
Band Filter Freq Q Gain
1 30 Hz 24.0 -13.0 dB
2 50 Hz 24.0 13.0 dB
3 370 Hz 2.0 -9.0 dB
4 7000 Hz 2.0 9.0 dB
Flat
Equalisation
✞ Church Audio ✞

SOUND WAVES ARE VIBRATIONS OF AIR MOLECULES

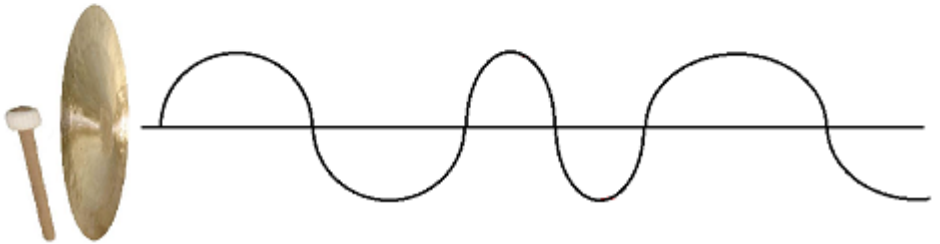
Vibrating Air Molecules will cause areas of high pressure, and areas of low pressure, as the vibrations go back and forth.

High Pressure is called **Compression**. Low Pressure is called **Rarefaction**.

Here is the same sound-wave seen in three different ways:

Longitudinal (*this is what sound really looks like)*:
High pressure air molecules bunched together, Low pressure air molecules spread out.

Longitudinal (*vibrations*):
High pressure wave-fronts bunched together, Low pressure wave-fronts spread out.



Transverse (*electrical audio signals look like this)*:
High Pressure (positive voltage) above the zero-line, Low Pressure (negative voltage) below the zero line.

There are two elements required to measure sound:

1. VOLUME (AMPLITUDE) (GAIN)

The Volume of a sound is the highest pressure it produces. The measurement for volume is Decibels (dB).

For "Live Sound" volume we can use a **Sound Pressure Level (SPL) Meter**. This measures the maximum dB of Air pressure.

If you speak so quietly that only half of the words are audible, then you are speaking at what we call the ***Threshold of Hearing*** *(this is around* ***30dB****).*
Normal conversation *is double that, around* ***60dB****. The* ***Threshold of Pain*** *(so loud it starts hurting) is double that, around* ***120dB****.*

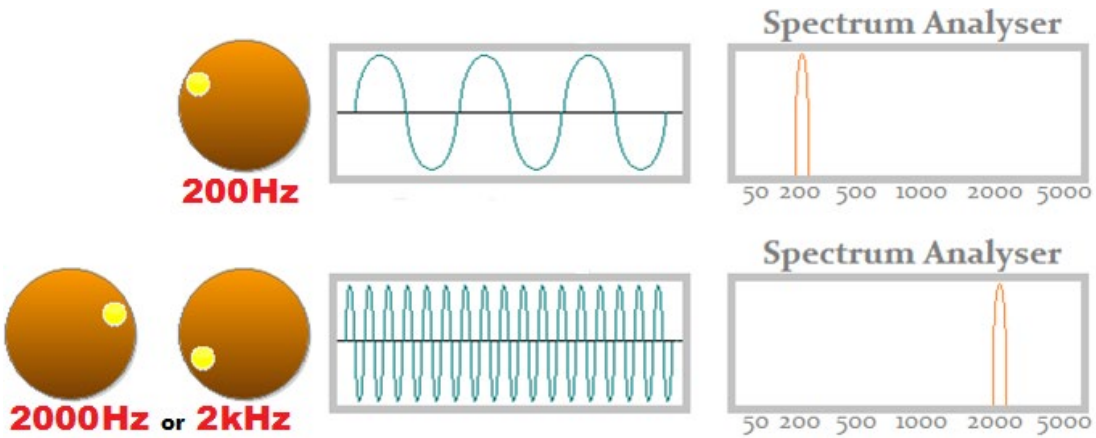
When we collect the sound vibrations through a microphone, we convert the air vibrations into electrical vibrations. We use a Level Meter to measure the electrical vibrations (volume).

There are two ways that you will see electrical signals displayed…
The first two examples show a dial that goes up as far as 15dB, which is obviously it's maximum. This is the most common way we see signal voltage displayed.
The second two examples consider the maximum volume as 0, and anything below that is shown as a negative (-15dB).

