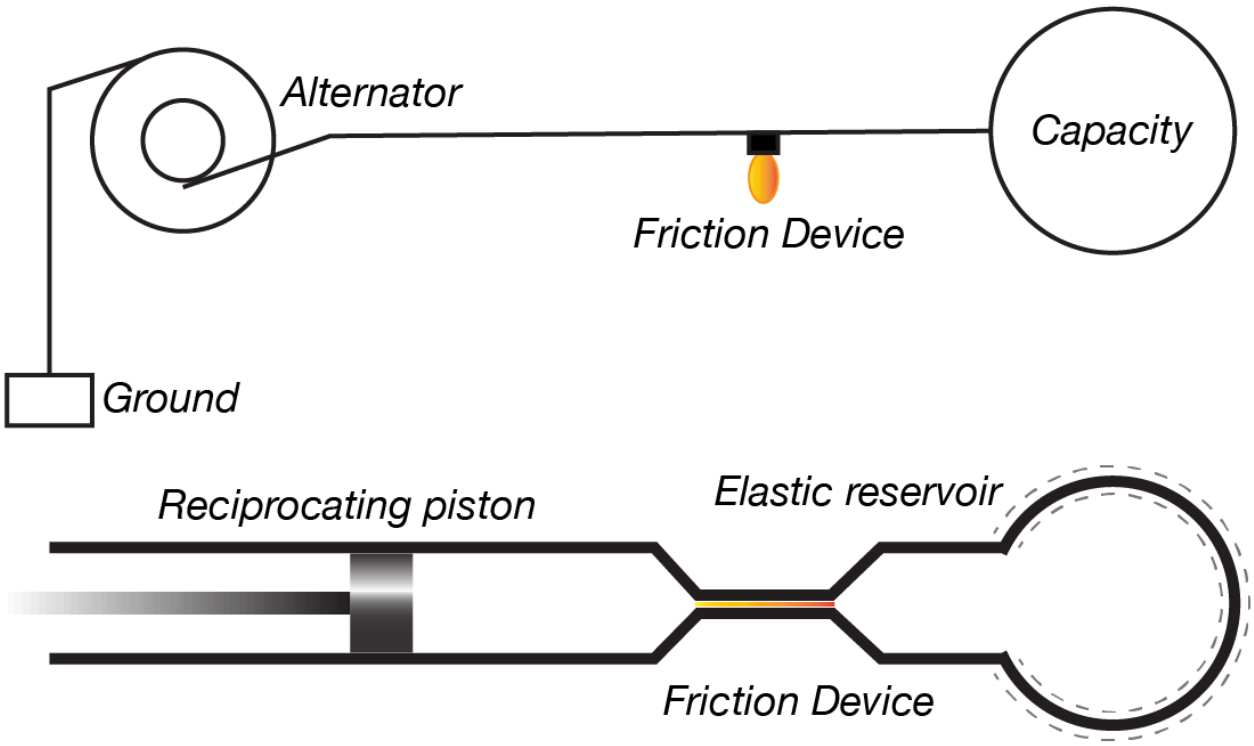
Nick Kraakman (https://waveguide.blog/author/nick-kraakman/) July 11, 2019

4 Methods for Single Wire Power Transmission



Today's 3-phase power grid uses 3 or 4 wires to transmit electrical energy. This article describes 4 innovative methods, some over 100 years old, which use only a single wire to transmit the same amount of power or more, without a return wire!

These methods hold the promise to drastically reduce costs and lower line losses, and imply that our Electrical Engineering textbooks might be due for an update.

In order of increasing exoticness, these are the methods we will cover in this article:

1. Single-Wire Earth Return (SWER)
2. B-Line *or* Single Line Electricity (SLE)
3. Tesla's Single Wire Transmission Without Return
4. Avramenko / Strebkov Single-Wire Electric Power System (SWEPS)

Before we dive in, let's take a quick look at what makes our current power transmission system less than ideal.

3-Phase: why we use it, and why it is flawed

The 3-phase system has been used to transmit power for more than 120 years now, and hasn't changed much since. So why use 3-phase? There are a few good reasons:

1. A minimum of 3-phases are required to establish a smooth rotating magnetic field, which is needed to achieve optimal torque in electric motors. Nikola Tesla (https://waveguide.blog/glossary/nikola-tesla/), who played a key role in designing our current power system, invented the AC induction motor [1], and was therefore a strong proponent of a 3-phase system.

2. Another major benefit of 3 phases is that since each phase is 120° apart, they add up to zero at each point in time. This is why we can transmit 3-phases without needing 3 return wires as well. *As long as the loads are balanced between phases*, we can combine the returning currents into one, which then cancel each other out, mitigating the need for a return wire, or using only a single, relatively small return wire if the phases aren't perfectly balanced.

If you want a more entertaining explanation, see the video below.

Why 3 Phase AC instead of Single Phase???
ElectroBOOM

It's a pretty nifty system. However, there are several major downsides as well:

- 3 or 4 wires are needed for power transmission
- Large support towers for the wires
- Very expensive to place underground, since wires need to be spaced sufficiently far apart
- Significant energy losses

- Constant reactive power compensation needed
- Complex load balancing
- Risk of phase-to-phase faults due to wind

So is there no better way? Back in the day, not really. AC was chosen over DC mainly because transformers could be used to easily step-up and step-down the currents.

This was needed because transmission losses are smaller at higher voltages, but you can't push hundreds of kilovolt into someone's household appliances, so conversion was needed.

Thanks to solid-state technology, this is now also possible for DC, albeit at much greater costs and lower reliability, which is why High-Voltage DC (HVDC) (https://en.wikipedia.org/wiki/High-voltage_direct_current) lines are currently mainly used for very large distances or to connect two AC systems, even though HVDC promises to reduce line losses and requires less conductors than a 3-phase AC system.

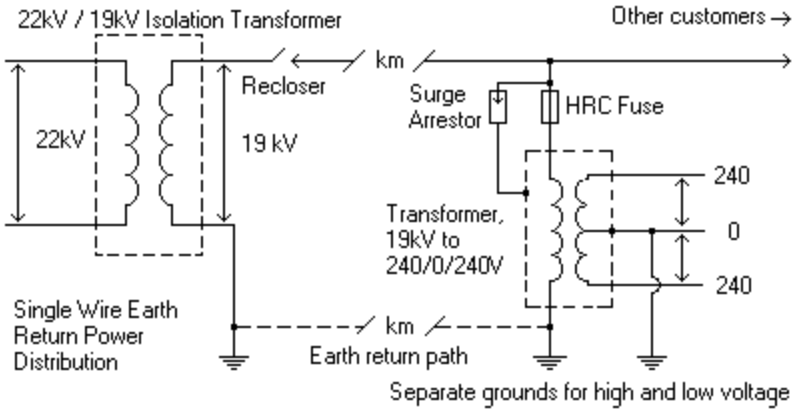
What follows are 4 alternative systems that only need *a single conductor* to transmit power, and which solve most, if not all, of the above mentioned issues.

