
A NEW APPROACH TO POYNTING VECTOR SYNTHESIS (PVS)

By Claudio Re, IIRFQ & Federico Vavassori

Preface

This series of articles was started by author, Claudio Re. After recognizing that the development of the second configuration proposed involved a very deep mathematical analysis, Re joined with Federico Vavassori, a graduate at the Polytecnic of Milan that developed his thesis on the mathematical analysis of the C-Cube and further development of other “Cubical configurations.”

Introduction

Starting around from 1980 some claims of the possibility to generate a new category of antennas have been proposed from Hately, Kabbary, Zimmerman, Hart and others. Strangely no one of the proponents was able to put together any mathematical theory or demonstration that can survive to a minimal check.

Most of the claims implied that PVS could give the possibility of building very short, but very efficient antennas. Some typically fuzzy experiments were given to prove this assumption. As far as we know, no one of these survived a scientific revision or was reproduced with the same results using scientific methods. Among many others, Re personally tested some of these antennas (EH, DLA, X3), finding that there was nothing contrary to classical Maxwell theories.

Some at first sight strange results in the non-clinical and non-critical tests were typically due to common-mode currents on the feeder lines. All these effects disappeared with true no feeder tests or good precautions to minimize the effects of the common mode currents until they were negligible in the measurements.

Zimmerman and others were honest to admit the typical error of the common-mode currents. After using the experimental way to check PVS, one day Re had the idea to see what can happen if someone would try to turn over the approach. This was summarized in this question:

“What could theoretically happen when combining the E and H fields produced from two different antennas?”

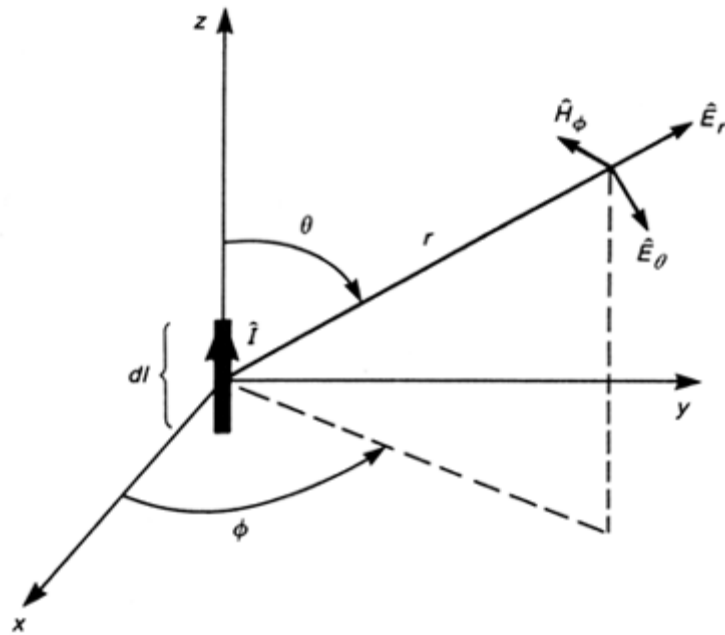
We think that this is the first question that everyone who would like to think to formulate a PVS theory has to ask himself.

The path we decided to follow was:

- 1) No prejudices
- 2) Use math as a universal language
- 3) Use a check point if paradoxes are not developed

In every book that deal with antennas and electromagnetic theories, you can find the two most common field solutions for the infinitesimal elementary dipole and for the infinitesimal elementary loop (**Figures 1 and 2**). Please do not be scared about these solutions.

If you would like to follow us, we hope you will see soon that the results are much easier to understand than you could think by looking at the pictures and the formulas. In **Figure 3**, you already can see something practical that you know well. We hope this will allow you to relax a bit.



$$E_r = 60\beta^2 I dz \left[\frac{1}{(\beta r)^2} - \frac{j}{(\beta r)^3} \right] \cos \theta e^{-j\beta r}$$

$$E_\theta = j30\beta^2 I dz \left[\frac{1}{\beta r} - \frac{j}{(\beta r)^2} - \frac{1}{(\beta r)^3} \right] \sin \theta e^{-j\beta r}$$