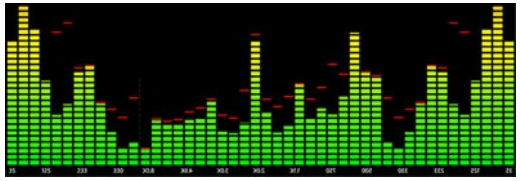
2. FREQUENCY (PITCH)

The speed of sound vibrations are measured in Hertz (Hz). One complete vibration back and forth (one cycle) in one second is called 1 Hertz (1 Hz).
Humans can hear up to about 20,000 Hz (*yes, 20 thousand vibrations a second*). 200 Hz will sound like a low (bass) sound. 2,000 Hz will sound like a high pitch.
We call this the "frequency".

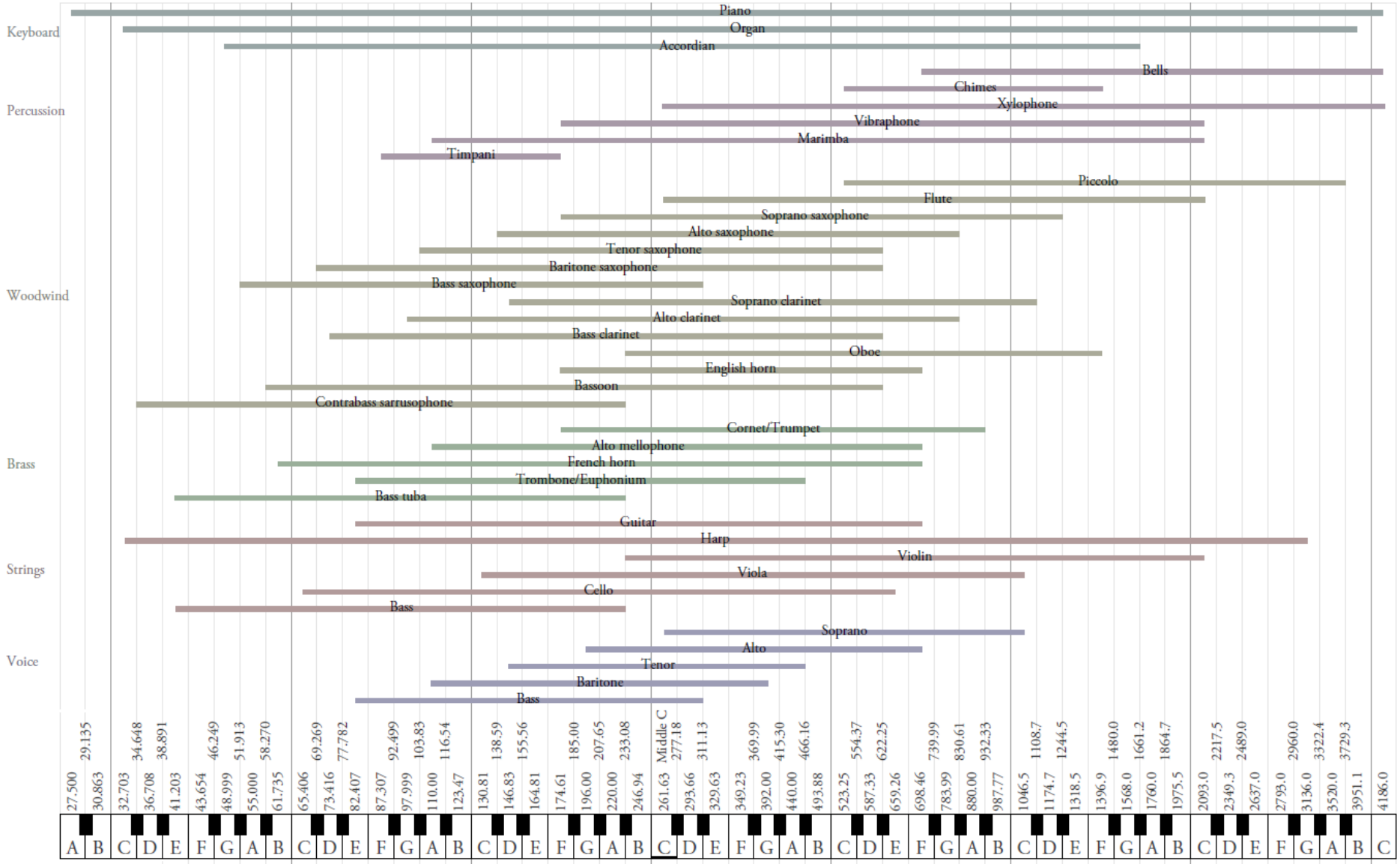
1,000 **Hz** may be abbreviated 1 **kHz** (1 Kilohertz). 2000 **Hz** = 2 **kHz**. 5,482 **Hz** = 5.482 **kHz.**



A "Sound" is usually a mixture of very many frequencies, and these frequencies are all continually changing their volumes.



