Broad-Band EMI Suppression Absorber

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Abstract—: **Broad-band thin EMI suppression absorbers were designed to suppress radiated noise from electronic devices for broadband frequency range. The material consists of flexible, soft ferromagnetic alloy flakes filler in a polymer resin. Attenuation (S11 reflection loss) and power loss of the material of 1.5 mm thickness was measured from 600 MHz to 3.0 GHz by using a VNA. Reflection loss was measured by 14 mm / 6.08 mm, 50 ohm air coaxial line against short by taking data in frequency domain , converting it in time domain , doing time gating and bringing back the gated data in frequency domain as per IEEE-STD-1128-1998. The transmission attenuation power loss was measured as per IEC-62333-2 compliant method using a 50 ohm Micro Strip Line. Reflection loss was found to vary between – 5.4 dB to – 7.9 dB in 600 MHz to 3 GHz frequency range. The power loss gradually increase from a value of 0.24 at 600 MHz to 0.6 at 900 MHz to 0.75 at 1.0 GHz to 0.9 at 1.4 GHz to more than 0.92 between 2.0 GHz to 3.0 GHz. Due to their unique properties these absorbers find use in mobile phone (SAR reduction), computer, digital still camera, RF block and for radar stealth performance.**

Keywords— EMI suppression absorber, broadband absorber, Transmission Attenuation Power loss, Near field absorber, RADAR Absorbing Material (RAM), Microwave Absorber, Surface Current attenuating sheets etc.

I. INTRODUCTION

Electromagnetic interference (EMI) is very serious problem arise in electromagnetic circuits and equipments with unforeseeable troublesome effects. Electromagnetic interference (EMI) is caused by undesirable radiated electromagnetic field or conducted voltage and current. The interference is generated by oscillator and detected by a susceptible victim via a coupling path. The EMI coupling path may involve one or more of the following coupling mechanisms:

1. Conduction- electric current
2. Radiation- electromagnetic field
3. Capacitive Coupling - electric field
4. Inductive Coupling - magnetic field

These issues challenge hardware design engineers, and the challenges escalate as today's electronic equipment becomes both thinner and multifunctional. for example modem , advanced cellular phones are being equipped with high-speed microprocessors, wireless LANs, Bluetooth, MP3s,High switching cameras, motion sensors, touch screens, GPS trackers and many other devices.

Generally for solving EMI and RF noise problem we use conductive material such as shield can, conductive gasket, foil, mesh-type tapes and copper tapes etc for shielding.

The shielding system envelops the noise source, increases the grounding level, and suppresses radiated noise. However, modern electronic devices operate at hundreds of MHz with harmonic noise emissions in the GHz region. At these high frequencies, the reflected signal in a conductive shielding system can cause serious problems for the shielded device itself and for other adjacent components. Moreover, highly integrated electronic systems can create very complex issues around RF noise that cannot be eliminated with simple shielding and grounding techniques.

Recently introduced EMI suppressing absorber sheet can provide a relatively easy and most effective solution for suppressing unwanted RF noise. [1]

II. EMI NOISE SUPPRESSION MECHANISM

The Electromagnetic interference (EMI) absorbing phenomenon in a composite absorber can be described in terms of both near-field and far-field applications. In the near-field application, magnetic loss of the absorber plays a dominant role in absorbing high frequency noise. Composite absorbers are magnetic materials characterized by complex permeability is represented in the following equation, where μ_r' is the real part of permeability and μ_r'' is the imaginary part of permeability. [1, 2, 3, 4, 5, 6]

$$\mu_r = \mu_r' - j\mu_r'' \qquad (1)$$

The pattern of μ_r'' correlates closely with the noise-absorbing performance of the material because it takes into account the magnetic loss, from "ferromagnetic resonance and relaxation. The power loss can be measured by the Micro Strip Line (MSL) method. Both ends of the MSL, with initial impedance adjusted to 50 Ω, are connected to a vector network analyzer through coaxial cables to measure the reflected signal S_{11} and transmitted signal S_{21} of the Electromagnetic interference

(EMI) absorbing sheet. The energy loss is expressed in the following equation.[3,6]

$$\textbf{Power Loss (\%)} = 1 - S_{11}^2 \cdot S_{21}^2 \qquad (2)$$

Absorbing performance increases with sheet thickness over a broad frequency range. In the far field application the reflection loss (RL) of the absorber is determined which is based on the relative complex permeability (μ_r) and complex permittivity (ε_r) at a given frequency and absorber thickness with the following equation.[4,5]

$$\varepsilon_r = \varepsilon_r' - j\varepsilon_r'' \qquad (3)$$

$$RL = 20\log\left[(Z_{in} - Z_0) / (Z_{in} + Z_0)\right] \qquad (4)$$

$$Zin = Z0\sqrt{\frac{\mu_r}{\varepsilon_r}}\ \tanh\left(j\frac{2\Pi d}{\lambda_0}\sqrt{\mu_r\,\varepsilon_r}\right) \qquad (5)$$