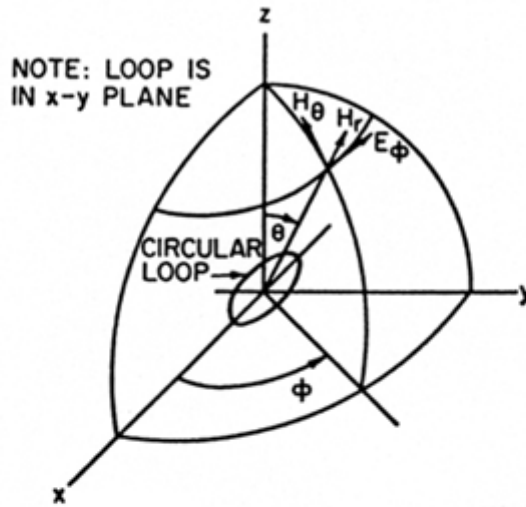
$$H_\phi = j \frac{\beta^2}{4\pi} I dz \left[\frac{1}{\beta r} - \frac{j}{(\beta r)^2} \right] \sin \theta e^{-j\beta r}$$

$$E_\phi = H_r = H_\theta = 0$$

Figure 1: A sinusoidal current element produces large electric fields in the near field because of the $1/r^3$ term.

Note the following:

1. Both electric and magnetic fields are present.
2. $\beta = 2\pi/\lambda = 2\pi f/c = \omega/c$; $\beta r = 2\pi(r/\lambda)$
3. If we consider f fixed, the electric field contains components which vary as $1/r^3$, $1/r^2$, and $1/r$.
4. If we consider f fixed the magnetic field contains components which vary as $1/r^2$, and $1/r$.



$$E_{\phi} = 30\beta^3 dm \left[\frac{1}{\beta r} - \frac{j}{(\beta r)^2} \right] \sin \theta e^{-j\beta r}$$

$$H_r = \frac{\beta^3}{2\pi} dm \left[\frac{j}{(\beta r)^2} + \frac{1}{(\beta r)^3} \right] \cos \theta e^{-j\beta r}$$

$$H_{\theta} = -\frac{\beta^3}{4\pi} dm \left[\frac{1}{\beta r} - \frac{j}{(\beta r)^2} - \frac{1}{(\beta r)^3} \right] \sin \theta e^{-j\beta r}$$

$$E_r = E_{\theta} = H_{\phi} = 0$$

Figure 2: A sinusoidal current loop produces large magnetic fields in the near field because of the $1/r^3$ term.

Note the following:

1. Both magnetic and electric fields are present.
2. $\beta = 2\pi/\lambda = 2\pi f/c = \omega/c$; $\beta r = 2\pi(r/\lambda)$
3. If we consider f fixed, the magnetic field contains components which vary as $1/r^3$, $1/r^2$, and $1/r$,
4. If we consider f fixed the electric field contains components which vary as $1/r^2$, and $1/r$.
5. In the formulae, the term dm stands for the magnetic moment, given by the product of current and loop area (IA).

Notes:

- 1) See the dualities between the **E** and **H** in the two cases.
- 2) In the far field, both sources “look” the same. That is, given measuring equipment—antennas and a field strength meter—we would have no way of knowing whether the electric and magnetic fields we measured were created by a dipolar current or current loop source.

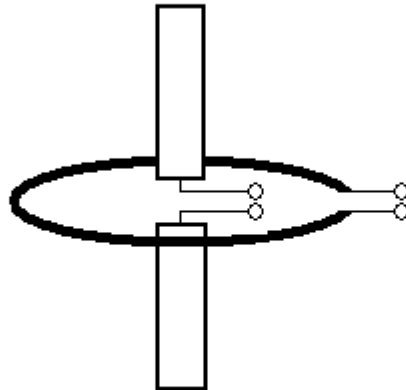


Figure 3: A dipole encircled with a loop .

Trying to “build” the conditions for PVS

With the starting known configuration of **Figure 3**, we will try to build the conditions for having PVS. On this point, “inventors“ of PVS are very fuzzy. There are no real math formulas, only a lot of “technical new age words” with always different dictionaries.

We would assume that they are speaking about creating in near field the same conditions we have for any antenna in the far field.

