Power Consumption Analysis of Distributed Lift System

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Abstract – **In this paper the distributed power supply for the embedded lift processor system is analyzed, drawbacks exaggerated and solution is suggested. A basic structure of lift system and practical lift processor realization is described. Power supply requirements for the lift processor are defined accordingly industry standard classifications. Power consumption analyse of the distributed power system is analyzed. The results shown that number of floors is greater than six, a dc/dc structure of floor processor power supply is optimal solution.**

Keywords – **Lift system, reconfigurable power supply, distributed power architecture**

I. Introduction

Most nowadays systems are highly dependent on computers for their basic day-to-day functioning. One of significant functional requirements of those systems is related to safety reliability. An aircraft and traffic control, medical devices, automated manufacturing, military systems and for appliance-type applications such as automobiles, washing machines, temperature control, and telephony, name a few for instance. The cost and consequences of these systems failing can range from mildly annoying to catastrophic, with serious injury occurring or lives lost, systems (both human-made and natural) destroyed, security breached, businesses failed, or opportunities lost. [1]

Very important aspect of system reliability in addition to the above is the segment of power supply. Today's computer-based electronic systems require power supplies that are safe and reliable as well.

Generally, a modern electric power system is a very large and complex network consisting of generators, transformers, transmission and distribution lines, buses, reactors, capacitors, and other devices. A power system has to provide high-quality electric energy to the user instantly, constantly, and exactly in the amount that is needed.

But in practice, despite significant protection, since it is impractical and not cost effective to design and build a fault-proof power system at this level, we must consider the protection, reliability at the lower levels, in order to the designed the system worked without failure.

A typical electronic system is implemented in two ways: with a central power source, and with a distributed power scheme. [2]

One of the quiet design revolutions of the 1980s was the rapid growth of distributed power architecture in a wide variety of complex electronic systems. Distributed power architectures replace multiple central power sources with a single bulk supply that is converted to the end-use voltages by dc/dc converters located at the point of need.

Distributed power networks let engineers power all the subsystems from a single bus and a central battery bank rather than running redundant wiring for each voltage level throughout the system.

Another important advantage that distributed power brought to high reliability programs is isolation. Using switching DC/DC converters that use transformers in the conversion process, they can provide electrical isolation, making it easy to build in redundancy and to protect whole systems from failure effects caused by no isolated issues.

In this paper one distributed power supply for the embedded lift processor system is analyzed, drawbacks exaggerated and solution is suggested. At the beginning a basic structure of lift system is described followed by description of the distributed lift processor realization. In the next section most of power supply requirements for the processor are defined. All demands are defined accordingly industry standard classifications. Finally, power consumption is analyzed on realized system. The results shown that number of floors is greater than six, a dc/dc structure of floor processor power supply is optimal solution.

A. Lift System

There are many types of lifts, and their classification is usually based on the principle of running the cabin. Starting cabin with ropes is usually used, and there are so-called hydraulic and lifts with vertical guides. In the following we will briefly describe the principles of each of them.

Type of lift which is most commonly used is the lift on the rope. With this type of lift cabin to move up and down with wire ropes. Domesticated is that this type of lift is called an elevator driven by electric motors. Ropes were attached to the cabin lift and wrapped around the drive pulley - sheave. A sheave has a number of grooves in the scope in which they are put ropes. Turning a sheave leads to the withdrawal of rope to one side or the other, or the cabin up or down. A sheave through the gear system mechanically linked to drive an electric motor. Nowadays, you can find solutions to drive a sheave without gear. In this case a special type of motor runs directly a sheave. Typically sheave, motor and control system located in the so-called machine room above the elevator shaft.

The systems of hydraulic lift raise the cabin that sits on the carrier. Carrier is in connection with a hydraulic piston which is built into the cylinder. The cylinder is located in the hydraulic circuit pump as uncompressed fluid used oil. Hydraulic system consists of three parts:

- Oil tank
- Electromotive pump
- Valves

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By activating the pump creates enough pressure to ensure insertion of oil from the tank into the main pipe cylinder. When the valve is open under the pressure of oil will go the way of least resistance and return to the reservoir of oil or cabin is lowered. When the valve is closed, the oil pressure remains the only time in the cylinder. As the amount of oil in the cylinder increases it pushes the piston upwards, thus raising the cabin lift. The valve is operated electrically by a basic solenoid switch. Variable valve timing is achieved by bringing the power solenoid which mechanically powered core and enables the opening and closing valves.

