Wireless Power Su-Field Modeling

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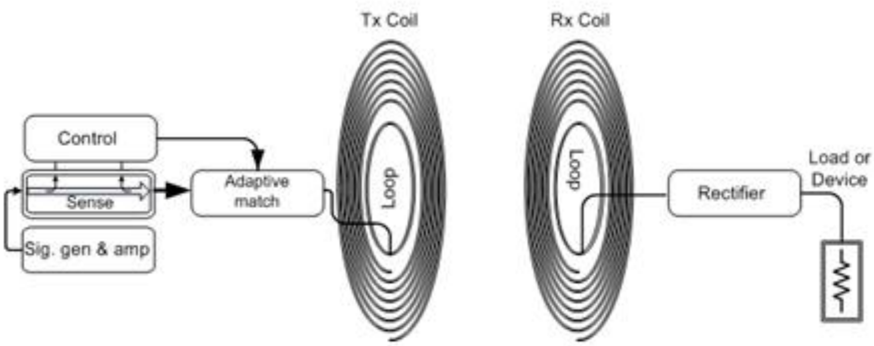
MATRIZ L4

Introduction: In late 2010 I was asked to support Intel Labs, based in Seattle, Washington, in identifying solution concepts around improving the effectiveness of a wireless power system. Kevin Brune and Rathish Jayabharathi, both from IAG, also supported the analysis. This article discusses the thought process and methods utilized in generating the associated problem model and how the general solution directions were identified.

Background and Tool Selection: A wireless power system is an engineering system that transmits electrical power "through the air" opposed to through a solid conductor such as wiring. As you can image not being tethered to an electrical power outlet, without the need for batteries, would be a big plus for a wide variety of electrical appliances including computing platforms. The fundamental issue was that while the development team had a functional system, they were interested in improving its transmission efficiency. Improving the transmission efficiency would reduce the power usage of the system, increase the range over which it could operate (power transmitter to power receiver distance) or both. You may recall from one of your TRIZ classes that depending on what you are trying to accomplish, some TRIZ tools are better than others. For this particular problem there is already an operating system but Intel Labs was interested in improving its performance and therefore improving the interaction between the system components. For interaction type problems Su-Field (Substance-Field) modeling and Standard Inventive Solutions (SIS) are suggested by the TRIZ methodology. This article focuses on the development of a Su-Field model for a wireless power transmission engineering system. Then we will examine what the Su-Field model tells us about which SIS should be employed in order to generate general solution concepts for wireless power problem.

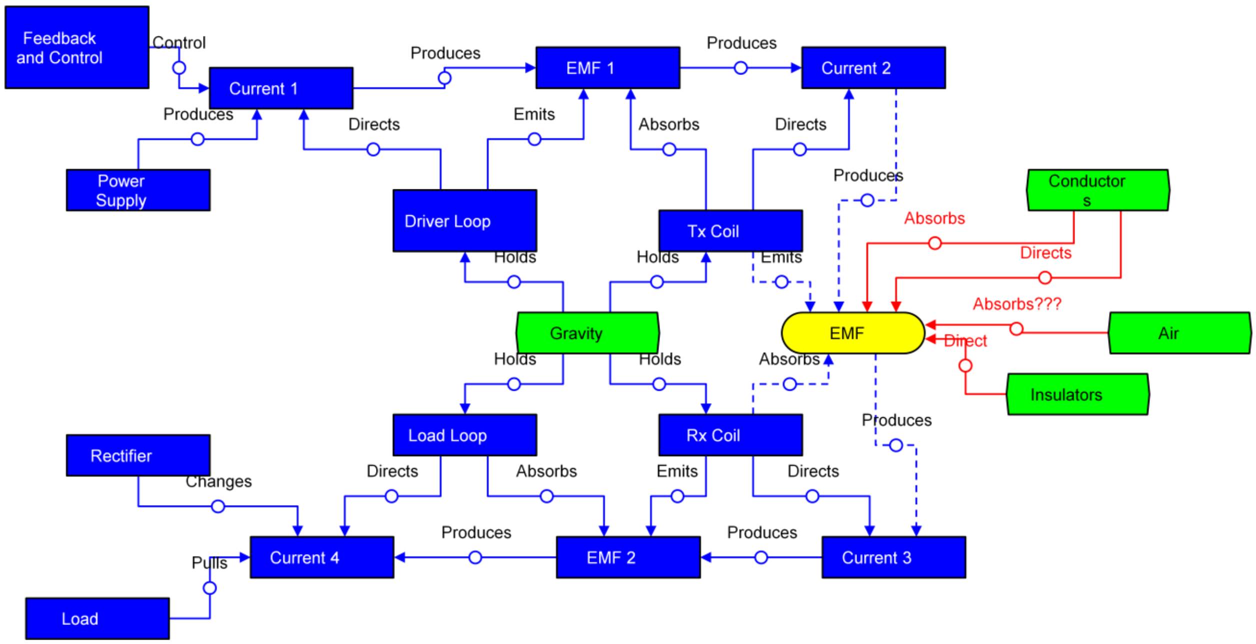
Problem Modeling: While it is easy to say that we need to draw a Su-Field model of the system knowing what about the system should be represented as a Su-Field model it is not so straight forward. In other words, how do we know what system components to focus on so as to improve their interactions and therefore the overall operation of the engineering system? Even more challenging for this particular problem I, nor Kevin or Rathish, had any particular expertise or experience with wireless power system. When you find yourself in this situation I suggest that you start off by building a functional model of the engineering system you are modeling. Having an accurate functional model is crucial to the success of the project as an inaccurate model will lead you down the wrong solution paths (garbage in is garbage out). In order to insure you have an accurate functional model it is best to engage system level experts in the feedback and review of your model. Enter the Wireless Power Team (WPT) from Intel Labs. How cool is that? The same folks who would like some different ideas as how to solve a problem are the very folks who have the expertise to insure that we do not do anything silly during the analysis process and can also give us feedback during the solution generation process.

