41

Basics Of MagLev Transportation

The purpose of this chapter is to describe the basics of MagLev (Magnetic Levitation) transportation systems and then to go on to describe how spin wave technology can be utilized to improve the design of the magnetic systems used for levitation and propulsion in these systems. The primary advantage of spin wave technology over conventional electromagnetic systems is that the MagLev rails or MagLev guide ways can be dispensed with and the transportation compartment can be made to push against spin waves present in any type of ground material. This claim sounds extraordinary but in this chapter it will be explained in simple terms how it is possible.

There are two main processes taking place in MagLev systems: levitation and propulsion. Electromagnetic systems are used for both functions. Usually, each electromagnetic system works independently of the other but some systems combine the electromagnetic designs into one system that both lifts and propels. Both the levitation and the propulsion functions are based on utilizing the push of opposing magnetic fields and/or the pull of attracting magnetic fields.

Here are some links to give you the basics of the EM (electromagnetic) theory involved.

Click on the little diagrams at these first two links:

- http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magfie.html#c1
- http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/faracon.html#c1

At the following link just skip down to Chapter 31 if you want:

- http://maxwell.byu.edu/~spencerr/websumm122/web.html

If your browser has Java enabled then try these links:

- http://www.micro.magnet.fsu.edu/electromag/java/magneticlines2/
- http://www.micro.magnet.fsu.edu/electromag/java/faraday2/
- http://www.micro.magnet.fsu.edu/electromag/java/lenzlaw/
- http://www.micro.magnet.fsu.edu/electromag/java/pulsedmagnet/

MagLev systems usually use either LIM (Linear Induction Motor) or (LSM (Linear Synchronous Motor) propulsion so here are some sites about these motors:

- http://unofficial.capital.edu/admin-staff/dalthoff/lim.html
- http://www.theproductfinder.com/motors/elemot.htm
- http://www.nctransportation.com/LinearMotor.html
- http://www.prod.sandia.gov/cgi-bin/techlib/access-control.pl/1995/951268.pdf
- http://www.baldor.com/pdf/brochures/br1800/Section6.pdf
- http://www.calinear.com/
- http://www.xrefer.com/xrefs.jsp?xrefid=508565
- http://www.ecn.purdue.edu/ESAC/Example_Simulations/example.whtml

Here are some links to give you an overview of various MagLev systems:

- http://www.skytran.net/press/sciam01.htm
- http://www.maglev2000.com/works/how-04.html
- http://www.phy.uct.ac.za/courses/phy209s/projects/EDWDAV004/edwdav004.htm
- http://www.rtri.or.jp/rd/maglev/html/english/maglev_frame_E.html
- http://www.llnl.gov/str/Post.html
- http://www.pa.msu.edu/people/roberson/Inductrack/post.pdf_1.pdf
- http://www.pa.msu.edu/people/roberson/Inductrack/ieee1099.pdf
- http://www.pa.msu.edu/people/roberson/Inductrack/Inductrack_files/frame.htm

Now that you have an idea of what MagLev levitation and propulsion is all about, we will explain how spin wave technology can be utilized to design an improved MagLev system. Some basic design changes are made to utilize the characteristics of spin waves. Later MagLev design examples are given that will seem impractical using conventional magnetic levitation equipment but this is just to give preliminary insight into how it can be done using spin waves.

42

Propagation Velocity in MagLev Systems

To describe how to use spin waves for a MagLev system, comparisons are made to a MagLev system using LSMs (Linear Synchronous Motors) or LIMs (Linear Induction Motors). The forward speed of the bogie (train compartment) of a MagLev system that uses LSMs is determined by the propagation velocity of the electromagnetic fields of the guide rail coils that push against the magnets of the bogie. The frequency and wavelength of the electromagnetic fields that do the pushing have to be considered.

The velocity of an electromagnetic wave in free space is referred to as "c".

This velocity is constant and is approximately $c = 3*10^8$ meters/second. This velocity is established by the coefficient of inductive permeability and coefficient of capacitive permittivity of space itself.

Diagram of an Electromagnetic Wave in Free Space

The velocity of an electromagnetic wave moving along a single wire is about 95% of the velocity in free space. This is due to the inductance down the length of the wire and the capacitive coupling of the surface of the wire to free space. Keep in mind that even though electromagnetic signals move along the wire at almost the velocity of light, the current of electrons within the wire will have an average drift in one direction or the other at a much lower velocity in reaction to the changing electromagnetic signals on the wire. This is called drift current.

