





MULTIFUNCTIONAL and POWERFUL SPECIALIZED EXPERT SYSTEM for cost-effective electromagnetic compatibility analysis and design in complex co-site systems and/or in spatially-limited ground/water areas





A new era in EMC analysis and prediction!



GENERAL DESCRIPTION

The "EMC-Analyzer" specialized expert system is a unique software proposal in the international software market, providing the analysis and the solving of the most complicated EMC problems at a system level ("as a whole") by using the modernized resumptive platform of known research program IEMCAP (USA) in a combination with original and effective EMC models and technologies developed in USSR and Belarus (e.g., a technology of nonlinear discrete EMC analysis and radio receiver behavior simulation).

"EMC-Analyzer" is capable to provide essential simplification, acceleration, and reduction in price of works on area of EMC problems detecting and solving in local onboard and ground-based systems.

"EMC-Analyzer" can be efficiently used at all stages of life cycle of these systems (preliminary research, detailed designing of system and subsystems, systems exploitation, support, modernization, etc.), but its application is especially effective at early stages of the life cycle (such as research and design).

Pessimistic nature of EMC estimation results allows to decrease essentially risks of losses caused by probable electromagnetic incompatibility of on-board or ground-based system equipment during designing of these systems.





Intrasystem EMC analysis, design, and maintenance of on-board systems (aircraft, helicopter, missile, satellite, ship, vehicle, etc.) by taking into consideration the following:

- various on-board radio and electronic equipment (radio systems, computers and control systems, data-measuring systems, power supply equipment);
- different on-board spurious electromagnetic couplings ("antenna to antenna", "field to antenna", "antenna to wire", "wire to wire", "field to wire", "case to case", "field to case");
- external electromagnetic environment (EME) formed by various ground-based radio systems of different radio services (radio communication, radar, radio navigation, radio monitoring, etc.), as well as by spatially distributed radiofrequency (RF) devices and systems.





Intrasystem EMC analysis, design, and maintenance of local ground-based systems (building, antenna tower) by taking into consideration the following:

- various radio subsystems of different services (radio communication, radar, radio navigation, radio monitoring, etc.);
- spurious electromagnetic couplings of type "antenna to antenna";
- ➤ external EME.





Intersystem EMC analysis, design, and maintenance of spatially-limited ground/water areas and aggregate systems (airport, seaport, military base, radio communication and control center, campus, etc.; several aircrafts, helicopters, ships, etc.) which may contain:

- several on-board systems;
- several ground-based systems;
- ➢ pieces of vegetation.





Analysis of the electromagnetic ecology and electromagnetic safety of radio transmitters located in a spatially-limited ground/water area by calculating the total electromagnetic field intensity (EMFI) distribution over the area.







Linear analysis of EMC: linear simulation of signals and disturbances, detection of linear interference, calculation of the interference intensity, finding the sources of linear interference.



