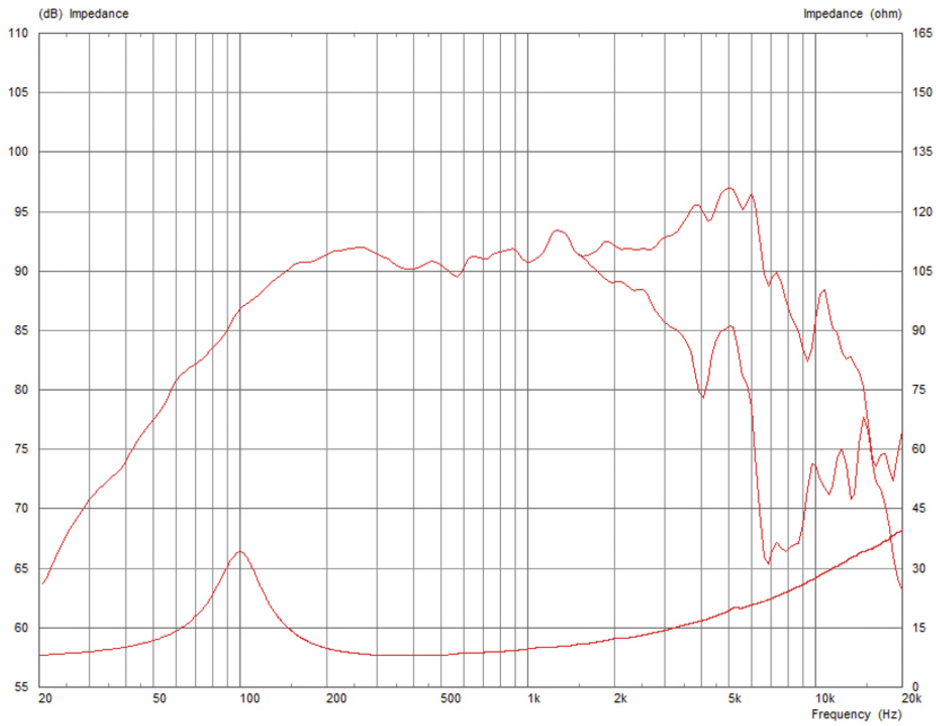
If extra speakers need to be fitted to extend the system, in the above example a 50w amplifier would have to be replaced perhaps with a 100w amplifier.

It is always a good idea to allow a margin for amplifier power + 10 % is a reasonable margin, so a 100w amplifier could be used with loads up to about 90 watts, 120w amplifier could be used with loads up to about 110 watts and so on, multiple amplifiers would be used on larger installations.

* It was noted that there was a error of 9.5 ohms whilst measuring the 4.7 ohm load, as explained this is due to the output impedance of the amplifier - in this case 9.5 ohms effectively being in series with the speaker load, so it will be seen that measuring a low impedance speaker system using this method will not be as accurate, the error value was double the value of the load, this error can be mitigated if a known value dummy load is measured first to asses any potential error, whilst a 9.5 ohm error is relevant when trying to asses the load of a low impedance speaker system, this error becomes insignificant on high impedance speaker systems - say for instance above 100 ohms.

** Its is always preferable to use the low impedance amplifier output to carry out the test, as the output impedance of the 70v or 100v output will be higher than the low impedance output, this in turn will cause a greater error.

*** This method is not intended to measure the speaker load impedance at all frequencies - we are just concerned with the lowest impedance to assess the maximum load on the amplifier, it is of no concern that the impedance rises at resonance, which will occur at various different frequencies due to the fact there will probably be multiple drivers of different types on the system, the impedance will also steadily rise with increasing frequency from about 1kHz – see below an example driver, the lower curve showing a peak of about 40 ohms at 100 Hz (resonance) then staying relatively flat from 200Hz to 1kHz, then a gradual increase to over 40 ohms at 20kHz.



The test is carried out at a low voltage, at higher voltages the impedance will increase due to the effects of the voice coils heating up and causing a rise in voice coil resistance, again this is of no concern.

1 kHz is used as the test frequency on commercial impedance meters such as the trusty TOA ZM104A and the TENMA MODEL 72-6948, a quick trawl of impedance characteristics for various speakers from different manufactures reveals the lowest impedance usually occurs between about 400Hz and 1kHz - see above, so this method could easily be used with a 400Hz test tone in exactly the same way.

I hope these notes will prove useful to other engineers.