The best place to see this is with a **Spectrum Analyser**. This device separates the frequencies and shows their individual volumes.



Redrawn by John Schneider. See John R. Pierce, *The Science of Musical Sound* (New York, 1992), pp. 18-19; Donald E. Hall, *Mucical Acoustics: An Introduction* (Pacific Grove, California)

The above image shows how various singing voices and musical instruments start and finish in different places.
Their lowest note depends on their ability to generate bass frequencies, then each one will have a note-range above their lowest note of a few octaves.

When something starts vibrating, and generates a note, this is the ***fundamental*** frequency. Anything vibrating will start a cascade-effect which generates new ripples (higher multiples) of itself. These extra (bonus) frequencies that multiply off a note, are known as ***Harmonics***.

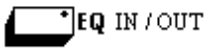
Boosting/Cutting the 'fundamental' frequencies of an instrument (the ones you see on the chart) will have a powerful effect on the body of the sound as these are the base notes, and responsible for the musicality. Boosting these fundamentals will raise the 'apparent volume' of the sound in the mix. Boosting too much will cause a nasal, muddy sounding.
Boosting the 'harmonic' frequencies gives air, breath and freshness to a sound. The exact frequency area of the harmonics will depend on the instrument. Some instruments have a lot of harmonics, and some have only a few.

FILTERING (EQUALISING)

Filtering is what occurs when we select a certain area (band) of the sound, and raise or lower it, changing the internal frequency balance.

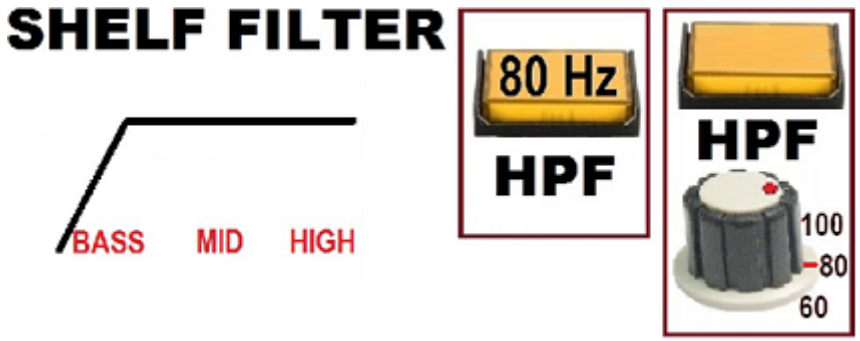
Basically, we try to adjust (**filter**) things so the bass, mid and high frequency areas are all audible... "***equal***" ... we call it ***Equalising***.
If there is an excess of Bass frequencies, then the sound will be boomy. Too few Basses and it will sound thin and weak.
An excess of Mid frequencies causes a nasal, horn sound. Too few Mids and it sounds hollow, without any substance.
Too many High frequencies and it will be disturbing, piercing to the ear. Too few Highs and the sound will become muffled and unintelligible.

While every listener has their own personal preference, ***everybody*** knows a bad sound. Nobody likes a sound that is boomy, thin and weak, nasal, muffled, squealing, metallic etc. etc. The congregation might not be able to tell you what's wrong with a sound, but they will soon tell you if it's bad (eg. *unbalanced)*.

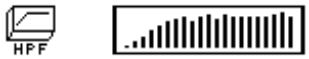


Some Equalisers/Filters have a **Bypass** switch. If you press Bypass the sound will stop being filtered so you can hear the original again. This lets you compare the original with your new filtered version (at the push of a button) to hear how you are improving (or worsening) the sound which sometimes happens.

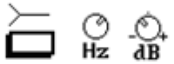
If an electric guitarist plays a rhythmic accompaniment throughout a song, you can filter it and make a nice sound. Unfortunately, if he changes his pedal effect and does a distorted solo in the middle of the song, your filtering may sound terrible during the guitar solo sound. You can press Bypass until the solo has ended, and the guitar pedal is moved back to the accompaniment sound, then pop the equalisation back on.



This Filter (Equaliser) has a **Cut-off Frequency**. Everything below (or above) the cut-off point will slowly die away (or slowly increase), resembling a "**Shelf**".

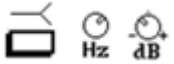


The most common form of Shelf Filter is the High Pass Filter (**HPF**). This filter passes all frequencies that are higher than its cut-off, but frequencies below the cut-off will be filtered (the lower the frequency, the more it will be reduced). The **High Pass** is sometimes called a **Low Cut**.
The HPF is invaluable for lowering the explosive letter 'P' from Singers (who have bad microphone technique), and also good for getting the low frequency boom sound out of microphones and instruments.

