Power transfer in velocity-vortex acceleration

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Abstract: A theoretical model is presented of an electron acceleration-as-oscillator method derived from the work of Joseph Larmor unified with J. Clerk Maxwell's theory of vorticity for the displacement of radiation into free-space at an antenna interface.

Keywords: electron acceleration; push-pull oscillator; vorticity.

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Biographical notes: Christopher A. Tucker received his BS from the University of Utah in 2003. He received his PhD from the University of Reading in 2013. His main research areas include classic and quantum electrodynamic theory, spatial harmonics, and power transfer in human and robotic proximity.

1 Introduction

Late in the 19th century, the theory of the electron was being formulated and conditionally verified. During the evolution of the Lorentz (1895) transformation, Larmor (1895) described the electron and its velocity in a series of three papers, noting that time dilation is a consequence of the transformation since the individual electrons describe corresponding parts of their orbits in times shorter for the (rest) system in the ratio $\varepsilon^{-1/2}$ (Macrossan, 1986). Velocity, Larmor argues, is a central concept to describe the transformation of energy from a force to a particle in a quasi-continuous system.

Following the work in Tucker (2011) and Tucker et al. (2012), this paper proposes that an application of force to electrons in a molecular-structured conductor exhibits a characteristic motion of magnetic fields impressed onto free-space. The radiated field links to resonant objects forming a cavity-like structure demarcated by force-lines. Motion along these lines exhibits vorticity predicted by Maxwell (1861) with energy expressed at the interface.

This theoretical construct is illustrated by a circuit consisting of transistors and capacitors joined to a loop of wire which couples to a distant loop of like parameters containing a load. The transition between mathematical constructs and the physical device will be bridged by a theoretical model containing simulated results from solutions of the equations of motion and energy.

2 The theoretical model

The theoretical model will be derived by the universal oscillator technique (Hofbauer, 2003) in both the transient and steady-state solutions in a fractionally-ordered frequency domain (Amairi et al., 2012). The model is divided into three subsections, given each component of the system.

2.1 *Transmitting power by accelerating electrons*

Larmor (1895) argues a precession of the magnetic moments of electrons about an external magnetic field, **H**, exerts a torque on the magnetic moment,

$$\vec{\Gamma} = \vec{\mu} \times \vec{B} = \gamma \vec{J} \times \vec{B}, \tag{1}$$

where $\vec{\Gamma}$ is the torque, $\vec{\mu}$ is the magnetic dipole moment, $\vec{J}$ is the angular momentum vector, $\vec{B}$ is the external magnetic field, and γ is the gyro-magnetic ratio which gives the proportionality constant between the magnetic moment and the angular momentum. Combined with the Larmor angular frequency,

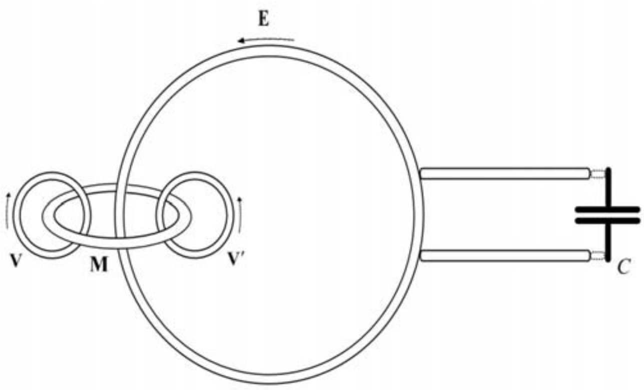
$$\omega = \frac{egB}{2m}, \tag{2}$$

where $\gamma = \frac{-eg}{2m}$ and B is the magnetic field, a two-dimensional polar-rotational frame of coordinates pertaining to the motion can be expressed numerically – as an irrotational flow about the peak intensity of the magnetic field $\mathbf{B}_0$ at the centre of the loop. This model now becomes useful to calculate the total power radiated by a nonrelativistic point charge as it accelerates. A limitation is the frequency relative to the speed of light; for the purposes of the model, this will be small. The total power radiated by an antenna is given by Larmor,

$$P = \frac{q^2 a^2}{6\pi\varepsilon_0 c^3}, \tag{3}$$

where a is the acceleration, q is the charge, and c is the speed of light, connected to gauge potentials (Wiechert, 1899), larger than the quantum level. The analytical formulation, then, relies explicitly on the definition of electron distribution between the circuit and field model. If reduced to multi-vectored velocity relations between orders as v/c, and not considering any particular trajectory of force, the force coefficient, f, serves to set the system in motion, independent of the energy U that is expressed at the interface. In the antenna, the transition of states at the interface following f is a motion from a current, **E**, impressing a vorticity, **V** and **V′**, at right angles to the magnetic force, **M**, of the conductor L, of Maxwell's (1861) description illustrated in Figure 1, including a capacitor, C.

Figure 1 Maxwell magnetic field vortices at the interface of a loop



The contribution offered here is unification between Maxwell and Larmor concerning the motion of electrons and the field forces that result on a loop of a given material. The implication is the motion in free-space away from the antenna is displacing energy in the manifold of the environment in order that the forces consisting the field are directly observable. In the 19th century, they had termed it as confirmation of *aether*, evidence of a displacement current first described by Maxwell. In the case of the experiment in this paper, this is shown at least partially true, only if restricted to a local neighbourhood of particles and fields in a very specific context, consistent with Fitzgerald's (1885) contention.