B. Standards

Standard defined guidelines for planning and building lift system, especially concentrating on network design and cabling systems [3]. It specifies minimum requirements for communications and power infrastructure of data centres' and machine rooms and proposes rules for the following segments of the system:
• Infrastructure architecture • Electrical design • Environmental and mechanical design (HVAC) • System redundancy and infrastructure • Cabling systems • Access control and security • Environmental control • Power management • Protection against physical hazards (fire, flood, windstorm)

In accordance with the standards we have the following:

a) Loading Capacity - Loading capacity is a function of the desired platform size and/or maximum weight to be moved.

b) Machine Type - Machine types in use today are the hydraulic pump, geared traction and gearless traction.

- The hydraulic pump can generate speeds of 0.25 m/s to 0.75 m/s. For high-capacity applications, more than one pump may be needed to generate the required lifting capacity and speed. Hydraulic machine rooms should be located adjacent to the elevator hoist way at the lowest landing.
- Geared traction machines are used for medium-speed applications up to 2.0 m/s. The machines are normally located overhead, directly over the hoist way, but can be mounted to the side and below
- Gearless traction machines are used for high-speed passenger elevator applications. The machines should be located over the hoist way in an overhead machine room.

c) Hoist Drive Systems

The motors in use today are either alternating current (*AC*) or direct current (*DC*).

- *AC* motors are used directly in hydraulic elevator applications. They have across-the-line starting unless they are larger than 40 hp, in which case they should be provided with wye-delta starting.
- *AC* motors for virtually all geared traction and some gearless traction machines use variable-voltage, variable frequency (*VVVF*) drives systems.
- Gearless traction machines typically use dc motors driven by motor generator (*MG*) or silicon-controlled rectifiers (*SCR*). *MG* is a better application when there is a possibility of fluctuating line voltage or the building contains very sensitive electronic equipment. *SCR* use less power and require less maintenance, however, they are currently more expensive than *MG*. By the turn of the century, virtually all new gearless traction machines are expected to use ac motors driven by the *VVVF* drive

C. Electrical Requirements

Globally a lift system, in the accordance with the classification given in the previous segment of paper, there are requirements for the power supply voltage levels as shown in Fig. 1.

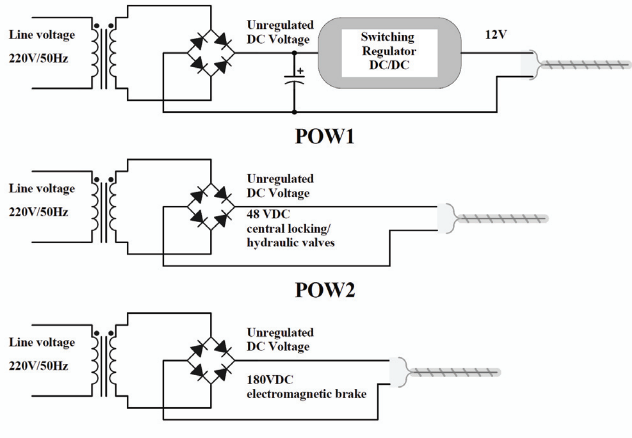

Fig. 1. Typical voltage values of the lift system

Power supply mainly consists of three parts. First, POW1 is DC power supply for lift processor electronics that have to provide supplying for all sensors and actuators also. POW2 is unregulated and unfiltered power supply for controlling a central locking system; typically drive a solenoid, in case of manual or semiautomatic doors, this power supply can be used for hydraulic lifts for driving valves. Finally, POW3 is used to drive electromagnetic brake that is energized during lift movement.

A global functional structure of the lift processor system is given in Fig. 2. Structure is composed of a number of lift processor clusters *LPCi*. Such the system is intended for controlling more lift units so-called multiplex lift system (duplex, triplex). The clusters are connected by *XNET* bus based on *RS485*. As can be seen on Fig 2, the lift processor cluster has distributed structure. Nodes are connected by *LNET* bus, also of *RS485* type. The lift processor cluster is composed of following nodes:

- Master node, M, which directly controls most of actuators in system (motor, valves, brakes, and others).
- Cabin node, *CAB*, acquire all information from moving car, and for automatic door control.
- Register box, *RB,* for collecting requests from passengers in lift and displaying all necessary information.
- A corresponding number of floor processors *FPi* on each floor.