Diagram of an Electromagnetic Wave in a Wire

The velocity of an electromagnetic wave in a coaxial cable is slower still than an electromagnetic wave along a single wire. It is typically around 65-75% of the velocity in free space. This is due to the inductive and capacitive coupling to the coaxial shield. It takes more time as a signal moves along the wire to charge up the capacitance between the wire and the shield. There is also self inductance of the center conductor and finally a mutual inductance with the shield such that a changing magnetic field from the signal moving along the wire induces current in the opposite direction in the shield. This in turn generates its own magnetic field which induces a CEMF (counter electromotive force) opposing and thus slowing the propagation of the signal along the wire.

Diagram of an Electromagnetic Wave in a Coax Cable

The propagation velocity of an electromagnetic wave through a series of large coils and large capacitors is slower still. This is due to the much greater time it takes to charge up the capacitors and to overcome the greater self-inductance of the coils.

Diagram of an Electromagnetic Wave in a Series of Coils and Capacitors

For MagLev propulsion systems, the propagation of the signal energizing the succession of coils along the guide rails can be slowed down even more by simply switching on each coil in succession at the rate desired.

Diagram of an Electromagnetic Wave of a Series Switched Coils

In each of the above examples the propagation velocity gets slower and slower and the physical wavelength of the electromagnetic wave gets shorter and shorter compared to the wavelength of the same frequency electromagnetic wave in free space.

The system of electromagnetic coils and capacitors has the effect of compressing the wavelength and slowing the propagation of the signal. If the coil excitation frequency is 10 Hz (10 Hertz = 10 cycles per second) for example, this equates to an electromagnetic wavelength in free space of:

(1 divided by (10 cycles per second)) x (3x10^8 meters per second) = 3x10^7 meters

This wave travels through space at a velocity of 3x10^8 meters per second.

Diagram Comparing Wavelength in Free Space
to Wavelength in Series of Coils and Capacitors

If a MagLev system used a succession of coils and capacitors along the MagLev guide rails then it is the propagation velocity of the electromagnetic coil excitation signal that determines the velocity of the bogie. In a MagLev system using LSMs the bogie will move exactly at the propagation velocity. In a MagLev system using LIMs the bogie will have a certain amount of slip and will travel at a somewhat slower rate than the propagation velocity of the electromagnetic coil excitation signal that pushes and pulls on the magnetic fields of the bogie.

It is necessary to be able to adjust the propagation velocity in order to control the bogie velocity and this can be done in various ways. Adjusting the capacitance between the coils can change the propagation velocity but this alone is not very practical. One way to solve this problem is to have a switched system in which the guide way coils can be switched on and off in a faster or slower succession.

Another solution is to have a succession of excitation coils driven by a succession of multiple phases of the same AC coil excitation signal. This then becomes the same as a multi-pole rotary motor coil that has been laid out flat. The multiple phases of a higher frequency coil excitation signal will drive the excitation coils at a faster succession rate. The propagation velocity of the coil excitation signal then becomes dependant of the frequency of the excitation signal. This allows the bogie to be easily accelerated by simply increasing the frequency of the coil excitation signal. There will likely still be various values of capacitors switched in along the succession of coils to maintain an optimum power correction factor for various ranges of coil excitation frequencies. Also, only those excitation coils will be driven that are where the bogie is at any particular time rather than all the excitation coils along the whole length of the guide rails.

Now let's get back to analyzing the whole thing in terms of how it can be implemented using spin waves to propel the bogie. For bogies driven by LSMs, the wavelength of the coil excitation signal will match the pitch (spacing between North-South-North-South poles) of the bogie magnets. The bogie magnets have static magnetic fields that push and pull against the magnetic fields of the drive coils along the guide rails.

