Cables Shield in Aircraft

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***Abstract*— the set of electric field (E) and magnetic field (H) associated to the same conductor is called electromagnetic field and, when the whole systems of fields travel, it is said that or an electromagnetic wave or radiation exist. Within an aircraft all causes of disturbances occur adding same equipment inside and which that can be included because of the type of transportation, in the case of a commercial aircraft. Any kind of system that can produce E and H time varying fields (even the static ones) has a potential of causing electromagnetic interference (EMI), which consist in any kind of electromagnetic phenomenon that can degrade the performance of an equipment/system or negatively affect to living/inert matter.**

The studies and analysis of electromagnetic compatibility (EMC) try to avoid the appearance of EMIs and if they exist, try to do not exceed certain levels that could be harmful.

***Keywords*— EMI, EMC, Aircraft.**

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I. INTRODUCTION

The aviation is the most exalted thing of the human species, is detached from the safety ground to ascend to heaven and return to earth once received communion with the infinite.

Since the days of the Wright brothers and the birth of aviation in which man could successfully control a substantially heavier than air at 17 December 1903 aircraft has undergone a number of modifications to make the flight safer experience through advances in engineering and technology.

Within these advances, it is placed as the physical fact of Aviation Electronics and Communication Systems, through Multiple Systems and Independent Systems comprise technical, theoretical and practical solutions based on science to produce practical results.

All this by applying kinds of knowledge, Positive: How things have to be done, and Negative: the way in which things have not to be done.

It is so, an aircraft sustained in a given air link, the electromagnetic environment can be due to natural sources (lightning strikes, solar and cosmic sources) or manmade sources (electromagnetic pulse, due to nuclear explosions, electrical and electronic systems of industrial kind, and radio transmitters).

Any kind of system that can produce E and H time varying fields (even the static ones) has a potential of causing electromagnetic interference (EMI), which consist in any kind of electromagnetic phenomenon that can degrade the performance of an equipment/system or negatively affect to living/inert matter [2][3].

II. MANMADE EMI SOURCES IN AIRCRAFTS.

A. Theorical stage

An aircraft is not immune to this phenomenon since they are also immersed in an EM environment. At present virtually all the Earth's Surface and atmosphere are subjected to electromagnetic radiation due to, we receive and handle all types of information transmitted in the form of EM wave.

All EMI sources can be listed in:

- Changes in marking an indicator cabin.
- Loss of EFIS.
- Flashing lights.
- Illegibility EADI (Electronic Attitude Indicator Director).
- Loss of control panel autopilot.
- Illegibility the display of the control unit.
- Instability in the presentation of electronic displays.
- Movement control actuators flight controls, nose wheel, etc.
- Noise in cab communications systems.
- Failures in the flight computer memory.
- Failure in the operation of air data computer.

B. Practical stage

An aircraft (system) before operating in an EM environment, it should ensure that it will not have problems listed above and therefore is subjected to tests for electromagnetic compatibility (EMC). The EMC is the ability of a device, equipment or system to function satisfactorily in an EM environment without introducing intolerable electromagnetic interference in any other part of your environment. The manmade EMI sources are divided into

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C. Figures

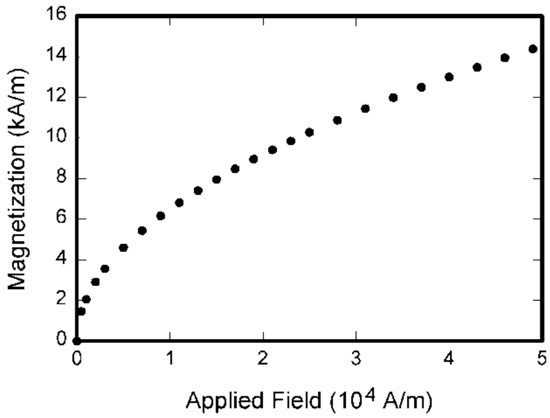

Fig. 1. Magnetization as a function of an applied field [2].

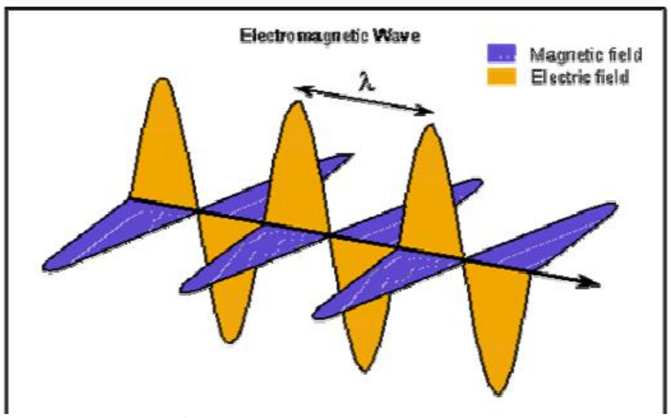

Fig. 2. Illustration of an electromagnetic wave and the relationship between their fields [2].