Where ε_r' & ε_r'' are real and imaginary parts of the permittivity, λ_0 is the wavelength in free space, d is the thickness of absorber, Z_0 is the air impedance and Z_{in} is the input impedance of the absorber. Thus for minimal reflection

$$d = \frac{n\lambda}{4} = \frac{n\lambda_0}{4\sqrt{(\mu_r\varepsilon_r)}} \quad (n=1, 3, 5\ldots\ldots\ldots..) \quad (6)$$

$$Z_{in} = Z_0\sqrt{\frac{\mu_r}{\varepsilon_r}} \qquad (7)$$

Or

$$\sqrt{\frac{\mu_r}{\varepsilon_r}}\ \tanh\left(j\frac{2\Pi d}{\lambda_0}\sqrt{\mu_r\,\varepsilon_r}\right) = 1 \qquad (8)$$

Thus to realize a thin good absorber, both high and almost equal permeability and permittivity are needed at the same time.[4]

The permeability of traditional magnetic materials at the quasi-microwave frequency range from 1 to 2 GHz is small due to snoek's limit as follows:

$$(\mu_i - 1)f_r = \frac{2}{3}\gamma' M_s \qquad (9)$$

Where μ_i, f_r, γ', and M_s are the initial permeability ,resonance frequency, gyromagnetic ratio and saturation magnetization of the material, respectively. However, if the magnetic moment of the material lies mainly in plane (denoted as planar anisotropy), based on the Landau-Lifshiftz-Gilbert (LLG) equation, Snoek's limit becomes

$$(\mu_i - 1)f_r = \frac{2}{3}\gamma' M_s\sqrt{\frac{H_{ha}}{H_{ea}}} \qquad (10)$$

Where H_{ea} and H_{ha} represent the in-plane and out of plane anisotropic field respectively.[7]

In the present development the planar anisotropy has been achieved by using soft ferromagnetic alloy flake-like particles preferentially oriented in a plane. The composite is termed as KV-SCA-SK-1

III. MEASUREMENT

A. *Power loss (P_{loss}/P_{in}):-*

The transmission microstrip line (MSL) technique was used for evaluation of Power loss ability of the composite Electromagnetic interference (EMI) absorbing sheet (KV-SCA-SK-1) in near field. MSL was designed with the characteristic impedance of 50Ω and fabricated by IEC standard (IEC62333) as shown in Fig.1.[8] MSL was composed of 17μm thick, and 4.42mm wide and 100 mm-long Cu signal line on a FR-4 substrate with Cu ground. When the power absorption of composite was measured, the 50 mm X50mm (W X L) sized composite specimen was closely contacted on the MSL. To measure and calculate the Transmission Power loss, the reflection (S11) and transmission (S21) coefficients were measured by vector network analyzer (Agilent E 5061B) in the frequency range of 600 MHz to 3 GHz. From these coefficients, the absorbed power loss can be calculated by the relation, [2]

$$\frac{P_{loss}}{P_{in}} = 1 - \left[S_{11}{}^2 + S_{21}{}^2\right] \qquad (11)$$

Measured power loss of The KV-SCA-SK-1 was found gradually increasing from a value of 0.24 at 600 MHz to 0.6 at 900 MHz to 0.75 at 1.0 GHz to 0.9 at 1.4 GHz to more than 0.92 between 2.0 GHz to 3.0 GHz .For comparison an equivalent sheet marketed for similar application by supplier from USA is picked up and its transmission power loss was measured in the same setup. Those results are translated in table-I and graphically shown in Fig.2. [6]

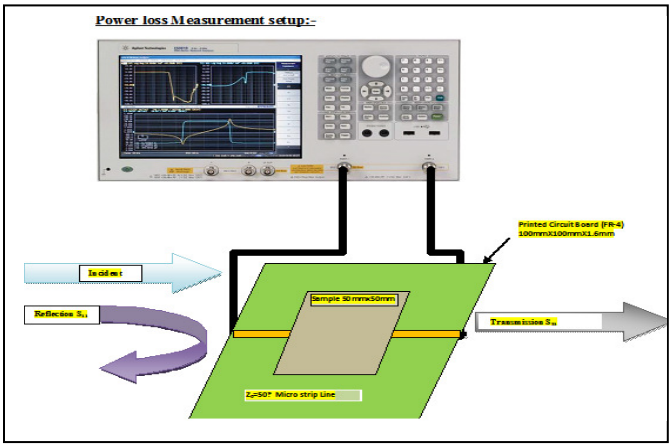

Fig.1. Microstrip Line Test setup for transmission attenuation Power loss measurement as per (IEC 62333)