2.2 A system of equations

The force coefficient, f, expressed as acceleration – a second-order expression – is represented in the oscillator equation as the force function in a static context. Over a period of time, the function stabilises around resonance between the antenna-capacitor circuit and accelerative force oscillating between the endpoints of the circuit $-\pi < 0 < \pi$. When decaying to a velocity, it remains distant from the force at a ratio of v/c; transformed to a quasi-stable motion, it is described as a vortex. If current and voltage input to a pair of n-mosfet power transistors is stable and a force maintained between the drain-gate of each, the circuit will emit an energy field. The voltage is force, the current linear velocity, and the charge is linear displacement.

The circuit illustrated in Figure 2 is a push-pull oscillator driven by n-mosfet power transistors Q1 in π and Q2 in π; each part in 2π applying force in quantities of voltage yielding a magnitude of acceleration to electrons relative to the current at an atomic structure on a conductor. For simulation in SIMetrix, resistors, R1–R4, are added to create a differential in the force across the circuit so that it will oscillate. A physical circuit does not require these resistors.

Figure 2 The circuit of the push-pull oscillator

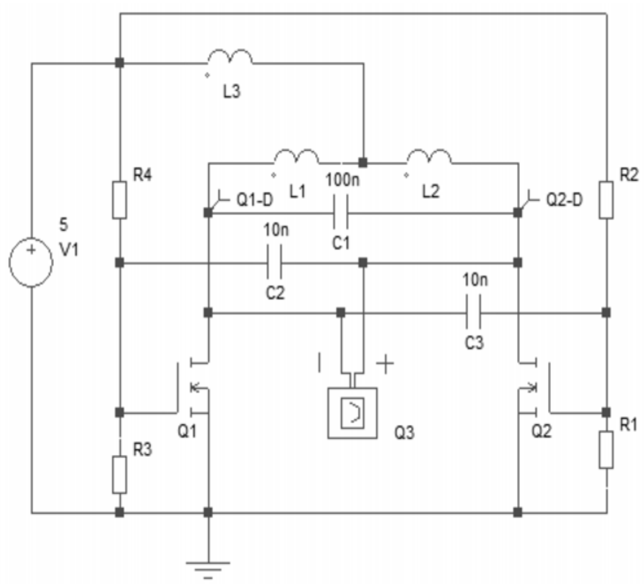
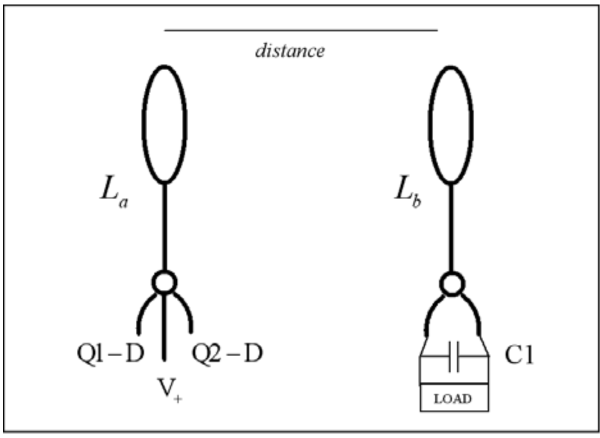


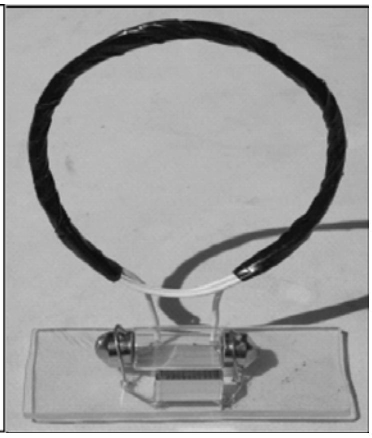
Figure 2 illustrates a schematic of the circuit of two transistors, Q1 and Q2, a tuning capacitor C1, and an antenna consisting of a loop L1, L2 of wire where at half its length, a third wire, L3, connects to the positive terminal of the dc source. Probes Q1-D and Q2-D show each half-cycle of the sinusoidal signal impressed on the antenna, shown in Figure 12, while the differential probe Q3 feeds data for the spectral analysis, shown in Figure 13. The loop of insulated wire, L1, L2, L3 of Figure 2, is connected to capacitor C1 in parallel at ends L1 and L2.

The antenna part of the circuit is designed to transport energy resonantly in the form of radiation between two circular loops of insulated wire. A drawing of the radiative circuit is illustrated on the left-side of Figure 3. An example receiver with load to convert radiation to electrical current is shown on the right-side of Figure 3. The antenna L_a has a capacity to emit currents based on its dimension and orientation with the receiver L_b. The thicker the wire and the greater the number of turns, the more energy is transmitted at a given distance. The more axially-aligned the two coils are, the more coupling between and the stronger the waveguide. The receiver utilises a tuning capacitor to keep its signature in phase with the transmitter.

Dynamically-speaking, the combination of the transmission antenna with its capacitor and the relationship between it and the n-mosfet power transistors Q1, Q2, results in a synchronous oscillation between charges in the circuit and charges in the conductor. The pattern of this behaviour is illustrated in Figure 4.

