

What is phase imbalance? Is it possible to use 230v / 240v on a three phase 400v generator?

TLDR: *In short, yes you can, but this will need to be within a certain limited threshold to make sure you do not cause the generator to trip, or cause damage to the alternator due to a phase imbalance.*

When trying to specify which diesel generator is suitable for your power or backup requirements, you may be tempted to purchase a 3-phase or 400 volt generator. On the face of it, these 400v / 230v generators provide more power output compared to single phase 230v stand alone sets in a cost to power comparison.

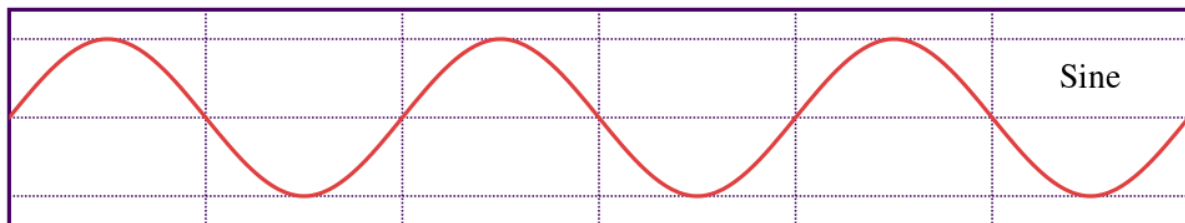
Given the fact that from most 400v three phase generators, you see them listed with 230v output too, it looks appealing to purchase one of those - even if you do not have 400v equipment to power. If you do have any 400v equipment then a three phase diesel generator would be essential. All of our Cummins powered and Hyundai diesel gensets are three phase 230v / 400v outputs.

Before we explain exactly what a phase imbalance is, it is helpful to know the difference between single phase 230 volt power and three phase 400 volt power.

What is single phase and three phase power?

It is quite a technical answer to explain the difference between single phase and three phase generators, however the very simple answer is that 230v / 240v is one phase of alternating current or voltage within an electrical system or alternator. It is one 'pulse' of electricity switching between negative and positive polarity, and this can be seen using an oscilloscope - a device which maps out the sine wave against time.

AC or alternating current describes the way in which the sine wave, or power output alternates over time, as shown below.



(Extract from an image By Omegatron - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=343520>)

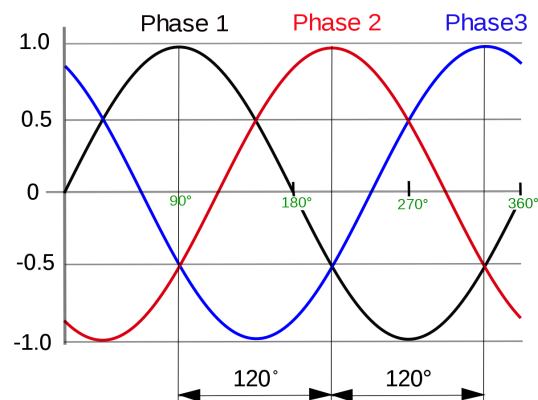
The above would be representative of a typical 230 volt, single phase power output sine wave. As you can see, there is one 'pulse' of electricity alternating over time.

In three phase, or 3 phase power systems of diesel generators, there are 3 pulses of electricity produced as the motor turns components within the alternator. The alternator is usually made up of copper wires and magnets in different arrangements.

In single phase alternators, there is usually one copper winding, which is what produces the single pulse of electricity as the magnetic field oscillates.

In three phase alternators / 3 phase generators, there are three separate copper winding sections, so, as the internal components spin three pulses of electrically are created as an output.

If using an oscilloscope, a 3 phase generator output would be shown as below;



(Image By User:J JMesserly modification of original svg by User:SiriusA - File:3-fas-spänningar.svg, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=5607023>)

As you can see, there are three pulses of current/voltage created over time from the alternators three sets of windings, referenced to the neutral.

So now you may be asking, why is three phase 400v (Not 690v)?

Without going into extreme technical detail, this is due to the fact none of the phases 'peak' at the same time. As shown in the representative image, each phase is offset slightly, so when Phase 1 is at peak output, Phase 2 and 3 are in negative voltage/current.

How do you get 230v out of a three phase generator?

This is by connecting to one phase, and the neutral/earth terminals. This gives you a reference of 230 volts between that individual phase, and the reference neutral point.

How do you get 400v out of a three phase generator?

This would be by connecting to all three 'live' phases, and also the neutral and earth. In some systems the neutral and earth are linked, which means your plug or socket would have 4 pins, Live 1, 2 & 3 and Neutral/Earth. In other systems, the neutral and Earth are not linked, meaning you would have a 5 pin set up. For further clarification on any of this, please ensure you consult a qualified expert.

What is a phase imbalance on a diesel generator?

At the start of this article, we stated it is possible to run 230v equipment from a 3 phase diesel genset. Now that we have covered the basic principles of single phase vs three phase, we need to explain why it can be difficult to run 230v / 240v equipment from a 400v three phase generator.

Whilst this is possible, you need to be careful not to run the generator in a way which can cause phase imbalance. Trying to draw too much 230v power from a three phase generator can lead to the breakers tripping and you losing power to your equipment or for prolonged periods of time it can cause major damage to the alternator windings which can be a costly repair.

There are two main reasons for damage.

Magnetic / Electrical & Temperature.

Almost all three phase diesel generators have an alternator with three copper windings, and a rotating section attached to the drive from the engine.

While this component spins within the alternator, it creates a magnetic field / flux in the copper windings. It is this magnetic field of flux, alternating in polarity that creates a current or voltage between the winding and neutral.

If you are drawing heavily from one of the phases, this will create a stronger magnetic field between the internal component and one set of windings. As the rotor inside the alternator spins, it will be drawn to one winding more than the others. This can cause the rotor to spin off center, which strains the crankshaft from the engine and can cause damage to the rotor or the engine.

Secondly, as you are drawing heavily from one phase, the winding can become extremely hot which can cause it to perish, which breaks the circuit and means you may need to get your alternator 'rewound'.

How can I prevent phase imbalance or damage to my generator?

In order to prevent this happening, all of our Cummins powered ECO range of gensets have Deep Sea Electronics control panels, and our Hyundai sets have ComAp panels. Both of which have many built in safety features - one of these safety parameters is set to protect your generator against phase imbalance by shutting it down in the event of an imbalance across the phases.

If the control panel senses a dangerous amount of power being drawn from one phase, it will automatically trip the breakers, meaning the power output ceases - but this prevents damage to your engine or alternator.

Most three phase gensets have a tolerance of around 50% use from one phase against the load being applied to the others. In simple terms, if you had a three phase generator which produced 30 amps, 10 amps per phase, running from one phase on 230v you could draw 5 amps without the control panel kicking in for safety.

As this is a % based tolerance, using the same theoretical 30 amp generator, if you are drawing 5 amps from 2 phases, on the third phase you could draw between 2.5 amps and 7.5 amps - the third phase would be within 50% to the other two.

As you can see, this can quite easily become very complicated so we always advise you to get advice and help from qualified experts for the purchase of your generator to make sure you specify the correct one for your needs.