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Main Analysis											
🕅 Jeep.emcp 🛛 🛱 🗙	The official and an and a SMC	Materia									
Project Jeep	the of seeplement twice	iviacitic				i			N.		3 🐨 02: Polynedra-Body System Jeep of Jeep.emcp
E Polyhedra-Body System Jeep	Re	ceptor	Name V	🕑 Case	Ethernet	Power sup	ピ Case	Ethernet	💵 External	Case 🕑	<u>é</u> ^
⊕- 🛸 Antenna VHF - Monopole	Emitter		Level V	(51.1;NA)	(-0.4)	(-16.5)	(53.2;NA)	(-21.9)	(-26.7)	(48.7;N/	rolEqp.
Antenna VSAT - Table	Name	•									cal Data
Control Eqp. (Front): Commander PC	划 Case		v v			-	(-3.1:NA)	-	-	. ^	^ puter P
Electric Case Port Case			<u> </u>								
V Electric Suscentibility 1	🥲 Case		V V	(7.5;NA)		-	(-2.1;NA)	-	-	(9.6;1	
E Besults	11 Care										
	Case		T T			-	(-3.3;NA)	-	-	(18.3)	
	E RE			(51.1.0.0.)						146.5	C O Other Edp. (Bark):
			• •	(31.1,104)	-	-	-	-		(40.1)	VSAT - VHF - Gunner
Spectrum (electric) from	Power supply 27 V		•		-51.4		-	-54.7	-		Table Monopole Headset
Text Report (electric) from											Other Egp.
Text Report (electric) fro	I: RF		V V	-	-1.7	-16.5	(53.2;NA)	-22.2	-26.7	(45.2)	
Text Report (electric) fro	B Dhamat 10/100 D	neo Tu		1							Control
E Text Report (electric) fro	- Enlettier 10/100 Ba	aseix	•	-	-	-119.7	-	-	-		Transceiver Transceiver Eqp.
Receptor Summary \Jeep	🕲 Case	1				-	(-2.2-NA)			16.70	(Back): D (Back): D (Back): D (Back): D (Back): D
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I M (electric) from (Jeep)	03: Text Report from Uee	p\Tactical	Data Router\/	ort Ethernet 🔤		-	-	-	-	-	
		C12 = 3.	693961e-11		<u> </u>						
In (electric) from Usep\		(for emit	ter) Lsw = 3.	766780e-07		-	-	-	-	-	· · · · · · · · · · · · · · · · · · ·
B Port Ethernet 10/100 Base Rx		L12 twist	ed pair to tw	sted pair = 1.680	592e-08	Ad: Plot: Spectrur	n (electric total) (N	B) of lean emon Po	Jubedra-Body Syst	em leen\Cont	nter 🗰 👘 👘
B Port Ethernet 10/100 Base Tx		L1 = 4.9	12024e-07			a out too opeend	in (circuite total) (in	b) of seeplemep (re	iyncaia oody syst	chrocep (cont	
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E Control Eqp. (Pront): Driver VolP		Cwire_sh	ield for rece	otor = 4.092064e	10	1					
Control Eqp. (Back): Tactical Data Ro		C12 = 3.	693961e-11		-						
B- Gother Eqp. (Front): Commander Heat		(for emit	ter) Lsw = 3.	/66/80e-07		100-1111					
ID-ID Other Eqp. {Front}: Driver Headset		L12 twist	ed pair to tw	sted pair = 1.680	592e-08						
B-G Other Eqp. (Back): Gunner Headset		L1 = 4.9	12024e-07	1.1		a					
Other Eqp. {Back}: WAN Connector		L2 = 4.9	12024e-07	5 300000 . 04	=						
Power Supply Eqp. (Back): 220 V Cor		Owire-sh	ield (for emit	ter) = 4.092064e	-10	1					
E - Transceiver / Back): VHE		Cwire_sh	ield for rece	otor = 4.092064e	10	-100			***********	********	
Transceiver (Back): VSAT		C12 = 1.	183822e-11								
B Bundle Commander Audio		(for emit	ter) Lsw = 3.	766780e-07							
L Bundle Driver Audio		L12 twist	ed pair to tw	sted pair = 5.399	239e-09	-200-0111					
B-L Bundle Gunner Audio		L1 = 4.93	12024e-07			1					
L Bundle Main		L2 = 4.9	12024e-07	1 000000 000		-300-0000					
Bundle VHF_TX-Antenna		Cwire-sh	ield (for emit	ter) = 4.092064e	-10						
Project Summary		Cwire_sh	ield for rece	otor = 4.092064e	10						
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		(for emit	ter) LSW = 8. recentor) = 8	628501e-07							
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		L1 = 9.6	55922e-07								Hz
		LZ = 9.6	009226-07		•						· · · · · · · · · · · · · · · · · · ·
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Nonlinear analysis of EMC: detailed nonlinear behavior simulation of radio receiver operation in severe EME, detection of linear and nonlinear interference, calculation of the interference intensity, finding the sources of linear and nonlinear interference.



Hz

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EMFI analysis: calculation of the field distribution in the spatially-limited ground/water area. Analysis results are represented as color map (EM Field distribution), numerical values (EM field intensity), and graphs (EM spectra).







Automated adjustment of equipment characteristics in order to solve the EMC problem.





Representation of linear analysis results in the matrix view and in the spurious path tree view.