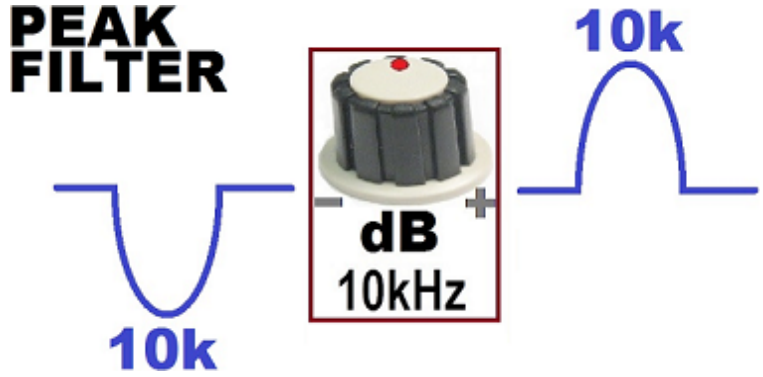


The HPF on a mixer is often just a push-button (with a cut-off frequency pre-set at around 80Hz). Occasionally the manufacturer will let you choose the cut-off frequency for yourself and may even let you choose to cut or boost the shelf.

A Low-Pass Filter (LPF) will pass everything below the cut-off frequency but slope away frequencies above the cut-off point. This is used to remove excessive hiss from a sound, or to remove the high frequencies before a sound goes in to a Bass-Bin Subwoofer cabinet (where you only want the basses).
The **Low Pass** is sometimes called a **High Cut**.

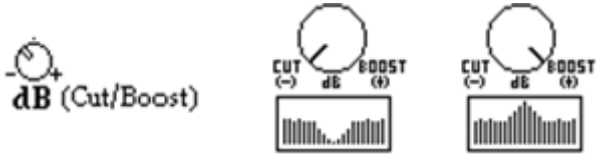


The cut-off frequency may be selectable, and you may be able to choose whether to cut or boost the shelf.



This type of Filter (Equaliser) permits us to raise (boost) (+) or lower (cut)(-) a pre-set band of Frequencies. This is commonly the band of high frequencies, and it permits us to increase (boost) the freshness if a sound is dull or muffled, or lower (cut) the high frequencies if a sound is getting too screechy or metallic.

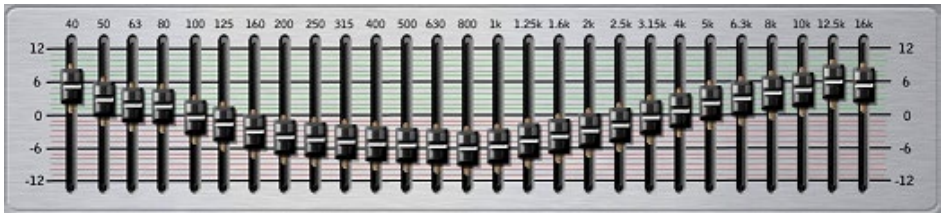
When we cut or boost a band of frequencies, we will create a 'Peak'. This is how it gets the name "**Peak Filter**". Sometimes you will see it labelled as "**Bell**".

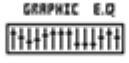


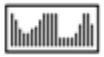
Because a Peak Filter can cut ⩒ or boost ⩓ many manufacturers use the symbol ◇—

Sometimes mixer manufacturers will offer you a push button on the high, or low, frequency band so that you can choose whether it is a shelf or a peak (bell).

