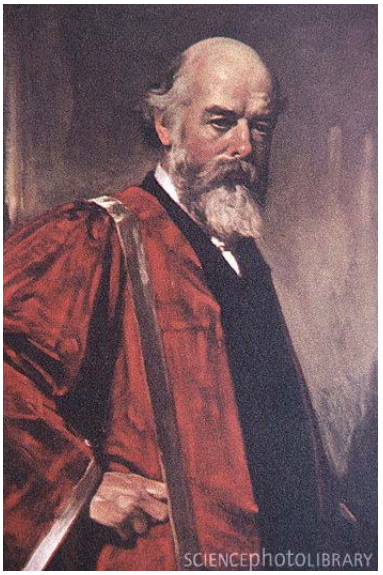
Syntony
by Gerald Fitton



Sir Oliver Lodge FRS

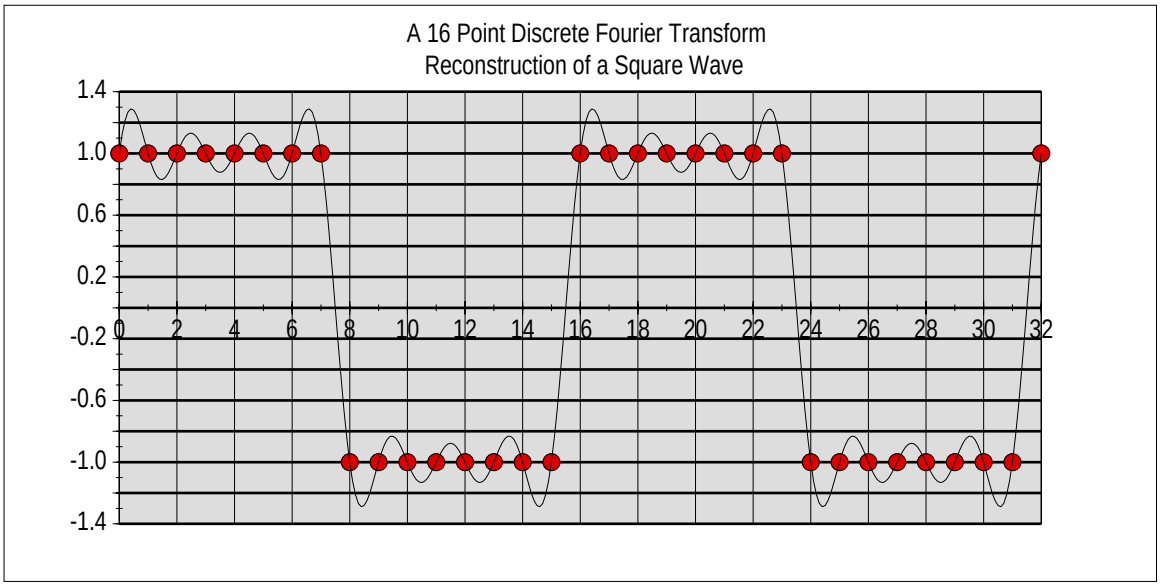
... it seems as if even Time would become discontinuous and be supplied in atoms, as money is doled out in pence or centimes instead of continuously; in which case our customary existence will turn out to be no more really continuous than the events on a cinematograph screen; while that great agent of continuity, the Ether of Space, will be relegated to the museum of historical curiosities.

Sir Oliver Joseph Lodge - The Nature of Continuity 1913

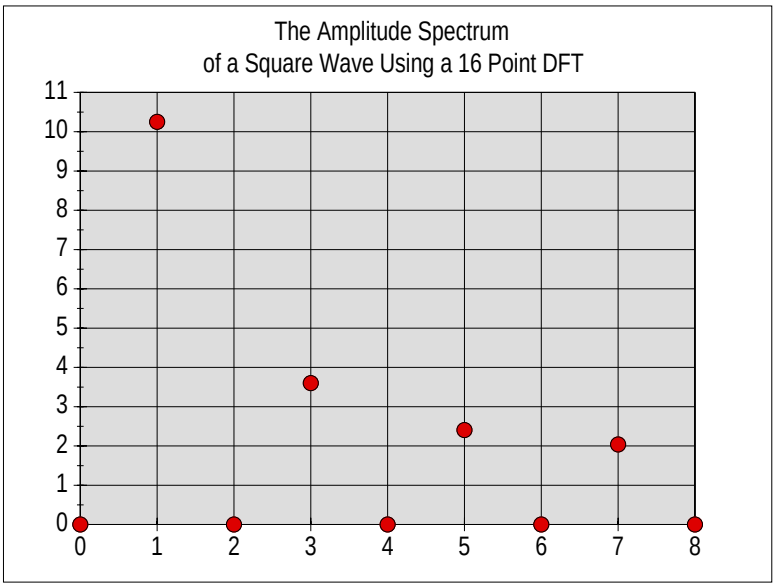
Sir Oliver Joseph Lodge (1851–1940) was knighted by King Edward VII in 1902. It was in August 1894, about two years before Marconi's first broadcast, that Lodge demonstrated the Syntonic transmission and reception of radio signals at a meeting of a Scientific Society held at Oxford University. Many regard him as 'The Father of Radio' because of his discovery and use of Syntony. He invented the spark plug used in internal combustion engines to this day. He called it the 'Lodge Igniter'. Lodge Plugs Ltd was founded by his two sons to develop this invention. I remember buying Lodge Plugs for my first motor bike in the 1950s.