Since many people will say outright that single wire power transmission is impossible, I will try to offer as much credible evidence as I can, and will make it clear how these results can be replicated for easy verification.

Single-Wire Earth Return (SWER)

The first system we'll describe, SWER, is also the only one in the list that is currently in active service.

This system, which supplies single-phase power over one conductor while using the earth (or the ocean) as a return path, was developed around 1925 in New Zealand for the economical electrification of thinly populated rural areas. Today SWER is actively used in New Zealand, Australia, Alaska, Canada, Brazil, and Africa, as well as in HVDC submarine power cables [2].



SWER circuit diagram

Interactive SWER circuit diagram. Click on the open switches to close them and see the current flowing through the circuit.

The main benefit of this system is its affordability, since SWER only uses one instead of two conductors, and because current drawn by these rural customers is relatively small, thinner cables, and therefore fewer and smaller poles can be used to hold the cable up.

19kV Single-Wire Earth Return wire in Australia

The downside is that these lines are not very efficient, and they often experience significant voltage drops. However, the main issue is that currents of up to 8 amps can flow through the ground near the earth points, so there is a danger of shocking people and animals if the earth connection is faulty.

And while SWER systems are great to economically transmit relatively small amounts of power to thinly populated areas, they cannot be used to provide cities and industry of power, so their use case is fairly limited.

The next single-wire power transmission method we will discuss solves some of the problems inherent to SWER, and does away with the need for a return current through the ground altogether.

B-Line *or* Single Line Electricity (SLE)

Professor Michael Bank from the Jerusalem College of Technology devised a highly interesting way to enable single-wire power transmission by creating equal phase currents in the live wire and the

return wire, which then allows these wires to be combined into one [3].

His system, which he calls a B-Line, achieves this by using a 180° phase shifter after the source, combining the two wires into one transmission line, and then transforming this back to a regular two wire current before the load by using another 180° phase shifter. Both load and generator won't "see" the difference!

The phase shift is achieved by using a reverse connected 1:1 transformer, and for higher frequencies a half period delay line (https://en.wikipedia.org/wiki/Analog_delay_line) could be used. The following interactive circuit diagram should make this idea more clear.

Interactive B-Line circuit diagram

If you look at the current graph in the interactive circuit above, you'll see that the current in the single-wire transmission line is *twice* that of the source, because the two wires are combined into one.

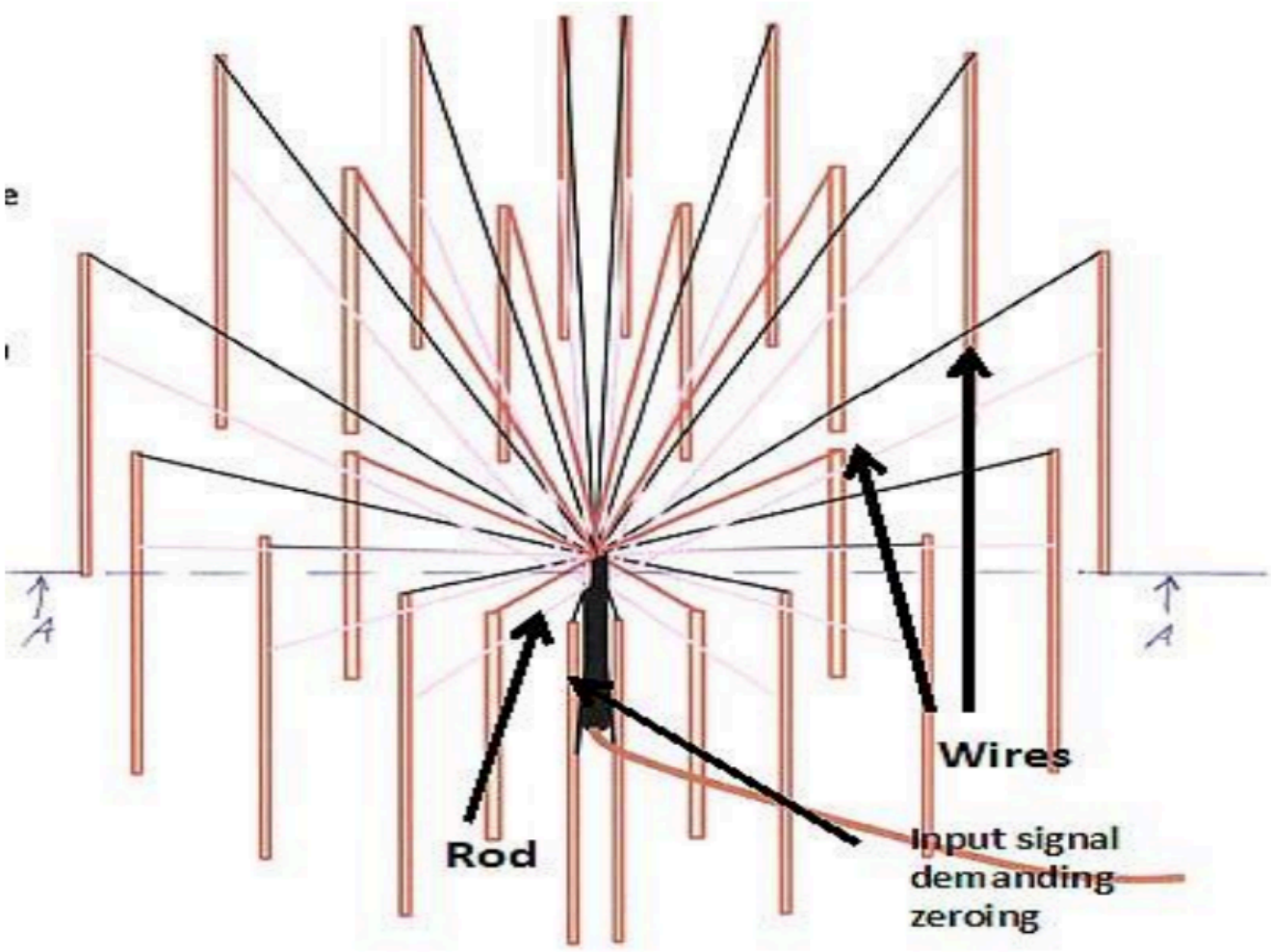
This means that to transmit the same amount of power, the single transmission line needs to have *half* the resistance, hence a more expensive wire is needed, but at least you'll only need one!

