Bulk Cable Injection

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Rationale

Limitations inherent in radiated susceptibility testing

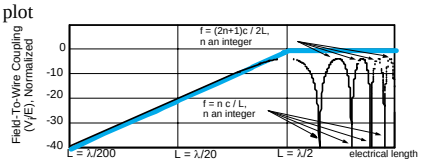
Coupling efficiency in shield room different than in situ

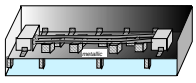
Poor control of field orientation and illumination spot size at low frequencies, Electromagnetic hall of mirrors effect

Field-to-Wire Coupling

For gory details, see "On Field-to-Wire Coupling versus Conducted Injection Techniques" in the 1997 IEEE Symposium, or download from www.emccompliance.com download page

Evaluation of Faraday's Law for the loop formed by a wire above a ground plane results in the following expression and Bode plot

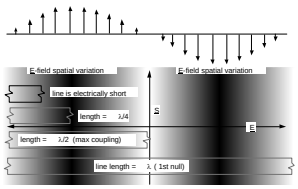




coupling efficiency

$\frac{V_i}{E_i} = 2h \sin(\pi l/\lambda)$

Intuitive Feel for FTW Coupling



Inference

If a cable is electrically short and the exposed test sample cable is shorter than the in situ cable, a radiated susceptibility test does not adequately stress the test sample.

The previous analysis provides the framework for calculating the real world stress.

Derivation of CS114 limit

$V_I/E_i = 2h \sin(\pi l/\lambda)$

When the cable is electrically short, the argument of the sine function roughly equals the sine of the argument (sin x = x for small x)

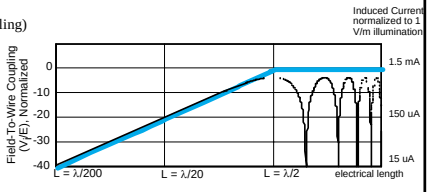
$V_I/E_i = 2\pi lh/\lambda$

When $l = \lambda/2$ (max coupling)

$V_I/E_i = \pi h$

For h = 5 cm,

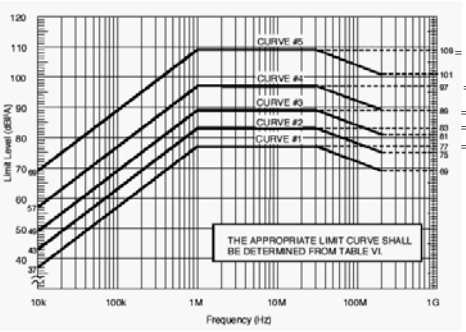
V_I/E_i = 157 mV per V/m



Per the CS114 calibration method, this potential is induced in series in a 100 Ω loop, so the induced current is:

