Induction in SR Electrodynamics with Experimental Support (2nd Ed.)

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SR Electrodynamics was developed in a previous paper by the author: "Experimental Support for SR Electrodynamics" [1]. The purpose of the present paper is to expand upon the induction part of electrodynamics and to present supporting experimental evidence. The first part of SR Electrodynamics deals with development of the force formulas related to relative moving isolated charges and to force formulas related to current elements. The Special Relativity (SR) development shows that the correct formula for force between current elements is the steady state formula developed by Andre Ampère in about 1822. The development further shows that electromagnetic induction can be derived from that force formula. While many formulas exists replacing the old Ampère's Law, it is the intent of the present author to show that this old law is the correct one and can be used for derivation of induction formulas corresponding to Faraday's induction laws. Another purpose of this paper is to show the magnetic field as is currently defined is a mathematical artifact and detracts from the reality of a true magnetic field related to relative moving charges.
Key Words: electrodynamics, special relativity (SR), electric field (e-field), relative moving charges, magnetic force, Coulomb force, magnetic field energy, steady-state, current element, induction.

1. Introduction

The theory for induction was developed in the author's paper on SR Electrodynamics [1]. In this paper, it was show that the Lorentz Force Law is essentially replaced with a new similar law for force between isolated charges:

$$\mathbf{f_{12}} = q_2\left(e_1 + e_{m1}\right)\hat{\mathbf{r}}_{\mathbf{12}} \tag{1}$$

where e_1 is the static electric field of q_1 and e_{m1} is the new definition of the magnetic field created by the moving charge q_1:

$$\mathbf{e_{m1}} = \frac{\mu_o q_1 v^2}{4\pi r_1^{\,2}}\left(0.5 - 1.5\cos^2\theta\right)\hat{\mathbf{r}}_1 \tag{2}$$

The Magnetic Force Law between a Stationary Current Element and a Stationary Charge differs slightly from Eq.(2):

$$d\mathbf{f_{12}} = \frac{\mu_o q_2 \sigma_1 ds_1 v^2}{4\pi r^2}\hat{\mathbf{r}}_{12}\left(1\text{-}1.5\cos^2\theta\right) \tag{3}$$

When Eq.(3) is mathematically applied to two current elements positioned at various angles one with respect to each other, then one arrives at the old Andre Ampère's Law. Expressed in vector notation this law is:

$$d^2\mathbf{f_{12}} = \text{-}\hat{\mathbf{r}}_{12}\frac{\mu_o I_1 I_2 ds_1 ds_2}{4\pi r_{12}^{\,2}}\left(2d\hat{\mathbf{s}}_1 \bullet d\hat{\mathbf{s}}_\mathbf{2}\text{-}3(d\hat{\mathbf{s}}_\mathbf{1} \bullet \hat{\mathbf{r}}_\mathbf{12})(d\hat{\mathbf{s}}_\mathbf{2} \bullet \hat{\mathbf{r}}_\mathbf{12})\right) \tag{4}$$

where $d^2\mathbf{f_{12}}$ is the force on current element 1 caused by current element 2, $\mathbf{r_{12}}$ is the three- vector displacement from 1 to 2, and I_1 and I_2 are current magnitudes in current elements 1 and 2 respectively. μ_o is the permeability of free space. The vectors $\boldsymbol{ds_1}$ and $\boldsymbol{ds_2}$ are three-vectors describing the length and direction of the two current elements. As shown in Eq(4), these three-vectors including $\mathbf{r_{12}}$ are replaced with unit vectors and magnitudes.

Eq. (4) is a steady state equation, that is, it represents the force between two current elements with constant currents in them.

2. Induction

No new SR Electrodynamics laws need to be created to show how induction occurs. It is known from experience with induction that it can occur in a wire two different ways. One way (induction by movement) is to move a charge, wire or current element in a magnetic field, so that a voltage (emf) is acquired by the charge or is induced along the wire or current element. The other way (induction by changing magnetic field) is to vary the magnetic field created by a current in a wire or current element so that a voltage or emf is induced in a separated charge or current element. Since the magnetic field in SR Electrodynamics is a compressed or reduced **e**-field, Eq. (4), it is easy to determine the induced voltages using the existing SR Electrodynamics laws.