He coined the word Syntony to describe what today we would call tuning. He tuned both his radio transmitter and receiver to the same frequency thus filtering out all the other radio interference which limited the range of previous experiments in radio transmission and reception. Marconi was forced to accept that Lodge had a valid patent describing Syntony and did a deal with Lodge for the use of that patent. Without the discovery of Syntony, radio would not exist because it would be impossible to select one wanted radio signal from the cacophony of electromagnetic energy which pervades all space and time.

A Nearly Square Wave



The drawfile shows two cycles of a nearly square wave; each cycle consists of 16 points (red circles) plus a 33rd point at t = 32 which I have added in order to show the start of a 3rd cycle. The wave is a ‘nearly’ square wave because, ideally, there would be one value of time (along the horizontal axis) for which the amplitude of the wave would be both +1.0 and −1.0. For the first 8 values of the time (t = 0 to t = 7) the amplitude of the pressure wave, p = +1.0; for the second 8 values (t = 8 to t = 15) p = −1.0; unlike a true square wave, there is no value of t for which the amplitude is both +1.0 and −1.0.



In this next drawfile you will see the amplitude spectrum of this nearly square wave. I have used a 16 point Discrete Fourier Transform (8 of which have an amplitude of p = +1.0 and 8 have an amplitude of p = −1.0) to calculate this spectrum. The reconstructed waveform consists of 9 sine waves and 9 cosine waves. These 18 waveforms have been added together to reconstruct a periodic function, the continuous black line, which passes exactly through the 16 original points. As you will see from the screenshot, the reconstruction is not a ‘nearly’ square wave; it is a waveform that differs from a the original ‘nearly’ square wave but only between the original 16 points.

PipeDream: hostfs::201.$.2012.GC1202.Files.PipeDream.dft-12.general16-01d *

sum(I3I11*sin(H3H11*pi*$C3/8))/8+sum($J3J$11*cos($H3H$11*pi*$C3/8))/8

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Original		Reconstructed		Reconstructed			Spectrum	Spectrum		Phase	Phase
2	t	Waveform	t	Waveform	t	Waveform		m	Sin	Cos	Amplitude	Angle	Offset
3	0	1.0000	0.00	1.0000	0	1.0000		0	0.0000	0.0000	0.0000	0.0000	0.0000
4	1	1.0000	0.10	1.1233	1	1.0000		1	10.0547	2.0000	10.2517	1.3744	3.5000
5	2	1.0000	0.20	1.2123	2	1.0000		2	-0.0000	-0.0000	0.0000	0.0000	0.0000
6	3	1.0000	0.30	1.2669	3	1.0000		3	2.9932	2.0000	3.5999	0.9817	2.5000
7	4	1.0000	0.40	1.2888	4	1.0000		4	0.0000	-0.0000	0.0000	0.0000	0.0000
8	5	1.0000	0.50	1.2815	5	1.0000		5	1.3364	2.0000	2.4054	0.5890	1.5000
9	6	1.0000	0.60	1.2495	6	1.0000		6	0.0000	-0.0000	0.0000	0.0000	0.0000
10	7	1.0000	0.70	1.1990	7	1.0000		7	0.3978	2.0000	2.0392	0.1963	0.5000
11	8	-1.0000	0.80	1.1361	8	-1.0000		8	0.0000	0.0000	0.0000	0.0000	0.0000
12	9	-1.0000	0.90	1.0677	9	-1.0000							
13	10	-1.0000	1.00	1.0000	10	-1.0000							
14	11	-1.0000	1.10	0.9388	11	-1.0000							
15	12	-1.0000	1.20	0.8886	12	-1.0000							
16	13	-1.0000	1.30	0.8530	13	-1.0000							
17	14	-1.0000	1.40	0.8338	14	-1.0000							
18	15	-1.0000	1.50	0.8315	15	-1.0000							
19	16	1.0000	1.60	0.8450	16	1.0000							

The 18 components

In columns I and J of the spreadsheet (shown in the next screenshot) you will see the amplitudes of the 18 components of the composite waveform which, when added together, produce the continuous black line.

