# Usage of models in the areas of EMC and communication

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*Abstract*— **Models are widely introduced and used in various spheres as a means to improve the understanding of basic conditions as the spheres may require. Though the types of models depend on the particular sphere and though they vary in a broad spectrum some common aspects and similarities can be identified even for models used in very different areas. This paper describes some considerations on models used in the areas of electromagnetic compatibility and communication. These models as well as their constituting elements are compared and attempts are carried out to assess their common structure. Furthermore the role of measures in both areas, to reduce interference on one side and to improve communicating on the other, is discussed.**
**Key words: communication, EMC, interference, model, measures**

## I. Introduction

The term "model" originates from Latin language, i.e. from "modulus" which means "measure". This specific meaning had been transferred to a more general one during the last centuries: on the one hand to a means which enables to describe the "reality" but at the same time it can be used as a basis for the forecast of the type of reality under consideration. In this regard, establishing a model has been shown to be a very powerful tool in a lot of spheres, such as technical disciplines on the one hand but also to social disciplines on the other.

Even though such disciplines are considered not to be related to each other in most cases – at least not in an obvious or evident way – they can be considered to be related in a certain manner as far as they use models as a tool inside their disciplines. Not only the fact of using models is a common methodology but also the fact that they use very similarly structured models to describe fundamental aspects. And in many cases correspondences and similarities between those models can be identified. This will be shown and assessed for two areas of different disciplines: for the area "electromagnetic compatibility" (EMC) used in technical sciences and the area "communication" (COM) used in social sciences.

## II. Basic Models

### A. Types of Models

The terminus 'model' represents a more or less abstract one and is used in a wide range of application spheres. Models could be distinguished for example into:

- material models: a piece made as a single unit for example as master for further replication;
- arts: a particular object (could be a human being, a flower, etc.) used as basis for an artistic forming;
- mathematics: a term used to describe for example a set which elements and their connections have an abstract structure which is defined by some axioms;
- models used to describe a situation (or the facts of a 'situation' or of a 'relationship'): they represent an abstract image of the nature, reality or world with the emphasis on the relevant properties and characteristics. In this respect a model is used to describe the experienced reality, to generate terms for the description of this reality and to use it as basis for the forecast of the future behaviour of the type of 'reality' under consideration.

The latter types of models will be discussed in this paper. The more realistic or closer to reality the more consistently they enable to illustrate the situation under consideration and the more their forecasts hold true. They are the more powerful the bigger their application range is.

Such models result from the interaction between building up hypothesises and observation of reality. A hypothesis guides the observation and the results of it again give evidence concerning the verification of the hypothesis. Hence a model cannot be assumed to be an ultimate one in any case. It may have to be adapted to the reality – or to be rejected if such an adaptation is not possible in a consistent way.

A particular class of models is used to describe the fundamental situation of a 'relationship' between two items. In this context the term 'relationship' is used as a general one for any kind of connection several items could have and the term item also is used here in a general sense and is not restricted to the technical area. It can be for example a person, a piece of equipment or a process. Since such a situation exists in various spheres this class of models represents a very usual one which implicitly demonstrates that situations in those various spheres can be described by a relative similar model.

### B. Basic interference model in the field of electromagnetic compatibility

The definition of electromagnetic compatibility (EMC) as
*"the ability of an equipment or system to function satisfactorily in its electro-magnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment"* [1]

inherently shows that there may be situations where this ability does not exist in any case. Hence incompatibilities have to be taken into account which can be traced back to the fact that an item of equipment or a system does not function satisfactorily due to harmful electromagnetic interference.

This seems to be indeed the main work of an EMC engineer, i.e. to check any cases of harmful electromagnetic interference, to assess them and to provide adequate solutions to prevent them [2]. The fundamental approach to investigate such cases can be described by means of the basic interference model which is schematically shown in Fig. 1.

It describes the situation that there is an interference source which produces electromagnetic emissions possibly acting on a victim by analysing the interference situation within five elements. This model seems to be a very simple one: nonetheless in many practical cases building up this model is challenging because identification of source and coupling is not a trivial process. On the other side: identification of these elements is stringently required because otherwise it would not be possible to conclude on appropriate countermeasures to avoid such harmful interference.

Element no. 1, 3 and 5 represent the pure interference model; element no. 2 and 4 are additional elements and they result from the fact that the emissions of a source do not necessarily represent the disturbances at the location of the victim. They can for example be attenuated on the propagation path.