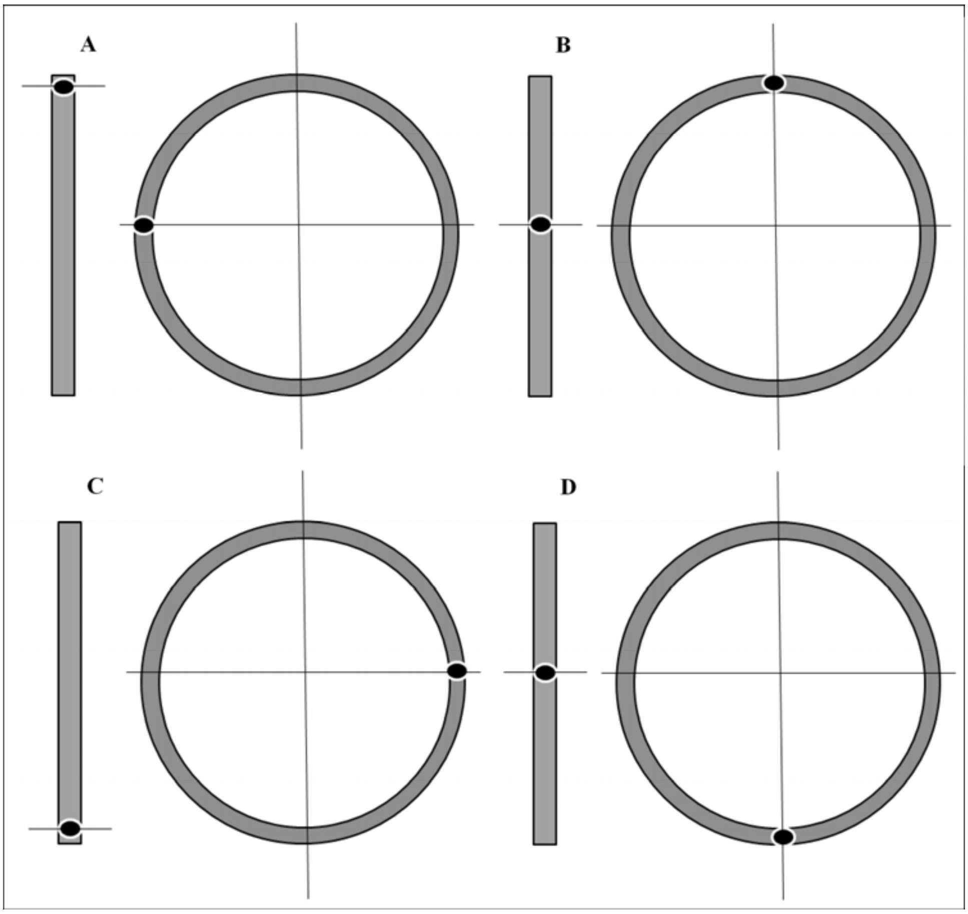
Figure 3 (a) Two circular loops set at a distance (b) Receiver with load





(a) (b)

Figure 4 Dynamic representation of oscillator cycle circulating charges in the antenna conductor



Each movement through the circle is marked at points $\pi/2$.

At the start of the cycle, A of Figure 4, one transistor is responsible for the acceleration of charges moving them through π, B and C of Figure 4. For the end of the cycle, the other transistor accelerates the charges through the remainder of the loop, D and A, through π, returning the cycle to its starting point. The system of equations for this arrangement begins around the use of an inductor and capacitor placed in parallel relative to each other. Based on Kirchhoff's circuital laws, the relationship between these elements is

$$-\frac{q}{C} - L\frac{di}{dt} = 0. \tag{4}$$

Representing the current, i, as $i = dq/dt$,

$$L\frac{d^2q}{dt^2} + \frac{q}{C} = 0, \tag{5}$$

and the angular frequency, ω, as $\omega = 1/\sqrt{LC}$, (5) is transformed to

$$\frac{d^2q}{dt^2} + \omega^2 q = 0, \tag{6}$$

which takes the form of the equation for a mass on a string

$$m\frac{d^2x}{dt^2} + kx = 0. \tag{7}$$

In terms of a real circuit, the value of resistance, regardless of the size, is included as

$$L\frac{dq^2}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = 0. \tag{8}$$

The implicit solution for the oscillations in the circuit, in terms of charge, q,

$$q = q_{\max} e^{-tR/2L} \cos(\omega' t + \theta), \tag{9}$$

where $q_{\max}$ is the maximum charge on the capacitor, and θ is the phase. Maximum current at any arbitrary point is

$$i = -\omega q_{\max} \sin(\omega t + \theta) = -i_{\max} \sin(\omega t + \theta), \tag{10}$$

and the first-order angular frequency, from (9), is

$$\omega' = \sqrt{1/LC - \left(R/2L\right)^2}. \tag{11}$$

The total energy oscillating in the circuit is therefore a component of the capacitance, inductance, and resonance frequency dependent upon the polarisation of the material comprising the loop. If the phase between the capacitor and inductor are offset by 90 degrees, the stored energy in each component is expressed as