It is helpful to recall the definition of voltage from a physics book: "It is the work W done by a unit charge in passing between two points of a circuit equal to the *potential drop* between these two points. If W is now taken to represent the work done by the charge Q in moving between two such points, the potential drop between the points is $V = W/Q$. The term *potential difference* applies to both emf and potential drop; the practical unit is the volt. *The potential difference between two points is one volt if a charge of one coulomb either requires or expends one joule of energy in moving from one point to the other*" .

2.1 Induction by movement of a charge with respect to a stationary current element

The formula to be derived will be an elemental type formula as contrasted to formulas applied to macro circuits like large coils. Let $\mathbf{u_2}$ be the vector velocity of q_2 and $\mathbf{u_1}$ be the vector velocity of the electron lattice in the current element. Then $\mathbf{v} = \mathbf{u}_2 - \mathbf{u}_1$ and v is the magnitude of this relative velocity as used in the formula. β is the angle between $\mathbf{v}$ and $\mathbf{r_{12}}$. So the induced voltage will be:

$$dV_{emf} = df_{\mathbf{12}}dr = \frac{\mu_o q_2 \sigma_1 ds_1 v^2}{4\pi r_{12}{}^2}\left(1\text{-}1.5\cos^2\beta\right) u_2\left(\hat{\mathbf{u}}_2 \bullet \hat{\mathbf{r}}_{12}\right) dt \tag{5}$$

where $v^2 = u_1{}^2 + u_2{}^2 - 2u_1u_2\left(\hat{\mathbf{u}}_1 \bullet \hat{\mathbf{u}}_2\right)$.

2.2 Induction on a stationary charge with respect to a stationary current element by varying current in the current element

This is the situation where a changing magnetic field induces a voltage on the stationary charge with the distance between the current element and the charge remaining constant. The energy stored in the field between the current element and charge is given by:

$$dE_{12} = \int_{\infty}^{r_{12}} d\mathbf{f_{12}} dr \tag{6}$$

So that:
$$dE_{12} = -\frac{kq_2\sigma_1 ds_1}{r}\frac{v^2}{c^2}\left(1\text{-}1.5\cos^2\theta\right) \tag{7}$$

A change in dE_{12} due to a change in relative velocity would represent the work done on q_2.

So that the induced emf voltage dV_{emf} is:

$$dV_{emf} = d(dE_{12}) = -\frac{\mu_o q_2 \sigma_1 ds_1 2v_1}{4\pi r_{12}}\left(1\text{-}1.5\cos^2\theta\right)dv_1 \tag{8}$$

Since $I_1 = \sigma_1 v_1$ then $dv_1 = dI_1 / \sigma_1$. Substituting in Eq. (8):

$$dV_{emf} = d(dE_{12}) = -\frac{\mu_o q_2 I_1 ds_1}{4\pi r_{12}}\frac{2}{\sigma_1}\left(1\text{-}1.5\cos^2\theta\right)dI_1 \tag{9}$$

2.3 Induction between a stationary current element and a moving current element

Let $\mathbf{u}_1$ be the velocity vector of $d\mathbf{s}_1$ with respect to $d\mathbf{s}_2$, then:

$$d^2V_{emf}(t) = (d^2 f_{12})\frac{dr_{12}}{dt} = \text{-}\frac{\mu_o I_2 ds_2 I_1 ds_1}{4\pi r_{12}{}^2}\left[2d\hat{\mathbf{s}}_1 \bullet d\hat{\mathbf{s}}_2 \text{-}3(d\hat{\mathbf{s}}_1 \bullet \hat{\mathbf{r}}_{12})(d\hat{\mathbf{s}}_2 \bullet \hat{\mathbf{r}}_{12})\right]\left(\mathbf{u}_1 \bullet \hat{\mathbf{r}}_{12}\right) \tag{10}$$

2.4 Induction between two stationary current elements with varying current in one element

In this case, we integrate Eq. (4) from ∞ to r to get the energy in the field between the two current elements and then vary the current in one of the current elements to vary its field energy. The change in field energy then induces a voltage in the other current element. These current elements can be in the same circuit or each in separate circuits:

$$d^2V_{2emf}(t) = \frac{d(d^2E_{12})}{dt} = \text{-}\frac{\mu_o ds_1 ds_2 I_2}{4\pi r_{12}}\frac{dI_1}{dt}\left[2d\hat{\mathbf{s}}_1 \bullet d\hat{\mathbf{s}}_2 \text{-}3(d\hat{\mathbf{s}}_1 \bullet \hat{\mathbf{r}}_{12})(d\hat{\mathbf{s}}_2 \bullet \hat{\mathbf{r}}_{12})\right] \tag{11}$$