Since EMC describes a state which is affected by harmful interference the model is given in a more negative representation, i.e. it describes the process as it is not wanted. This may be different in other areas where the relationship between the various elements is described for both purposes, i.e. to establish a good interrelation or to prevent any bad interrelation.

### C. Basic model in communication theory

In a broad sense "communication" (originating from Latin "communico" – "I connect, associate, make it common") is the generic process of translating information from one domain to one or more domains through a medium. Human communication is the exchange of ideas, opinions and information through a common system of symbols, signs, behaviour, speech, writing or signals [3] (this definition focuses on the active two-way communication process instead of one-way transmission of information from a sender to a receiver which is more usual for the concept of global communication). The communication process can be positive or negative according to the goals the communicators achieved or try to achieve, to the degree of divergence of sense, to the character of strategies used, etc. Negative communication (or pseudo-communication) is a communication process in which divergence of sense of message sent and received takes place.

A communication model is an abstract, speech or graphic representation of the communication process, demonstrating interdependence between a sender (communicator), a message, medium of communication, means of communication and an addressee (communicant). These models can serve to explain existing communication pathways, to analyse negative factors and failures of communication process and also to recommend communication strategies to achieve better results.



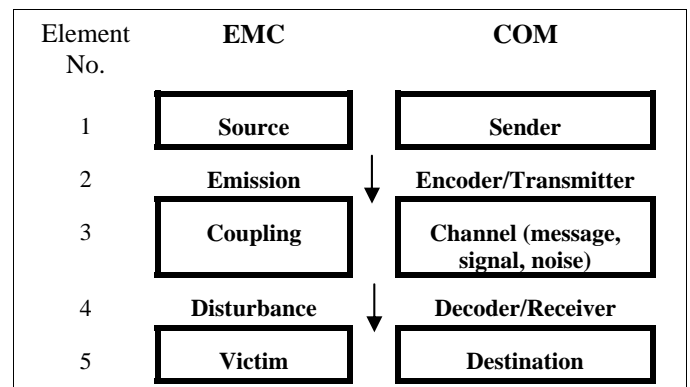| Element No. | EMC | COM |
|---|---|---|
| 1 | Source | Sender |
| 2 | Emission | Encoder/Transmitter |
| 3 | Coupling | Channel (message, signal, noise) |
| 4 | Disturbance | Decoder/Receiver |
| 5 | Victim | Destination |

Fig. 1 Basic interference models in the EMC area and the communication area (COM)

The simplistic basic communication model including the main elements of communication (given in Fig. 1) is a biased one. It is mainly based on Shannon's information theory model [4] and, referred to human communication, it can represent only a separate distorted step of transmitting information from one person to another. According to the information theory, communication is a process in which the message at a transmitter is reproduced with some errors at a receiver – thus, a negative character of communication process and its results is implied [3]. This model is intended to facilitate analysis of negative communication factors by accurate indication of an element causing divergence and also to increase the efficiency of communication by thorough development of each element.

Since this basic model represents a simplistic one only it should be mentioned that transmitters, receivers, channels, signals, and even messages are often layered both serially and in parallel so that there are multiple signals transmitted and received, even when they are converged into a common signal stream and a common channel. Furthermore some additional elements are used to describe the element "CHANNEL" in more detail.

- **message**, which is both sent by the information source and received by the destination. The main goal of communication is to avoid any conflict of sent and consumed messages.
- **signal**, which flows through a channel. There may be multiple serial signals, with sound and/or gesture turned into electronic signals, or words and pictures in a book. In face-to-face interaction sound and gesture involve different parallel signal systems that depend on different channels and modes of transmission. In communication studies signal systems used to encode a message for transmitting are usually called "languages".
- **noise**, in the form of secondary signals that obscure or confuse the signal carried. In context of face-to-face communication "noise" is used more as a metaphor for problems associated with communication situation, conflicting goals of sender and receiver, effective listening, etc.

In communication studies identifying the elements of communication process helps to identify the changing role of each element in concrete situations, to estimate effectiveness of different communication tools, steps, recommendations and

policies. In case of negative communication it allows to identify a source of a possible or an actual problem and to solve it by correcting a failing element.

The transactional model, usually referred to face-to-face communication, presumes symmetries, with each of participants creating messages that are received by the other communicator. This model shows the cycle of learning between participants. Emphasis is given on mutual understanding and consensus, on relationships within networks which consist of interconnected individuals linked by patterned flows of information which provide continuous feedback [4]. It is, however, a distinctly interpersonal model that implies equality between communicators that often does not exist, even in interpersonal contexts – so, this is a model of a positive communication process rather than negative one.