- 1) **E and H fields are in phase and orthogonal**
- 2) **Both E and H fields are orthogonal to the direction of propagation (r)**
- 3) **$E/H = Z_0$**
- 4) **Some of them ask that E and H need to have the same “curvature “ , but this concept is not explained in math form .**

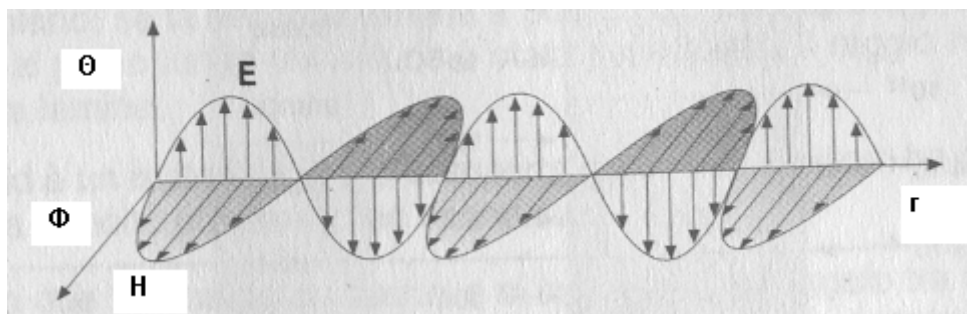


Figure 4: The **E** and **H** fields while propagating in the Far Field

If we have to try to find the way to start with this configuration in the near field, it is natural to use the strongest components of the fields. Obviously the strongest components in near field are that one proportional to $1/r^3$.

We can use the formulas of the elementary loop and dipole, with the assumption that these elements are very small respect the wavelength λ and so the currents are constant on the elements.

If we look at Figure 1 for the **E** fields (dipole), we can find in the formulas the $1/r^3$ components for:

E_θ and E_r

E_r is not suitable because is in the direction of propagation.

If we look at **Figure 2** for the **H** fields (loop), we can find in the formulas the components for:

H_θ and H_r

H_r is not suitable because is in the direction of propagation.

If we have to try to generate a Poynting Vector, we need to consider the couples:

E_θ for the dipole

H_Φ for the loop = 0

We could not have Poynting Vector:

$S = \mathbf{E} \times \mathbf{H}$ (see APPENDIX B)

The same is if we consider the other possible couples:

H_θ for the loop

E_Φ for the dipole = 0

The full results are in Appendix A-1. The same happens for the components proportional to $1/r^2$ (Appendix A-2). The same also happens for the components proportional to $1/r$ (Appendix A-3).

First Conclusions

So far, objectively speaking, we have to say that there is a good reason why we weren't able to find any Poynting vector from the combined \mathbf{E} and \mathbf{H} fields of the two antennas. If we look at **Figure 5**, we see that in the configuration we have considered until now, the polarizations of the two antennas (the \mathbf{E} field direction) are orthogonal. Of course we have a Poynting vector generated separately from each antenna.

Just see at appendix A-3 to see that you have different from zero:

E_θ and H_ϕ for the dipole

and

H_θ and E_ϕ for the loop

This confirms that the polarizations of the antennas are crossed (**Figure 6**).

If we want to calculate a more interesting case, we have to change configuration like in the second drawing of **Figure 5**. In this case the polarizations of the antenna will be the same and we will have a vector sum of the fields. In any case, what we have computed so far was a good exercise that now we can use for the second configuration.