This formula is tested in experiments presented below with current elements in separate circuits. It expresses a voltage induced in current element $d\mathbf{s}_2$ caused by a varying current in current element $d\mathbf{s}_1$ when I_2 is set to 1amp. Eq. (11) presents the challenge of defining what *mutual* inductance exactly is. If one defines it according to how energy is stored in a single coil with a current, then based on the formula for that situation:

$$E = I^2L/2 \text{ or } L = 2E \text{ with } I^{\,2} = 1 \tag{12}$$

Then the mutual inductance calculated from Eq. (11) would be increased by factor of two as shown in Eq. (12:

$$d^2L_{M12} = \frac{2\mu_o ds_1 ds_2}{4\pi r_{12}}\left[2d\hat{\mathbf{s}}_1 \bullet d\hat{\mathbf{s}}_2 \text{-}3(d\hat{\mathbf{s}}_1 \bullet \hat{\mathbf{r}}_{12})(d\hat{\mathbf{s}}_2 \bullet \hat{\mathbf{r}}_{12})\right] \tag{13}$$

But if we take the definition of mutual inductance from the formula:

$$V = L\frac{dI}{dt} \tag{14}$$

which fits the situation depicted by Eq. (11), then one would use the formula for mutual inductance without the factor of two:

$$d^2L_{M12} = d^2L_{12} = \frac{\mu_o ds_1 ds_2}{4\pi r_{12}}\left[2d\hat{\mathbf{s}}_1 \bullet d\hat{\mathbf{s}}_2 \text{-} 3(d\hat{\mathbf{s}}_1 \bullet \hat{\mathbf{r}}_{12})(d\hat{\mathbf{s}}_2 \bullet \hat{\mathbf{r}}_{12})\right] \tag{15}$$

This mutual inductance as defined by Eq. (15) is herein, accepted and used in this paper. L_{M12}, mutual inductance for two separate circuits, can be calculated on a computer using Eq. (15) and finite current element size as follows:

$$L_{M12} = \sum_{1}^{n_1}\sum_{1}^{n_2} d^2L_{M12} \tag{16}$$

So, the induced voltage for an open secondary circuit based on Eq. (11) is:

$$V_{M12} = L_{M12}\frac{dI_1}{dt} \tag{17}$$

Say $V_1 = V_{1\max}\sin\left(wt\right)$ and $I_1 = -I_{1\max}\cos\left(wt\right)$ so that $\frac{dI_1}{dt} = I_{1\max}w\sin\left(wt\right)$:

$$V_{M12} = L_{M12}\omega I_{1\max}\sin(\omega t) \tag{18}$$

By recognizing that magnitude of $I_{1\max} = V_{1\max} / wL_{S1}$ where L_{S1} is the self-inductance of circuit 1, then Eq. (18) can be expressed as:

$$V_{M12} = V_{1\max}\frac{L_{M12}}{L_{S1}}\sin(\omega t) \tag{19}$$

Eq. (19) shows the induced voltage in circuit 2 is in phase with the voltage across the inductance in circuit 1.

Experiments were performed for varying conditions of L_{M12} and primary and secondary inductances to compare the calculated V_{M12} with the measured V_{M12}. Eqs. (15) and (16) are employed to calculate L_{M12}. The results of the experiments are presented below. The major role that the old Andre Ampère's Law has in induction is its ability to calculate accurately the inductance of a circuit and the mutual inductance between two circuits.

2.5 Self-Inductance

It is shown next how to calculate the self-inductance L_{S1} of a single circuit. It involves just changing the limits of the summations of Eq. (16) and multiplying the terms by a factor of two:

$$L_{S1} = \sum_{1}^{n-1}\sum_{n_1+1}^{n} 2d^2L_{12} \tag{20}$$

Recognize that energy stored in a coil is given by $E_{12} = I_1 I_2 L_{12} / 2$. If $I_1 = I_2 = 1$, then $L_{12} = 2E_{12}$. This is where the factor of two (2) is included for a single coil self- inductance.

