# The moving transmission line - antenna 'paradox'

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## Abstract

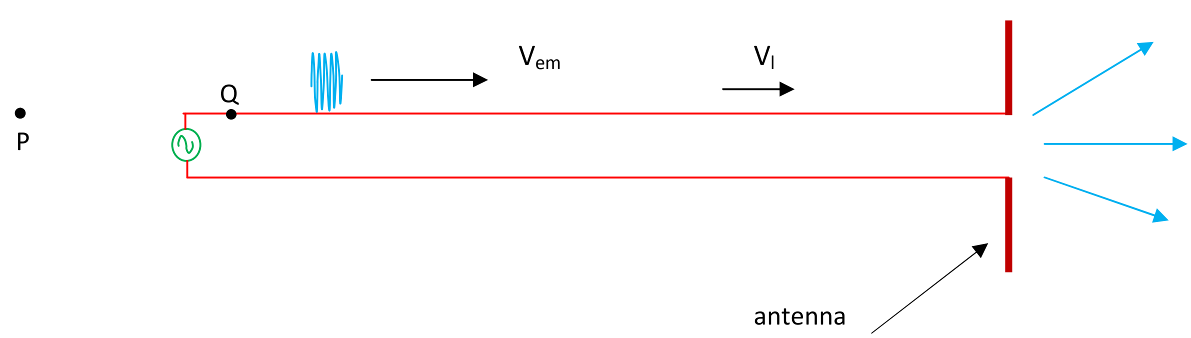
This paper presents a 'paradox' which is meant to challenge the firmly established belief that the speed of EM waves (light) is an absolute constant, C. An electromagnetic wave travelling on a transmission line (terminated by an antenna) which itself is moving relative to an observer will be investigated to show the contradictions arising from the assumption of the source independent speed of electromagnetic waves (light) and to invalidate the postulate that the speed of light is a universal constant and the highest possible speed.

## Introduction

The speed of light (C) has been postulated to be independent of the speed of its source and to be the highest possible speed, in special relativity theory. In this paper, we will investigate an electromagnetic wave travelling on a transmission line terminated by an antenna to determine what speed of the EM wave two observers will measure: an observer at rest relative to the transmission line and an observer in relative motion with the transmission line.

## Discussions

Consider an electromagnetic wave travelling forward on a transmission line (terminated by an antenna) with speed $V_{em}$ as shown in Fig.1.



Suppose also that the transmission line itself is moving forward in space along its own axis at a speed $V_l$ relative to an observer P and another observer Q is moving forward with the same speed $V_l$ (i.e. he/she is at rest relative to the transmission line).

Let us determine at first what speed of the EM wave the observer Q will measure ($V_{em}$).

The speed of an EM wave on a transmission line is given by (as measured by observer Q):

$$V_{em} = \frac{1}{\sqrt{LC}}$$

Therefore the speed $V_{em}$ depends on the inductance and capacitance per unit length of the line. For an air dielectric this speed is typically 0.95C, where C is the speed of light in vacuum (300,000 Km/s).

Now we will present and discuss the contradictions regarding the speed of the EM wave as observed (measured) by observer P, by applying relativity theory (1 and 2 below) and present the explanation (3) considered to be correct in this paper, and the speed of the wave in space radiated through the antenna (4 ).

1. According to special relativity [1],

$$V'em = \frac{Vem + Vl}{1 + Vl\frac{Vem}{C^2}}$$

Where $V'_{em}$ is the speed of the EM wave as measured by observer P and $Vem$ is the speed measured by observer Q. Here we are assuming that the EM wave is 'detached' from its source (the line), as postulated in relativity theory. (actually it is obvious that it is 'attached' to the line)

If $V_{em}$ =0.95 C , $V_l$ = 0.05 C are substituted in the above equation, $V'_{em}$ will be :

$V'_{em}$ = 0.954654C

Therefore, the two observers are measuring different speeds of the same EM wave ($V_{em} \neq V'_{em}$ ) whereas it is postulated in the theory of relativity that the speed of EM waves (light) is the same constant for all observers. So the theory of special relativity contradicts itself in this case. This analysis is not correct in the first place because it is based on the assumption that the EM wave is 'detached' from the line, when it is obviously not.

2. If one argues that observer P should measure the same speed of the EM wave as observer Q (i. e $V'_{em} = V_{em}$), this contradicts relativity theory because only the speed C is the same to all observers and no other speed.

3. Therefore, the most straightforward determination of the speed of the EM wave as measured by observer P is as follows, by applying Galilean transformation. We know that the EM wave is 'attached' to the transmission line (so its speed 0.95C is relative to the transmission line). Therefore, in addition to its velocity $V_{em}$ with respect to the transmission line, it will have an additional forward velocity $V_l$. Therefore,

$$V'_{em} = V_{em} + V_l$$

In this case, the two observers P and Q will measure different speeds of the same EM waves.
This analysis is perhaps the only logically acceptable one of the three, because it is obvious that the wave is 'attached' to the line. The EM wave is always moving together with and confined to the transmission line. In this case we can see that the speed of the EM wave ($V'_{em}$) as measured by observer P can be greater than the speed of light, if $V_l$ is greater than 0.05C in the above example.

$$V'_{em} = V_{em} + V_l = 0.95C + V_l$$

$$V'_{em} > C \quad \Rightarrow \quad 0.95C + V_l > C \quad \Rightarrow \quad V_l > 0.05C$$

This invalidates the postulate of special relativity that nothing moves at a speed greater than the speed of light. The EM wave can have a speed greater than C relative to observer P.

4. So far we have been discussing about the EM wave travelling on the line. The wave travelling on the line will eventually be radiated into space through the antenna. Then what will be the speed of the radiated EM wave in space? Is it different from the speed of the wave on the line, equal to C ?
   Since the same wave that was travelling on the line was radiated through the antenna, its speed in space should also be the same, $0.95C + V_l$ .

Therefore, whether an EM wave is propagating in space or on a transmission line, the fundamental nature of the speed of EM waves is the same. Therefore, since the speed of an EM wave on a transmission line is defined with respect to the source (and the transmission line), the speed of an EM waves (light) in space is also defined with respect to its source.

## Conclusion

The fundamental nature of EM waves is the same whether they are travelling in space or on a transmission line. It doesn't also depend on the frequency of the EM wave (whether it is light or an EM wave propagating on a transmission line). Therefore, since EM waves travelling on a transmission line are defined with respect to and 'attached' to the line, the speed of light should also depend on the speed of its source.

## References

1. *Introduction to the Basic Concept of Modern Physics*, Carlo Maria Becchi, Massimo D'Elid, April 2007, page 6