Gateway for connecting to *XNET* bus is realized trough master node. *PNET* is a network of bus power, which is in the most practical implementation of the lift system distributed by two pairs together with the pair communication bus LNET same cable.

The consumption of the lift system have influence two factors:

1. number of floors that cover the lift with a one cab, so called "simplex" system, where the dominant influence is that number of *FPi* and cable lengths, and

2. multiplex lift system, or different types of lift control system such as the "duplex" system with two cabs, or systems that have three or more cabins known as a "group supervisory operation" so called cluster structure.

Below paper it is interesting to consider and analyze the firstly mentioned problem.

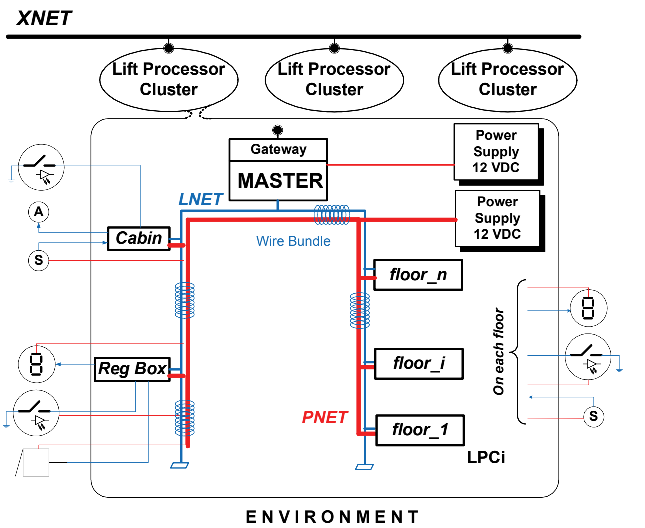

Fig. 2. Topology of the lift system (communication and distributed power supply)

As can be seen from Fig. 2, Master node has near locating power source POW1A, and is not of interest for our analysis. We can only point out that it is designed and implemented in the accordance with the functional requirements.

On the other hand, nodes *CAB*, *RB* and *FP*, in terms of power supply consist of one unit, and are connected to the POW1B through PNET bus.

II. Practical Results

The system was implemented and installed at several locations in public buildings in simplex mode with AC motors and sensors and actuators given in Fig 2.

In addition to the power block, a very important aspect in designing and implementing such a system is the cabling to communication networks and power networks. Namely, if the cable system is not designed and installed properly, the consequences could be drastic.

On the one hand, the occurrence of incomplete or dropped packets. Dropped packets are more difficult to detect because they are "lost" on the wire. When data is lost on the wire, the data is transmitted properly but, due to problems with the cabling, the data never arrives at the destination or it arrives in an incomplete format.

On the other hand we have the appearance of voltage drop. Voltage drop is the reduction in voltage in the passive elements of an electrical circuit. Voltage drops across conductors, contacts, connectors and internal source resistances are undesired as they reduce the supplied voltage.

Also, by standard, communications cables or wires shall not be placed in any raceway, compartment, outlet box, junction box, or similar fitting with conductors of any electrical power.

Generally, lift systems are located in harsh environments with extreme conditions, caused by vulnerability to external interferences from electric motors, lighting, cell phones, etc. Because of this, the performance of the cables used in lift applications is arguably more critical than that of other applications. The moving parts of the lift system (cabin) also add to the already heightened level of importance of proper cable selection. Therefore, it was necessary to perform cable system that will meet the requirements of an environment such as flexibility, low attenuation, low *EMI*, etc. The choice was *CAT3*. *UTP* Category 3 cable is usually four-pair twisted-pair cable with copper conductors, solid and *24 AWG* (*American Wire Gauge*).[4]

Practical measurement of power consumption of the system described in Fig.2, are shown in Table 1. Table shows current consumption for Register Box, Cabin and Floor controllers when no actuators is driven (led diodes, displays ...), and for peak current consumption.