2.6 An example of induction is the self-induction law:

$$V = L\frac{dI}{dt} \tag{21}$$

where V is the back electromotive force (emf) voltage induced in a coil due to a changing current dI/dt in it. The value of the inductance L of a simple coil is calculated by the classical Ampère's Law which is derived from SR [10]. A popular formula for calculating the voltage induced in a coil is:

$$V = N \times d\varphi / dt \tag{22}$$

where V is the voltage induced in a coil of N turns due to a changing magnetic flux φ with time t. Eq. (22) involves the concept of a magnetic field (magnetic flux density) B employed by Faraday, Lorentz, and Maxwell. This concept of the magnetic field is a mathematical aid to handle macroscopic circuits that involve electrical currents. It works well in engineering applications and some physics applications. This concept of the magnetic field summarizes gross conditions in electrical circuits, but it fails at the elemental level. (Maxwell applied Faraday's gross results to guess at his equations for electromagnetic wave propagation).

3. Experiments with Induction

3.1 Experiment with induction between two square coils

Test Equipment:

1) HP 3490A Multimeter (Used to calibrate resistor and capacitor values and to measure rms voltages)
2) HP 5360A Computing Counter with 5365A Input Module (Used to measure frequency of Test Oscillator)
3) HP 652A Test Oscillator (Used to supply sine wave voltage for achieving resonance in LC parallel circuit)
4) Tektronix 2245 100 MHz Oscilloscope (Used for detecting resonance of LC parallel circuit)

Using the conditions described in the above Sections 2.4 and 2.5 on induction between two stationary current elements with varying current in one element and Eqs. (15), (16), (19), and (20) an experiment on induction in Einsteinian Electrodynamics was performed. A wooden multi-coil form was constructed much like four table legs around which five single turn coils were wound. (See Figures 1 & 2) The coils were square being 0.46 meters to a side. 22 a. w. g. stranded wire made up the single-turn coils. The first coil was the primary coil on which an oscillating voltage was applied. The other four coils were spaced parallel on the "legs" from the primary coil at approximately 0.5 in., 1.0 in., 2.0 in., and 3.0 in. These four coils were left open circuited. The process of this experiment is as follows: Calculate with computer the mutual inductance of each of the four coils with respect to the primary coil that had the oscillating current. Then calculate the induced voltage on the coils. The calculated induced voltage was then compared with the measured induced voltage on the coils. Peak-to-peak voltages were observed on both the primary coil and the secondary coils with the oscilloscope (4 above). The RMS voltages were measured with the multi-meter (1 above). A 0.233 μf capacitor was placed in parallel with the primary coil. The output of the test oscillator was connected directly to the parallel circuit of the primary coil and capacitor and its frequency adjusted to cause resonance. The primary voltage was set to approximately 8.0 volts p-p. Table 2 presents the results of the experiment with multi-meter measurements (scaled to having 8.0 v p-p on the primary coil.)