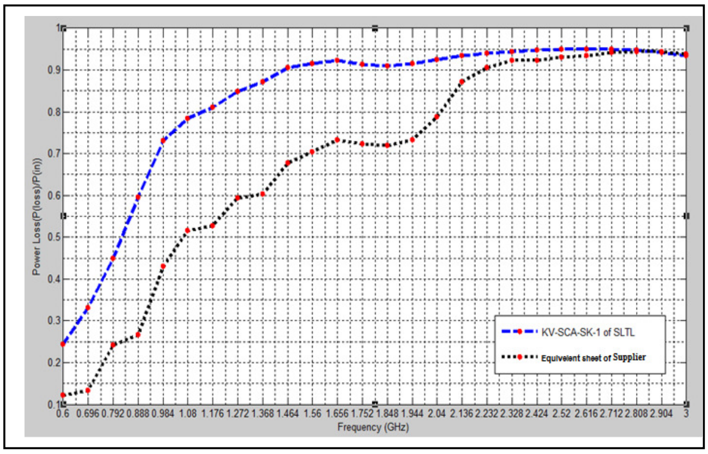

Fig.2. Comparative graph of Transmission attenuation Power loss between KV-SCA-SK-1 of SLTL and Equivalent Sheet of Supplier from USA

TABLE I Comparative data of Transmission attenuation Power loss between KV-SCA-SK-1 of SLTL and Equivalent Sheet of Supplier from USA

Frequency (GHz)	(P_{loss}/P_{in}) of KV-SCA-SK-1 of SLTL	(P_{loss}/P_{in}) of Equivalent Sheet of supplier from USA
0.6	0.24308	0.12108
0.696	0.33127	0.13312
0.792	0.44877	0.24186
0.888	0.59485	0.26661
0.984	0.73034	0.43028
1.08	0.78373	0.51557
1.176	0.80997	0.52705
1.272	0 .84933	0.59368
1.368	0.8724	0.60271
1.464	0.90611	0.67829
1.56	0.91609	0.70437
1.656	0.92209	0.73339
1.752	0.91353	0.72297
1.848	0.90902	0.7201
1.944	0.91466	0.73205
2.04	0.92471	0.78803
2.136	0.93461	0.87251
2.232	0.94036	0.90587
2.328	0.94478	0.92292
2.424	0.94752	0.92346
2.52	0.94947	0.92977
2.616	0.94974	0.935
2.712	0.94948	0.94128
2.808	0.94699	0.94434
2.904	0.94259	0.94382
3	0.93517	0.93836

Reflection Loss (RL):-

Reflection loss was measured by 14 mm / 6.08 mm, 50 ohm air coaxial line against short by taking data in frequency domain, converting it in time domain, doing time gating and bringing back the gated data in frequency domain as per IEEE-STD-1128-1998. Reflection loss was found in KV-SCA-SK-1 to vary between – 5.4 dB to – 7.9 dB in 600 MHz to 3 GHz frequency range. Similarly the reflection loss of the equivalent sheet from a supplier from USA have also been measured, graphically shown in Fig.4 and tabulated in Table-II in the same frequency range for comparison. [9]

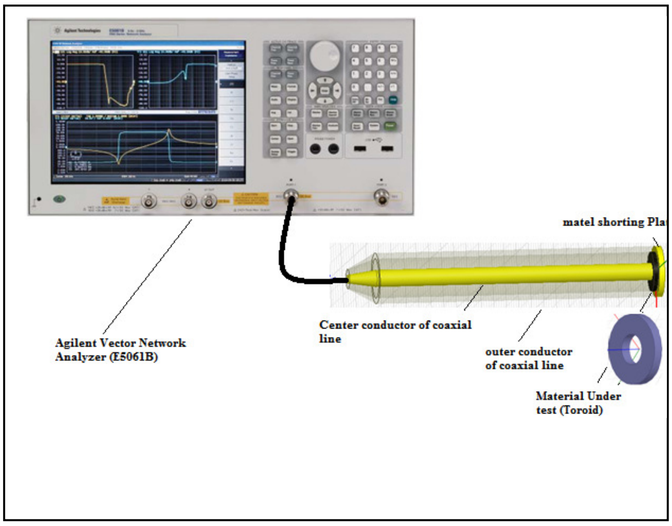

Fig.3. Air Coaxial Line Test setup for Reflection loss measurement as per IEEE-std-1128-1998