### III. Benefits in Using Models

Establishing models does not represent an end in itself. In opposite, as mentioned already in the introduction they can represent a very powerful means within their sphere.

In the EMC area it is more or less a basic condition to build up such an interference model: the model has to be applied to an actual, practical interference situation and only identification of the various elements of the model does enable it to cope with the interference situation and to solve it. For example: only when the interference source is detected and only when the "way" is detected how the interference disturbances reach the victim it is possible to determine appropriate measures to reduce or avoid any harmful interference. In this regard the application of the basic interference model to a practical case is a must when confronted to EMC problems.

Though modelling in communication studies is challenging because of numerous theories, approaches and interpretations of basic communication phenomena, various models are widely adopted in this sphere, proving their theoretical and practical application.

Part of success of communication models, even biased ones, is due to their structuralised reduction of the communication process to a set of basic constituents that not only explain how communication happens, but which are also used to create recommendations on effective communication behaviour and to analyse and prevent communication failures and mistakes.

### IV. Comparison of Models

Though the models given above result from completely different spheres it would be interesting to compare them from a general point of view. Particularly their application in spheres considered to be very far from each other can be used not only as an indication for the overall validity of such simple models but also as a sign of their power. Their application in different spheres may even be helpful to understand the idea behind these models and the familiarity with the model in one sphere could improve the understanding of it in the other one.

Table I gives an idea of the meaning behind the elements of the basic interference model when applied to different areas, i.e. a technical area on one hand and a social area on the other. It should be noted, however, that since these areas are not linked directly to each other the comparison of models is carried out in a kind of top-level approach.

TABLE I

COMPARISON OF THE MAIN ELEMENTS OF THE BASIC INTERFERENCE MODEL APPLIED TO DIFFERENT AREAS

| | **EMC Area** | **COM Area** |
|---|---|---|
| 1 | **Source:** item of equipment that produces electromagnetic emissions | **Sender:** presumably a person who creates and sends a message |
| 2 | **Emission:** a source can produce electromagnetic emissions due to its functional principle or due to the basic mechanism of a physical process (lightning stroke, switching actions, electrostatic discharge). The emissions can propagate via different paths, i.e. as conducted emissions on lines (power or signal lines) or as radiated emissions through the air. The emissions are described by various parameters such as amplitude or frequency in the case of continuous emissions, or by pulse time or rise time in the case of transient emissions. | **Encoder, Transmitter:** encoding a message with any system of signals available for a human being (called a semiotic system or a language). "Language" is used in COM area in a wide sense as any system of signals used by participants of a communication process. In face-to-face communication a message is basically encoded into sound and gesture language. Transmitter is readily generalized within information theory to encompass a wide range of transmitters. The simplest transmission system associated with face-to-face communication has at least two components: the mouth and body which create and modulate signals. |
| 3 | **Coupling:** physical mechanisms by which electromagnetic emissions find a "way" to reach a victim | **Channel:** most commonly used channels include air, light, electricity, radio waves, paper and postal system |
| 4 | **Disturbance:** the original emissions might be modified in most cases by or through the coupling mechanism and therefore they occur at the victim in a modified way, for example reduced by means of attenuation. | **Decoder, Receiver:** the received message needs to be decoded from the used language (i.e. system of signals) into information to be consumed. In face-to-face communication a basic receiving system includes a set of ears (sound) and eyes (gesture). Note that verbal and non-verbal parts of a message can be incongruent; |
| 5 | **Victim:** item of equipment which can potentially be affected by disturbances. The degree of being affected is described by performance criteria indicating how the equipment is allowed to react on disturbances. Those criteria ranges from "no effect allowed", to "certain effect allowed during the presence of the disturbing phenomenon", further to "effect allowed and operator has to reset the equipment", etc. | **Destination:** Presumably a person who consumes and processes the message. At this step the senses of messages sent and received are compared and the degree of divergence is estimated in order to indicate the communication as positive or negative one. |

### V. Comparison of Measures

In the EMC area there are a few basic measures which can be used for mitigation purposes, i.e. for reducing the efficiency of any harmful interference between source and victim. The actual measure to be applied depends on the various characteristics of the interference emissions but also on aspects outside the pure technical interference model, such as economic aspects or organizational conditions. Depending on these circumstances a mitigation measure can be applied for

example to the interference source, to the coupling path or to the victim. Furthermore it can be applied to one of these elements solely or in combination. The basic mitigation measures in the EMC area which are discussed in the following are: grounding, shielding, filtering, cabling, separation.