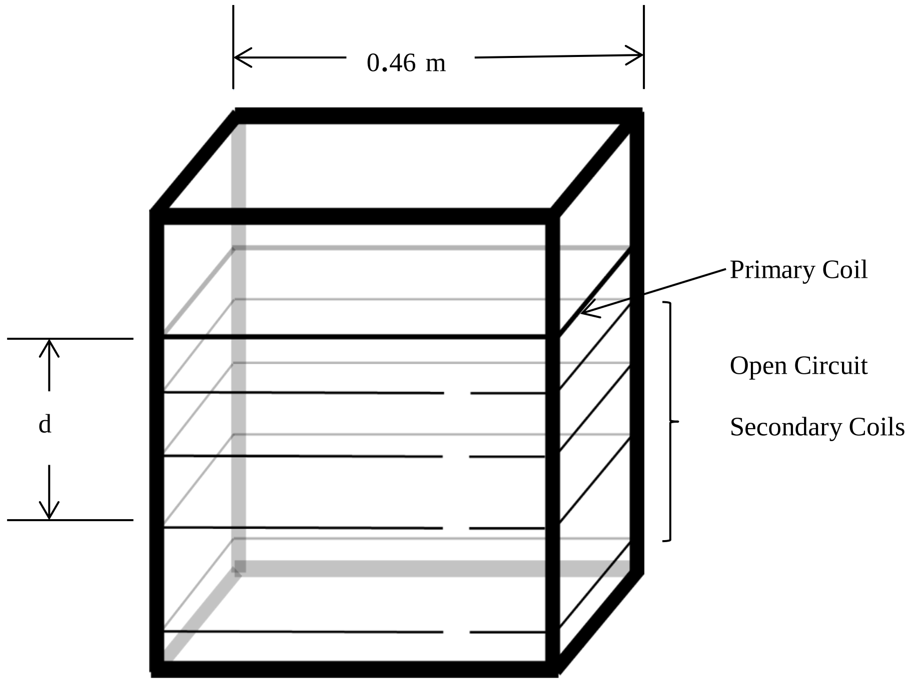

Figure 1. Square coil form, 0.46 m /side, used in induction

Figure 2. Picture of square coil form used for testing induction. Also pictured is the test equipment employed in the experiment.

Table 2. Einsteinian Electrodynamics Induction Experiment, primary voltage = 8.0 v p-p.

Coil	Distance d in.	Distance Avg. d mm	Measured V v p-p	Computed V v p-p	% Difference
1	0.5	13.7	3.357	3.356	-0.02
2	1.0	26.0	2.607	2.575	-1.24
3	2.0	52.1	1.831	1.813	-0.95
4	3.0	77.1	1.422	1.429	+0.49

3.1.1 Discussion of Results

1. The results were close enough to support the induction formula of Eq. (11). This law is like the induction law of Neumann [2]. It is based on current elements instead of having to have flux-linkages of a closed coil.
2. Because this induction law is supported, the other induction laws based on the same derivation as Eq. (11) are strongly supported, even though they are not tested here.
3. It supports the new concept of a magnetic field which acts directly between the two current elements and allows the induction voltage to be calculated. The conventional method of representing magnetic flux and induction by flux linkages requires a closed circuit instead of an open circuit. Thus, these experimental results may be possible by conventional means, but that option is not explored in this paper
4. The phase of the ac voltage induced into the secondary coil is in phase with the ac voltage applied to the primary coil. No phase lag due to mutual inductance was observed. This conforms to the phase relationships depicted in Eq. (19).

3.2 Experiment with induction with two round coils

Two identical round single turn solenoid coils each with a diameter of 0.422 m were wound on flat cardboard cake plates. (See Figures 6 & 7). The inductance of one of the coils was measured to be 1.548 µH. For a computed inductance match, a *ds* = to 8.51 mm was required. Stranded wire was used. For the ds length to have zero stored energy (zero inductance), it was found that 64-81 sub-wires were required in the current element computation. Coil 2 was made primary and Coil 1 was placed 42.4 mm and 107 mm directly above Coil 2 in two tests. A 0.233 µh capacitor was connected in parallel with Coil 2 and the test oscillator was connected directly to the parallel LC circuit of Coil 2. Resonance was achieved by varying the frequency of the test oscillator. An approximate 8.0 v p-p was applied to Coil 2. The RMS voltages were measured on the open terminals of Coil 1and at the input of the primary coil. These RMS voltages were scaled to represent having an exact 8.00 v p-p on primary Coil 2. The corresponding v p-p on secondary Coil 1 is presented in Table 3 below. Computed values were calculated using Eqs. (15), (16) and (20).

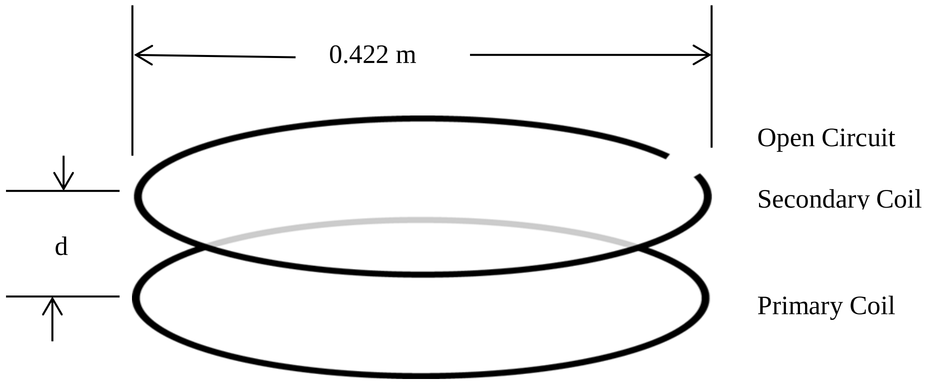

Figure 3. Round coils for induction experiment.