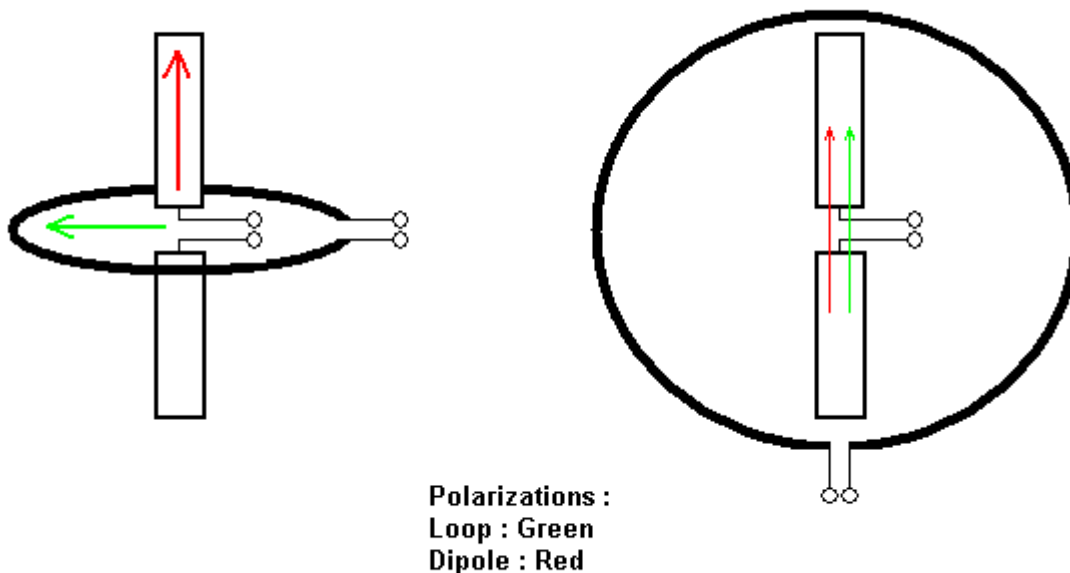


Figure 5: Polarizations of two different configurations of Dipole + Loop

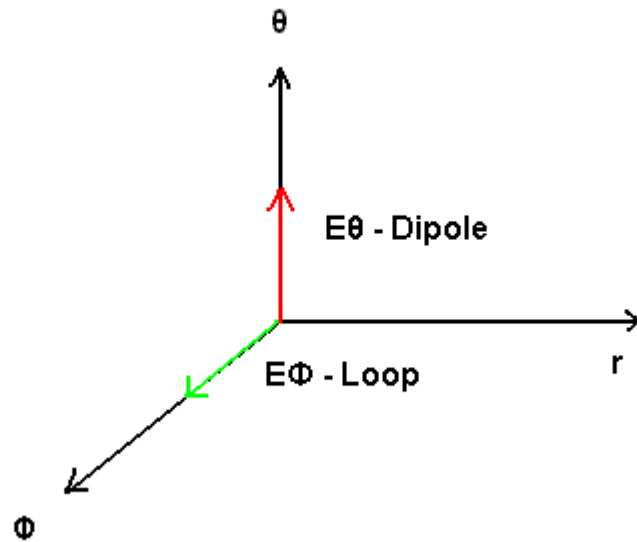


Figure 6: Crossed polarization of the first configuration

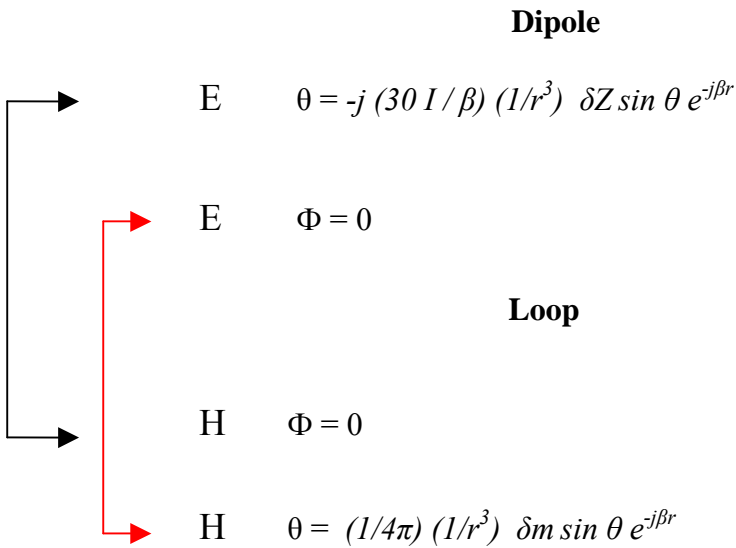
In the second part of the article, we will face and compute the second configuration of **Figure 5**.

Many thanks to Alan Boswell, Vadim Demidov, Jan Gunmar, and Kirk Mc Donald for some suggestions. -30-

See Appendices and Brief Author Biographies on the following pages.

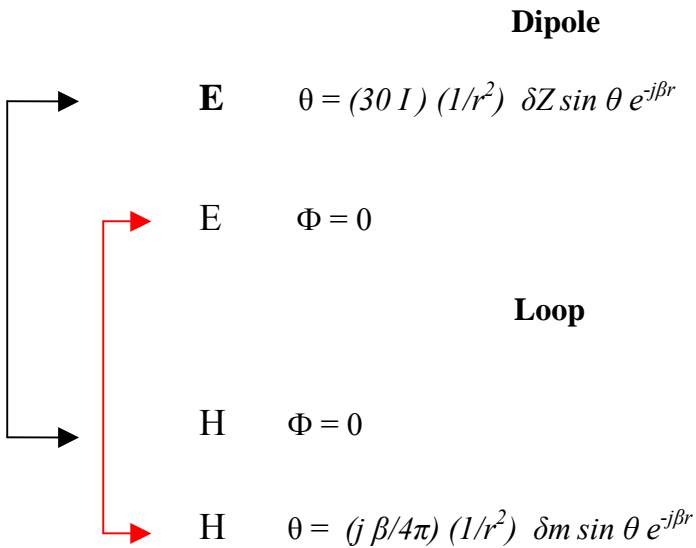
APPENDIX A-1

Components proportional to $1/r^3$.
 Doublets for computing the Poynting vector.



