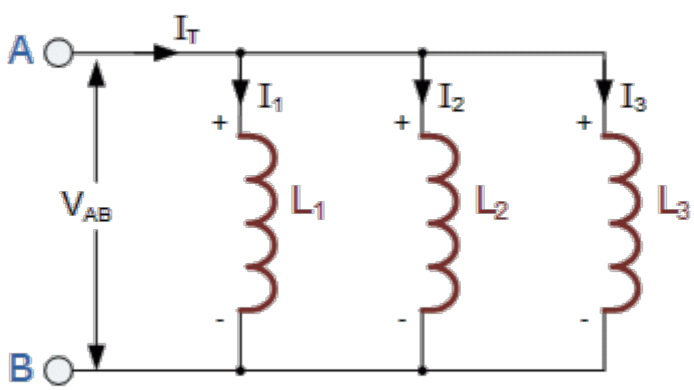


Inductors in Parallel

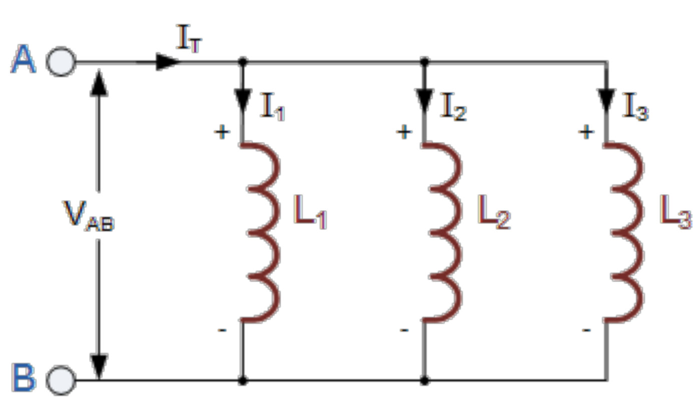
Inductors are said to be connected together in Parallel when both of their terminals are respectively connected to each terminal of another inductor or inductors

The voltage drop across all of the inductors in parallel will be the same. Then, **Inductors in Parallel** have a **Common Voltage** across them and in our example below the voltage across the inductors is given as:

$$V_{L1} = V_{L2} = V_{L3} = V_{AB} \text{ ...etc}$$

In the following circuit the inductors L_1, L_2 and L_3 are all connected together in parallel between the two points A and B.

Inductors in Parallel Circuit



In the previous series inductors tutorial, we saw that the total inductance, L_T of the circuit was equal to the sum of all the individual inductors added together. For inductors in parallel the equivalent circuit inductance L_T is calculated differently.

The sum of the individual currents flowing through each inductor can be found using Kirchoff's Current Law (KCL) where, $I_T = I_1 + I_2 + I_3$ and we know from the previous tutorials on inductance that the self-induced emf across an inductor is given as: V = L di/dt

Then by taking the values of the individual currents flowing through each inductor in our circuit above, and substituting the current i for $i_1 + i_2 + i_3$ the voltage across the parallel combination is given as:

$$V_{AB} = L_T \frac{d}{dt}(i_1 + i_2 + i_3) = L_T\left(\frac{di_1}{dt} + \frac{di_2}{dt} + \frac{di_3}{dt}\right)$$

By substituting di/dt in the above equation with v/L gives:

$$V_{AB} = L_T\left(\frac{V}{L_1} + \frac{V}{L_2} + \frac{V}{L_3}\right)$$

We can reduce it to give a final expression for calculating the total inductance of a circuit when connecting inductors in parallel and this is given as:

Parallel Inductor Equation

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \;\ldots\ldots + \frac{1}{L_N}$$

Here, like the calculations for parallel resistors, the reciprocal (1/Ln) value of the individual inductances are all added together instead of the inductances themselves. But again as with series connected inductances, the above equation only holds true when there is "NO" mutual inductance or magnetic coupling between two or more of the inductors, (they are magnetically isolated from each other). Where there is coupling between coils, the total inductance is also affected by the amount of coupling.