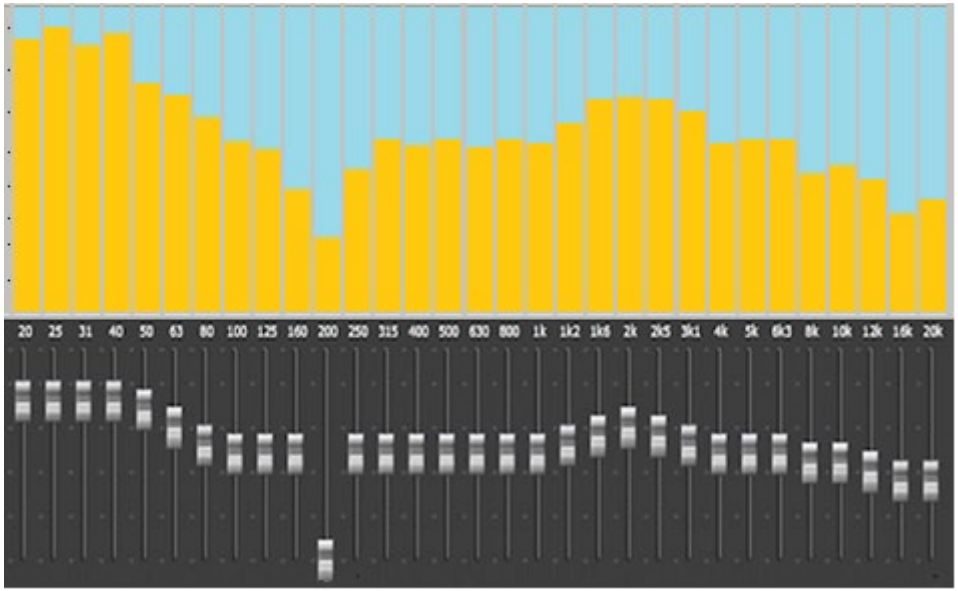
GRAPHIC EQUALISER



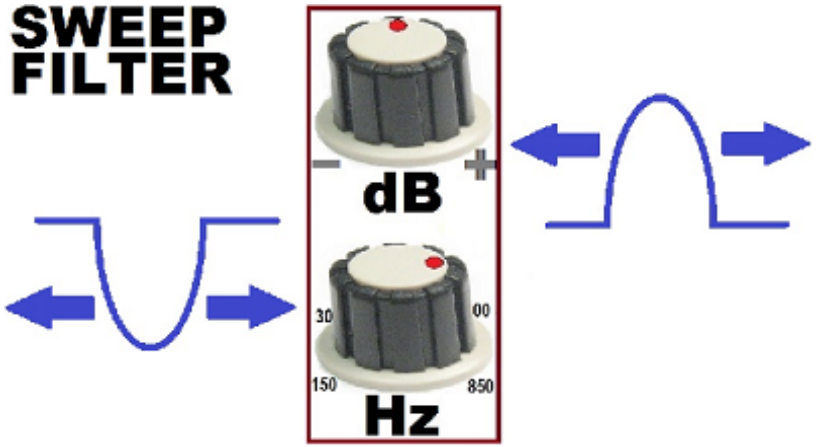




This is a collection of Peak Filters. The frequencies are all pre-set, and the sliding faders (dB) let you see (graphically) the curve that you are making, so we call it a '**Graphic**' Equaliser ☺ Rocket Science!!