We requested a block diagram of the wireless power system and the image below was furnished.



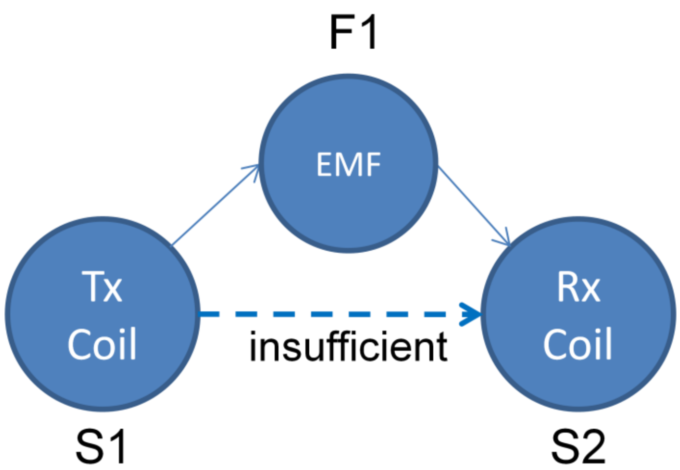
This diagram shows all of the material components of the engineering system. However, remember that according to TRIZ definitions a component can be either a material object or a field (electro-magnetic., etc.). Therefore, the block diagram is missing some key components required to build a complete functional model. Take a few minutes before reading on and see if you can identify all or some of the missing (field) components from the block diagram. Please note that the transmitting (Tx) side of the system is made up of a physically disconnected loop and a coil. Further, the receiving (Rx) end of the engineering system is also made up of a loop and a coil which are not physically connected. And, of course the Tx and Rx sides of the system are physically separated which represents the "wireless power" feature of the engineering system. What are the missing field components? ……………………………………… If you identified electrical current and electro-magnetic flux (emf) as the missing components you are correct. The way this power system works is by way of the Hall Effect. The Hall Effect says that when an electrical current is moved through a conductor a corresponding magnetic field sweeps around the conductor. Accordingly when you pass a magnetic field over a conductor it induces a corresponding electric field within the conductor.

Now that we have identified all of the material components, and the existence of field components, we have identified all of the component categories needed to create a functional model. Before examining the following functional model we created, try drawing one yourself. ………………………………………



Did you draw your functional model differently from the one shown? It may still be alright if you did as slightly different models may also be useful in solving this particular problem.

