Why 3 phase is used

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If I rotate this magnet past this coil of wire, we can see it produces a sine wave. The magnetic field interacts with the electrons in the wire and forces them to move. Imagine the north pole is pushing them away and the south pole is pulling them back. The electrons are alternating their direction forward and backwards.

To prove this, we can use LED"s. Because, led"s only allow current to flow in one direction. So, by connecting two led"s in opposite directions, we can tell which direction current is flowing. At normal speed it"s a little hard to see, but in slow motion, we can clearly see only one LED illuminates at a time so the current is definitely flowing forwards and backwards in the sine wave.

The magnet in our generator rotates and pushes the electrons forwards, then pulls them backwards. This will create a single phase, alternating current with a sine wave which repeats every time the magnet makes a full rotation past the coil.

So, we have a single phase generator. The voltage will start at zero, then increase up to the peak positive value and then decrease back to zero. Then on the negative half the value will increase to the peak negative value and again decrease back to zero. This is what the sine wave is representing. Notice, this value changes but the voltage at the outlet is constant, I"ll explain why later in the article.

As a side note, if you use the slow-motion feature on your smart phone, you can see an incandescent lamp flicker because of the AC current. But It"s too fast for the human eye to see. However, most lights are now LED which are usually constant so you probably won"t see those flicker.

The current is flowing back and forth in each phase, we can prove that with this small 3 phase generator and some LED"s. We arrange the LED"s in pairs of opposite polarities, so that only one will illuminate at any time depending on the direction of current in the wire. We can see they are illuminating, and in slow motion we can clearly see the current is alternating direction.

The coils in the generator are placed 120 degrees apart simply because that gives us even spacing of the sine waves that are produced. We can move the coil to any angle, but the sine wave will also move and we won"t have equal spacing.

You can download my excel sheet and see how the angle changes, as well as the instantaneous phase voltages HERE.

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We could add a 4th phase, a 5th phase or 6th phase, but the generator becomes more and more complex and expensive. We also need more cables, more control and protection equipment, complex transmission and distribution infrastructure, more complex transformers and motors etc. It"s then harder to balance the network and it"s very hard to synchronise generators to work together.

So, we instead settled on 3 phase for generators and equipment. Perfect. Oh, but unfortunately each country decided to us a different voltage, frequency and distribution design. Great.

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