Diagram of magnetic fields of bogie and guide rail coils

The North-South-North-South fields of the drive coils can be thought of like teeth on a timing belt. It's the propagation velocity of the belt that matters and the pitch of the teeth will match the pitch of the bogie magnets. Since the magnetic fields of the bogie magnets are static they can be said to have a propagation velocity along the bogie of zero. A more generalized equation for the bogie velocity would be as follows:

$v1$ = Propagation Velocity of Guide Rail Drive Coils' Magnetic Fields

$v2$ = Propagation Velocity of Bogie Magnetic Fields

vb = Bogie Velocity

$vb = v2 - v1$

This means that if the bogie's magnetic fields propagation velocity is zero then:

$vb = v1$

Also, if there are magnetic fields on the bogie moving at the same rate and direction as the magnetic fields of the guide rail drive coils then:

$v1 = v2$

$vb = v1 - v2 = 0$ so the bogie will not move. This is like walking at the same speed but in the wrong direction on an escalator or an airport moving walkway.

Animated diagram of bogie not moving but with moving magnetic fields and guide rail coils magnetic fields

If the propagation velocity of the bogie's magnetic fields is in the opposite direction then the bogie velocity will be:

v2 = - v1

vb = v1 – (-v1) = 2 * v1

Animated diagram of bogie moving and with moving magnetic fields and guide rail coils magnetic fields

Now consider a system where there are standing waves on the drive coils such that the drive magnetic fields are toggling in North-South orientation but that have a propagation velocity of zero.

Animated diagram of guide rail drive coils' signal and toggling drive coil magnetic fields

It is also possible for there to be standing waves on the bogie magnetic field coils making bogie magnetic fields that are toggling in North-South orientation but that have a propagation velocity of zero.

Animated diagram of bogie magnetic field coils' signal and toggling bogie magnetic fields

If both the bogie and the guide rail coils have standing waves then there is a way to propel the bogie. The phase of the standing waves of the bogie relative to the standing waves of the guide way drive coils can be adjusted so that the two sets of magnetic fields push against each other in one direction or the other depending on the direction and amount of phase shift. However, once the phase shift causes the bogie to be pushed to a new position, the phases will be back in alignment. To maintain a phase shift, the bogie's standing waves must not be perfect standing waves but will need to have a small propagation velocity in addition to being standing waves. Then the bogie's velocity will equal the propagation velocity of its partially standing waves/partially traveling waves.

Animated diagram of toggling bogie magnetic fields pushing against toggling guide rail coil magnetic fields

43

Levitating with Spin Waves

If you have studied the various web links about Faraday's Law, Lenz's Law and the web links about various MagLev systems then you should already understand the theory of MagLev levitation. Modifications to these basic designs will be described to explain how it would be done with spin waves. Repelling and/or attracting forces of the guideway magnetic fields with the bogie magnetic fields will push or pull a bogie up causing it to levitate.

There will be alternating magnetic field orientations along the guideway and alternating magnetic field orientations of the bogie's magnetic fields. The phase of the bogie's alternating magnetic fields can be adjusted to control the amount of repulsive and attractive forces with the magnetic fields of the guideway. Previously, the amount of forward or reverse propulsion force on the bogie was described as caused by adjusting the phase of the alternating magnetic fields. This is still true. Now there will be another type of phase adjustment that can be made to control the degree of levitation. To understand the difference it is necessary to describe better how the magnetic fields of a guideway and of a bogie are created using spin waves.

The magnetic fields of spin waves are caused not by current flow of electrons but by the changing spin axis orientations of electrons. A magnetic field can be created by the flow of electrons through a coil of wire as has already been described.

Diagram of coil of wire and its magnetic field

A magnetic field can also be created from many electron spin axis orientations all pointing in a similar direction. Each individual electron will already have its own little magnetic field associated with its own particle spin characteristics.

Diagram of electron spin and its magnetic field

When all the spin axes orientations point in a similar direction then it makes a large macroscopic magnetic field.

Diagram of many electron spins and their magnetic field

The electron's spin axis also has a tendency to precess like a gyroscope.

Animated diagram of an electron spin precessing and its magnetic field

Many electron spin axes all precessing together at microwave frequencies will send out microwave frequency electromagnetic waves.

Animated diagram of many electron spins precessing and their magnetic field

For our application we want all the electrons to precess together but we don't want to make large microwave frequency electromagnetic waves. There is a way to prevent this. For every electron that precesses clockwise we will have an electron that precesses counter-clockwise. The combined electromagnetic waves from these motions will cancel each other except for waves of changing magnetic field orientation.

Animated diagram of two electrons' spins precessing opposite directions

Both North poles point the same way and then both South poles point that same way. Now we need many electron pairs doing the same thing. It is not important that their precession axes all be pointing similar directions but they do need to all lay in the same plane and precess in phase at the same rate such that all the North poles point a particular direction and then all the South poles point that same direction.