APPENDIX A-2

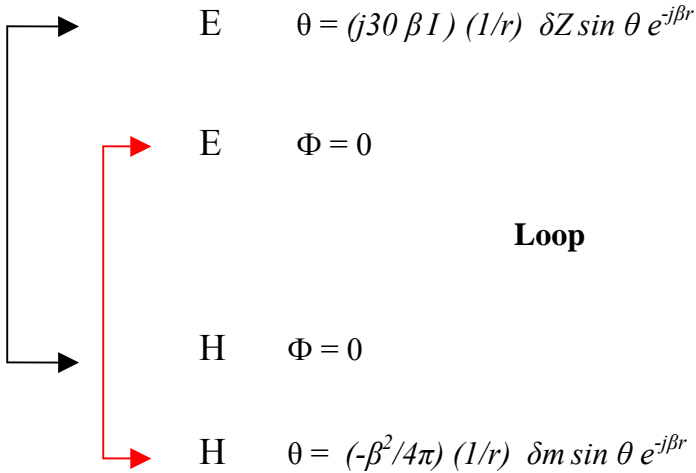
Components proportional to $1/r^2$.
 Doublets for computing the Poynting vector.



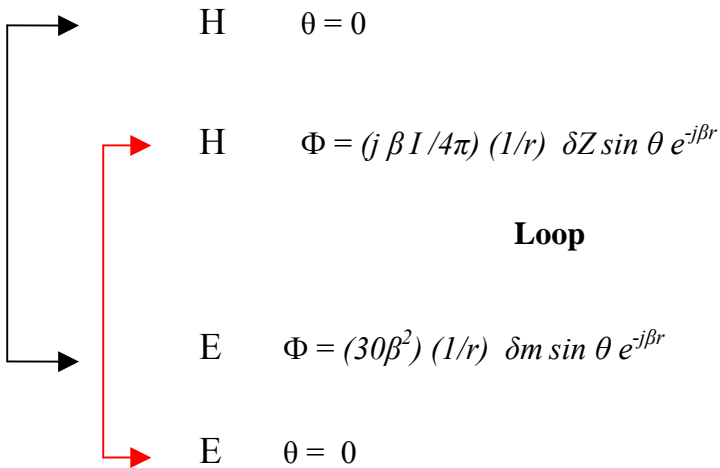
APPENDIX A-3

Components proportional to $1/r$.
 Doublets for computing the Poynting vector.

Dipole



Dipole



APPENDIX – B

In the expression of Poynting vector we have used the typical general expression $\mathbf{S} = \mathbf{E} \times \mathbf{H}$, where \mathbf{E} , \mathbf{H} , and \mathbf{S} are time-dependent vectors, so these are their instantaneous values. But in sinusoidal regime we have used all the formulas written for \mathbf{E} and \mathbf{H} complex fields of the electric dipole and the circular loop. \mathbf{E} and \mathbf{H} are vectors in the frequency domain too, but their components can be considered phasors, i.e. the amplitudes of the correspondent time domain sinusoids, and in this case $S = E \times H^*/2$, or they can be considered rms values, i.e. (phasor)/(2)^{0.5}, and in this case $S = E \times H^*$.

BRIEF BIOGRAPHY OF CO-AUTHOR

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Claudio Re is a graduate of Polytecnic of Turin in 1980 with specialization in Telecommunications and Hyperfrequencies. He is an owner of Sistel SRL and Sinfotel SRL, two small telecommunications companies in Italy. He is also a consultant and the Network Director of the World Family of Radio Maria, a Catholic Broadcasting Network that broadcasts now in 27 different countries of the globe.

Claudio has experimented with all kinds of equipment from 136 KHz to the optical frequencies (one-way communications at 22km). He was born in 1956, built his first crystal set receiver at age 6 and at 16, obtained his license with the callsign I1RFQ.



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Federico Vavassori took his degree in 2004 at the Polytecnic of Milan (Italy).

He is an Engineer of Telecommunications.

Federico derived several compact cubes from the C-Cube and studied them through both with theoretical and simulations approach during his thesis.

Federico was born in 1977.

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