ARC FLASH ANALYSIS FOR
A Chemical Manufacturer in Chiplun

Compliance Standard: IEEE 1584, NFPE 70E
Report on

- Site survey, Load measurements.
- ETAP based System simulation.
- ARC Flash Analysis, Incident Energy.
- ARC flash boundaries.
- Fuse coordination to reduce hazard.

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Basics of ARC Flash HAZARD

Origin of Arc flash study and governing codes and standards
In the early 1980's Mr. Ralph Lee published a paper "The Other Electrical Hazard: Electric Arc Blast Burns" in the IEEE Transactions on Industrial Applications. As a result the world realized need to protect people from the hazards of arc flash.

Four separate industry standards guide for prevention of arc flash incidents:

- OSHA 29 Code of Federal Regulations (CFR) Part 1910 Subpart S.
- NFPA 70-2002 National Electrical Code.
- NFPA 70E-2000 Standard for Electrical Safety Requirements for Employee Workplaces.
- IEEE Standard 1584-2002 Guide for Performing Arc Flash Hazard Calculations.

Compliance with OSHA involves adherence to a six-point plan:

- A facility must provide, and be able to demonstrate, a safety program with defined responsibilities.
- Calculations for the degree of arc flash hazard.
- Correct personal protective equipment (PPE) for workers.
- Training for workers on the hazards of arc flash.
- Appropriate tools for safe working.
- Warning labels on equipment. Note that the labels are provided by the equipment owners, not the manufacturers. It is expected that the labels contain the equipment's flash protection boundary, its incident energy level, and the required personal protective equipment (PPE).

- Arc Flash is the result of a rapid release of energy due to an arcing fault between a phase bus bar and another phase bus bar, neutral or a ground. During an arc fault the air is the conductor. Arc faults are generally limited to systems where the bus voltage is more than 120 volts. Lower voltage levels normally will not sustain an arc. An arc fault is like the arc obtained during electric welding and the fault must be manually started by something creating the path of conduction or a failure such as a breakdown in insulation.
- The cause of the short normally burns away during the initial flash and the arc fault is then sustained by the establishment of a highly-conductive plasma. The plasma will conduct as much energy as is available and is only limited by the impedance of the arc. This massive energy discharge burns the bus bars, vaporizing the copper and thus causing an explosive volumetric increase, the arc blast, conservatively estimated, as an expansion of 40,000 to 1. This fiery explosion devastates everything in its path, creating deadly shrapnel as it dissipates.
- The arc fault current is usually much less than the available bolted fault current and below the rating of circuit breakers. Unless these devices have been selected to handle the arc fault condition, they will not trip and the full force of an arc flash will occur. The electrical equation for energy is volts x current x time. The transition from arc fault to arc

flash takes a finite time, increasing in intensity as the pressure wave develops. *The challenge is to sense the arc fault current and shut off the voltage in a timely manner before it develops into a serious arc flash condition.**Time taken is Fault clearing time**.*

- ARC FLASH study involves determination of actual arc flash energy levels at working distances (From where a maintenance or operating person usually works with the panel boards.) from ARC SOURCE. These energy levels are dependent on Source Fault levels, Fault currents at location, Physical arrangements and clearances between electrically conducting parts in side the panel, time taken by fault clearing devices to clear the fault. Once this is known and optimized, one can select personal protective equipment like Arc suits, shields, gloves etc to get adequate protection while working on these feeders. The calculations being quite involved, use of electrical system simulation software tool helps in ensuring compliance with standards and also bring in accuracy and safety in real life.

Important Definitions

- **Bolted Fault** - Short circuit current resulting from conductors at different potentials becoming solidly connected.
- **Arc Fault** - Short circuit current resulting from conductors at different potentials making a less than solid contact. This results in a relatively high resistant connection with respect to a bolted fault.*Arc fault currents are less than Bolted fault current, but "Air Plasma" resulting due to Arc has extremely high temperature. Melting of metal and other effects of this high temperature give rise to associated damage.*
- **FCT** – Fault clearing time – Protective devices arranged ensure disconnecting the circuit. The energy released during this arcing is proportional to square of arcing current and time taken to disconnect this fault.
- **AFB** - Arc Flash Boundary - During arcing flash extends to this distance from the source of arcing.
- **IE** – Incident energy – Calories per Cm^2.
- **PPE** – Personal Protective Equipment.