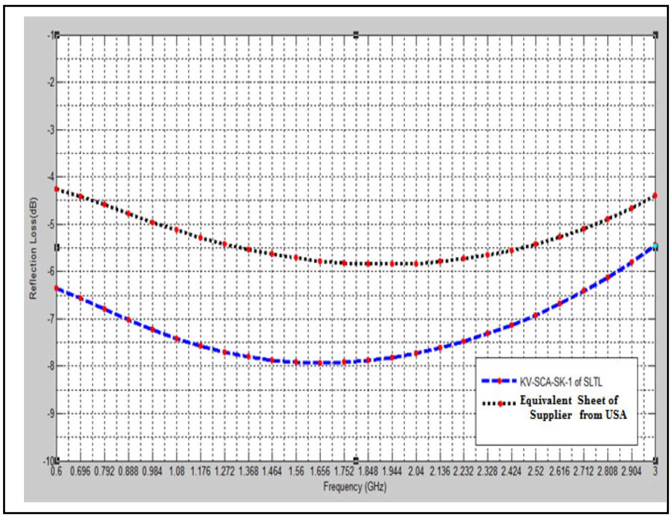

Fig.4. Comparative graph of Reflection loss between KV-SCA-SK-1 of SLTL and Equivalent Sheet of Supplier from USA

TABLE II Comparative data of Transmission attenuation Power loss between KV-SCA-SK-1 of SLTL and Equivalent Sheet of Supplier from USA

Frequency (GHz)	**Reflection loss (dB) of KV-SCA-SK-1 of SLTL**	**Reflection loss (dB) of Equivalent Sheet of supplier from USA**
0.6	-6.3536	-4.2559
0.696	-6.5634	-4.4169
0.792	-6.7893	-4.5958
0.888	-7.0156	-4.7809
0.984	-7.2275	-4.9608
1.08	-7.4156	-5.1288
1.176	-7.5754	-5.2816
1.272	-7.7052	-5.4174
1.368	-7.8044	-5.5352
1.464	-7.8738	-5.6346
1.56	-7.9147	-5.7155
1.656	-7.9284	-5.7778
1.752	-7.9161	-5.8214
1.848	-7.8787	-5.846
1.944	-7.8157	-5.8502
2.04	-7.7271	-5.8331
2.136	-7.6137	-5.7945
2.232	-7.4759	-5.7344
2.328	-7.3143	-5.6526
2.424	-7.1288	-5.5489
2.52	-6.9186	-5.4224
2.616	-6.6825	-5.2719
2.712	-6.4183	-5.0957
2.808	-6.1241	-4.8921
2.904	-5.7993	-4.6603
3	-5.4454	-4.4011

IV. COMPARATIVE CHART SUMMERY

Description	Specification of Equivalent Sheet of Supplier from USA	Specification of SLTL	Remark
Product name:	xxxxxx	KV-SCA-SK-1	
Composition:	Polymeric Resin (chlorinated Polyethylene a halogen compound)with Magnetic Metal Flake Filler	Synthetic Rubber with Magnetic Metal Flake Filler with pressure sensitive adhesive	SLTL product is halogen free.
Thickness:	1mm	1.5mm	
Standard Size:	300mm X 300mm	300mm X 300mm	
Temperature Range:	-25° to +85°	-25° to +85°	
Reflection Loss: (RL)	RL tested between 0.7to 2.3 GHz. At 1.0 GHz RL=-5.1288 dB	RL tested between 0.7to 2.3 GHz. At 1.0 GHz RL=-7.4156 dB	Tested in Coaxial line (Table 2 and figure4 Method details)
Power Loss (P_{loss}/P_{in}): (PL)	Pl measured between 1.0 GHz to 2.3 GHz. AT 1.0GHz PL= 0.5155	Pl measured between 1.0 GHz to 2.3 GHz. AT 1.0GHz PL= 0.7837	Measured using 5cm x 5cm sized absorber placed on a 50ohm Microstrip line.

V. APPLICATION EMI SUPPRESSION ABSORBERS

Keeping in view that the developed absorbers effective both in near field and far field application at very low thickness having high intrinsic electrical resistivity, it find many application such as

A. Directly mount on Noisy Component.

B. Wrapped around the interconnecting Field Programmable Circuit Board (FPCB) cable

C. Applied to the inside of a shielded can.

D. To suppress noise reflected by casing.

E. To suppress cross talk between substrates.

F. To suppress radiation noise from LSI and IC.

G. To suppress noise cables.

H. To suppress noise radiation in mobile phone, note book pc, set top box, car audio and video system, and Optical reception module, wireless LAN, Scanner and HDD.

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