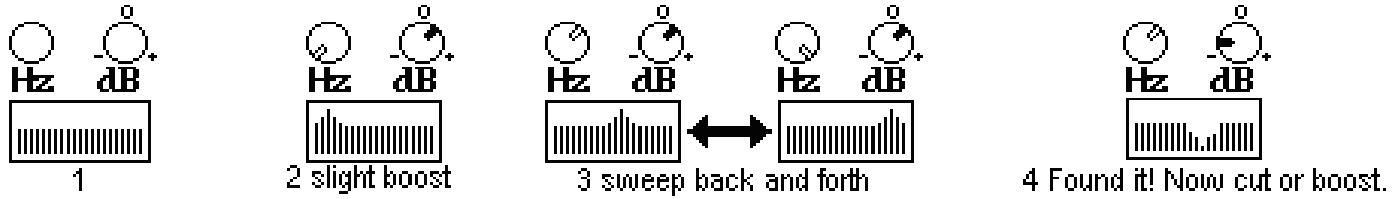


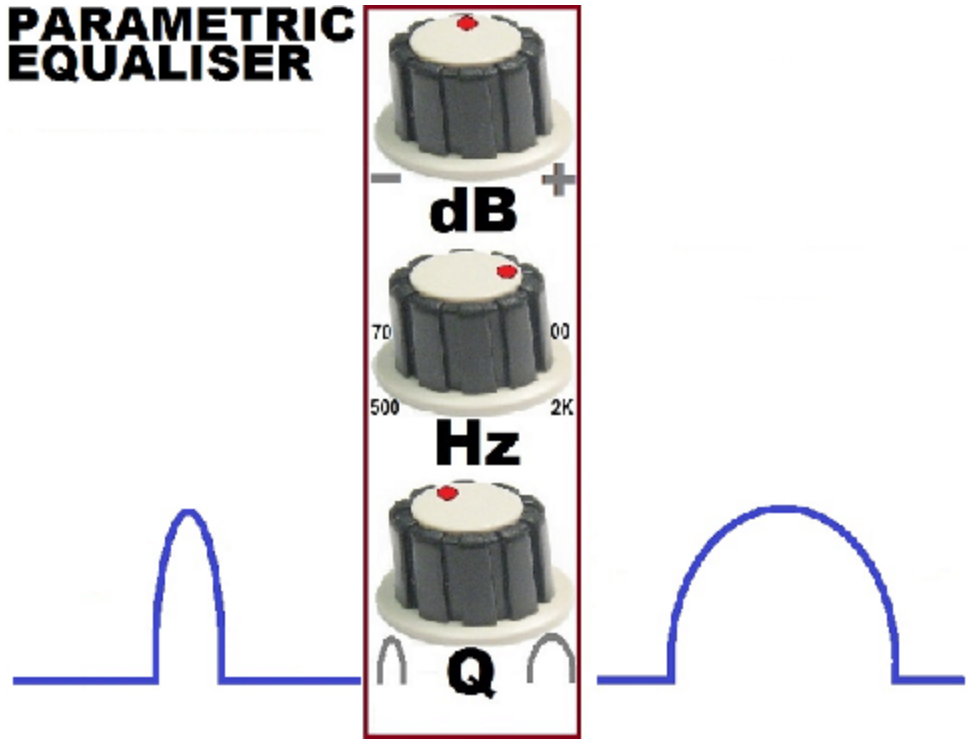
A Professional ***Graphic Equaliser*** has 31 frequencies (31 band) that have been pre-chosen (International agreement). This is so that the Professional ***Spectrum Analyser*** (31 band) will line up exactly with the Graphic Equaliser (31 band) Faders. Graphic Eq is ideal for equalising Floor Monitors and Front-of-House Monitors. If you have a sound on a mixer channel that you just can't get right, the only solution is to insert one of these Equalisers into the channel... mixer equalisers often don't have enough mechanics to fix really difficult sound. The ideal is to pass a difficult sound through a 31 band Equaliser then on to a 31 band Spectrum Analyser, then back into the channel.



This Filter (Equaliser) has a ***variable*** **Frequency** knob (Hz) so that you can '**sweep**' back and forth till you find the "***Sweet Spot***".

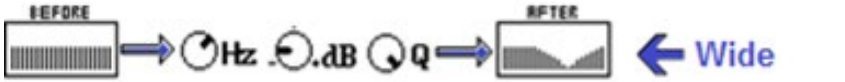
The best way to use this type of filter is to boost slightly (it is the easiest way to hear the *sweeping*). Now turn the frequency-band knob back and forth listening to the sound changing. If you turn knobs slowly you can actually do it with a live congregation, and they don't realise (be discrete in your movements). Once you have found the area of interest (which will stand out because you gave it a slight boost) then cut or boost using the dB knob as you desire.

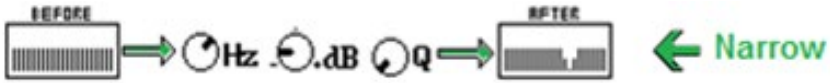




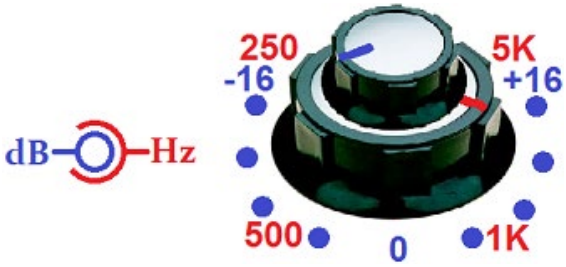
Previous Filters (Equalisers) gave us access to two parameters, Cut/Boost (dB) and Frequency (Hz). There is a third parameter available, which is called the **Bandwidth**, or the **Q**. This lets you choose how many frequencies will be affected either side of the centre frequency that you select with your Frequency knob. Because this type of Equaliser offers all 3 filtering parameters, we call it a **Parametric Equaliser**.

We measure the width of the band of frequencies using either **Octaves**, or **Q** (***Quality factor***). They are the inverse of each other. A narrow band of frequencies will have a small Octave number but a high Q number, and a wide band of frequencies will have a high Octave number but a small Q number. Fortunately, Mixer manufacturers realise that we Sound Operators can get confused, and they often draw hoops so we can easily see where wide band and narrow band are.