A major benefit of the B-Line over a SWER system is that *the B-Line does not use the ground as a return circuit!*

Yes, it seems in the animation above that the ground is involved, but since the current in the single transmission line is doubled in this system, and the current between source and load adheres to Ohm's law, no other current can exist! Ground current does not exist here, since it is all kept inside the circuit.

Professor Bank ran two experiments to further prove that ground is not involved in this circuit.

1. He used a 300 kHz signal, which then allowed him to replace the *grounded* inverter coil by a 500m long, half period delay line *without a connection to the ground*. The system still functioned as before.
2. In the chapter *Zeroing without the current injection into the ground*, Bank describes a device which he calls a "nullifier" which offers an adequate zero-voltage reference level, and can therefore replace a ground connection. His transmission system still worked when the ground connection was replaced with a nullifier, further proving that no current flows through the ground in this circuit.



Nullifier as designed by Professor Michael Bank, which offers a zero-voltage reference level adequate to zero a current. It is an aerial consisting of a considerable quantity of monopoles, with length much smaller than a quarter of a wavelength.

Bank mentions that the downside of using his system is that his single wire creates a stronger EM field than a 3-phase system, which offers compensating polarity, and so has a larger effect on humans. This downside is countered by the fact that a single conductor requires way less space, and is therefore much cheaper to place underground where is can't harm humans.

The delay line also needs to be adjusted when the frequency changes to keep the phase shift equal to 180°. However, the major drawback of this system seems to be the fact that double the current needs to be transferred over a single conductor, creating larger transmission losses

due to heat dissipation (I (https://uk.farnell.com/i2r-loss-definition)**2 (https://uk.farnell.com/i2r-loss-definition)**R losses (https://uk.farnell.com/i2r-loss-definition)), unless more expensive, lower resistance cables are employed.

The next system, which is very easy to replicate, solves the high-current problem of the B-Line, and is the first in the list that seems to defy explanation by today's Electrical Engineering models.

Tesla's Single Wire Transmission Without Return

> *"I had already proved in my lecture at Columbia College that I could transmit energy through one wire"* [4]

All the way back in 1891, during a lecture at Columbia College in front of the American Institute of Electrical Engineers, Nikola Tesla was the first to demonstrate definitively that electrical energy can be transmitted through a single wire without a return, and be used to power loads, like incandescent lamps.

> *"In several demonstrative lectures before scientific societies... I showed that it was not necessary to use two wires in transmitting electrical energy, but that one only might be employed equally well."* [5]

In its most basic form, Tesla's single wire system is simply a grounded alternator with the other terminal connected to a capacitance, like a large metallic object. Tesla explains the workings of this system using

an illuminating analog in his article “The True Wireless”.

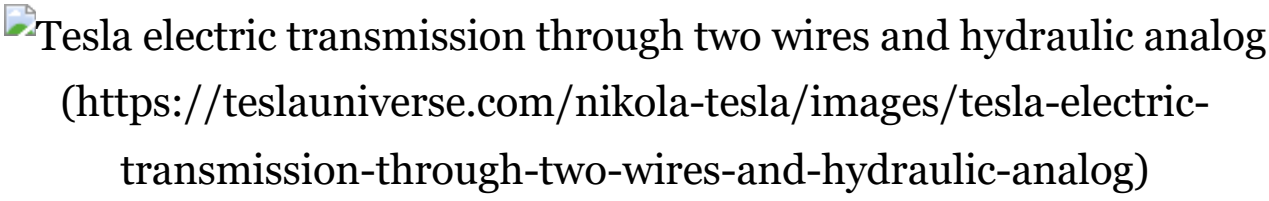


Fig. 3. — Electric Transmission Thru Two Wires and Hydraulic Analog.

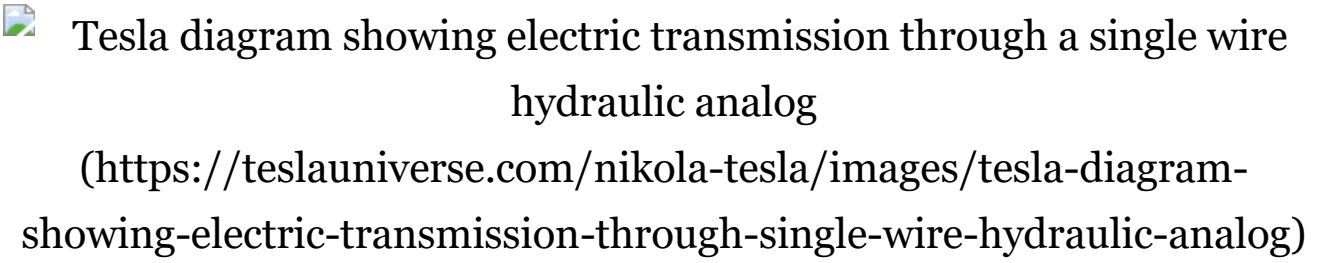
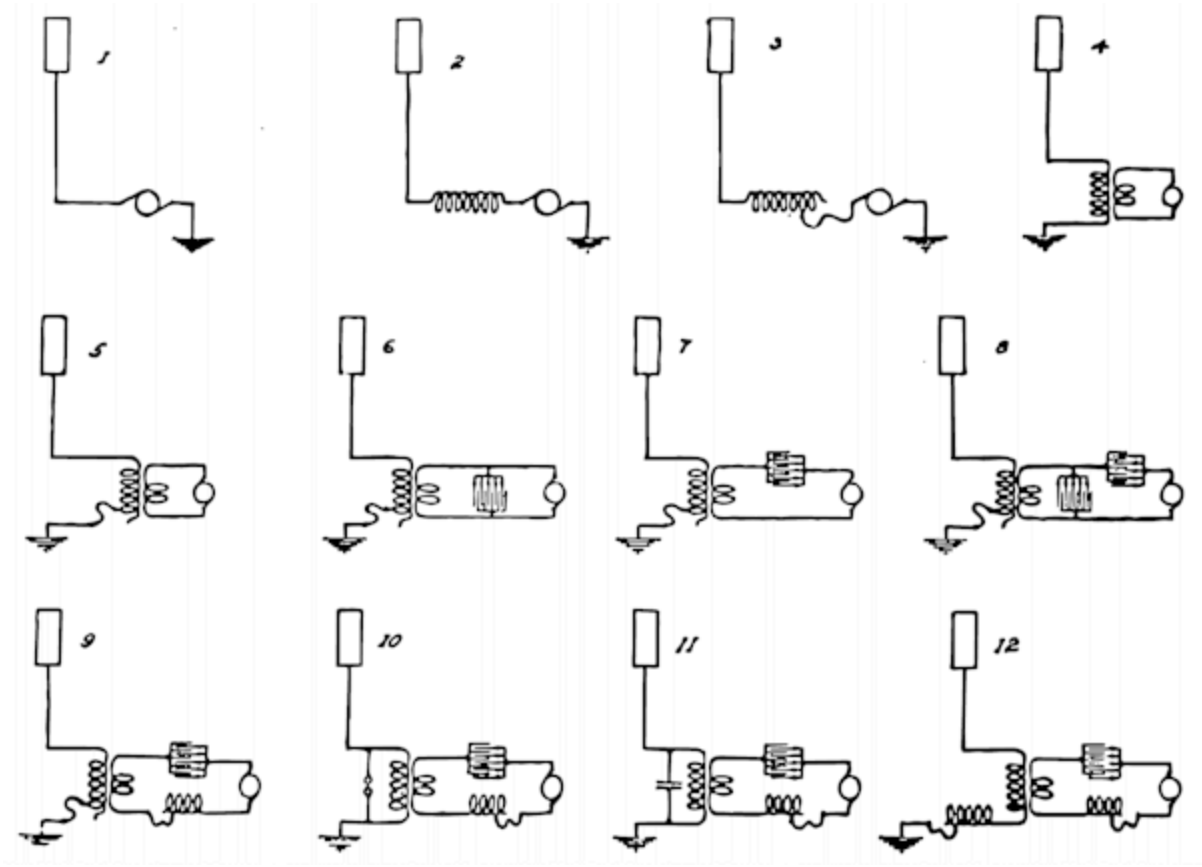