$$\begin{aligned} U_C &= \frac{q^2}{2C}\cos^2(\omega t + \theta), \\ U_L &= \frac{1}{2}Li^2 \\ &= \frac{1}{2}L\omega^2 q^2 \sin^2(\omega t + \theta) \\ &= \frac{q^2}{2C}\sin^2(\omega t + \theta) \\ &= i^2 R, \end{aligned} \tag{12}$$

while the total energy stored by the oscillation is

$$U_C + U_L \approx -e^{-tR/L}. \tag{13}$$

In consideration of velocity, the circuit is an oscillatory, second-order system

$$\frac{d^2q}{dt^2} + 2\zeta\omega_0\frac{dq}{dt} + \omega_0^2 q = 0, \tag{14}$$

where the force coefficient, f, is the sum of the amplitudes,

$$f_0 = \mathrm{A}_+ \cos(\omega t) + \mathrm{A}_- \sin(\omega t), \tag{15}$$

governed by polynomials expressed by the oscillator,

$$2x^2 - 2x + 1,\ 2x^2 + 2x + 1, \tag{16}$$

where the $2x$ component is for the first cycle in π and $-2x$ for the second cycle of π, illustrated in Figure 4. The force following from the sum of amplitudes of the under-damped system at the damping ratio of $0 \le \zeta < 1$ sustains oscillations to a transient solution, q_{ts},

$$q_{ts} = e^{-\zeta t}\left[c_1 \cos\left(\sqrt{1-\zeta^2\omega_0 t}\right) + c_2 \sin\left(\sqrt{1-\zeta^2\omega_0 t}\right)\right], \tag{17}$$

which converges to a steady-state solution of the form,

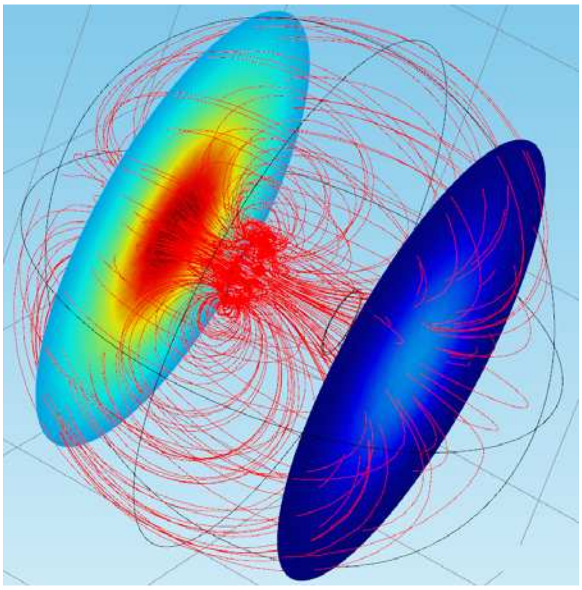
$$q_s(t) = Ae^{i(\omega t + \phi)}, \tag{18}$$

where its derivatives are

$$\begin{aligned} \frac{d^2q_s}{dt^2} &= -\omega^2 Ae^{i(\omega t+\phi)}, \\ \frac{dq_s}{dt} &= i\omega Ae^{i(\omega t+\phi)}, \\ q_s &= Ae^{i(\omega t+\phi)}. \end{aligned} \tag{19}$$

The amount of magnetic force, as a density of linked flux-lines, influences the density of the energy transported on the waveguide. Modelling the magnetic flux linkage and field intensity, as action at a distance, is illustrated in Figure 5.

Figure 5 Faraday model of magnetic force-lines linking between antenna (see online version for colours)



Rather than considering the boundary as a result of the linkage, if it is conceived as a component property of the space, a generalised mathematical framework emerges. In such a case, the cavity is a preferred model in that the waves traversing the space are not only contained within the boundary but exhibit a positive and negative group velocity along it, as well as an irrotational magnetic field, $\mathbf{B}_0$, at the centre of the aperture created by the coils. The density of the energy at the boundary is dependent upon the strength of the linking κ_λ. An increase of κ_λ is a matter of increasing the surface area of the coils, increasing the surface potential of the skin, since the wave does not appear inside the conductor of the antenna (Larmor, 1895). Coupling in such a manner, between vector fields to the circuit, is also described in Vandenbosch (2013), Tucker et al. (2013) and Rangelov and Vitanov (2012). At the characteristic frequency, shown in Table 1, energy flows in both directions, e.g., from transmitter to receiver in the case of acceleration by transistors, and from receiver to transmitter in the case of reflection, while also subject to a projection, $\bar{\mathbf{H}}$.

The substance of $\bar{\mathbf{H}}$, derived from the vorticity of Maxwell and represented as a force here, in terms of **M** from Figure 1, is defined a rotational force whose centre is the conductor creating a subtended force at its centre, numerically conceived as a dynamic elasticity problem (Hentati et al., 2013). Following Larmor's conjecture, if the coordinates of the space where the equations are operating include potential energy, a material framework per unit volume is a force,

$$\begin{pmatrix} u\dfrac{dF}{dx}+v\dfrac{dG}{dx}+w\dfrac{dH}{dx}, \\ u\dfrac{dF}{dy}+v\dfrac{dG}{dy}+w\dfrac{dH}{dy}, \\ u\dfrac{dF}{dz}+v\dfrac{dG}{dz}+w\dfrac{dH}{dz} \end{pmatrix}, \tag{20}$$

and a couple,

$$\left(vH-wH, wF-uH, uG-vF\right), \tag{21}$$

from a rotational virtual displacement of the elements. In the case of the Ampere-Maxwell, there should simply be a force at right angles to the current,

$$\left(vc-wb, wa-uc, ub-va\right), \tag{22}$$

forming the special axes of coordinates,

$$\left\{-w\left(\frac{dF}{dz}-\frac{dH}{dx}\right), w\left(\frac{dH}{dy}-\frac{dG}{dz}\right), 0\right\}. \tag{23}$$

