Electrical System Design of a 15-Storey Hotel in Alabang, Muntinlupa City

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***Abstract*: This paper presents the comprehensive electrical system design for a 15-Storey Hotel located in Alabang, Muntinlupa City. The study focuses on creating a design that is safe, reliable, and cost-effective, adhering to the Philippine Electrical Code (PEC) and international standards (IEEE/NEC). The scope encompasses load computation, transformer sizing, and advanced system studies including harmonic analysis, short circuit calculations, protection coordination, and arc-flash hazard analysis. The system employs a 2000 kVA pad-mounted oil-type transformer stepping down 34.5 kV utility power to 0.230 kV. Results indicate that the proposed design maintains voltage drops within a 3-5% margin and ensures coordinated protection against fault currents up to 76.2 kA at the main bus.**

***Keywords*: Electrical Design, 15 Storey Hotel, Short Circuit Analysis, Harmonic Distortion, Protection Coordination, Arc-Flash Analysis, Philippine Electrical Code.**

1. Introduction

The rapid urbanization of Alabang, Muntinlupa City, requires high-density commercial infrastructures equipped with robust electrical systems. This report details the design for a 15-storey hotel, which includes a three-level parking area, a grand lobby, a restaurant, and luxury guest rooms.

The primary objective is to develop an electrical distribution network that meets the "CARS" criteria: Capability, Availability, Reliability, and Stability. The system is supplied by the local utility (Meralco) at a primary voltage of 34.5 kV, connected to a 2000 kVA power transformer stepped down to 0.230 kV. This research provides a technical benchmark for Professional Electrical Engineers regarding the impact of nonlinear loads and fault duty calculations in high-rise applications.

2. Design Methodology and Assumptions

The conceptual framework follows a systematic data collection and design coordination process.

A. Load Categorization

Loads are categorized into lighting, receptacle outlets, and motor loads (HVAC, fire pumps, and elevators). Lighting loads are treated as continuous (100% Demand Factor), while power outlets and HVAC equipment are assigned an 80% Demand Factor per PEC 2017 Table 2.20.3.5.

B. Key Assumptions

- Initial Power Factor: 85% lagging.
- Motor Efficiency: 85% (assumed in the absence of manufacturer data).
- Transient Reactance (X^" d): 28% for motors <50 HP; 20% for 50-150 HP; 25% for lumped motor loads.
- System Grounding: Minimum 80mm² copper system grounding conductor.

3. System Analysis and Calculations

A. Load Computation and Transformer Sizing

The total connected load was calculated at 1,645.02 kVA. Applying demand factors resulted in a maximum demand of 1,332.00 kVA.

Total Current (I_total): 3,865.49 A
Transformer Rating: Using the formula
Rating=1.732×kV×I_total×1.25,

the required capacity is 1,970.47 kVA. A 2000 kVA, 3-Phase, 34.5 kV/0.230 kV pad-mounted transformer was selected.

B. Harmonic Analysis

With the inclusion of non-linear loads (Variable Speed Drives for chillers and elevators), current distortion was evaluated.

- Total Harmonic Distortion (THD): Evaluated at 0.199% for current and 0.345% for voltage at the 0.230 kV bus.
- Compliance: Results fall within IEEE 519 limits (7.0% limit for the 14.36 RSC category).

C. Voltage Drop Computation

Voltage drop was calculated using the formula:

$$V_{DLL} = 1.732 \times L \times I \times (R\cos\ \phi + X\sin\ \phi)$$

- Transformer to LVSG: 3.02% drop (calculated at

6.95 V).

- Branch Circuits: Maintained below the 3% threshold for furthest outlets.

D. Short Circuit and Fault Duty

Using the Per-Unit (p.u.) method with a 10 MVA base:

- Utility Impedance (Z_u): 0.00425+ j 0.03094 p.u.
- Highest Fault Current at Main Bus (Bus 1): 76.208 kA.
- Recommended Interrupting Capacity: 130 kAIC for the Low Voltage Switchgear (LVSG).

E. Protection Coordination

Time-Current Curves (TCC) were developed to ensure selectivity between the 30E primary fuse and the 6300A Main Air Circuit Breaker (ACB). A Coordination Time Interval (CTI) of 0.75 seconds was established to ensure that downstream faults do not trigger a total building blackout.

F. Arc-Flash Hazard Analysis

Arc-flash boundary and incident energy were calculated to determine Personal Protective Equipment (PPE) requirements.

- Arcing Current (I_a): 17.6496 kA at the LVSG.
- Incident Energy (E): 3.9790 cal/cm².
- PPE Category: Category 1 (Arc-rated clothing with minimum 4 cal/cm² rating).
- Flash Protection Boundary: 1.1131 meters.

4. Conclusion and Recommendations

The electrical system design for the 15-Storey Hotel successfully meets the stringent safety and reliability requirements of the Philippine Electrical Code.

A. Main Findings:

- A 2000 kVA transformer is sufficient to handle the peak demand while allowing for future expansion.
- The short circuit level of 76.2 kA requires high-performance circuit breakers; an 85 kAIC rating is recommended for distribution panels and 130 kAIC for the main LVSG.
- Harmonic levels are well within the permissible limits of IEEE 519, minimizing the risk of equipment overheating.
- Arc-Flash hazard at the main bus requires personnel to wear Category 1 PPE during live maintenance.

B. Recommendations:

- Strict adherence to the periodic preventive maintenance schedule for the 6300A ACB to ensure the calculated CTI remains valid.
- Use of THW-type conductors to withstand high-humidity conditions typical of the project location.

References

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