Animated diagram of many electron pairs precessing opposite directions with various precession axis orientations but all in the same plane

Now we have a magnetic field that alternates North-South-North-South but it does not send out microwave frequency transverse electromagnetic waves. These magnetic field waves can pull on similar magnetic waves from the guideway that are alternating in phase.

Animated diagram in phase magnetic waves and attractive forces

Similarly, they can push against alternating magnetic fields from the guideway that are of opposite phase.

Animated diagram of opposite phase magnetic waves and repulsive forces

The phase changes associated with the attractive or repulsive bogie levitating forces are demonstrated below using just a pair of electrons of the guideway and one pair of electrons of the bogie.

Animated diagram of both pairs precessing in opposite directions and sending out magnetic waves that are in-phase

Animated diagram of both pairs precessing in opposite directions and sending out magnetic waves that are 45 degrees out of phase

Animated diagram of both pairs precessing in opposite directions and sending out magnetic waves that are 90 degrees out of phase

Animated diagram of both pairs precessing in opposite directions and sending out magnetic waves that are 135 degrees out of phase

Animated diagram of both pairs precessing in opposite directions and sending out magnetic waves that are 180 degrees out of phase

However, the magnetic forces between the two are only ever attractive or repulsive if the magnetic fields diverge as opposed to being completely homogeneous.

Before this line of explaining things continues, it may be necessary to first explain more about naturally occurring alternating magnetic waves within materials and to explain about diverging magnetic fields from large bodies of material that are experiencing this phenomena. Please read the next chapter, Diverging Alternating Magnetic Fields (*Chapter 44*).

44

Diverging Alternating Magnetic Fields

If a small magnetized sample of material is in a large magnetic field and it has become oriented such that its magnetic field is oriented with the large magnetic field, then it is not the strength of the large magnetic field alone that determines how strongly the small magnetic sample is attracted. Rather, it is also the amount of divergence of the large magnetic field that determines how strongly the small sample is attracted towards the diverging magnetic fields.

Diagram of sample in non-diverging magnetic field

Diagram of sample in diverging magnetic field

This same phenomena is true when the strong magnetic field is an alternating magnetic field. If a small sample of material is radiating magnetic waves that are in-phase with the magnetic waves of the diverging magnetic field, then both the strength and the amount of divergence affect how strongly the sample is attracted.

It is the natural tendency of paired electrons in orbitals around all atoms to precess clockwise and counter-clockwise and to develop in-phase magnetic waves among all of them. With a large body of atoms like the Earth, all of these in-phase magnetic waves add in strength.

However, this is not the only natural source of magnetic waves. There are also extremely high frequency precessional motions of quarks within protons and neutrons of all atoms. These motions generate their own frequency of magnetic waves. These also have a natural tendency to move to a state where all their magnetic fields alternate in phase. The typical transverse electric field components normally induced are cancelled due to the nature of the compensating precessional motions for sets of quarks and for pairs of electrons. The total attractive force of the alternating magnetic fields of various frequencies that remain from all particle precessional motions within the Earth is equal to an accelerating force of exactly 1G at sea level. In other words, gravitational force can be explained as caused by the attraction among all matter as a consequence of in-phase magnetic waves.

At any given distance out from the center of the Earth there will not be perfect phase alignment among the magnetic waves that are all at that exact distance from the center. Instead there will be spin waves and spin temperature fluctuations of the otherwise perfect phase alignment of these magnetic waves.

These magnetic waves are not the same as the following that you may find if surfing the internet for “magnetic waves”:

- http://www.space.com/news/solarwind.html
- http://helios.gsfc.nasa.gov/solarmag.html
- http://www-solar.mcs.st-andrews.ac.uk/~robert/statement.html
- http://science.nasa.gov/newhome/headlines/ast08jul99_2.htm
- http://www.gsfc.nasa.gov/gsfc/spacesci/swind/swind.htm
- http://www.planetary.org/news/articlearchive/headlines/1999/headln-071399.html
- http://history.nasa.gov/presrep99/pages/smithso.html
- http://science.nasa.gov/newhome/headlines/ast02sep99_1.htm

The difference is that the magnetic waves described in the NASA articles, as well as the other articles, are waves of changing magnetic field intensity and orientation over periods of perhaps 300 seconds or more. However, the magnetic waves described in this paper are oriented along the same direction that the magnetic waves travel, completely toggle in direction of orientation and toggle at extremely high frequencies. The magnetic waves described in this chapter are radiating outward in all directions from gravitational centers as opposed to directions somewhat related to the orientation of magnetic poles of a large body like the sun.

