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| **[Electronics Fundamentals: Transformer](http://www.jameco.com/Jameco/workshop/learning-center/transformer.html)**  **[Building a Transformer](http://www.jameco.com/Jameco/workshop/learning-center/transformer.html" \l "anchor1)** |  |

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| **Background Theory:  What Does a Transformer Do?**  How does electricity get generated in massive amounts from huge nuclear power plants (or wind generator farms, solar fields, etc.) and then travel into your living room outlet at the correct voltage to power your TV so you can catch the latest episode of *Wheel of Fortune?*  A **transformer** is a device that adjusts AC voltage levels, which makes it economically possible to transmit and distribute electricity to greater distances more efficiently and cost-effective.   The transformer is considered by many as one of the most fundamental electrical components to play a key role in today's society. Without it, we probably would not be able to provide [electricity](http://www.amazon.com/gp/search/ref=as_li_qf_sp_sr_tl?ie=UTF8&camp=1789&creative=9325&index=aps&keywords=electricity%20books&linkCode=ur2&tag=jameco0b-20) to as many homes and offices as we do today, nor would we be able to provide it to the more rural areas in the world.   You would think that technology this important to our every day lives would have a complicated structure, but when you break it down, the transformer is only a few basic parts with a wide range of theoretical possibilities.   **Transformer Structure**   *The Core*  The core of the transformer is a metal structure that gets wrapped around with coils of insulated wire and allows magnetic flux to flow. The core is typically made from iron or steel and can be made in a number of configurations: square-shaped, toroidal-shaped, E-shaped, solid-cored, air-cored and even steel-laminate-cored. A gap in the core may also be used in order to limit the amount of short-circuit current. Each combination has its own properties in minimizing losses or being most efficient when used in high frequency, depending on the application. |  |  |

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| [[Ferrite E Core](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2160665&catalogId=10001)*Ferrite E Core*](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2160665&catalogId=10001) |  | Square-Magnetic Core of a Transformer*Square-Magnetic Core of a Transformer* |

*The Windings*  
  
The input and output voltages/currents of the transformer depend on the number of windings of wire known as the "turns ratio." There is a primary side and a secondary side, and the number of windings on each side represents the ratio directly proportional to the voltage ratio. The two sides are affected by one another through the **induction property** and the magnetic flux that flows through the transformer core. 

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| To calculate the turns ratio, use the following formula: |  | Formula |

Where

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|  | |  |  |  | | --- | --- | --- | | VP | = | Voltage on primary side | | VS | = | Voltage on secondary side | | IP | = | Current on primary side | | IS | = | Current on secondary side | | NP | = | Number of windings on primary side | | NS | = | Number of windings on secondary side | | a | = | Turns ratio | |

As you can see, the primary and secondary voltages are directly proportional to the number of turns on the primary and secondary side, respectively, but inversely proportional to the primary and secondary currents.   
  
**The Project**  
  
This [DIY Transformer Kit](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2160681&catalogId=10001) provides some great hands-on experience with winding your own transformer and calculating different turns ratios.   
  
***Warning: If you are unsure of the dangers involved with your particular project, consult with someone who is experienced before beginning your project.***   
  
   
  
*Rob Urbanovich demonstrates how to wind your own transformer in his YouTube video.*   
  
**Kit includes:** 

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| **Qty.** | **Description** | **Manufacturer Part Number** |
| 2 | [Magnet Wire 26 AWG](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2119347&catalogId=10001) | [26PE](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2119347&catalogId=10001) |
| 1 | [Magnet Wire 20 AWG](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2098398&catalogId=10001) | [20PE](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2098398&catalogId=10001) |
| 1 | [Transformer Bobbin Horizontal Mount](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2160657&catalogId=10001) | [BER35AHP16T](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2160657&catalogId=10001) |
| 2 | [Ferrite E Core (Ungapped)](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2160665&catalogId=10001) | [PC40HEER35-Z](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2160665&catalogId=10001) |
| 1 | Instructions |  |

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| **You will need:**  • [Soldering iron](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&categoryName=cat_6020&subCategoryName=Test%2C%20Tools%20%26%20Supplies%20%2F%20Soldering%20Equipment%20%2F%20Irons&category=602040&refine=1&po) • [Solder](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&categoryName=cat_6020&subCategoryName=Test%2C%20Tools%20%26%20Supplies%20%2F%20Soldering%20Equipment%20%2F%20Solder&category=602050&refine=1&p) • [Calculator](http://www.amazon.com/gp/search/ref=as_li_qf_sp_sr_tl?ie=UTF8&camp=1789&creative=9325&index=aps&keywords=scientific%20calculator&linkCode=ur2&tag=jameco0b-20) • [Electrical tape](http://www.jameco.com/webapp/wcs/stores/servlet/JamecoSearch?langId=-1&storeId=10001&catalogId=10001&categoryName=cat_6035&subCategoryName=Test%2C%20Tools%20%26%20Supplies%20%2F%20Tape%2CMastics%20%2F%20Adhesive%20Products&category=603510&refi) • [AC to AC power source](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=100061&catalogId=10001) |  | Ferrite E Core |

**Directions:** 

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| 1. Start by calculating the turns ratio using the formula: |  | Formula |

2. Winding a transformer a few hundred times will take a while, so make sure you have the time to do it in one sitting and are able to focus on the count at the same time. In this lesson, we will use the example of making a step-up transformer and increasing the output of the transformer to double the input.   
  
3. Take one end of the thinner wire (26 AWG) and solder it to a connector pin on the corner of the bobbin.   
  
4. Wind the secondary side with your calculated number of turns. In our example, we will wind 800 turns. Try to wind it relatively tight and evenly throughout that side of the core.   
  
5. Once the 800 turns have completed, solder the end to the other corner connector pin on the transformer bobbin. It is a good idea to use the pin next to the previous one so it's easier for you to track.   
  
6. Using the thicker wire (20 AWG), solder one end to the third corner of the bobbin.   
  
7. Wind the primary side with half the number of turns as the secondary side. In our example, this will be 400 turns. Again, try to wind it relatively tight and evenly throughout the side of the core.   
  
8. After soldering the end of the wire to the last corner of the bobbin, wrap everything in electrical tape to protect it from the environment and ensure there are no opportunities for accidental short circuits.   
  
9. Snap each E-core piece onto the bobbin with the center of the "E" going through the core of the bobbin.   
  
***Note:****You have the option of adding an additional center tap by soldering a wire onto the iron core itself to create a more advanced transformer.*   
  
10. You will notice that only four pins have been used. This is mainly for safety and simplicity. Following our example, you can add an AC voltage to the primary side to double its voltage across the secondary side. Remember to measure it with a multimeter before using it in any applications.   
  
Your project is complete – congratulations!   
  
**Discussion Questions**   
  
1. When does **maximum power transfer** happen from the source to the load?  
2. What will increasing the number of turns of wire on the secondary side of a transformer do?  
3. What will be the result of a 100:200 winding transformer compared to a 400:800 winding transformer?  
4. What is the purpose of a center-tapped transformer?   
  
[Click here to build your own transformer kit](http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&productId=2160681&catalogId=10001).   
  
Reference   
  
<http://edisontechcenter.org/Transformers.html>