Larmor argues such a forcive differs from Ampere-Maxwell by

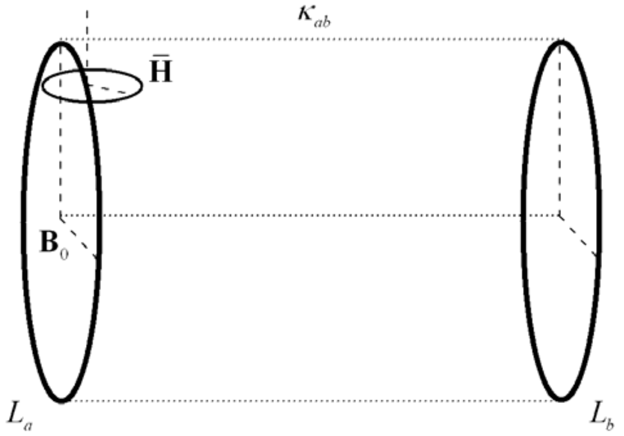
$$\begin{aligned} &\text{a force } \left(u\frac{dF}{dz}, v\frac{dG}{dz}, w\frac{dH}{dz}\right), \\ &\text{and a couple } \left(-wG, wF, 0\right), \end{aligned} \tag{24}$$

constrained to an equivalency of forces acting on the ends of each linear current element, equal at each end to (wF, wG, wH) per unit of cross-section, positive and the front and negative at the rear. Therefore, the internal stresses are homeostatic for each circuital current and do not disturb the resultant force on the conductor due to the presence of the field. The circulation of energy through the rings, illustrated in Figure 1, expressed for the energy in the field, U_ϕ, in terms of vortex filaments,

$$U_\phi = \frac{1}{2}\sum\iint \sigma_1\sigma_2 r^{-1}\cos\varepsilon\, \mathrm{ds}_1\mathrm{ds}_2, \tag{25}$$

is a potential difference of energy of all filament since they are constrained by an identical forcive. Thus, when using the coordinate system in (20) and ignoring internal stress of any kinetic components, the distribution holds since the electric velocity is not generalised, and we are only interested in the forcive at the aperture.

Figure 6 Model of a virtual cylindrical boundary between coils, including Maxwell's vorticity projection, $\bar{\mathbf{H}}$



It is therefore possible to calculate the energy contained in the field using a complete elliptic integral at the aperture, which from Figure 6, is considered continuous and statistically complete in the local neighbourhood. It is of the first kind,

$$K(m) = \int_0^{\pi/2} \frac{dt}{\sqrt{1 - m\sin^2(t)}}, \tag{26}$$

where $m = m - m_1$ using the approximation $P(x) - \log xQ(x)$, and $K(0) = \pi/2$ for the first rotational velocity, illustrated in Figure 4, and of the second kind,

$$E(m) = \int_0^{\pi/2} \sqrt{1 - m\sin^2(t)}\, dt \tag{27}$$

using the approximation $P(x) - x\log xQ(x)$. Displacement of the field in directions away from the aperture yield the virtual waveguide in terms of forces. The strength between these forces, expressed as resonant linking, referring to Figure 5 and determined by classical methods (Poynting, 1885; Haus and Huang, 1991; Fano et al., 1969; Adler et al., 1969; Zierhofer, 1996; Corum and Corum, 2001; Paul, 1993), yields a simple relationship of a coupling coefficient κ_{ab} between magnetically-resonant coils,

$$\kappa_{ab} = \frac{M_{ab}}{\sqrt{L_a L_b}}, \tag{28}$$

where M_{ab} is the mutual inductances, L_a, L_b are the self-inductances of the coils. An approximation of the inductance of these loops (Tucker et al., 2013) is

$$\begin{aligned} L_a &\approx \mu_0 \mu_r n_a^2 r_a \left(\ln \frac{8r_a}{a_a} - 2 + Y \right), \\ L_b &\approx \mu_0 \mu_r n_b^2 r_b \left(\ln \frac{8r_b}{a_b} - 2 + Y \right), \end{aligned} \tag{29}$$

where r_a, r_b is the loop radius and a_a, a_b is the wire radius, n_a, n_b is the number of turns, and Y is the flow constant of the skin-effect of the emitted radiation, which is relevant here since in the theoretical model, it is affirms the current flows on the outside of the conductor in the space. The calculation of mutual induction as a function of the circuital properties (Wheeler, 1928; Hannakam, 1967; Grover, 1946; Kurs, 2007) is shown in Table 1.

The result here is that Maxwell's vorticity can be analytically expressed and numerically construed for a system of two resonant loops. The simulation results show energy exchange at the interface for each of the property groups.