Table 3. Measured and Computed Induced Voltage in Round Coil 1.

Coil 1	Distance mm	Measured v p-p	Computed v p-p	% Difference
Position 1	42.0	2.152	2.163	+0.51
Position 2	107.0	1.083	1.084	+0.09

Figure 4. Picture of the two round coil forms employed in an experiment with induction.

3.2.1 Discussion of results

1. Again the induction formula of Eq. (11) is supported.
2. This was confirmed in computing the inductance with finite length of current elements that in order to properly set the limits of the piece-wise computer integration, every current element of Coil 2 must relate to every current element of Coil 1 only once in the computation.

3.3 Side-by-side distance test with two single-turn round coils

Figure 5. Setup showing side-by-side distance test with two single-turn round coils.

Lying flat in a plane and side-by-side the two single-turn coils were separated by a measured distance and induction between the two was tested. A 0.233 µF capacitor was connected in parallel with the primary coil. The applied sine-wave voltage resonated the circuit at a frequency of 269 kHz with amplitude of 8.02 v p-p. The induced largest voltages voltage on the secondary coil were measured by the digital multi-meter and the smallest voltages were measured by the scope . Distances that were based on using the radius of the coils (.2016 m) as a unit of measure were set by a factor (fac), used in the computer program to calculate the induced voltage. The results of the test are shown in Table 4 below.

Table 4. Measured and Computed Induced Voltage in Secondary Coil in Side-by-Side Test.
(8.02 v p-p applied to primary coil)

Factor (fac)	**Distance between centers m**	**Measured mv p-p**	**Computed (-)mv p-p**
3.1	0.423	286	286
3.5	0.504	106	108
4.0	0.605	50.3	51.4
5.0	0.806	19.2	18.7
6.0	1.01	9.5	9.0
7.0	1.21	5.5	5.1
8.0	1.41	3.2	3.1
20	3.83	------	150µv p-p

3.3.1 Discussion of results of side-by-side test

1. Again the induction formula of Eq. (11) is supported.
2. This author finds it absolutely amazing that you can calculate the induced voltage accurately at large distances of coil separation.
3. While the author has not attempted to use the conventionally accepted force and induction formulas for calculation, it is expected that the attempt to do so would be very difficult. You would come up against violation of Newton's Third Law and the problem of calculating flux linkages at large distances from the primary coil. It may be possible to do so, but has not been attempted by the present author.
4. The full significance of these results has not been fully realized by the author. He suspects it denotes something about the reality of the e-field, the magnetic field, relativity, space, and gravity.

3.4 Test of mutual inductance with load in the secondary circuit

The tests so far reported on were conducted with the secondary coil being open, that is, no current flowing thru the secondary coil. Consequently, there was no energy stored in the mutual inductance and none dissipated in the secondary coil circuit. This test with a load in the secondary is more complex and involves more parameters. The circuit employed in this test is described with Figure 6.

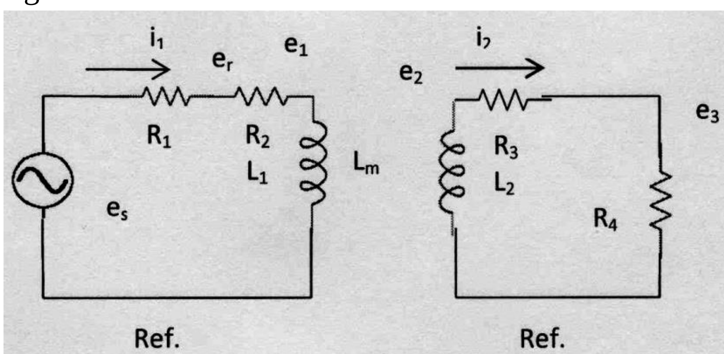

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Figure 6. General circuit for testing mutual inductance with load in secondary circuit, R_4.

The following are descriptions of the parameters in the circuit of Figure 6: L_1 is the inductance of the primary coil. L_2 is the inductance of the secondary coil. L_m is the mutual inductance between L_1 and L_2. R_2 is the internal resistance of coil 1. R_3 is the internal resistance of coil 2. R_1 is an external resistance which includes the ac source supply's output resistance. R_4 is the load resistance of the secondary coil. The ac voltages e_r and e_3 are the only voltages accessible for measurement in the complete circuit and appear at the terminals of coil 1 and coil 2 respectively. The ac source voltage, e_s, is accessible via use of Thèvenin's equivalent voltage and source resistance only when the primary coil is disconnected. The ac voltages e_1 and e_2 are not directly accessible for measurement, but appear in the calculations.