Fig. 4. — Electric Transmission Thru a Single Wire Hydraulic Analog.

> *"The operation of devices thru a single wire without return was puzzling at first because of its novelty, but can be readily explained by suitable analogs. For this purpose reference is made to Figs. 3 and 4.*
>
> *In the former the low resistance electrical conductors are represented by pipes of large section, the alternator by an oscillating piston and the filament of an incandescent lamp by a minute channel connecting the pipes. It will be clear from a glance at the diagram that very slight excursions of the piston would cause the fluid to rush with high velocity thru the small channel and that virtually all the energy of movement would be transformed into heat by friction, similarly to that of the electric current in the lamp filament.*
>
> *The second diagram will now be self-explanatory. Corresponding to the terminal capacity of the electric system an elastic reservoir is employed which dispenses with the necessity of a return pipe. As the piston oscillates the bag expands and contracts, and the fluid is made to surge thru the restricted passage with great speed, this resulting in the generation of heat as in the incandescent lamp. Theoretically considered, the efficiency of conversion of energy should be the same in both cases."* [6]

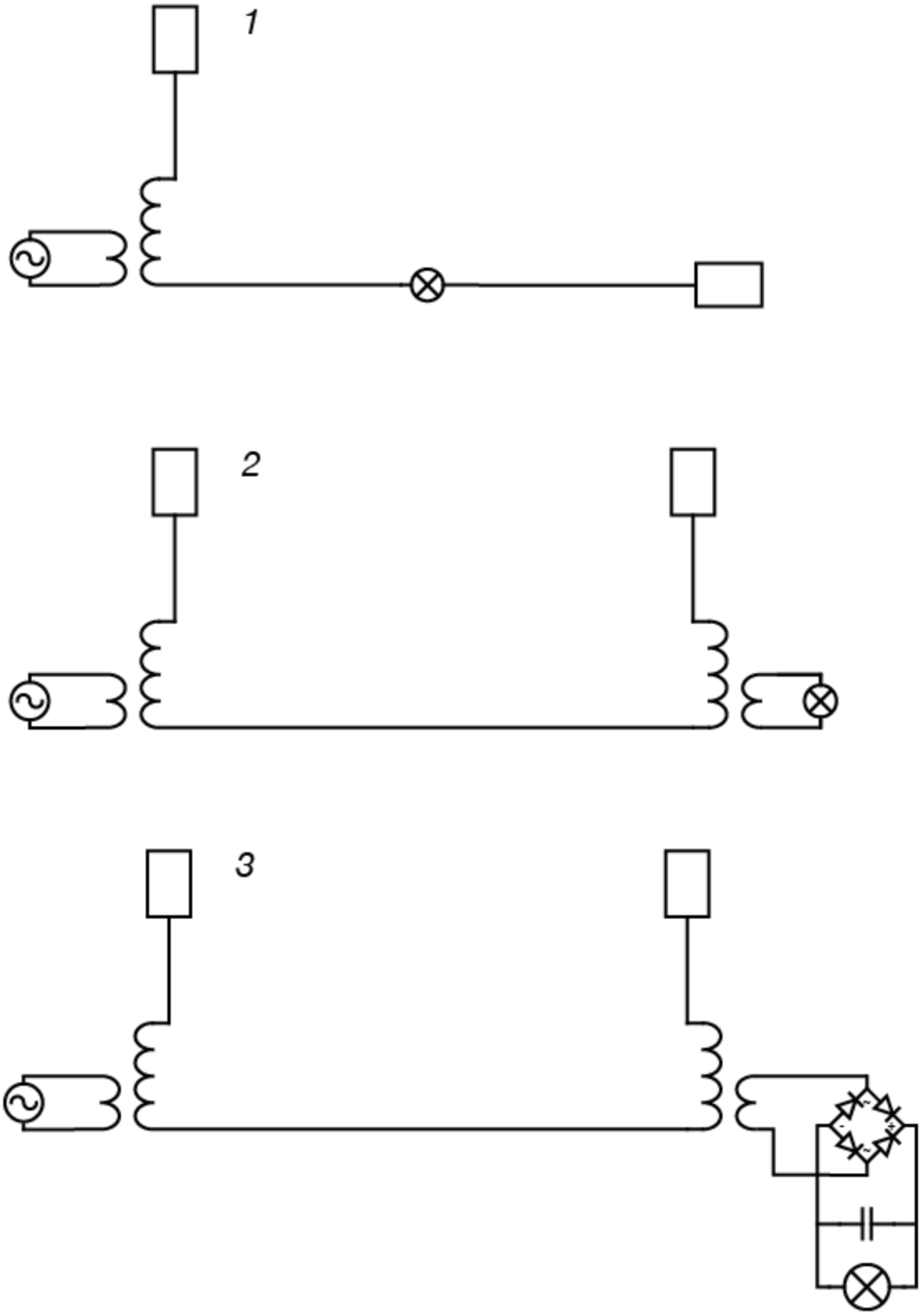
This basic single wire system was further perfected by Tesla over the years, culminating in the development of Tesla's Magnifying Transmitter (https://waveguide.blog/history-tesla-coil-geometries/#magnifying-transmitter), which would use the entire globe as the "wire". In the image below, Tesla shows us the evolution of his device.