19 03: Jeep.emcp : EMC Matrix										x			
Emitter	Receptor	Name Vame Level Vame	Ethernet (0.5)	Ethernet (-2)	Ethernet (-6.3)	Ethernet (-13.2)	Ethernet (-0.4)	Ethernet (-1.8)	Ethernet (-10.1)	🔰 Pi	ower su (-27.6)	ıp ♥ Case (48.7;N	NA)
Name	•		•	•	•	—	•	•	•		▼		▼
Power suppl	y 27 V	▼	-9.2	-13.6	-9.3	-13.3	-7.4	-7.3	-10.8		-	-	^
Power suppl	y 27 V	▼	-57.6	-62.1	-54.7	-61.4	-56.1	Ether	net 10/10	Name	•	Ethernet S/FTP7 2	
Power suppl	y 27 V	▼	-57.6	-62.1	-54.7	-61.4	-56.1	Power supply		Level	▼	(-7.3)	
Power suppl	y 27 V	▼	-52.1	-62.1	-54.7	-61.4	-56.1	Name Power supply 27 V					1
Power suppl	y 27 V	▼	-57.6	-62.1	-46.3	-61.4	-56.1	MGSHV1.0_1	_PowerS			-22.7	
Power suppl	y 27 V	▼	-	-	-	-	-	Power supply MGSHV1.0_2	27 V PowerSu	▼		-25.7	
Ethernet 10/	100 Base	▼	-	-	-	-	-	Power supply 27 V MGSHV1.0_3_PowerSup					
Ethernet 10/	100 Base Tx	▼	-17.6	-17.7	-	-46.2	-					-27	
Ethernet 10/	100 Base	▼	-	-	-	-	-	Power supply MGSHV1.0_4	27 V _PowerSu	•		-22.4	
Ethernet 10/	100 Base Tx	▼	-	-17.4	-	-45.8	-	Power supply	27 V		_		
Ethernet 10/	100 Base	▼	-	-	-	-	-	MGSHV1.0_6	_PowerS			-22.5	
Ethernet 10/	100 Base Tx	▼	-17.4	-	-	-44.2	-	Power supply MGSHV1.0_7	27 V PowerS	▼		-19.3	
Ethernet 10/	100 Base	▼	-	-	-	-	-	Power supply	27 V				
Ethernet 10/	100 Base Tx	▼	-	-	-50	-	-	~ MGSHV1.0_8	_PowerSu			-7.3	Ļ
Ethernet 10/	100 Base	-	•	1	1	1	1	1				- III - •	+

🔫 01: Jeep.emcp : Spurious Paths	- • ×
Project: 34 emitter(s), 32 receptor(s), 1098 spurious path(s), maxTIIM=53.2 dB, ResultSize = 18'000kB	*
Der Port Ethernet 10/100 Base Rx, 13 emitter(s), 13 spurious path(s), ResultSize = 234kB, TIM = -13.3 dB	
Port Power supply 27 V, 15 emitter(s), 69 spurious path(s), ResultSize = 1'464kB, TIM = -60.5 dB	
Equipment Case Port Case, 5 emitter(s), 5 spurious path(s), ResultSize = 117kB, TIM(e;m) = (51.1; NA) dB	
Spurious coupling Equipment Case to Equipment Case	
Sparlous cooping Equipment case to Equipment case Sparlous cooping Equipment case for Equipment case	
🕀 💊 Spurious coupling "Equipment Case to Equipment Case"	
Equipment Case Port Case, IM(e;m) = (7.5; NA) dB	-
🖻 🗝 📎 Spurious coupling "Equipment Case to Equipment Case"	=
Equipment Case Port Case, IM(e;m) = (18.7; NA) dB	
E Spurious coupling "Antenna to Equipment Case"	
E Antenna VSAT - Table	
$= \frac{1}{10} \text{Port KF, IM(e;m)} = (51.1; NA) \text{ dB}$	
For the subscription of the second s	
\oplus \oplus Four over supply 27 V, 10 emitter(s), 70 spurious path(s), ResultSize = 117kB, TIM(e;m) = (53.2; NA) dB	
E	
Equipment Case Port Case, 6 emitter(s), 6 spurious path(s), ResultSize = 117kB, TIM(e;m) = (48.7; NA) dB	
🗄 📲 Port Ethernet 10/100 Base Rx, 15 emitter(s), 63 spurious path(s), ResultSize = 765kB, TIM = -1.7 dB	
Port Ethernet 10/100 Base Rx, 14 emitter(s), 35 spurious path(s), ResultSize = 469kB, TIM = 1.2 dB	
Port Power supply 27 V, 16 emitter(s), 73 spurious path(s), ResultSize = 1'494kB, TIM = -14.8 dB	
Equipment Case Port Case, 4 emitter(s), 4 spurious path(s), ResultSize = 70kB, FIM(e;m) = (45.7; NA) dB	
For the point entries 10/100 base RX, 14 entitle(s), 55 spurious path(s), ResultSize = 409 kB, 114 = 0.0 dB	
\oplus \oplus Fouriement Case Port Case, 4 emitter(s), 75 spurious path(s), ResultSize = 7.648, TIM(em) = (45.7; NA) dB	
P- Port Ethernet 10/100 Base Rx, 14 emitter(s), 35 spurious path(s), ResultSize = 469kB, TIM = -1.8 dB	
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Ability to import the system geometry from CAD software.