2.3 System losses

Losses are due to distortions on the interface between the charging and discharging cycles of electron velocities between the coil and the space. There are two types of losses: the losses due to resistance on the conductor,

$$R_o = \sqrt{\frac{\mu_0 \omega_0}{2\sigma}} \frac{\ell^2}{4\pi R}, \tag{30}$$

where σ is the conductivity of the material, ℓ the wire length of the coil and R is the wire radius, and the losses due to radiation (Kurs, 2007),

$$R_r = \sqrt{\frac{\mu_0}{\varepsilon_0}} \left[\frac{\pi}{12} n^2 \left(\frac{\omega r}{c} \right)^4 + \frac{2}{3\pi^3} \left(\frac{wh}{c} \right)^2 \right], \tag{31}$$

where n is the number of turns of the coil, ω is the angular frequency, c is the speed of light, r is the radius of the coil, and h is the distance between the emission and where it is measured.

3 Simulation results

Results from the simulations of the circuit, illustrated in Figure 2, focus around the pattern of energy emitted by the antenna as a consequence of the action by the transistors. Although there are disagreements, generally speaking, between circuit and field modelling, this paper only addresses any anticipated structures of energy emission of a radiation pattern, given the theoretical model. What is most interesting is the transfer function of energy from antenna to free-space. A simulation of energy patterns at the interface is shown in Figure 7, while the field aperture is shown in Figure 8.

Table 1 Circuit properties

Element	*Coil turns – Radius (cm)*	*Inductance (μH)*	*Coupling (κ_λ)*	*Mutual inductance (μH)*	*Frequency (kHz)*
A, B	3 – 3	1.414	0.01761	0.0249	422.931
A', B'	10 – 3	15.735	0.00158	0.0249	126.879
A'', B''	25 – 3	98.342	0.00025	0.0249	71.773

Figure 7 Energy pattern at the interface

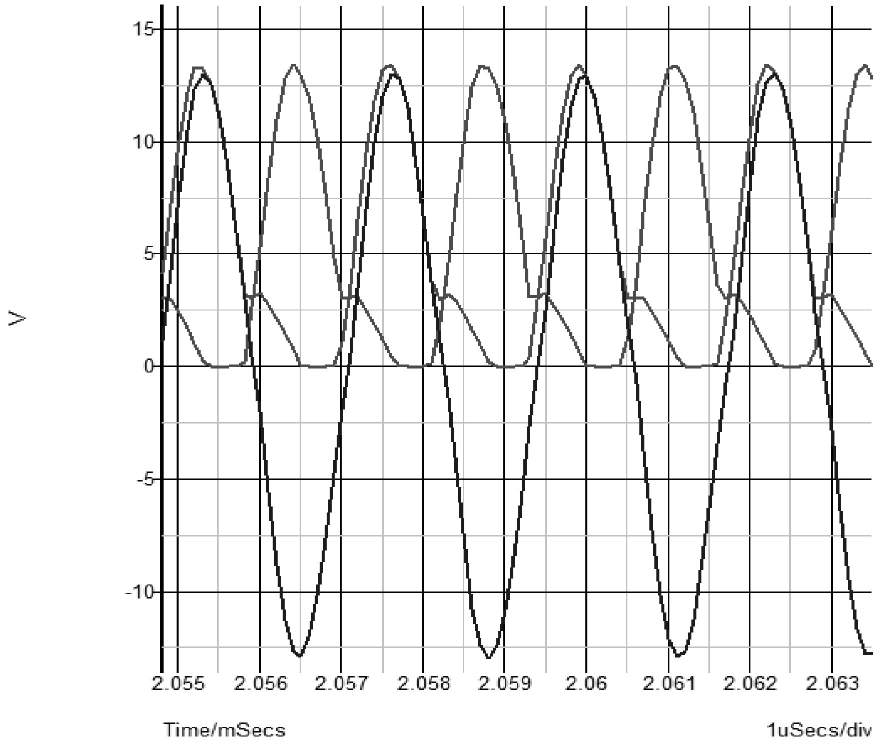
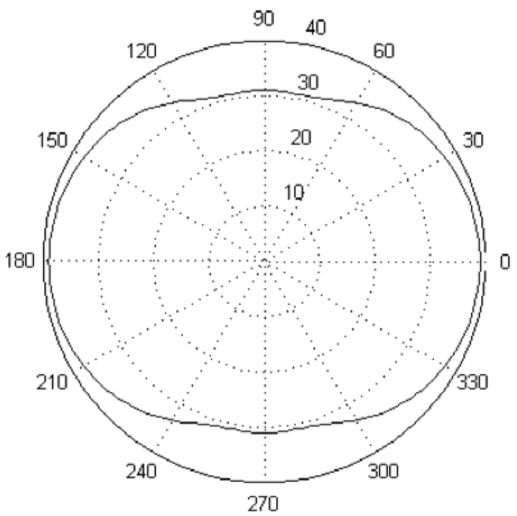


Figure 8 Radiation pattern at the aperture



The pattern is generally sinusoidal, as expected, since there is neither truncation nor clipping of the wave by any artificial means; if the oscillator continues to run the pattern will persist indefinitely. In terms of power: if the number of turns of wire in the antenna is increased, energy distribution illustrated in Figure 7 increases in magnitude linearly for each step increase in the self-inductance of the loop (Zeng et al., 2013). In terms of displacement: if the loop is uniform in its circular shape, turns of it can be unwrapped over a larger area, such as a honeycomb structure, where the components of the conductor and the circuit are under less operative strain and the receiver element can remain as a single loop, still absorbing power at the ratio before the transmitter was spread out. This is indicative of the vortex motion replicating itself onto each infinitesimal segment of loop.