Besides comparing interference models in various areas it would also be interesting to understand and compare relevant measures in those areas. An attempt to describe those measures and to identify some similarities and correspondences is made in Table II. Though the measures are used in completely different areas, their equivalences are quite easily to identify.

It should be noted, however, that the terminology for describing the measures is taken from the technical area of EMC. This terminology is not directly used in the COM area but can nonetheless be used to describe comparable aspects of measures in both areas. There are no equivalent terms for measures in communication studies as measures are grouped according to elements or steps of communication process.

According to the basic communication model, the divergence in communication process is usually caused by noise in communication channel. That is the reason why feedback as a necessary element of human communication is presented in further models – it enables both parties to work towards achieving a correspondence of meanings in case the meaning of the information or message being transmitted are different for sender and receiver.

Errors, misunderstandings, divergence of messages can be caused also by situation of communication – a combination of specific conditions and circumstances of performing a certain communication. For example, negative communication can be caused by communicative distance – a delay or/and an incompleteness of received information, caused by spatial remoteness and/or social isolation of an addressee [5].

TABLE II
COMPARISON OF MEASURES/COUNTERMEASURES TO COPE WITH THE SITUATIONS OF INTERFERENCE AND COMPATIBILITY

| EMC Area | COM Area |
|---|---|
| **Grounding:** this measure aims at various goals such as to provide a common reference, the "ground", or "reference" potential for any signal transmission and thus to avoid this transmission to be disturbed by electromagnetic phenomena. It is further required as basis for a good efficiency of other measures such as filtering or cable shielding. | **Common** interpretation of transmitted information is often impossible though desired. Effectiveness of communication can be obtained by stating from a **common** language – a **common** system of terms, definitions, signals, meanings, used to encode and transmit messages - and also by understanding of goals and purposes of communication. Feedback is strongly recommended. |
| **Shielding:** electromagnetic phenomena caused by a source should not reach the victim in order to reduce or avoid harmful interference. In case of radiated phenomena an effective shield has to be provided between source and victim in order to prevent any propagation of electromagnetic phenomena between them or at least to attenuate them in such a way that harmful interference does not occur. | "**Shielding**" in communication can mean isolation sometimes (that is in general controversial to communication). Shielding against certain people, information or communication acts can be provided by a person himself or can be provided by outer circumstances. The idea of "positive" shielding is more related to problem of independence from outer negative influence. |
| **Filtering:** electromagnetic phenomena caused by a source should not | "**Filtering**" in communication process is possible at two levels |

| reach the victim in order to reduce or avoid harmful interference. In case of conducted phenomena a filter has to be provided between source and victim. Such a filter reduces the amplitudes of the input quantities with respect to the output quantities. | - at outer level: protection from noises and disturbances providing a successful transmitting of a message through a channel; - at inner level: personal filtering of information on the basis of any individual aims, stereotypes, lines, psychological peculiarities. |
|---|---|
| **Cabling:** this includes both – providing a channel between items of equipment which is relatively immune because of the usage of a shielded cable and secondly to spatially separate cables in order to avoid any harmful coupling. | **Creation of a communication channel** which could not be affected by any disturbances is practically impossible, if presuming negative aspect of communication process, but it is possible to get rid of outer noises and disturbances. |
| **Separation:** the amount of coupling between source and victim decreases with increasing separation means or distances. | **Separation** from sources of disturbances and noises, unwished information or harmful influence is possible by isolation – spatial, social or psychological. |

To have effective communication it is needed to take into consideration all the factors: the different realities, the space the communication takes place in, verbal as well as non-verbal messages, the intended meaning versus the perceived meaning, etc. Therefore it is practically impossible to describe only several basic measures to prevent negative communication – only some examples demonstrating the role of each element can be given. The comments on possible measures are very abstract, that is caused mainly by an intention to disengage from personal aspect of communication connected to roles of its participants with their intentions, attitudes, personal features, etc.

VI. CONCLUSION

The basic approach to introduce models is a common one in various spheres. But as the considerations in this paper have shown, not only this approach is commonly used. There are areas which can be considered as to be not directly related to each other – nonetheless using similar and equivalent types of models. This was shown for the areas EMC and COM which use a similar model to describe the mechanisms and efficiency of interference and communication, respectively. In a second step it has been demonstrated that not only the structures of the models are equivalent but also some aspects derived from those models. Such aspects are for example activities, measures or countermeasures to be carried out to reduce (to mitigate) or to improve the efficiency of the 'interference'.

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