Evolution of Nikola Tesla's single wire system [7]

First an inductor is added (2), then this inductor becomes a variable inductor (3), and then a step-up transformer is introduced (4), effectively creating the famous Tesla Coil (https://waveguide.blog/glossary/tesla-coil/) setup. This is then further perfected to generate the highest possible efficiency and voltage by using tuned circuits and resonance.

Tesla planned to transmit large amounts of power through the earth, essentially removing the need for transmission lines altogether. However, in the core it is still a single wire transmission system, and instead of the earth, you can use two tuned Tesla coils connected by a single wire to transmit electrical energy the way Tesla originally intended.



Three ways to power loads from a single wire transmission line coming off of a Tesla Coil

The diagrams above show the following:

1. High-voltage, high-frequency loads can be directly powered from the single wire transmission line, as long as a capacitance is present

at the end of the line
2. A second Tesla Coil acts as a receiver and steps down the voltage of the transmission line to power low-voltage, high-frequency loads
3. After step-down, the high-frequency electricity is rectified using a full-wave bridge rectifier with smoothing capacitor (https://waveguide.blog/glossary/capacitor/) to power low-voltage DC loads

As you can see, Tesla's transmission system is highly versatile, and capable of powering a wide variety of loads from a single wire. Unfortunately, it was never taken into service, because Tesla put all his efforts into his "wireless" power transmission through the earth.

It is crazy to think that Tesla already called the "necessity of a return circuit for the conveyance of electrical energy in any considerable amount" an "old notion" back in 1898! [8] That's why I was elated to find that a group of Russian scientists is finally pushing this technology forward and is actually integrating it into the power grid. On top of that, they found that these single wire currents posses some curious properties...

Avramenko / Strebkov Single-Wire Electric Power System (SWEPS)

In 1993, the Russian duo Stanislav and Konstantin Avramenko filed for a patent titled "*Method and Apparatus for Single Line Electrical Transmission*" [9], which was granted to them on August 15, 2000.

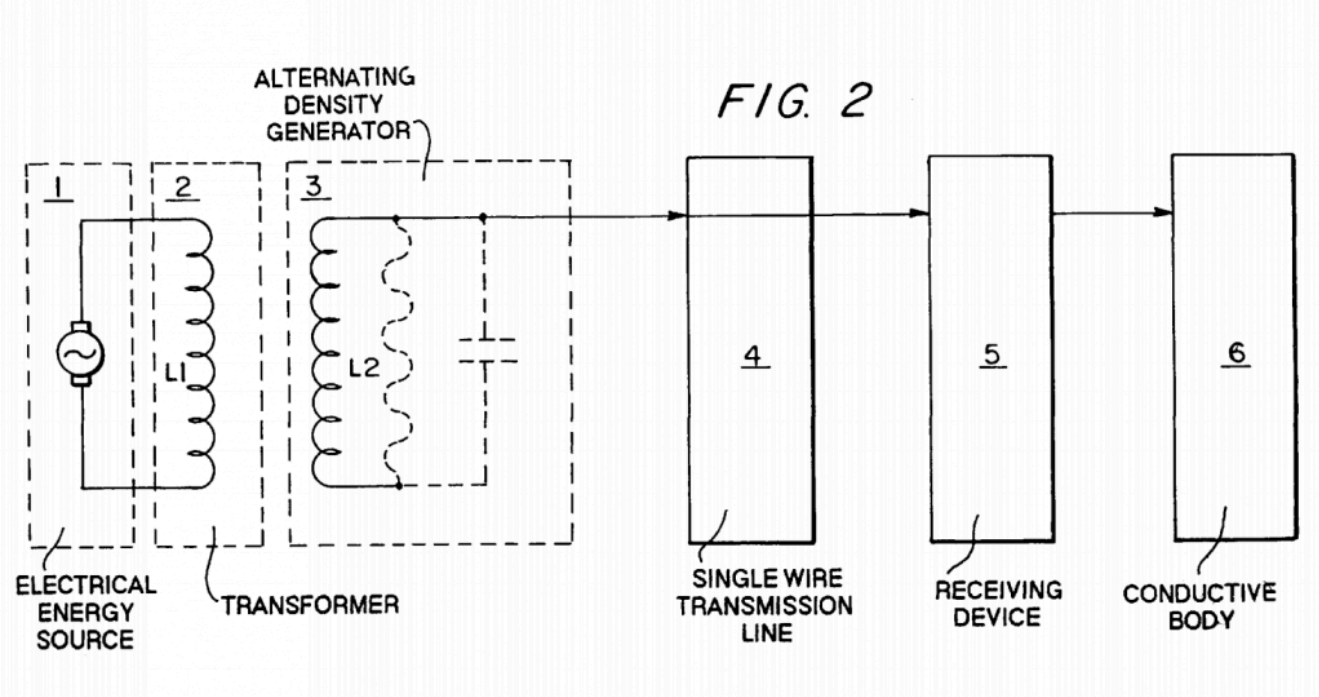
I'll let the authors describe the function of the apparatus described in the patent.

> *"Transformation of electrical energy… into the energy of oscillation of a field of free electrical charges such as the displacement current or longitudinal wave of an electric field, the density of which varies in time, and the transmission of the energy via a transmission line which does not form a closed circuit comprising a single-wire transmission line and, where necessary, its transformation into the electromagnetic energy of conduction currents."*

That snippet might need some explanation.

Essentially, Avramenko is saying that their apparatus transforms a regular conduction current into an oscillating electric field. This oscillating electric field is what is then transmitted along a single conductor transmission line, and finally at the end of the line transformed once more back into a regular conduction current.