It is probably easier to understand what I have added together if I start with just one of these 18 components. The one component I shall choose as my example is the component corresponding to the value shown in cell I6 of the spreadsheet. The content of cell I6 is the amplitude, $a_3 = 2.9932$ (to 4 decimal places), of the sine component corresponding to the frequency m = 3. This component of the pressure wave, p_{s3}, has the formula:

$$p_{s3}(t) = a_3\sin(m_3\pi t/8)/8 = 2.9932\sin(3\pi t/8)/8$$

In my previous article I suggested that we might regard the values of t as milliseconds; if we do this then a full cycle of the fundamental takes 16 milliseconds.

In total there are 18 components which, when added together, provide us with p = p(t) the smooth, continuous function which allows us to calculate the value of p for any value of t.

In column C of the spreadsheet you will find values of t from t = 0 to t = 32 in steps of 0.1. In column D I have calculated the numerical value of p for all these 321 values of t using the sum of the 9 sine and 9 cosine components which are similar to the formula for $p_{s3}(t)$.

Array Multiplication

In several earlier articles I have described in some detail matrix multiplication. The Array Multiplication built into both PipeDream and Fireworkz (as well as Fireworkz for Windows) is different. I have used this Array Multiplication facility to simplify the formulae which you will find in column D of the spreadsheet.

Concentrating for the moment on the value of just one of these 18 components with the value m = 3 (cell H6) and a = 2.9932 (cell I6):

$$p_{s3}(t) = a_3\sin(m_3\pi t/8)/8 = 2.9932\sin(3\pi t/8)/8$$

The formula (entered into a cell in column D) which would appear in the formula line for this one component is:

$$p_{s3}(t) = I6*\sin(H6*pi*t/8)/8$$

with ‘t’ replaced by a cell reference from column C.

Similarly another of those 18 components (cells H4 and I4) is:

$$p_{s1}(t) = a_1\sin(m_1\pi t/8)/8 = 10.0547\sin(1\pi t/8)/8$$

and the formula line would include:

$p_{s1}(t)$ = I4*sin(H4*pi*t/8)/8

What we want in column D is the sum of all 9 sine components the first four of which are:

(I3*sin(H3*pi*t/8)+I4*sin(H4*pi*t/8)+I5*sin(H5*pi*t/8)+I6*sin(H6*pi*t/8)+ ...)/8

plus the sum of all 9 cosine components from column J. There would be 18 terms in total.

Using Array Multiplication the sum of all 9 sine terms can be written as:

sum(I3I11*sin(H3H11*pi*t/8))/8

In the spreadsheet I have included the '$' to make the blocks I3I11 and H3H11 absolute cell references so that I can replicate the formula:

sum(I3I11*sin(H3H11*pi*t/8))/8

down the D column with these same arrays, I3I11 and H3H11, being used for all the cells.

Using Array Multiplication in this way, I3 is used in the formula with H3, I4 with H4, etc down to I11 with H11. The whole 9 sine function terms are added together using the function sum() in conjunction with Array Multiplication; it appears in the formula line as: sum(array1*array2) where array2 includes the array H3H11 within the sin() function.

Array Multiplication does work in the most recent 32 bit version of PipeDream. There was one recent version (quickly updated on the website) for which array multiplication failed.

Array Multiplication also works in Fireworkz and Fireworkz for Windows.

Particles and Points

In earlier articles I have waxed lyrical about the way in which the Continuity of Space and Time has been built into those Mathematical Models of our Universe devised by Scientists from Isaac Newton to James Clark Maxwell. As I have pointed out, there are fundamental Philosophical problems with this model, not the least of which is to identify that unique moment in time which is adjacent to, but not coincident with, t = 1.