I_I/E_i = 1.57 mA per V/m

CS114 limits

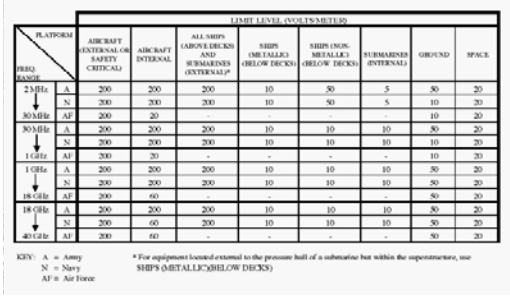


= 300 mA or 200 V/m

= 71 mA or 50 V/m

= 30 mA or 20 V/m
= 15 mA or 10 V/m
= 7 mA or 5 V/m

RS103 limits for comparison



PLATFORM / FREQ. RANGE		LIMIT LEVEL (VOLTS/METER) AIRCRAFT (EXTERNAL OR SAFETY CRITICAL)	AIRCRAFT INTERNAL	ALL SHIPS (ABOVE DECKS) AND SUBMARINES (EXTERNAL)*	SHIPS (METALLIC) (BELOW DECKS)	SHIPS (NON-METALLIC) (BELOW DECKS)	SUBMARINES (INTERNAL)	GROUND	SPACE
2 MHz	A	200	200	200	10	50	5	50	20
	N	200	200	200	10	50	5	10	20
30 MHz	AF	200	20	-	-	-	-	10	20
30 MHz	A	200	200	200	10	10	10	50	20
	N	200	200	200	10	10	10	10	20
1 GHz	AF	200	20	-	-	-	-	10	20
1 GHz	A	200	200	200	10	10	10	50	20
	N	200	200	200	10	10	10	50	20
18 GHz	AF	200	60	-	-	-	-	50	20
18 GHz	A	200	200	200	10	10	10	50	20
	N	200	60	200	10	10	10	50	20
40 GHz	AF	200	60	-	-	-	-	50	20

KEY: A = Army
N = Navy
AF = Air Force

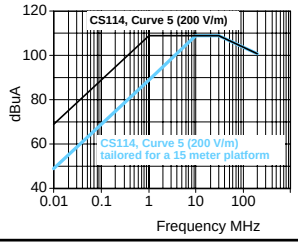
* For equipment located external to the pressure hull of a submarine but within the superstructure, use SHIPS (METALLIC)(BELOW DECKS)

Breakpoint Tailoring

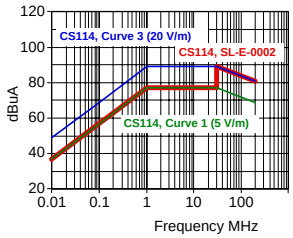
Breakpoint is frequency at where cable is one-half wavelength long.

Per CS114 limits, that breakpoint is at 1 MHz, which is a 300 meters long.

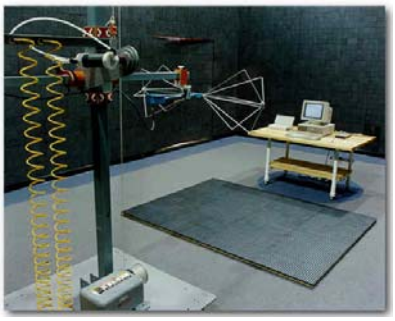
That means the CS114 limit is for a 150 meter long cable. Clearly, a tailoring approach for smaller platforms is to slide the breakpoint to the right.



Tailoring for Environment

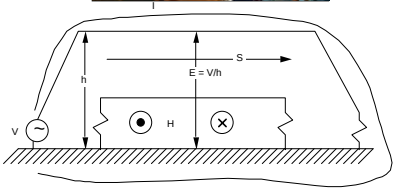


Coupling Issues due to Illumination Spot Size



Coupling Issues due to Illumination Spot Size

Field Polarization Relative to Cable Orientation



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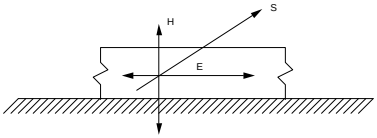
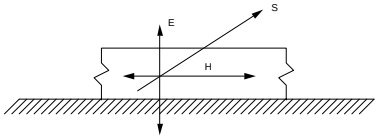


Field Polarization Relative to Cable Orientation

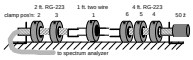


Test Observation

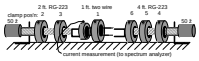
Test method mandates injection near test sample connector. Similar to antecedent CS02.

The purpose is to ensure that the measured injected quantity is what affects the test sample.

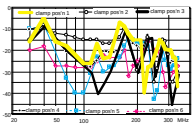
This is fine for an unshielded wire but it has no meaning for a shielded cable.



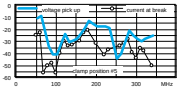
Test set up to measure pick-up as a function of clamp vs.shield break position



Measuring current as a function of clamp position



Pick-up as a function of clamp vs. shield break pos'n



Pick-up vs. current at shield break (typical)