Support of cable networks: creation, editing, and also import of cables from CAD software.



😍 01: Polyhedra-Body Sy	stem Jeep of Jeep.emcp
1	wie 5/11F1_5_EMOWICH_CONTINUEFFC
	Wire S/FTP1_1_LANS witch_CommanderPC Wire S/FTP2_2_LANS witch_CommanderVoIP
	Wire S/FTP2_1_LANS witch_CommanderVoIP Wire MGSHV1.0_1_Microphone Wire S/FTP3_2_LANS witch_DriverVoIP Wire MGSHV1.0_1_Ear-phones
Control Eqp. {Back}: Tactical Data <	Wire S/FTP3_1_LANS witch_DriverVoIP Wire MGSHV1.0_1_Ear-phones Wire S/FTP4_2_LANS witch_GunnerVoIP Wire MGSHV1.0_1_Microphone
Router	Wire S/FTP4_1_LANSwitch_GunnerVoIP Wire MGSHV1.0_1_Ear-phones Wire S/FTP5_2_LANSwitch_VHF Wire MGSHV1.0_1_Microphone
	Wire S/FTP5_1_LANSwitch_VHF Wire RK50_VHF_Antenna Wire S/FTP6_2_LANSwitch_VSAT Wire RK50_VSAT_Antenna
	Wire S/FTP5_1_LANSwitch_VSAT Wire S/FTP7_2_LANSwitch_WANConnector Wire S/FTP7_1_LANSwitch_WANConnector Other Eqp. Other Eqp. VAT- Table Other Eqp. VHF- Monopole Other Eqp. (Back): Gunner Headset A T Headset A T Headset
	Back): Control Control Control Control Eqp. Control Eqp. Eqp. Front): Control Eqp. With MCCLU(1 0, 7, Dependence): Transceiver Back): P General
	Wire MGSHV1.0_7_PowerSupply_IDR
	Wre MGShV1.0.9. PowerSupply_UHF
	Wre MGSHV1.0
	Wire MGSHV1.0_2_PowerSupply_CommanderVoIP
Local Bus	1 Wre MGSHV1.0 1 PowerSupply CommanderPC 2 3 4 5 6
Wire S/FTP8_1_L/	WSwitch_PowerSupply
Eqp. {Back}: Power Supply	Wire MGSHV1.5_2_220VConnector_PowerSupple V Connect
•	



Visualization of plots for various characteristics (spectra, susceptibilities, radiation patterns, etc.). Using high-precision markers to display values on the graph.









Variety of built-in models of filters and antennas.





Wide range of *built-in mathematical models of spectrum and susceptibility*; ability to involve user-defined models.









Displaying the *interference propagation paths*.

Ability to locate equipment in *subsystems*.





Creation of *effective computer (mathematical) model of on-board radio electronic system*; this model simplifies solving of EMC problems at all stages of system development and application.



Calculation and displaying of *diffraction paths*.





Ability to improve the created model by measurements and more precise modeling of separate spurious electromagnetic couplings.

Spurious coupling A-A		Σă	
Emitting object: Antenna A_T_0 Exposed object: Antenna A_R_180)	ОК	_
EMC-Analyzer model	Coupling factor	-	×
 Input/Output signal Coupling factor 	N Frequency Hz 1 1 110M 2 150M	Factor dB • 5 12	OK Cancel

Account for shielding by system body, ability to consider the compartments and field entry points.

Compartment Back of Jeep.emcp\Polyhedra-Body System Jeep									
E-field shielding effectiveness									
H-field shielding effectiveness									
Max. dimension:	Max. dimension: E-field shielding effectiveness								
Parameters of wa		Frequency	E-Field SE						
Shield regio	N	Hz 🔻	dB 👻	ОК					
E-Field Max	1	1	15	Cancel					
H-Field Max	2	40G	15						



Solving the EMC problems of on-board radio & electronic system and local group of on-board systems by using the system-level *EMC criterion "Total Integrated Interference Margin" (TIIM)*.



Simultaneous consideration and danger estimation of *spurious electromagnetic couplings of the various nature*.