The magnetic waves described in this chapter are present between all matter all of the time. The waves have associated with them a slight natural attractive force towards any centers of divergence. As more mass accumulates at these centers this naturally causes the divergence to increase. These diverging alternating magnetic waves have the attributes we associate with gravity.

Bibliography

Armstrong, A. H.. *An Introduction to Ancient Philosophy*.
The Newman Press, 1949

Einstein, Albert. *Principle of Relativity*. Dover Publications, 1924
found at: http://www.fourmilab.ch/etexts/einstein/specrel/www/

Feynman, Richard P. *Feynman Lectures on Physics, Volume 2*.
Reading, Massachusetts: Addison-Wesley Publishing Company, 1970

Hawking, Stephen W. *A Brief History of Time*. New York, NY:
Doubleday Dell Pub, 1998

Kittel, Charles. *Introduction to Solid State Physics*.
John Wiley & Sons, 1996

Lerner, Rita G. and George L. Trigg, eds. *Encyclopedia of Physics*.
John Wiley & Sons, 1990

Rajam, J B. *Atomic Physics*. New Delhi: S. Chand & Co., 1966

Stanford, Ray. *Socorro Saucer, in a Pentagon Pantry*.
Blueapple Books, 1976

Williams, W. and L. Pearce. *The Origins of Field Theory*.
University Press of America, 1966

Index

Summary:
Potential of Spin Wave Technology

Signal Processing:

There are 2 basic forms of motion of all electrically charged particles. Either they can change in position or change in spin axis orientation. Much of electronics today is based on the first of these 2 forms of motion. Signal processing electronics can be advanced by using devices based on the propagation of changing spin axis orientations.

Communications:

Almost all forms of radio communication today are based on the radiation of electromagnetic waves from electrically charged particles that move back and forth changing position. Communications technology can be advanced by instead using electromagnetic waves radiated from the precessional rotations of electrically charged particles. Fluctuations can be induced in and propagate through the sea of electromagnetic standing waves among all matter in the universe.

Power Generation:

It should be possible to build spin wave lasers and spin wave electrical power generation devices. It should be possible to absorb some of the energy present in standing waves among all matter and convert it to electricity to power electrical equipment. This can be accomplished through spin wave interactions with the electromagnetic standing waves among all matter.

Propulsion:

It should be possible to create and sustain spin wave processes within a flying vehicle that utilizes a metallic resonant cavity, also serving as a “Faraday cage”. These spin wave processes can be used to shift the phase of the precessional motions of all atomic particles of the vehicle and its contents relative to the phase of standing waves radiated to and from the precessional motions of all external matter. This can create electromagnetic forces between vehicle and these standing waves among all external matter. Force vectors can be controlled to lift and propel the vehicle at very high speeds.

About the Author

George J Bugh grew up on a small ranch-farm in the hill country near Austin, Texas. His Father had been an officer in Air Force Intelligence, working as a district director of the OSI and later working at the Pentagon before he retired to Austin, Texas. After graduating from high school in 1975, George Bugh also joined the Air Force where he became a specialist in the field of flight simulators.

After four years in the Air Force, he attended college and obtained a bachelor's degree in electrical engineering technology at the DeVry Institute of Technology in Irving, Texas. After graduation he was employed by a major aerospace company, again working on flight simulators.

Twenty years later George Bugh is a senior staff electronics engineer. He works with electronics, electromagnetic devices and test equipment for research and testing of advanced aircraft designs using flight simulation studies. On his own time he has made it his personal mission to figure out if there could be any truth to claims of excess electrical power output from many unusual electromagnetic devices discussed on the Web by different inventors. He has spent the last seven years studying physics, relativity, the nature of time and spin wave processes.

His personal research and theories are not related to his day job. After receiving permission from his day job employer, George Bugh has given the copyrights to his research files to the Vasant Corporation.

Turn back one more page to read a summary of the potential of spin wave technology.