This method of calculation can be used for calculating any number of individual inductances connected together within a single parallel network. If however, there are only two individual inductors in parallel then a much simpler and quicker formula can be used to find the total inductance value, and this is:

$$\boxed{L_T = \frac{L_1 \times L_2}{L_1 + L_2}}$$

One important point to remember about inductors in parallel circuits, the total inductance (L_T) of any two or more inductors connected together in parallel will always be **LESS** than the value of the smallest inductance in the parallel chain.

Inductors in Parallel Example No1

Three inductors of 60mH, 120mH and 75mH respectively, are connected together in a parallel combination with no mutual inductance between them. Calculate the total inductance of the parallel combination in millihenries.

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

$$\therefore L_T = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}} = \frac{1}{\frac{1}{60\text{mH}} + \frac{1}{120\text{mH}} + \frac{1}{75\text{mH}}}$$

$$L_T = \frac{1}{38.333} = 26\text{mH}$$

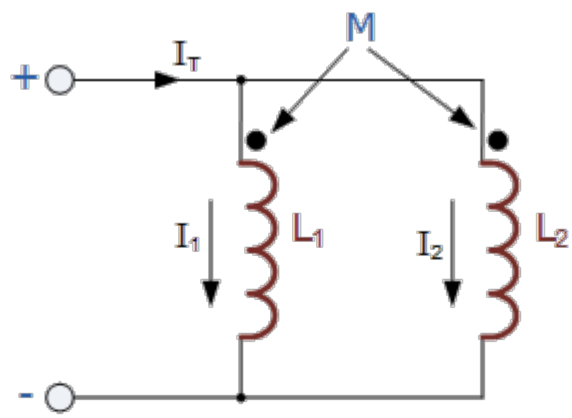
Mutually Coupled Inductors in Parallel

When inductors are connected together in parallel so that the magnetic field of one links with the other, the effect of mutual inductance either increases or decreases the total inductance depending upon the amount of magnetic coupling that exists between the coils. The effect of this mutual inductance depends upon the distance apart of the coils and their orientation to each other.

Mutually connected inductors in parallel can be classed as either “aiding” or “opposing” the total inductance with parallel aiding connected coils increasing the total equivalent inductance and parallel opposing coils decreasing the total equivalent inductance compared to coils that have zero mutual inductance.

Mutual coupled parallel coils can be shown as either connected in an aiding or opposing configuration by the use of polarity dots or polarity markers as shown below.

Parallel Aiding Inductors



The voltage across the two parallel aiding inductors above must be equal since they are in parallel so the two currents, i_1 and i_2 must vary so that the voltage across them stays the same. Then the total inductance, L_T for two parallel aiding inductors is given as:

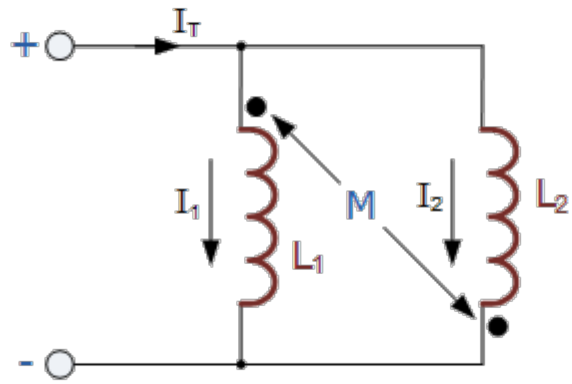
$$L_T = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$

Where: 2M represents the influence of coil L_1 on L_2 and likewise coil L_2 on L_1.

If the two inductances are equal and the magnetic coupling is perfect such as in a toroidal circuit, then the equivalent inductance of the two inductors in parallel is L as $L_T = L_1 = L_2 = M$. However, if the mutual inductance between them is zero, the equivalent inductance would be $L \div 2$ the same as for two self-induced inductors in parallel.