ADVANTAGES

- 1) Analysis and solving of the most complicated EMC problems at a system level ("as a whole") by taking into consideration the intensity of intrasystem interference.
- 2) Performing the analysis between several complex systems.
- 3) Quantitative estimation of all available spurious electromagnetic couplings of various physical nature (through antennas, between cables, between equipment cases, through external fields, etc.).
- 4) Decision-making on EMC compliance or incompliance in case of extremely large amount of spurious electromagnetic couplings.
- 5) Pinpoint accuracy of spectra representation (up to 1 000 000 frequency samples).
- 6) Ability of detailed nonlinear behavior simulation of radio receivers operating in a severe EME:
 - a) EME can be formed by thousands of unmodulated, modulated, and noise disturbances;
 - b) high-accuracy representation of radio receiver's nonlinearity by using high-order polynomial models (up to 25-th order) can be used;
 - c) simulation of nonlinear interference is performed very fast and accurately;
 - d) full identification of the sources, reasons, places of occurrence, and parameters of linear and nonlinear radio interference (co-channel, adjacent-channel, image-channel, intermediate-frequency-channel, intermodulation, desensitization, amplitude and phase crossmodulation, reciprocal mixing of local oscillator noise, etc.) can be carried out.
- 7) Trade-off EMC analysis.
- 8) Calculation of necessary adjustments of equipment spectra and/or susceptibilities for the intrasystem EMC problem solving, specification generation for the equipment by using system-level EMC criterion.
- 9) Improvements in models and procedures of the well-known "Intrasystem Electromagnetic Compatibility Analysis Program" (IEMCAP), USA.
- 10) Compatibility with MIL-STD-461/462 requirements.
- 11) Compatibility with Windows XP/7/10/11 operating systems.



COMPARISON WITH CEM SOFTWARE

There are many well-known and rather perfect computational electromagnetics (CEM) software declared for solving of EMC problems, e.g., in frequency domain by method of moments (MoM) or in time domain by using FDTD approach. These tools provide the decision of concrete particular problems, e.g., detailed electrodynamics calculation of electromagnetic field distribution, characteristics of electromagnetic couplings between antennas, or characteristics of a particular spurious electromagnetic coupling in an on-board or ground-based radio system.

Therefore all well-known software tools for computational electromagnetics (including the most advanced, perfect, and expensive) do not replace, but only supplement "EMC-Analyzer", providing the following opportunities:

- more precise characterization of separate (e.g., the most important) spurious electromagnetic couplings in an on-board or ground-based system;
- improving the accuracy of the "EMC-Analyzer" by using these results of a more precise calculation of separate spurious electromagnetic couplings.



APPLICATION EXPERIENCE

1) Hundreds of original and known models and procedures are used in "EMC-Analyzer". Approximately 80% of them are widely known and published in the scientific literature. Some of these models and procedures are not the most exact; however, the refusal of application of more exact models and procedures is caused by the need of obtaining a useful practical result with reasonable spending of time and computational burden.

2) It is very important that the "EMC-Analyzer" models of spurious electromagnetic couplings provide optimal for practice pessimistic nature of EMC estimations.

According to the published data, the application of these models to the EMC analysis of on-board aircraft equipment yields the following results:

- the probability of a correct prediction of interference presence or absence: 0.82;

- the probability of a false alarm (the interference is predicted, but in practice it is absent): 0.17;

- the probability of the interference omission (the interference is not predicted, but in practice it is present): 0.01.

Similar results are observed in case of "EMC-Analyzer" application to the EMC analysis of other on-board or ground-based systems: the probability of the interference omission does not exceed 1-5 %.

3) The ability of more accurate definition of characteristics of any spurious electromagnetic couplings existing in on-board or ground-based system is provided in "EMC-Analyzer" (the user must have the results of more exact modeling or measurements). Such feature allows to improve permanently the computer model of on-board or ground-based system created with the help of "EMC-Analyzer"; this makes extremely easier to solve the EMC problems at late stages of system life cycle, in particular, at exploitation and modernization phases (for example, if it is required to enter a new equipment into the structure of a system or to replace separate kinds of the equipment).





CONCLUSION

Thus, "EMC-Analyzer" is the indispensable assistant for:

- creation of complex radio and electronic systems, reducing the cost of development and realization stages;
- modernization of systems (in the way of replacing or adding the radio electronic equipment, changing equipment allocation, etc.);
- behavior simulation of complex systems for estimation of their ability to work in a very complicated EME.



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