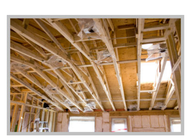
Impacts of Wireless Power on Medical Device Design Safety

Schneider J, Lucke L, Wessels D, Schauer T.

Presentation at Design of Medical Devices Conference, Minneapolis, MN, April 14-16, 2009

Wireless power holds great promise for solving many power distribution problems

No need to rewire to add capabilities

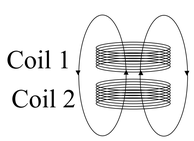


Powering devices without cords

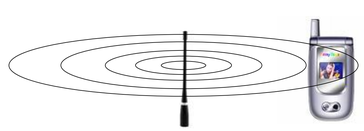
Charge portable electronics during normal activities

EM energy transfer methods

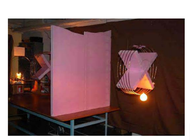
Technology	Frequency	Distance	Efficiency	Notes
Inductive coupling (a)	50KHz to 10MHz	few cm	up to 90%	Very limited separations
RF transmission (b)	Upper KHz to many GHz	meters	very low	cubic dissipation of energy with distance
Resonant evanescence (c)	1 to 10MHz	few meters	~ 40%	does not couple to non-resonant items



(a)



(b)



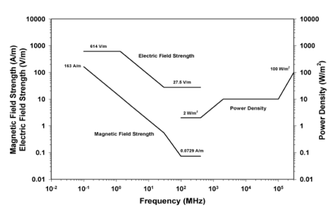
(c) [1]

How do we ensure safe co-existence of wireless power systems, humans, and medical devices?

Industry test standards?
Simulation?
Analysis?

Will present standards address the need?

Standard	Topic	Purpose	Frequency range	Issues	Relation to Wireless Power (WP)
IEC60601-1-2 [2]	EMC of Medical Devices	Traditional EMC test regiment for externals	9kHz to 1 GHz	Based on far-field locations: 3 to 10 meters	WP will operate in the near field
CISPR 11 [3]	ISM EMC – Emissions	Detailed radiated and conducted emissions	9kHz to 1 GHz	Magnetic field below 30MHz Electric field above 30MHz	WP can be E and/or H
ANSI/AAMI PC69 [6]	EMC of AIMD – Immunity	Near-filed immunity of therapy sensing in implantables	450 MHz to 3 GHz	Utilizes near field from dipole (2 cm distance)	WP may or may not be affected by tissue or other attenuators
IEEE's C95.1b [4]	Human Exposure	Safety limits for human tissue	3kHz to 300GHz	Time average thermal effects over a 6 minute interval	C95 does not address effect in devices



[4]

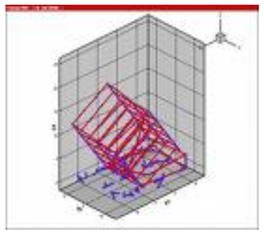
Human Exposure for General Public

Traditional EMC testing against standards

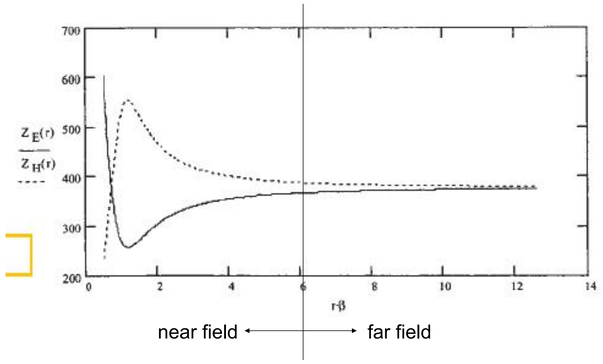
Is simulation appropriate?

PRESENT:
EM simulation is time consuming and expensive.
Present simulation typically focuses on emissions of device under development
Additional simulation may use parameters from test standards to minimize effort.

FUTURE:
Simulation of Medical Device with Wireless Power emitter may be needed until EMC test standards catch up.



Can analysis fill the gap?



PRESENT:
Presently when considering devices in the far field, the relationship of E to H is simply the far field impedance of 377 ohms.
Estimates are relatively simple to make.

FUTURE:
Wireless power brings devices into the EM near field
E & H are **not** related by a simple equation
Characteristics of the near field depend highly on the physical structure of the emitter
- V vs I drive
- Loops vs dipoles

Many devices will fall somewhere between the ideal E or H source (as seen above)
Even approximations become very involved.

Additional future efforts:

To ensure that medical devices safely use wireless power and operate safely in it's presence:

1) Need to expand EMC work into area not presently covered by standards
2) Standards need to be updated or created

3) Additional testing with wireless power emitters will need to be performed to address areas not presently covered by standards

4) Co-operative efforts with wireless power manufacturer will need to take place:

- Discussions of what MD manufacturers can do to harden their devices.
- Discussion of what Wireless Power manufacturers can do to minimize the impact on MDs.
- Co-operative efforts with standards bodies to modify or create EM test standards that are effective and appropriate.

References:

[1] Kurs, A., Karalis, A., Moffatt, R., Joannopoulos, J., Fisher, P., Soljacic, M., July 6, 2007, "Wireless Power Transfer via Strongly Coupled Magnetic Resonances", Science, **317**, pp. 83-86.
[2] IEC60601-1-2 Medical electrical equipment - Part 1-2: General requirements for basic safety and essential performance - Collateral standard: Electromagnetic compatibility - Requirements and tests.
[3] CISPR11 Industrial, scientific and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement.
[4] IEEE C95.1b Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3KHz to 300GHz
[5] BGV B11 Elektromagnetische Felder (bisher VBG 25) vom 1. Juni 2001
[6] ANSI/AAMI PC69: 2007 - Active implantable medical devices—Electromagnetic compatibility—EMC test protocols for implantable cardiac pacemakers and implantable cardioverter defibrillators