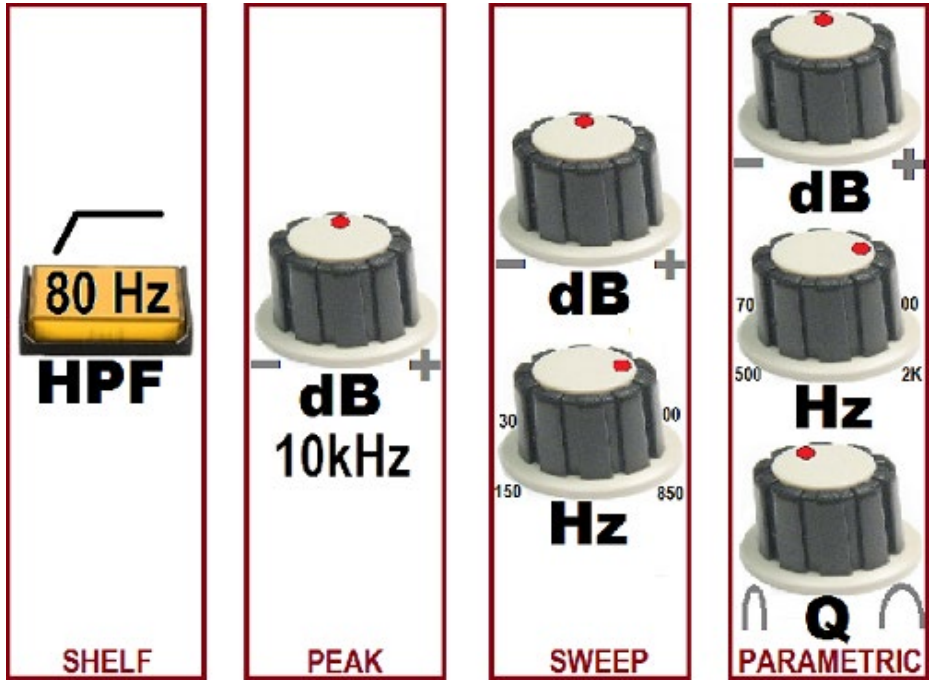




To cut/boost a large piece of the sound we would set it to a wide band-width. To cut/boost a few selected frequencies (that might be disturbing) we would set it to a narrow bandwidth.



To save space on a mixer we sometimes see manufacturers '**stack**' the dB knob and the Hz knob. There will always be a diagram showing you what the top and bottom knobs are for. In the example above, the larger outside Frequency (Hz) knob goes from 250 Hz to 5kHz. The upper knob can cut 16dB or boost 16dB.



To Summarise: Here are the normal everyday Filters/Equalisers used in the Audio industry.

Here are some examples of professional Mixing Console Equaliser sections.

When is it a “good” sound?

Equalizing (filtering) a sound is nothing more than raising or lowering certain frequency bands to improve the balance of the sound.

A balanced sound has warmth from its lowest frequencies, fullness from its mid-range frequencies, and freshness (presence) from its highest frequencies. Too much, or too little, of any of these will make the sound unnatural, and quickly become unpleasant to the ear.

Every instrument and voice has its own bass, mid-range and high frequency area. Obviously, the bass guitar has different zones to, say, a flute, and so we look at our charts, and learn the different instrument and voice ranges, and then we learn the rest by experience (using the sweep dial).

Always boost slightly (dB), then sweep the frequency (Hz) back and forth until you find the sweet spots (there will be more than one). Sweet spots are points that strongly affect the sound (you can’t miss them) and these are the best points to cut or boost.
Resist the temptation to use your **brain** too much, filtering must always be a “listening” thing. The exact point of the sweet spots differs each time. Sweep!! The **ear** must have the final say!

Don’t think that you don’t know when it’s a good sound. Do you have a hearing impediment? No! Everybody knows a bad sound when they hear it, so just make it as least bad as you can.
Does it sound the way it would if you were standing in front of it? Great! You’ve done your job!

Attention! Don’t just filter for the sake of filtering… if it’s not broken then don’t try and fix it.
A **quality** microphone placed in the **correct** position should require very little equalising.
If you have to cut or boost (dB) aggressively, then you should think about moving the position of the microphone, or even substituting it for a different one, as aggressive equalising ruins a sound.

A successful mix goes unnoticed. All the tracks sound balanced, nothing sticks out and nothing is hidden. You shouldn't hear emphasis on any part of the spectrum. Bass, Mid-range, and High bands are all heard in equal proportions (over-emphasis on any one band will cause listening fatigue).

A full frequency range (full use from low-frequencies to high frequencies) will mean that Kick Drum and Bass sound deep (but not overwhelming or muddy) while the Cymbals will sound crisp and distinct (but not sizzling and harsh).

If you filter a sound too much, it will become un-natural sounding. Over-equalising always finishes up with a harsh, over-coloured sound.

The "Ess" in people's voices (the Sibilants) should be clear, but not piercing. You need to hear **some** "Ess" sound in order to understand what someone is saying.