Classical Physics assumes not only the Continuity of Space and Time but also, in all the fundamental formulae, the mathematical model refers to Particles and Points. The Physics and Mathematics of particles and points is the basis for the mathematical model of fluids (e.g. Hydrodynamics and Aerodynamics) as well as for solids (e.g. rotating bodies such as gyroscopes or the Earth). Mysterious force fields, such as those of electromagnetism and gravity, act on particles at points. Classical electrostatic fields are defined by the force which the field would exert on an imaginary charge placed in the field. Our mathematical model of electromagnetic waves requires us to invent an imaginary Ether filled with imaginary particles which can be stressed and strained by these electromagnetic waves. In this model it is only by stressing and straining the Ether that the waves can be propagated.

Particles (even imaginary ones such as those fictitious particles of which the Luminiferous Ether is composed) and points are at the heart of Classical Physics.

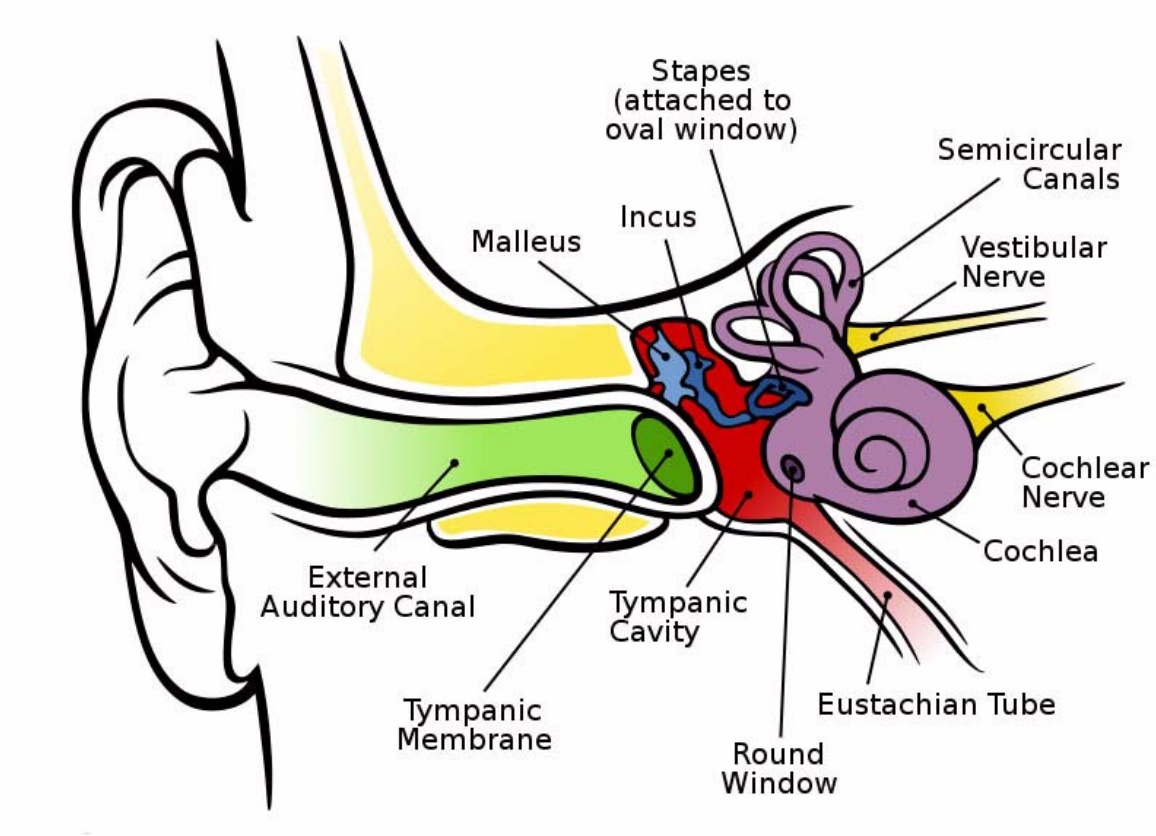
Waves

Particles are defined as having no size; they exist only at a point. From the alternative viewpoint of Quantum Physics, nothing exists at a point in space nor at a moment in time.

If the thought of discarding the notion of particles existing at points in space and moments of time fills you with horror, shock and even dread, then, as a reassuring example, I would ask you to consider a sound wave in air; a sound wave is an entity which can exist only when it fills a region of space and period of time.

Classically we fill space and time with dimensionless particles which are subject to mysterious fields of force such as those of gravity and electromagnetism. Quantum Physics replaces those particles and points with (equally mysterious) oscillating waves containing energy, but energy that is distributed over space and time instead of being attached in some way to a particle which is located at a point in space and time. The particles which, classically, we believed in, such as electrons and photons, are entities which manifest themselves only when these distributed, energy filled waves collapse. It is interesting to note that these fields containing oscillating energy collapse to particles only when we decide we want to make an observation on the particles which, we insist, have to be there - even if the energy filled wave is only the complex probability field of Shrödinger!