The circuit of Figure 6 is modeled in a computer program as shown in the block diagram of Figure 7.

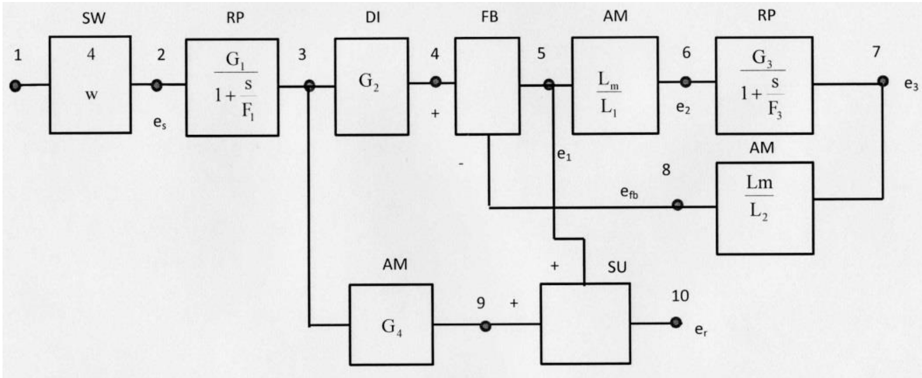

Figure 7. Block diagram for dynamic computer modeling of the circuit of Figure 6.

Several different tests were performed varying the parameters of the circuit of Figure 6. For this paper the author will only present one set of parameters and show the results for this set of parameters. They are defined for the square coil configuration as follows:

L_1 = 60.65 µh (A 5-turn primary coil is used. The self-inductance is increased 5x5 times the inductance of a single-turn coil.)

L_2 = 2.463 µh (A single-turn coil.)

L_m = 2.907 µh (Calculated from the physical parameters. The mutual inductance is increased 5 times.)

R_1 = 75.5 Ω

R_2 = 3.2 Ω

R_3 = 0.1 Ω

R_4 = 3.2 Ω

e_s = 4.00 v peak

$w = 942.5 \times 10^3$ (f_o = 150 kHz)

$G_1 = 1.0$

$F_1 = 1.2976 \times 10^6\ (R_1+R_2)/L_1$

$G_2 = 0.7706 \times 10^{-6}\ L_1/(R_1+R_2)$

G_4 0.04066 $R_1/(R_1+R_2)$

$G_3 = 0.9696\ R_4/(R_3+R_4)$

$F_3 = 1.340 \times 10^6\ (R_3+R_4)/L_2$

$L_m/L_1 = 0.04066$

$L_m/L_2 = 1.1801$

When the program is executed with the values of the parameters above, the printout of the program is Figure 8.