It is expected that the magnitude of the emission propagates at near-constant through the vortex at the edges of the loop and linearly over the distance at a ratio of ${}^{1}\!/_{r}$, illustrated in Figure 9, in the local neighbourhood, while ${}^{1}\!/_{r^2}$ elsewhere, illustrated in Figure 10. Measurement points are indicated as well as the cubic spline of the decay.

Figure 9 Intensity over distance, $d = 2r$ (see online version for colours)

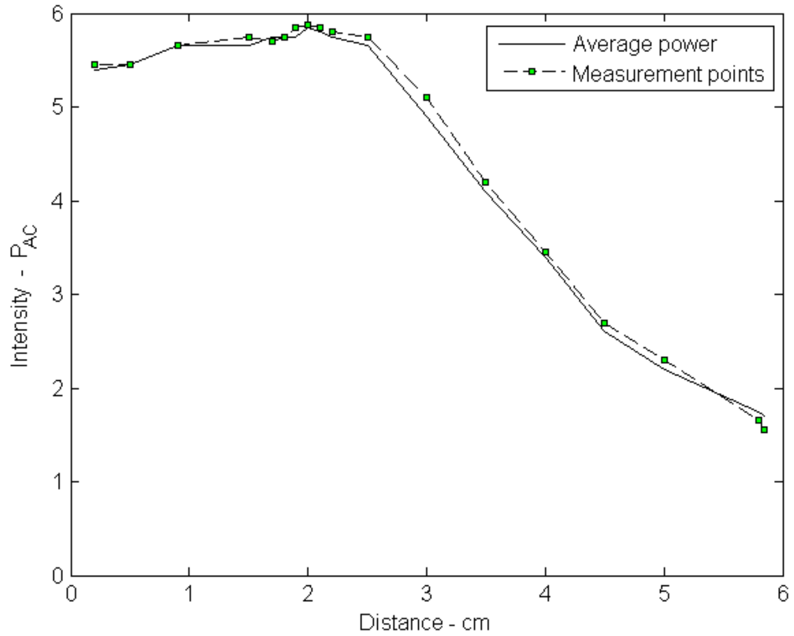
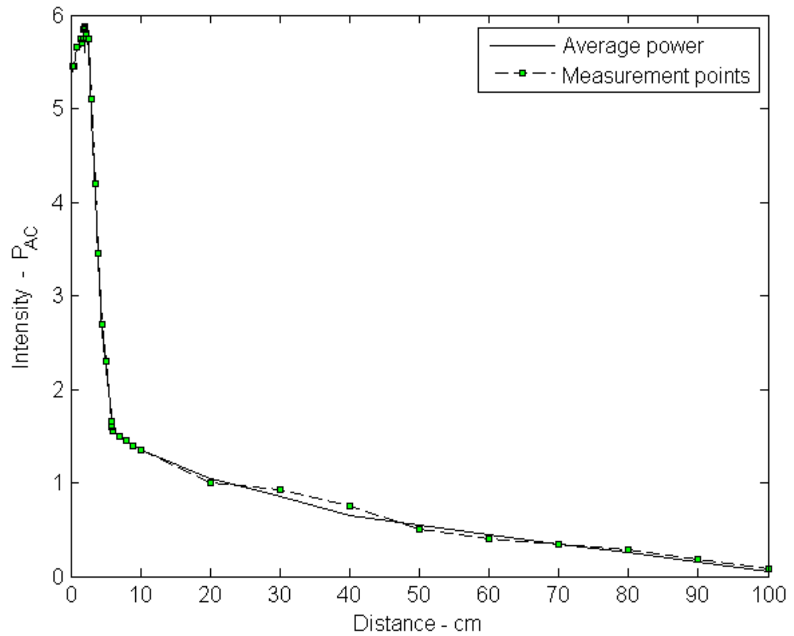


Figure 10 Intensity over distance, $d \gg r$ (see online version for colours)



The energy pattern shown in Figure 7 consists of several parts, corresponding to the rotational vector in π of the applied acceleration force, illustrated in Figure 4. The pattern is split into these parts, based on the positive and negative amplitudes of (15), illustrated in Figure 11.

In terms of pure signal, the function exhibited by the circuital energy at the probes and the differential is shown in Figure 11, and the spectral view is shown in Figure 12. Figure 8 could also be construed to be a view of the radiation pattern of the antenna from the z-direction away from the x-y plane.

4 Conclusions

The transfer of electrical currents without wires by applying an accelerating force to electrons in a molecularly-structured conductor results in the appearance of a velocity-vortex displacement of radiation on a loop antenna at the interface of free-space. The aim of this paper is to find agreement – at the very minimum in principle – between Larmor's conjecture and Maxwell's vorticity by moulding a body of theory into a framework which describes a physical example.