Apart from its distributed nature, the second most important property of a wave is that it has associated with it a frequency or frequencies of oscillation. Classically we conceive of energy at a point stored in a mass which has kinetic and potential energy; however, when it comes to storing energy in a wave then then the wave and its energy can exist only when the energy it contains is distributed over a region of space and a period of time.

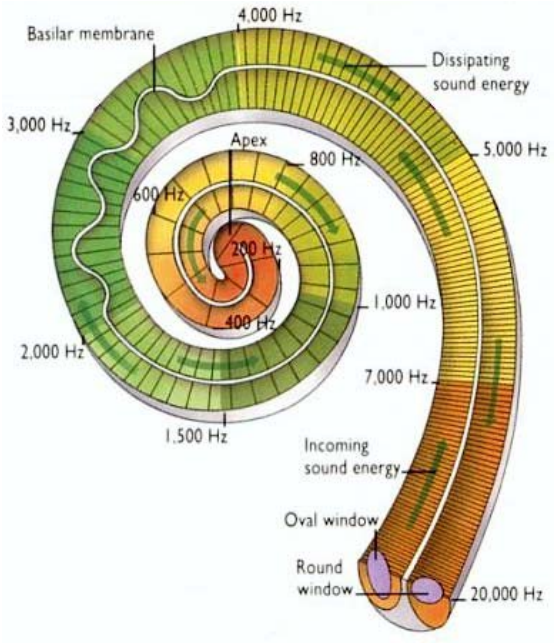


An essential and integral property of an oscillating wave is that it has a frequency or frequencies associated with it. The efficient transfer of energy from a flute to the cilia in our ears, requires some understanding of the concept of Sir Oliver Lodge's Syntony.

Syntony

It is the phenomenon of Syntony which allows a receiver of vibrational energy to collect just a little bit of energy from each cycle and store that energy within itself. It is only able to collect and then store energy at those frequencies at which it resonates. A syntonic store of oscillating energy, whether it is an electronic circuit, a child's swing or the cilia within the cochlea of our ears, occupies both space and time. By its very nature, the energy stored in syntonic devices cannot be located at a point in space nor can it be limited to a moment in time. A syntonic device is a distributed rather than a localised entity.

In my previous article I asked you to consider the sound wave created by a musical instrument such as a flute. Energy is added to the system by the flautist but not as a constant smooth flow; it consists of periodic 'pulses' at the mouthpiece. These pulses of energy are synchronised with the resonant frequency of the flute so that a small amount of energy is added to the vibrating column of air in the flute with every pulse of energy. Some of this energy escapes from the flute as a periodic pressure wave which is propagated through the air in all directions. This oscillating pressure wave is what we call a sound wave; this sound wave eventually reaches the cilia in our ears.



For each small range of sound frequencies there are cilia tuned to that small range. Different cilia are tuned to different audio frequencies. Our aural nerves pick up this selective vibration of particular cilia and we interpret the result as the sound of a flute. The energy which is collected by the syntonic cilia originated in the flute. If our ears did not have this syntonic ability by which different cilia resonate at different frequencies then we would be unable to distinguish the pitch of one note from another. There would be no melody, no harmonies and only rhythmic music.

Perhaps the single most important consequence of Syntony is that, without it, loud sounds would drown out quiet ones. By using a syntonous receiver which is tuned to the same frequency as the syntonous transmitter (rather than a broad band receiver) we can reject unwanted signals having a huge amplitude. It is because the energy in a wave has a frequency of oscillation and only because it has a frequency to which we can tune our receiver, that we can detect (collect) minute amounts of energy at that frequency whilst simultaneously attenuating to almost zero our collection of the energy present in waves having other frequencies. It is Syntony which ensures that a transmitter and receiver using the same frequency can communicate with each other over long distances in spite of the presence of waves, possibly large amplitude waves, having other frequencies.

Many waveforms are not single frequency sine waves but are a combination of several frequencies; the oscillating energy in the air which originated in the flute is no exception. A flute generates a set of harmonics of the fundamental note which are characteristic of a flute; it is these harmonics which allow us to say, “That’s not a clarinet, it’s a flute!”

Bio-Bit

Gerald doesn’t exist as trillions of trillions of particles (molecules) but only as a complex but syntonic probability wave which extends throughout all space and time. The illusion of Gerald in this photograph is caused by the expectation that he is being observed!