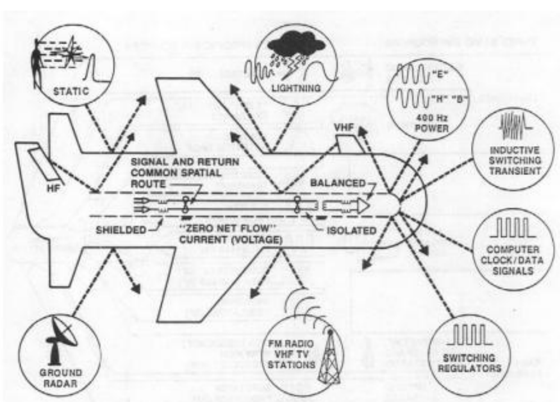

Fig.3. Outline of the different types of signals to be isolated from the internal aircraft navigation systems [7].

D. External EMI sources

The emissions of these EMI sources can come from terrestrial and extraterrestrial sources (satellites, spacecraft). The EM noise sources are mainly due to communications emitters (commercial band, air navigation communications and air radars) and industrial and consumer equipment. We will list some examples in this category:

- VOR (VHF Omni Range): 108 – 118 MHz
- MARKER BEACON: 74.6 – 75 MHz
- RADIOBEEPER ILS: 108 – 118 MHz
- GLIDE PATH: 328.6 – 355 MHz
- LORAN C: 90 – 110 MHz
- NAUTICAL BANDS: 285 – 325 MHz; 2.9 – 3.1 GHz; 5.7 – 5.65 GHz.
- RADARS.

Which they are the major sources of noise with the possibility of EMI due to its large peak pulsed power and its high bandwidth because of its harmonics. In addition to the radar systems on board the aircraft.

E. Internal EMI sources.

These sources of EM noise are all components of the aircraft that may conduct or radiate electromagnetic energy. The following are examples of these EMI sources:

- Cables: The cables provide a means of unwanted inductive coupling or conducting other cables, circuits or aircraft equipment.
- Connectors: Although not a source of electrical noise that itself, but may become so indirectly because of a bad connection.
- Generators and electric motors: Generators and motors using brushes and switches are EMI sources as transients that are generated because of the arc discharge generated by the separation of the brushes.
- Relay: electromagnetic relays and solenoids are capable of producing EMI on other equipment, once the relay is de-energized; the electromagnetic energy stored produces a voltage that produces arc discharge relay contacts EMI generating a transient form.

F. Electromagnetic Interference phenomenon EMI

Electromagnetic interference (EMI) we can understand the presence of undesirable voltages or currents that can appear on a computer or in their circuits, because of the operation of other electrical apparatus, or natural phenomena [4].

The basic outline of the elements involved in a problem of EMI is represented. It should be noted that only talk interference whenever a malfunction is causing the receiver.

Fig. 4.1. Basic outline of elements involved in an EMI problem [3].

The coupling between systems is that a device interacts and disturbs the operation of another. The way of coupling between source and receiver enables the Source to interfere with the receiver. There are four ways (roads) coupling:

- Driving (electric current).
- Coupling inductive (magnetic field).
- Capacitive coupling (electrical field).
- Radiation (electromagnetic field).

G. *Shielding effectiveness depending on the relative permeability of the material.*

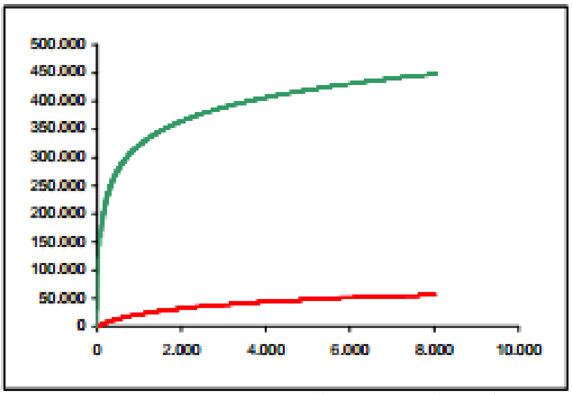

Fig. 4.2. Electrical shielding effectiveness of aircraft [2].

III. Direct and Indirect Effects

Direct effects are mainly structural in nature and include burns, erosions, explosion, and structural deformation caused; by binding of the lightning discharge arc, the high pressures produced by the shock waves or magnetic forces generated associated with the very high currents that occur during the phenomenon.