They refer to their transformer as a "alternating density generator", since it creates a wave by varying the density of the electric field, or a "monovibrator", since only a single terminal is connected to the line.



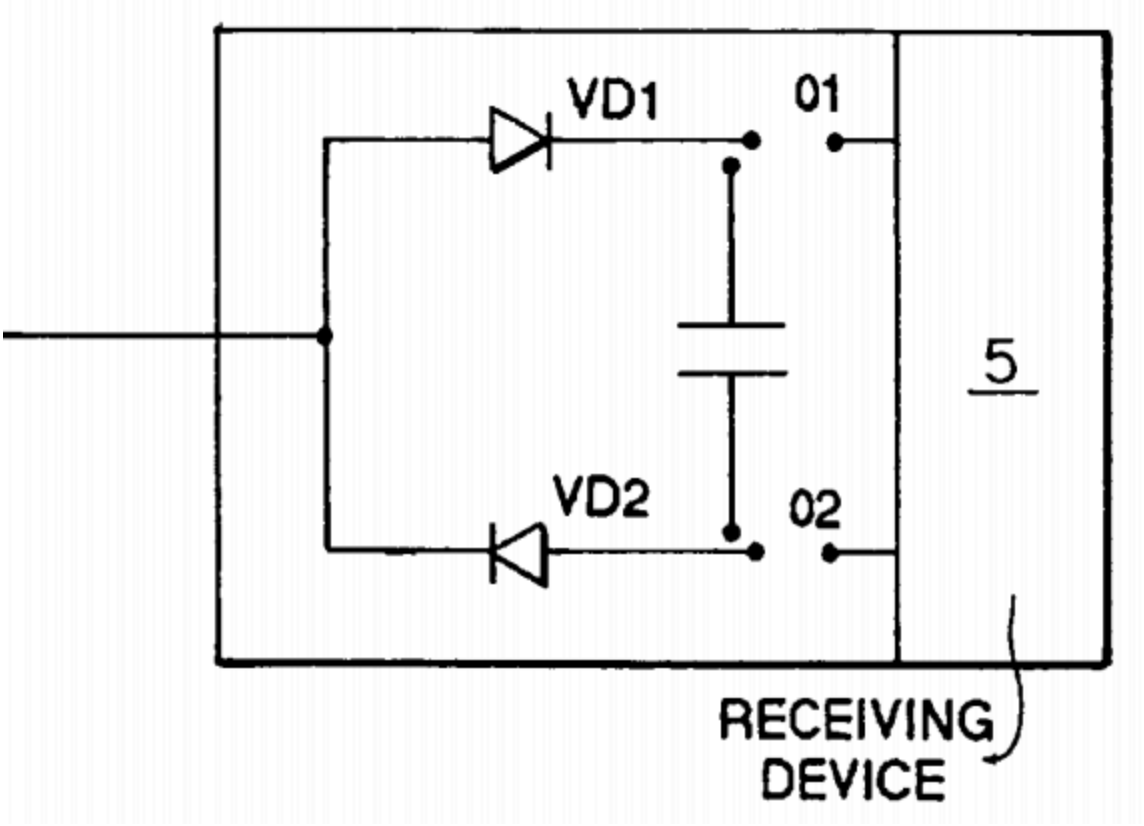
Avramenko's Alternating Density Generator is simply a secondary coil with one terminal disconnected, or alternatively connected to the other terminal with or without a series capacitance.

In the end though, any ol' transformer can be used, "with or without a ferromagnetic core", as long as only one terminal of the secondary is connected to the transmission line, although the authors recommend that for the best efficiency tuned transmitter and receiver coils should be used, in other words: Tesla Coils.

So far, the devices in the Avramenko patent are identical to Nikola Tesla's, apart from the fact that they were given a different name. The fact that they describe what they believe is the nature of the single wire current is something that is valuable though.

Avramenko Diode Plug

Besides transformer coils, one unique apparatus is introduced to transform the single wire current into a regular conduction current: the Avramenko diode plug.



Avramenko's diode plug can power a load with regular pulsed DC, directly from a single wire line

This device is really nothing more than a half-wave rectifier setup with the input terminals of the two diodes connected to the single wire transmission line, but it enables some thought-provoking results.

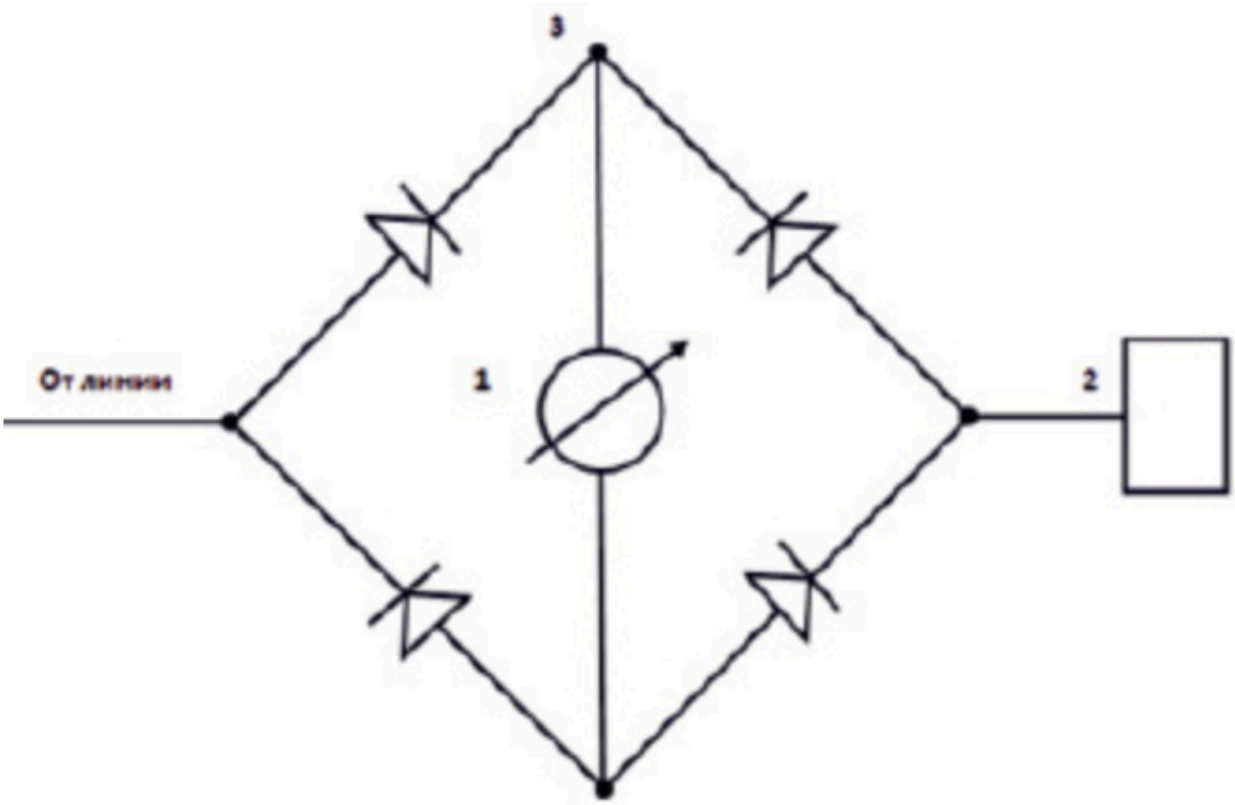
For example, when traditional magnetoelectric or thermoelectric milliammeter are used on the single-wire line, no current is measured, but when these same meters are connected to the Avramenko plug circuit, current *is* measured [10]