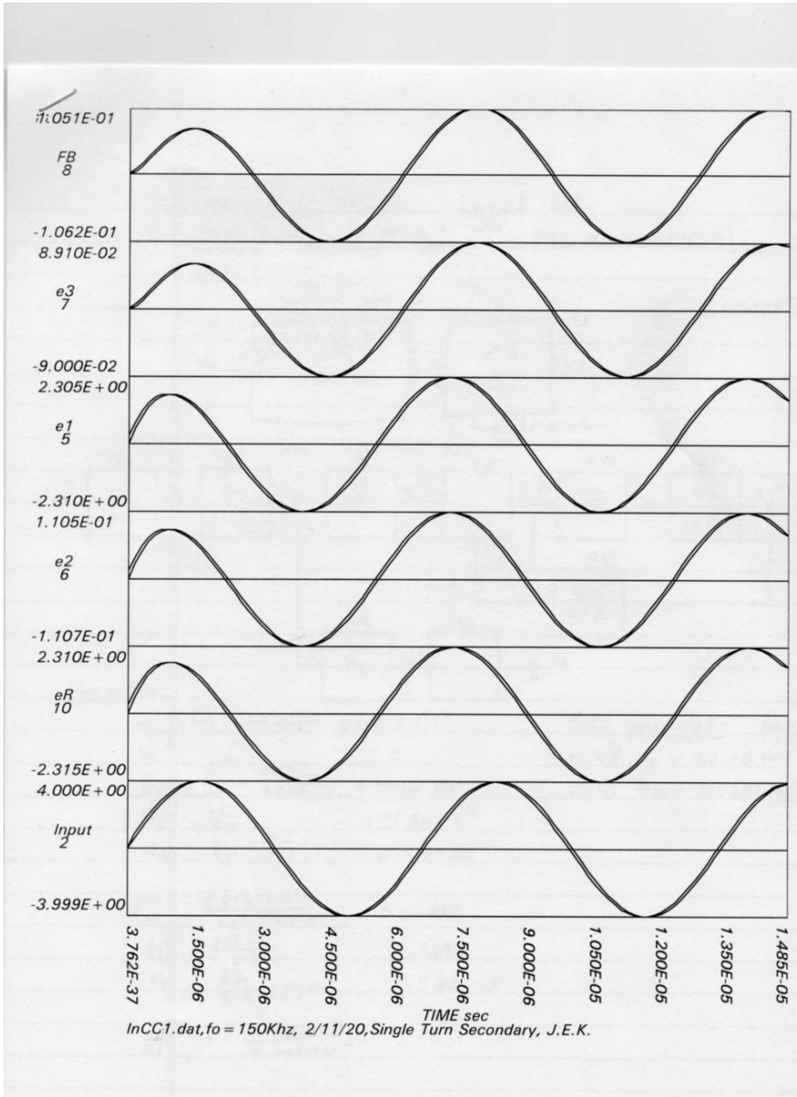

Figure 8. Printout of computer program showing peak voltages at various points represented in the circuit of Figure 6.

Some results from the program are shown in Table 5.

Table 5. Measured and computed peak voltages of circuit with Figure 8 printout.

Voltage	**Measured v peak**	**Computed v peak**	**% Difference**
e_3	87.48 mv	89.10 mv	1.8%
e_r	2.281 v	2.310 v	1.3%

3.4.1 Discussion of results of test with load in the secondary circuit

1. While measurements and values of entered parameters were made as accurately possible, the results show a small discrepancy between the measured values. However, the accuracy of the test and computer model supports the equations for calculating the mutual inductance and the program model itself.
2. The phase relations of the computed ac voltages correspond with the phase relations observed with the scope (not shown).
3. Note the phase of the induced voltage on the secondary coil is in phase with the ac voltage of the primary coil. In other words there is no phase lag associated with mutual inductance as is normally associated with inductance.
4. The mutual inductance is the same both ways in forward induction and in backward induction: It is the same from primary coil to secondary coil as is from the secondary coil to the primary coil. The feedback model of induction as appears in Figure 7 is the correct way to handle the effect of induction in the primary coil from the secondary coil.

9. Notes on the generated computer programs:

Seven short Borland Turbo Pascal programs were written for this paper. They are listed below. RMKS system of units is employed in all cases.

1. CAP_CAL.PAS Used for capacitor calibration.
2. L_CAL.PAS Used for calculating the “measured” inductance of a coil using resonance techniques.
3. IN_SQ7.PAS Used to calculate the inductance of the square one-turn coil.
4. CURELEMT.PAS Used to indicate zero energy storage or zero inductance in the length of a current element.
5. INDCTN3.PAS Used to calculate the induced voltage on a single-turn square coil from varying current in another single-turn square coil.
6. IN_SOL7.PAS Used to calculate the inductance of a single-turn circular coil.
7. IN-SOL8.PAS Used to calculate the induced voltage on a single-turn circular coil from varying current in another single-turn circular coil.
8. The program for calculating the ac voltage amplitudes and phases is one the author acquired and revised over his working career as an engineer.

4. Conclusions

1. The induction model provided by SR Electrodynamics is correct. Its only limitation is that it applies to relative velocities of charges much lower than the speed of light. Other formulas may be developed for much higher relative velocities.
2. The new model of the magnetic field may provide new insights in the force interactions of moving isolated charges and current elements. That is, the actual force between two coils may also be calculated.
3. It is absolutely astounding that one can accurately calculate the induced voltage on a secondary coil that is separated, say 3 meters, from the primary coil.

References

[1] J. Keele, “Experimental Support for SR Electrodynamics”, http://cybermesa.com/~jkeele9/ , (2019).

Notes

1. Updated formulas and subscripts 10/7/22. JK