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A CONCEPTUAL DESIGN FOR ELECTRICAL GROUNDING ARCHITECTURE OF KOREAN SPACE LAUNCH VEHICLE

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ABSTRACT

Electrical grounding is defined as referencing an electrical circuit or a common reference plane for preventing shock hazards and for enhancing operability of the circuit and EMI control. In order to realize the best electrical grounding system of korean space launch vehicle, we should design the electrical grounding architecture of korean space launch vehicle of system-level at the earliest point in design procedure. To minimize the electrical grounding loop and the unnecessary electromagnetic interference or radiation among the electronic subsystems, we should establish the electrical grounding rules of the all electrical interfaces. The electrical interfaces among the electronic subsystems are generally classified into the electrical power and signal interfaces. Because of using the primary and secondary power system architecture in the korean space launch vehicle system such as the common space launch vehicle systems, we need to establish the electrical grounding rules between the primary and secondary power system. We also need to establish the electrical signal grounding interface rules among the electronic subsystems. In this paper, we will describe the grounding schemes of the common space launch vehicle system and propose a conceptual design for the electrical grounding architecture of korean space launch vehicle system.

Keywords: electrical grounding architecture, korean space launch vehicle, grounding current loop, electrical power interface, electrical signal interface

1. INTRODUCTION

Electrical grounding architecture, including its implementation, is an important part of the overall mission success for the korean space launch vehicle. The primary objective of proper electrical grounding architecture is to minimize the electromagnetic interference and unwanted interaction between various electronic components and subsystems. And the architecture should provide an appropriate zero-potential reference systems for signal and power. The electrical grounding architecture should be established during the early conceptual design step.

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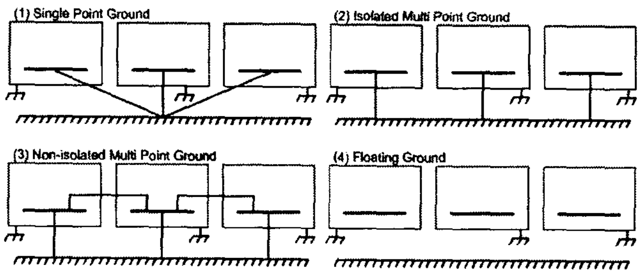

Figure 1. Types of Electrical Grounding Systems of System-level.

2. ELECTRICAL GROUNDING SYSTEMS

2.1 Types of Electrical Grounding Systems

Two major types of electrical grounding systems are single point grounding and multi point grounding system. Except for the two major grounding types, there are similar grounding schemes (Williams 2000). In the figure 1, we describe the types of electrical grounding systems. In the figure 1(1), all circuit commons are grounded by the wiring to one single point on the structure. The aim of the figure 1(1) is to reduce low frequency and dc current flow in the ground plane. But the weakness of this scheme is that the wiring used to make the ground connection has a higher reactance than resistance above a few kilohertz. A Large assembly may no longer have a zero potential reference in the SPG because inductances of long wires and other parasitic parameters are dominant in the higher frequency band. The figure 1(2) is more typical for a modern electronic subsystems. The each electronic boxes are isolated and electrically directly bonded with structure through only one path. There are shorter grounding wire, providing minimum ac impedance, and common dc reference among the electronic boxes through interconnected structure. The figure 1(3) is typical for radio frequency subsystems. But the grounding current loop is dominant factor in low frequency band. The figure 1(4) is generally not desirable. If the floating ground is needed, at least a static bleed resistance is required.

2.2 Electrical Power Interface

The first consideration of grounding architecture is the power distribution scheme between primary and secondary systems. The secondary power system is defined as the power stage of electronic subsystems including dc-dc converter. In the figure 2, we describe the electrical power grounding scheme. The SPG is adopted for the primary power distribution scheme using the negative terminal of battery. The primary power return should be isolated from the structure by some modest impedance, high enough to limit current in case of a fault but low enough to provide a stable reference. The isolation resistance of usually 2MΩ limits the fault current and keeps the power return close to reference potential. If the current return wire is grounded to the structure, it may permit a single un-fuzed fault from the high side to the structure to destroy mission. The MPG is adopted for the secondary power distribution scheme. The secondary power system is isolated from the primary power bus. At least 1MΩ dc isolation is required between primary and secondary power system.

2.3 Electrical Signal/Command Interface

Proper electrical signal and command interface rules of system-level can minimize the grounding current loop and electromagnetic interference or radiation due to the electrical interfaces between boxes (Clark et al. 1995). Generally system designers have chosen to isolate all electrical interfaces.