OK, now that we have a functional model how do we draw the associated Su-Field model(s)? You may recall from your TRIZ training that a Su-Field model can be draw to represent the relationship between any two, or more, components of a functional model. With that in mid we could draw 25, or more, Su-Field models to represent this functional model. However, that would be a little overkill and we should probably just focus on the "problem areas." How do we identify problem area? Remember that there are two general categories of functions: useful and harmful. Further there are three sub-categories of useful functions: sufficient, insufficient and excessive. It is logical to assume that useful/sufficient functions are just that, useful and sufficient, and therefore do not need to be improved. That leaves us with harmful, useful/excessive and useful/insufficient. All of the harmful, useful/excessive and useful/insufficient functional relationships between components are good candidates for Su-Field modeling. Examining the functional model we can see that there are harmful functions identified between the three super system components (conductors, air and insulators) and the product (emf). Further there are insufficient functions identified between four components (Current 2, Tx Coli, Rx coil and Current 3) and the product (emf). For this particular problem the WPT agreed that we could ignore the harmful interactions shown and concentrate on the insufficient interactions. We now need to draw a Su-Field model that represents the insufficient interactions between the components shown. Remember that while functional models and Su-Field models are related, they are not the same thing. Functional models show the functional relationships between two (or more) components. Those components can either be a material objects or fields. A Su-Field model shows the relationship between two (or more) substances by way of the field(s) that governs their interaction. Keeping these similarities and differences in mind draw a Su-Field model of the portion of the Functional Model that represents the insufficient interactions within the engineering system. ……………………………………….



Does your Su-Field model look the same or different from the one shown above? Remember that if it is different it is not necessarily wrong. There are different ways to draw the interactions and if yours is different it may provide different insight as to how to solve the problem. Now, even though the Functional Model does not show insufficient relationships between the loops and their associated coils the Hall Effect between the loops and coils suffers from the same inefficiencies (and therefore insufficient interactions) as the coil to coil interaction does. The WPT was happy with the loop / coil transmission and therefore it was drawn as sufficient but let us assuming that we would like to “fix” those relationships also. Draw a Su-Field model that shows all of the inefficiencies between the loops and coils. Hint, can be represented as a chain Su-Field.
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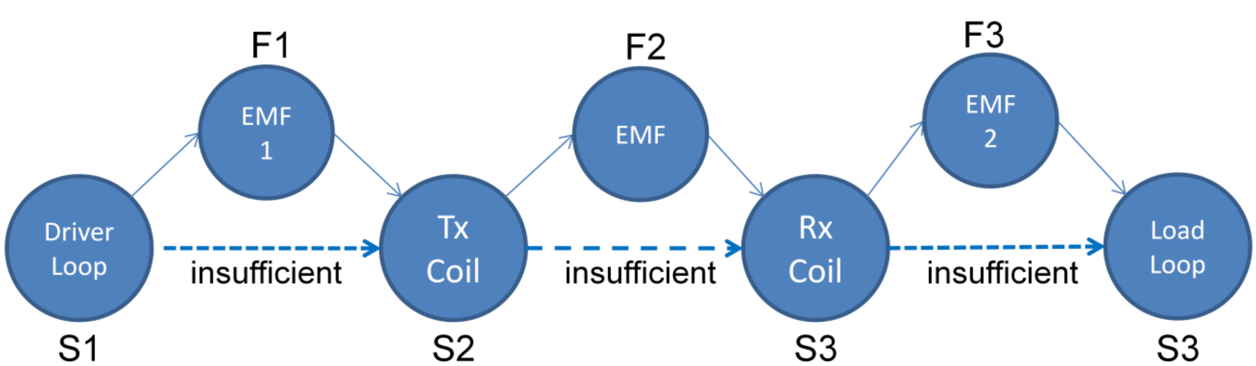

The above Su-Field model is the model that the team finally used in the solution generation for this issue. Now that we have a good Su-Field model we have to identify the SIS to be used in the solution concept generation process. If you have had Level 2 TRIZ training you may recall that there are five classes of SIS: 1.)birth/death, 2.)growth, 3.)marriage 4.)measurement and detection and 5.)how to improve the previous four. Knowing these five classes of SIS, which class would you use to solve this problem? If you said class 2 you were correct. Since there are insufficient functions represented throughout the Su-Field model using class 2 to strengthen (or grow) the Su-Field is a good direction. Take a look at the class 2 SIS and see what solution concepts you can generate. Feel free to share them with me and if you send me any unique ideas I will share them with the WPT. Maybe you too can contribute to the future to Intel's wireless powered products.