Always prefer to **cut** frequencies rather than **boost** them (*once you find your sweet spot*) because boosting a frequency zone too much will make the sound become peaky (spikey) and consequently harsh in sound. If you needed more highs, but boosting the highs causes a harsh sound, then consider slightly cutting the mid-range and basses, this will **expose** the highs more.

Don't start filtering until you are sure that the microphone is the right one, in the best position, and the instruments are properly tuned. If the source sounds bad to start with, or your microphone capture isn't good, an Equaliser isn't going to save you.

Don't filter a sound at really low volume because you aren't hearing all the 'detail' in the sound, and you won't make a good judgement (especially the high frequencies that are low in volume anyway). Don't filter a sound in cheap headphones because you aren't hearing all the 'detail' in the sound.

Equalizing Individual Instruments:

We equalize individual sounds to give them a realistic and pleasant sound in their own right, but also to ensure that they will still be heard clearly when mixed with the other sounds. When sounds are mixed together, frequencies in common to all instruments will blur the detail of all. Boosting 'slightly' the high frequencies (harmonics) of each sound creates a special sense of air or space around it (because it's harmonics are unique to it). This is powerful in ensuring each sound remains audible in a mix. The high frequencies for a bass guitar are obviously very different to the high frequencies of a flute.
Another consideration when making sounds that will mix well with others is to keep everything modest in their bass and mid-range frequencies as these will all sum with the others, eventually causing a muddy drone.

Equalizing the Mix:

By equalizing the complete mix (as it leaves the mixer) we have the chance to balance the overall sound going out to the Front-of-House Loudspeakers. A slight boost of the entire mix at 10-12kHz can give the whole song extra presence and freshness. Rolling off the basses with a low shelf (HPF) filter will tame down excessive basses and stop any nasty low frequency booms. Reducing the mid-range slightly will instantly clean up any drone, and make everything more audible.

As in all things to do with Equalisation, never push the boost or cut (dB) too far. Having to do that should be an alarm-bell for you, something is wrong!
Sound quality is only as good as the singers and musician's ability, the microphones, and the loudspeakers… mixer equalisers are actually at the bottom of the list.

HOW THE EAR RESPONDS TO DIFFERENT FREQUENCY ZONES

VERY LOW	BASS	LOW MID	MID	HIGH MID	HIGH	VERY HIGH
20-80	**80-300**	**300-800**	**800-2k**	**2k-5k**	**5k-8k**	**8k-12k**
These are almost subsonic and can only be heard on large loudspeaker cones. Even if the Kick Drum or the Bass aren't fat enough for you, resist boosting this far down. It just adds boom and rumble, and the result is mud and confusion.	This area gives warmth and fullness to a sound. It is very important. Too much and it will become muddy, too little and the sound will sound thin and weak. The best method is to use a narrow peak and boost a sweet spot in the area. This gives an 'apparent' full bass sound without overwhelming.	This zone is very delicate. It gives the sense of fullness (body). It will always make a sound suddenly appear much louder and stronger. Too much will sound like a box or sound nasal, too little will sound hollow and weak.	Boosting anywhere in this region tends to give a 'horn' like sound.	This is the most sensitive zone to the human ear. Boosting this area will immediately increase the clarity of a sound. Too much will cause a harsh result, too little will make it sound distant (not present).	This gives freshness to a sound. It improves intelligibility and makes each sound more distinct. Too much makes a sound harsh, too little makes a sound muffled.	These are almost supersonic frequencies yet if you boost them in a sound you can hear a noticeable brilliance and 'air' (sparkle).

CREDITS

This material is offered freely to the Christian Churches; downloadable at Pietango.com

Text: *Original, by the Author, a Christian Recording Engineer.*
Images: *Designed by the Author. Some photographs were sourced from the Internet, then re-worked.*

Ever since the creation of the world, God's invisible attributes and divine nature have been evident. They are clearly understood through his workmanship, and all the wonderful things that he has made. Therefore, those who fail to believe and trust in him are without excuse, or defence. **Romans 1:20**

All of us have sinned and fallen short of God's glory, but God treats us much better than we deserve.
Because of Christ Jesus, he freely accepts us and sets us free from our sins. God sent Christ to be our sacrifice. Christ offered his life's blood, so that by faith in him we could come to God. **Romans 3:23**

If you declare with your mouth, "Jesus is lord," and believe in your heart that God raised him from the dead, you will be saved. For it is with your heart that you believe and are justified, and it is with your mouth that you profess your faith and are saved. **Romans 10:9**

For the Scripture (*Isaiah 28:16*) says, "Whoever believes in Him will not be disappointed." **Romans 10:11**

These things have been written so that you may believe that Jesus is the Christ, the son of God; and that by believing, and relying on him, you may have new life in his name. **John 20:31**