If one of the two coils was reversed with respect to the other, we would then have two parallel opposing inductors and the mutual inductance, M that exists between the two coils will have a cancelling effect on each coil instead of an aiding effect as shown below.

Parallel Opposing Inductors



Then the total inductance, L_T for two parallel opposing inductors is given as:

$$L_T = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$

This time, if the two inductances are equal in value and the magnetic coupling is perfect between them, the equivalent inductance and also the self-induced emf across the inductors will be zero as the two inductors cancel each other out.

This is because as the two currents, i_1 and i_2 flow through each inductor in turn the total mutual flux generated between them is zero because the two flux's produced by each inductor are both equal in magnitude but in opposite directions.

Then the two coils effectively become a short circuit to the flow of current in the circuit so the equivalent inductance, L_T becomes equal to (L ± M) ÷ 2.

Inductors in Parallel Example No2

Two inductors whose self-inductances are of 75mH and 55mH respectively are connected together in parallel aiding. Their mutual inductance is given as 22.5mH. Calculate the total inductance of the parallel combination.

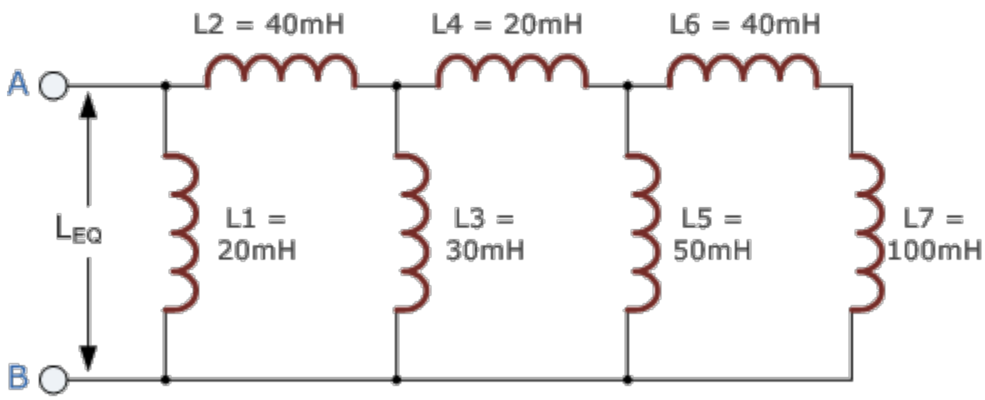
$$L_T = \frac{L_1 \times L_2 - M^2}{L_1 + L_2 - 2M}$$

$$L_T = \frac{75mH \times 55mH - 22.5mH^2}{75mH + 55mH - 2\times 22.5mH}$$

$$L_T = 42.6mH$$

Inductors in Parallel Example No3

Calculate the equivalent inductance of the following inductive circuit.



Calculate the first inductor branch L_A, (Inductor L_5 in parallel with inductors L_6 and L_7)

$$L_A = \frac{L5\times(L6 + L7)}{L5+L6+L7} = \frac{50mH\times(40mH+100mH)}{50mH+40mH+100mH} = 36.8mH$$

Calculate the second inductor branch L_B, (Inductor L_3 in parallel with inductors L_4 and L_A)

$$L_B = \frac{L3\times(L4 + L_A)}{L3+L4+L_A} = \frac{30mH\times(20mH+36.8mH)}{30mH+20mH+36.8mH} = 19.6mH$$

Calculate the equivalent circuit inductance L_{EQ}, (Inductor L_1 in parallel with inductors L_2 and L_B)

$$L_{EQ} = \frac{L1 \times (L2 + L_B)}{L1 + L2 + L_B} = \frac{20mH \times (40mH + 19.6mH)}{20mH + 40mH + 19.6mH} = 15mH$$

Then the equivalent inductance for the above circuit was found to be: 15mH.