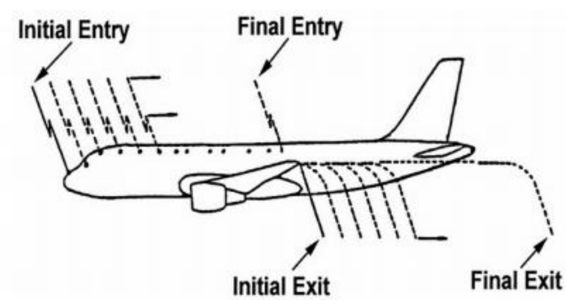

Fig. 5. Input and output areas shock electromagnetic waves in a plane [7].

Indirect effects occur predominantly as a result of the interaction of electric fields produced during discharge and current flow through the structure which can affect electronic equipment and its wiring. The impact of a beam interacts with the aircraft with a distributed current flow by the fuselage accompanied on its way by a variable magnetic field amplitude increases and decreases depending on the current values.

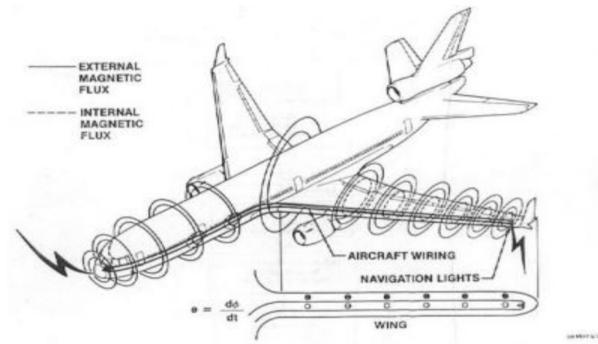

Fig. 6. Internal and external magnetic flux in an aircraft [7].

IV. Units

TABLE I
Units for Magnetic Properties

Symbol	Quantity	Conversion from Gaussian and CGS EMU to SI [a]
Φ	magnetic flux	1 Mx → 10^{-8}Wb = 10^{-8} V·s
B	magnetic flux density, magnetic induction	1 G → 10^{-4} T = 10^{-4}Wb/m^2
H	magnetic field strength	1 Oe → $10^3/(4\pi)$ A/m
m	magnetic moment	1 erg/G = 1 emu → 10^{-3} A·m^2 = 10^{-3} J/T
M	magnetization	1 erg/(G·cm^3) = 1 emu/cm^3 → 10^3 A/m
$4\pi M$	magnetization	1 G → $10^3/(4\pi)$ A/m
σ	specific magnetization	1 erg/(G·g) = 1 emu/g → 1 A·m^2/kg
j	magnetic dipole moment	1 erg/G = 1 emu → $4\pi\times 10^{-10}$Wb·m
J	magnetic polarization	1 erg/(G·cm^3) = 1 emu/cm^3 → $4\pi\times 10^{-4}$ T
χ,κ	susceptibility	1 → 4π
χ_ρ	mass susceptibility	1 cm^3/g → $4\pi\times 10^{-3}$ m^3/kg
μ	permeability	1 → $4\pi\times 10^{-7}$ H/m = $4\pi\times 10^{-7}$Wb/(A·m)
μ_r	relative permeability	$\mu \to \mu_r$
w, W	energy density	1 erg/cm^3→ 10^{-1} J/m^3
N, D	demagnetizing factor	1 → $1/(4\pi)$

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

[a]Gaussian units are the same as cgs emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

V. Electromagnetic Behavior Aircraft

An aircraft as a system, which is subjected to radio frequency radiation (RF) or microwave behaves similar to a combination of antennas, the most prominent being the wings, fuselage, horizontal stabilizer and the vertical stabilizer. The current flow produced by external radiation on the surface of the aircraft, penetrates and radiates into the structure.

The material used in the manufacture of aircraft has varied from those years in which they were totally metallic until today in which increasingly composite materials are used, which decrease the shielding of electromagnetic fields and therefore are more transparent to them [1].

Therefore, depending on the material of which it is constituted aircraft may penetrate more or less energy into it. The radiation couples directly inside the circuit elements through the slots, through cables onboard equipment malfunction causing it [2].

For the coupling of electromagnetic radiation, they are very important dimensions of the structure and wiring that feed the onboard equipment. The coupling of the electromagnetic radiation will be more efficient, more damaging, therefore, when its dimensions match half the wavelength of the interference. The HF band (3 to 30 MHz) therefore allows better coupling than in other frequency bands as correspond wavelengths between 100 and 10 m, thus influencing the dimensions of size, and length.

The frequency at which the coupling is more energetic in the aircraft is named resonance frequency.

In modern aircraft, flight controls that once were operated manually via cables and / or hydraulic systems these are being replaced by digital electronic systems. Due to the weight and maintenance advantages over both conventional hydraulic systems, future commercial aircraft are supposed to "fully electronic" [5] [6].

Electromagnetic waves are created on the surface of the aircraft, induced voltages within the airplane, which may cause damage to electrical equipment or malfunction thereof.