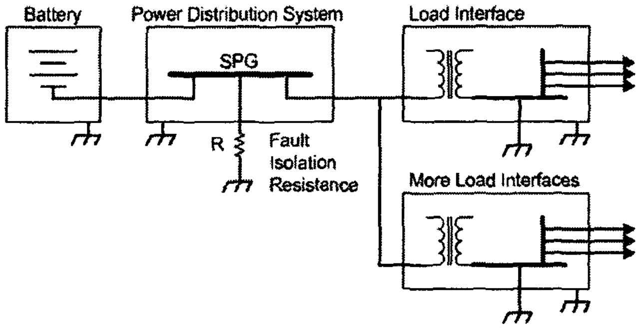

Figure 2. Electrical Power Interface.

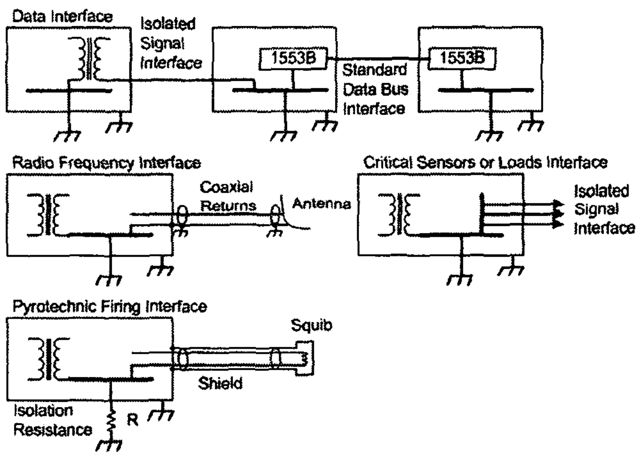

Figure 3. Electrical Command/Signal Interface.

Types of signal and command interfaces are classified into command/data/signal interfaces, RF interfaces, pyro firing interfaces and mission critical sensor/command interfaces (Shin et al. 2004). In the figure 3, electrical grounding schemes are showed as the characteristic of signal interfaces. In a pyro firing system such as a direct energy transfer system, ground fault current could continue indefinitely when fired by a battery. It could cause magnetic field noise coupling into nearby sensitive systems. To prevent pyro ground fault currents and magnetic field noise coupling, pyro firing system should be electrically isolated from the structure and completely shielded including a connector. RF signals usually are very high frequency. So, non RF interfaces within RF subsystems must be isolated like general signal interfaces. In the circuit-level, electrical signals sending between boxes are isolated in a number of various ways. The most common methods are transformer isolation, optical isolation, balanced differential circuits, single ended circuits with dedicated returns. But we are not discussed about this in the paper.

3. CONCEPTUAL GROUNDING ARCHITECTURE DESIGN

In the figure 4, we describe a conceptual electrical grounding architecture of korean space launch

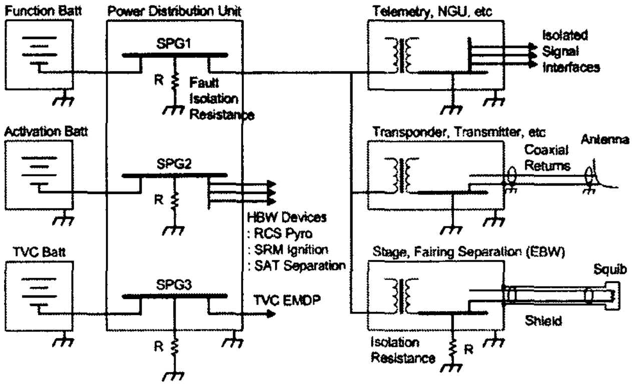

Figure 4. Conceptual Electrical Grounding Architecture of KSLV-I.

vehicle system. The power loads of korean space launch vehicle are classified into function, activation, TVC (Thrust Vector Control) load groups by the characteristics of loads (Kim et al. 2003, 2004). The primary power system delivers a single 28 voltage to user load groups. Each loads are responsible for both the dc-dc power conversion and over 1 isolation from primary to secondary power system used by the subsystem. The primary power distribution system has the SPG (Single Point Grounding) buses for the each load groups which are connected with the negative terminals of each batteries and isolated from the vehicle structure by the fault isolation impedance. The fault isolation impedance should be high enough to limit current in case of a fault but low enough to provide a stable reference. This soft grounding scheme has a possibility of greater power common mode noise. So, load groups should have a greater common noise immunity. In the figure, the functional power distribution system unusually supplies the power to some activation loads. Because the EBW (Exploding Bridge Wire) device is adopted for the stage and fairing separation as a design requirement unlike the other activation loads using HBW device, it is reasonable. The input stage of EBW device is functional load and isolated from output stage. In the side of signal interface, it is recommended to the dc isolation of all signal interfaces to minimize the electrical grounding loop and the unnecessary electromagnetic interference or radiation among the electronic subsystems. RF signals usually employ the multi-point ground scheme because of using high frequency bands. Pyro firing subsystem need special treatment. To prevent pyro ground-fault current during the pyro firing event, the pyro firing subsystem should be electrically isolated from vehicle structure.

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