Also, placing a 10 kΩ resistor, a capacitor, or an inductor in series with the single wire line, does not affect the current measured in the Avramenko plug circuit at the end of the line! [11] The single wire current seems to completely "ignore" those components, hinting at **superconductive properties**! They do *not* seem to adhere to Ohm's Law or Kirchoff's Laws.

Knowing this, the following claim from the Avramenko patent makes sense.

> *"The invention will make possible a sharp reduction in the costs involved in transmitting electrical energy over long distances, and a sharp reduction in the losses of Joulean heat from transmission lines."*

These results substantiate Avramenko's claim that the single wire currents, which he and his colleagues Zaev and Lisin call "polarization currents" in their 2012 paper, differ fundamentally from conduction currents, and that they are longitudinal rather than transverse in nature.



Improved Avramenko plug, with a full-wave bridge rectifier setup, a capacitance connected to the end of it, and a magnetoelectric milliammeter connected across, as suggested by Kasyanov (2015)

Other authors come to the same conclusions, but also mention that the Avramenko plug's efficiency can be improved by using a full-wave bridge rectifier setup [12] [13].

Implementation into the Russian power grid

The overwhelming experimental evidence suggests that single wire power transmission is possible and is much cheaper and more efficient than our ancient 3-phase power grid, because it uses less wires of smaller diameter, therefore less poles will be needed, smaller transformers can be used due to the higher frequency, less energy is lost during transmission, transmission distance and capacity are increased, and the danger of short-circuits is removed.

And while Western scientists still scoff at the feasibility of single wire currents, the Russian government has been funding research into this field for years now, with the goal to seriously upgrade over 1 *million* kilometers of outdated overhead transmission lines in the coming 15 years [14]

In a 2018 paper, the Federal Scientific Agroengineering Center VIM of Russia proposes to use this technology to enable…

> *"Direct solar energy conversion and transcontinental terawatt power transmission with the use of resonant wave-guide technology developed by N. Tesla"* [15]

Besides worldwide power transmission, the paper continues to describe other applications of Tesla's technology, some of which have already been patented by the authors, including:

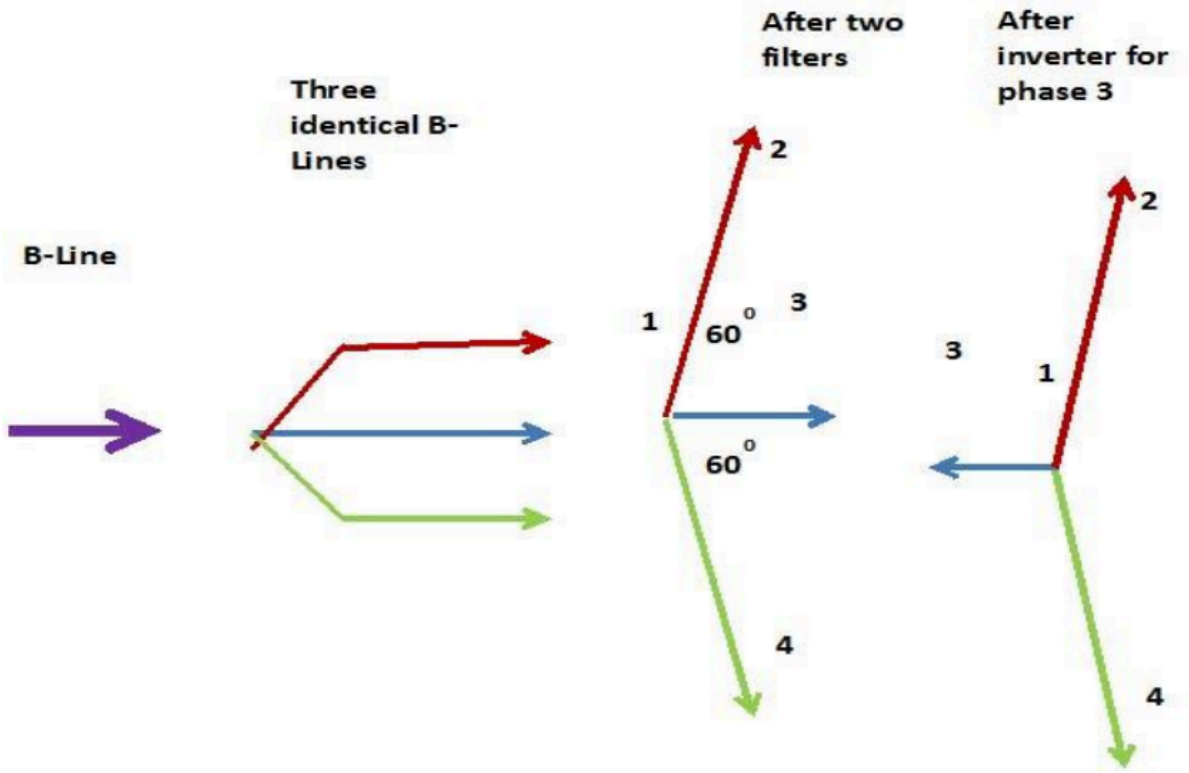
- Electric rockets
- Chlorine-free ways to build solar cells
- 10x lower electrolysis costs, to make hydrogen
- Batteryless electric cars
- Contactless power for trains
- Underground cables to replace the overhead ones

If the US and Europe want to stay competitive, it seems high time to start taking this revolutionary technology seriously, and to start pouring some serious R&D power into its development.

What about 3-phase motors?!