Figure 11 Signal pattern at probe points Q1-D, Q2-D, and differential probe

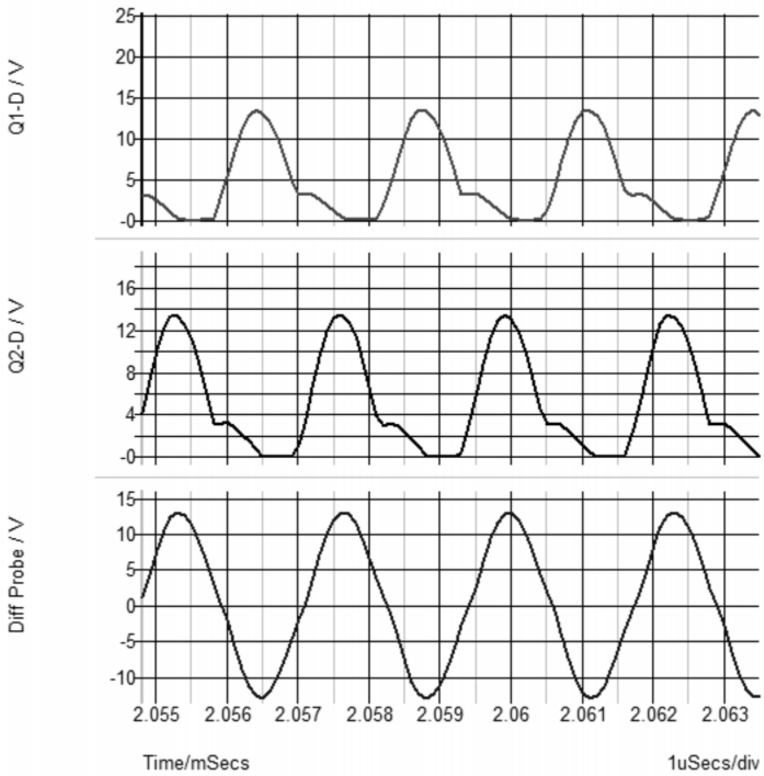
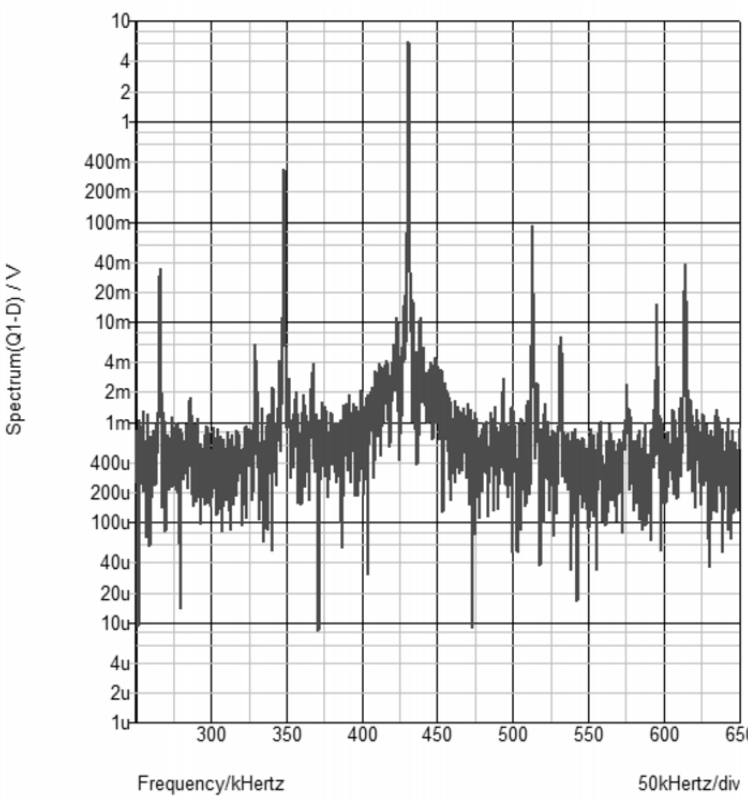


Figure 12 Spectrum around the fundamental frequency



The goal of this paper is to exhibit a model which satisfies a conclusion proposed by Larmor (1895): "Our conclusion is, then, that the only proper basis for the dynamical analysis of the phenomena of currents flowing in conductors, in fact, of all cases of the flow of true electricity, is to treat the currents as the statistical aggregates of the movements of electrons". Here the model has been applied to wireless currents where the aggregate movements of electrons yield quantised energy when their velocities shift from one continuum to another by an external force.

The conclusion offered by this paper is the suggestion that the flow electricity, as Larmor defines it, is not only a phenomenon restricted to conductors, but is also manifest in free-space where a virtual conductor is created as a consequence of resonant linking between magnetically-coupled coils *and* the space containing it. This is important in that it demonstrates there is elasticity present in the space around a conductor displacing vortex radiation, or radiation emission as a rotation which Maxwell describes as a vorticity. If there is elasticity, there are two alternatives: that the fields displace molecular objects, such as air, or the fields displace structures at the quantum level. If the latter is shown to be true, it opens the door of an access to the quantum world from our own where a diverse array of patterns can be impressed; topological structures containing or filtering energy can be utilised for many purposes including holography, containment, propulsion, and projection.

Finally, the results imply there are aspects of Maxwell's original theories which are of great import and can contribute to analytical assessments of wireless power and its transmission under such a transformation illustrated in this paper.

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