TABLE 1.
LIFT ELECTRIC POWER REQUIREMENTS

Electric Load	Units	Idle Power	Peak Power
Register Box			
Microcontroller	1	6.5mA	25mA
Communications Driver	1	10µA	500µA (*receive*)
			900µA (*transmit*)
Buttons	16	0	32mA
LED Drivers	2	160µA	3.0625mA
LED7SEG	2	0	106.4mA
LED diode	5	0	60.17mA
Cabin			
Microcontroller	1	6.5mA	25mA
Communications Driver	1	10µA	500µA (*receive*)
			900µA (*transmit*)
Relay Actuator	3	0	150mA
Optocouplers	15	0	40.90mA
Floor processor			
Microcontroller	1	6.5mA	25mA
Communications Driver	1	10µA	500µA (*receive*)
			900µA (*transmit*)
Buttons	5	0	10mA
LED Drivers	2	160µA	3.0625mA
LED7SEG	2	0	106.4mA
LED diode	5	0	60.17mA

Worst-case scenario of the lift system with a two floor (*CAB*, *RB* and *FP1* and *FP2*) has a requirement for the consumption of 857mA. It is obviously that increasing number of floors adds consumption of the floor processors only, while the other variables remain constant as shown in Fig 3.

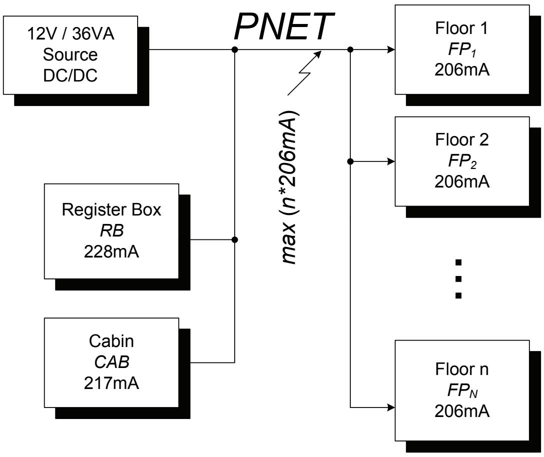

Fig. 3. Block presentation of distributed power supply with the required load

Based on characteristics of the cable [5] and requires the consumption presented in Table 1, the analysis of the voltage drop across the PNET bus conductor in the function of the number of floors served by lift (or length of cable) is performed. The resulting analyze is shown as diagram in Fig. 4.

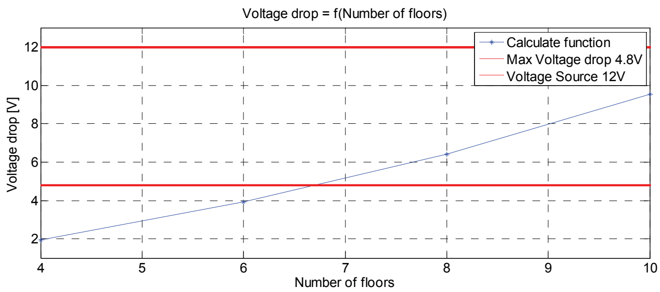

Fig. 4. Voltage drop in the function of the number of floors

Previous theoretical analysis and practical application of the system in real conditions have shown some disadvantages in the field of power supply. Initial solution with a linear voltage regulator is not optimal in situations where the building has many floors (more than 6 floors) and when there is a large fluctuation of supply voltage (spikes, surges, sags, and brownout or restore power). The main problem with linear regulators is that request minimal input voltage $7.2V@I_L=500mA$ to maintain linear regulation and exhibits a large loss. But the above solution is not expensive, requires no external components and is suitable for buildings with fewer floors.

III. Conclusion

This paper describes the realization of the power block in the lift system. Power block is implemented as a distributed power architecture which achieves its simplification and eliminates the redundant wiring. In the initial phase of design and implementation of the lift system convert to the end-use voltage is achieved using a linear voltage regulator. Despite the low efficiency and sensitivity to changes of input voltage is shown that the linear voltage regulator is a good choice for small buildings, especially because its low cost, easy implementation and high reliability. Future activities would be the design and implementation of high reliability DC/DC switching power supply. Standard features of the switching power supplies, such as low voltage drop, high efficiency, low quiescent supply current, and operation with a wider input voltage range, makes it ideal for use in lift systems. Building distributed power networks with dc/dc converters offers weight, size, isolation, and power quality advantages to the designer of complex electronic systems.

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