After reading this article, I hope the viability and revolutionary nature of single wire power transmission has become apparent. However, only 1 phase can be transmitted over a single wire, which is fine for most residential customers, but we learned in the beginning that 3-phase power is needed to run industrial motors…

Luckily there are several solutions to create 3-phase power from a single phase line.



Creating 3-phase power from a single wire line, as proposed by Michael Bank

1. TRiiiON (https://www.triiion.com/) offers plug & play 3-phase power solutions
2. The inventor of the B-Line mentioned in this article also offers a solution: split the single wire line into three lines at the customer end, then use simple L & C filters to shift 2 phases by 60° and 1 phase by 180° using an inverter coil, resulting in a 3-phase current [16]

Closing thoughts

This article described 4 methods to transmit electrical power over a single wire, without a return.

It turns out that the effect is ridiculously easy to replicate: take any transformer and only use one terminal of the secondary. That's it! You can then further increase transmission efficiency by running the transformer at its resonant frequency.

With replication being so incredibly simple, and the potential for room-temperature superconductivity being so blatantly obvious, it honestly baffles me that this technology is not pursued at full force by researchers around the world. It seems only Russia is taking this seriously.

I urge everyone who reads this to start experimenting and finding ways to get this technology out there. My guess is that it will not be accepted until a fully developed product or method is made available that saves businesses or consumers so much money that they will almost be forced to adopt it.

If you know any methods to achieve single wire power transmission that were not mentioned in this article, please share in the comments!

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Footnotes

1. Tesla, N. (1888). *Tesla Patent 381,968: Electro-Magnetic Motor*. Retrieved from https://teslauniverse.com/nikola-tesla/patents/us-patent-381968-electro-magnetic-motor
2. https://en.wikipedia.org/wiki/Single-wire_earth_return (https://en.wikipedia.org/wiki/Single-wire_earth_return)
3. Bank, M. (2016). *It's Quite Another Electricity*. Retrieved from: https://www.ofdma-manfred.com/wp-content/uploads/2019/05/M.-Banks-book-last.pdf (https://www.ofdma-manfred.com/wp-content/uploads/2019/05/M.-Banks-book-last.pdf)
4. Tesla, N. (1916). *Nikola Tesla on his work with alternating currents and their application to wireless telegraphy, telephony and transmission of power: an extended interview*. Retrieved from https://www.tfcbooks.com/tesla/nt_on_ac.htm
5. Tesla, N. (1927). *World System of Wireless Transmission of Energy*. Retrieved from: https://teslauniverse.com/nikola-tesla/articles/world-system-wireless-transmission-energy (https://teslauniverse.com/nikola-tesla/articles/world-system-wireless-transmission-energy)
6. Tesla, N. (1919). *The True Wireless*. The Electrical Experimenter. Retrieved from https://teslauniverse.com/nikola-tesla/articles/true-wireless
7. Tesla, N. (1916). *Nikola Tesla on his work with alternating currents and their application to wireless telegraphy, telephony and transmission of power: an extended interview*. Retrieved from https://www.tfcbooks.com/tesla/nt_on_ac.htm
8. Tesla, N. (1898). *High Frequency Oscillators for Electro-Therapeutic and Other Purposes*. Retrieved from https://www.tfcbooks.com/tesla/1898-11-17.htm
9. Avramenko et al. (1993). *United States Patent 6,104,107: Method and Apparatus for Single Line Electrical Transmission*. Retrieved from https://patents.google.com/patent/US6104107A/en (https://patents.google.com/patent/US6104107A/en)
10. Zaev N. E. Avramenko S. V., Lisin V. N. (2012). *Measurement of Conduction Current Excited by Polarization Current*. Retrieved from: https://drive.google.com/file/d/1K0JQPfhT7PFZ8P6mqMdv8MhCxGKyjqt6/view?usp=sharing
    >> This article was translated from Russian, so may contain translation errors

11. Zaev N. E. Avramenko S. V., Lisin V. N. (2012). *Measurement of Conduction Current Excited by Polarization Current*. Retrieved from: https://drive.google.com/file/d/1KoJQPfhT7PFZ8P6mqMdv8MhCxGKyjqt6/view?usp=sharing
    >>> This article was translated from Russian, so may contain translation errors
12. Kasyanov, G.T. (2015). *Single Wire Line and Single Wire Current*. Retrieved from: https://www.top-technologies.ru/ru/article/view?id=35013 (https://www.top-technologies.ru/ru/article/view?id=35013)
    >>> I used Google Translate to read the article
13. Kosinov, N.V., & Garbaruk, V.I. (2018). *Single-Wire And Wireless Electric Power Transmission*. Retrieved from: https://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=C8C59828ACC558CF4116F5CF1213B5B9?doi=10.1.1.470.7248&rep=rep1&type=pdf (https://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=C8C59828ACC558CF4116F5CF1213B5B9?doi=10.1.1.470.7248&rep=rep1&type=pdf)
14. Strebkov, D., Nekrasov, A., Trubnikov, V., & Nekrasov, A. (2018). *Single-Wire Resonant Electric Power Systems for Renewable-Based Electric Grid*. Retrieved from: https://drive.google.com/file/d/1lfIbTXaCEDC5fpXEfez8ZE14Wl7Nfg3E/view?usp=sharing
15. Strebkov, D., Nekrasov, A., Trubnikov, V., & Nekrasov, A. (2018). *Single-Wire Resonant Electric Power Systems for Renewable-Based Electric Grid*. Retrieved from: https://drive.google.com/file/d/1lfIbTXaCEDC5fpXEfez8ZE14Wl7Nfg3E/view?usp=sharing
16. Bank, M. (2016). *It's Quite Another Electricity*. Retrieved from: https://www.ofdma-manfred.com/wp-content/uploads/2019/05/M.-Banks-book-last.pdf (https://www.ofdma-manfred.com/wp-content/uploads/2019/05/M.-Banks-book-last.pdf)

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Another interesting method using solid state technology with Tesla's method.

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Nick Kraakman
October 13, 2019 at 12:24 pm (https://waveguide.blog/4-methods-for-single-wire-power-transmission/#comment-14)

Thanks for sharing that video! That is indeed how Tesla initially intended to transmit power, until he started fixating on transmitting through the earth. Of course there were not really any solid state components in those days, so this is an interesting development!

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Davide
November 19, 2019 at 8:52 am (https://waveguide.blog/4-methods-for-single-wire-power-transmission/#comment-15)

francobruno is that your video? I watched it a few days ago.

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