VI. Zoning of Aircraft

To study these effects, the aircraft is divided into three main areas:

- Zone 1: Areas of the aircraft that have a high probability of receiving the initial impact of lightning. In addition, they are the possible entry points of the beam.
- Zone 2: Areas of the aircraft that have a high probability of receiving a beam sweep is impacted in Zone 1.
- Zone 3: Includes the entire surface of the aircraft that cannot be classified as Zone 1 or 2. In this area, there is a low probability of direct impact or scanning a beam. However, for these zones will be lightning currents direct conduction between the points of entry and exit beam. Also in zones 1 and 2 the same driven currents will occur [7].

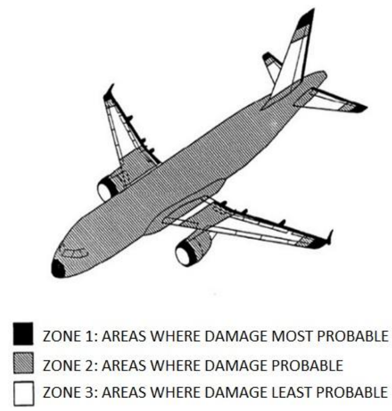

Fig. 7. Zoning of Aircraft [7].

VII. Protection from High-Energy Radiated Fields HIRF

A. External Environment HIRF.

The commercial or military communications systems, radars on the ground or on board ships, and even other high frequency transmitters that can be found installed in other aircrafts can generate high-energy fields [8]. These high-energy fields created by high-power transmitters, are often encompass in what we consider the HIRF Environment. The HIRF environment can cause alterations in the circuits and damage to aircraft systems that are not protected. For this reason, and since early 1990 for certification of a transport aircraft, it must be shown that all systems and equipment that perform critical functions for the safe operation of the aircraft must be protected against the effects of these fields high energy (HIRF) [6].

B. Internal Electromagnetic environment HIRF

The internal electromagnetic environment HIRF is the result of complex electromagnetic interactions of external environments, aircraft, and equipment and installed systems. External electromagnetic energy penetrates through the openings, composite materials, gaskets and antennas.

The electric field levels are expressed in volts per meter (V/m), and are set so that one of the frequency bands, according ED -107 standards, or MIL-STD- 464 [5] [7].

C. Protections against HIRF.

If the electronics need to operate in an area subject to electromagnetic waves and if the currents generated by these waves are dangerous, how to protect computers and connecting cables is shield them with conductive surfaces and then to ground these shields [3]. As a result, the currents generated by electromagnetic fields (HIRF) will flow through the ground external conductive surfaces avoiding the effects thereof on equipment. The location of equipment and cables inside the aircraft should be placed in the most appropriate locations, away from possible openings or transparent to radiation areas should be considered.

Fig. 8. Radar system of a small plane [8].

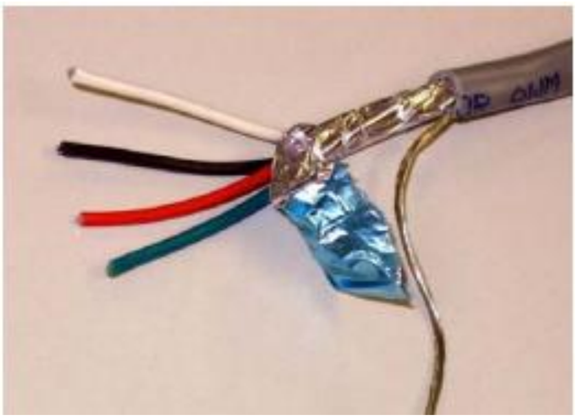

Fig. 9. Shielded Cable Suitable for Aeronautical Use [7].

VIII. CONCLUSIONS

The applications of electromagnetic theory are very diverse in the field of engineering and technological advances of information. In our analysis we chose the Air Force study, specifically the shield provides other functions besides avoiding the action of lightning and HIRF. This is to avoid low frequency noise (Hum) in audio circuits caused by AC systems 400 Hz.

The traditional solution is to put a shield with a ground connection at one end thereof, which provides protection very effective on low-frequency interference. Grounding at both ends is typically very effective lightning, but not for low frequency interference. Rays generate currents with frequencies well above 400 Hz. Under these conditions, shields grounded at one end are not effective. In some cases, they may be acting as antenna increasing interference on drivers as if they were unshielded.

There is no single point grounding since all the aircraft structure is used as ground. If a shield is grounded on both cable ends currents circulate through the aircraft structure and can return by shielding from the other point of creating a ground loop. Circulating loop currents cancel the magnetic field and causing common mode voltages. This concept is that opposes making ground connections through a single point. However, installing double shields with internal shielding grounded at one point and the outer shield connected at the opposite end eliminates low frequency interference Hum maintaining protection for lightning.

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