Inductors in Parallel Summary

As with the resistor, inductors connected together in parallel have the same voltage, V across them. Also connecting together inductors in parallel decreases the effective inductance of the circuit with the equivalent inductance of "N" inductors connected in parallel being the reciprocal of the sum of the reciprocals of the individual inductances.

As with series connected inductors, mutually connected inductors in parallel are classed as either "aiding" or "opposing" this total inductance depending whether the coils are cumulatively coupled (in the same direction) or differentially coupled (in opposite direction).

Thus far we have examined the inductor as a pure or ideal passive component. In the next tutorial about Inductors, we will look at non-ideal inductors that have real world resistive coils producing the equivalent circuit of an inductor in series with a resistance and examine the time constant of such a circuit.

54 Comments

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SUBMIT

Kamlesh Kumar

How to prove the formula of Total inductance in parallel connection of inductors when the mutual inductance exists?

Posted on September 02nd 2020 | 1:24 pm

Reply

Priyaranjan

Proper explains about inductors....

Posted on June 27th 2020 | 3:15 pm

Reply

Noorullah

Thanks

Posted on June 14th 2020 | 1:43 am

Reply

J

Juan Bautista

How would you find the equivalent inductance that has three inductors in a wye configuration but also have a mutual impedance affecting each other?

Posted on June 04th 2020 | 9:44 pm

Reply

Gilbert Kombe

Please how can this one be solved?
Circuit ABCD is made up as follows:
AB consists of a 10μF capacitor,
BC has three parallel branches, two being 8μF capacitors, whilst the third consists of two 8μFcapacitors in series.
CD consists of a 12μF capacitor shunted by one of 8μF
The circuit is supplied from a dc source of 400V.
Determine;
i). The effective capacitance between A and D
ii). The charge held by and the energy stored in the 12μF capacitor
iii). The potential difference between A and the junction between the series branch capacitors

Posted on May 21st 2020 | 10:18 pm

Reply

Collins

I appreciates your explanation.

Posted on March 26th 2020 | 3:54 am

Reply

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manish

Please tell how to solve equivalent inductance for 3 mutually coupled inductors in parallel

Posted on August 25th 2019 | 10:14 pm

Reply

Akshay Dambare

Bro u got the answer for equivalent inductance when 3 mutually induced are connected in parallel??
Then plz fwd it to me on the following email

Posted on September 09th 2019 | 3:04 pm

Reply

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janardon saikia

thank you

Posted on July 17th 2019 | 4:08 pm

Reply

Hemanth picchukala

what u explained is very nice

Posted on July 16th 2019 | 9:03 am

Reply

Shannu

Good explanation!!!!

Posted on April 16th 2019 | 7:51 am

Reply

Jeslin augustin

Very good

Posted on January 09th 2019 | 10:40 am Reply

Satyam Umarvaishya

its helpful thanks

Posted on December 28th 2018 | 4:45 pm Reply

Sibasish Ghosh

Good

Posted on October 26th 2018 | 4:46 pm Reply

Arjan

Nice , well written pages.
I'm trying to figure out the equations and formulas of the impedance matching autoformer. The circuit looks like example no. 3 with only the source, L6 and L7.L6 and L7 are mutually coupled.

Posted on September 18th 2018 | 10:28 am Reply

Riharika Pathipati

I want to know the derivation of inductor connected in parallel having mutual inductance along with self inductance?

Posted on September 09th 2018 | 3:54 pm Reply

Balu

Nice explanation

Posted on July 20th 2018 | 2:30 am Reply

Upendra

Good explained

Posted on April 11th 2018 | 2:15 am Reply

---

sudhanshu kumar kumar

this is very good

Posted on February 17th 2018 | 10:28 am Reply

Jayram yadav

very useful site........

Posted on November 01st 2017 | 9:24 am Reply

Ulyses

The formula of Inductance on parallel circuit are same as resistor in parallel circuit formula

Posted on October 15th 2017 | 1:03 pm

Reply

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