Energy Levels defined by NFPA 70E -2000 – 2015

Level ID	Cal / Cm^2	PPE Specifications to withstand Cal / Cm^2 mentioned in earlier column
A	**2**	Untreated Cotton
B	**4**	Flame retardant (FR) shirt and FR pants
C	**8**	Cotton underwear FR shirt and FR pants
D	**25**	Cotton underwear FR shirt, FR pants and FR coveralls
E	**40**	Cotton underwear FR shirt, FR pants and double layer switching coat and pants
F	**100**	
G	**120**	
Note that a hard hat with full-face shield and the appropriate gloves are required also.		

Methodology Followed:

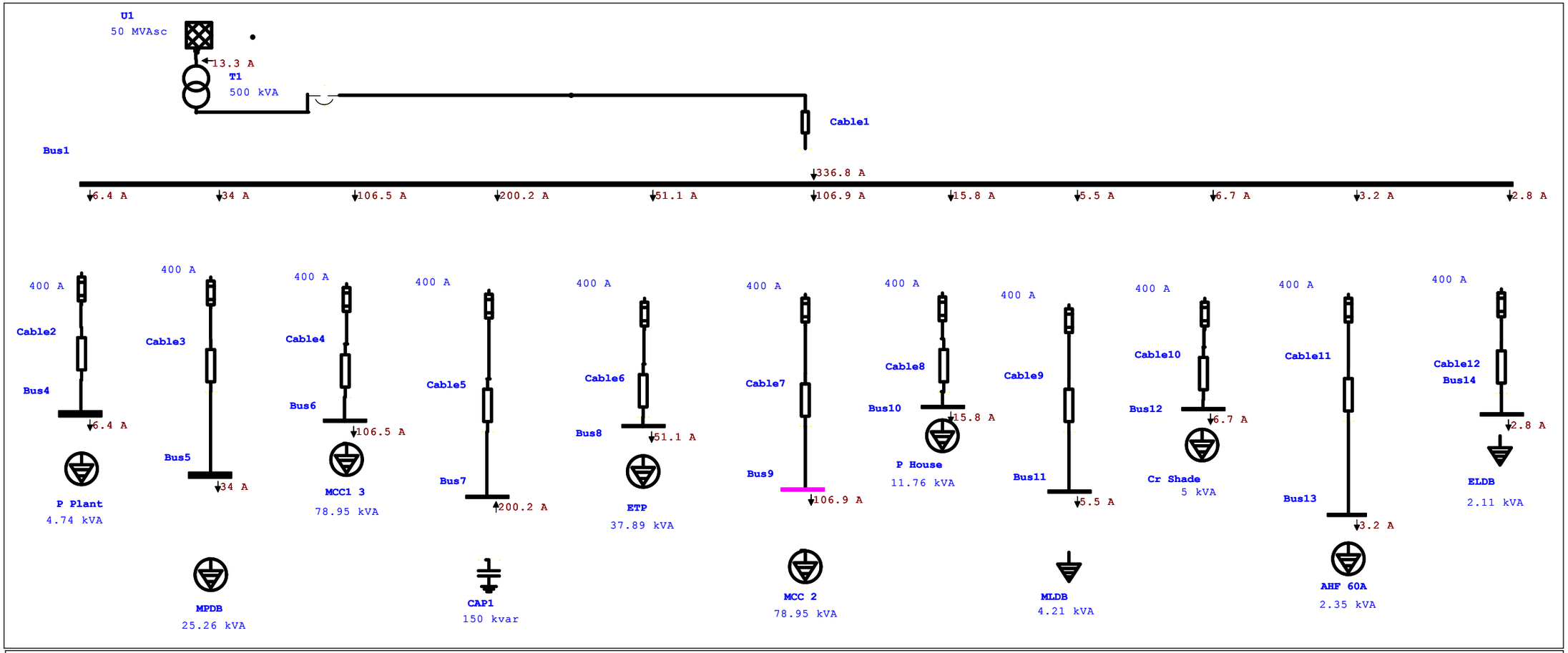
- LT panel feeder loads were measured at site.
- Data related to other system components was collected from site.
- Electrical system was simulated in electrical system simulation software ETAP.
- Load flow – short circuit analysis study was conducted on the simulation.
- Arc flash study was conducted using existing system components like cable runs and fuse ratings.
- Protection coordination module was used form ETAP to determine appropriate fuse ratings and optimum cable sizes.
- System component ratings were replaced in simulation from above revised study and Arc flash study was conducted again.
- Initial and optimized report is generated and presented here.

Plant Electrical infrastructure:

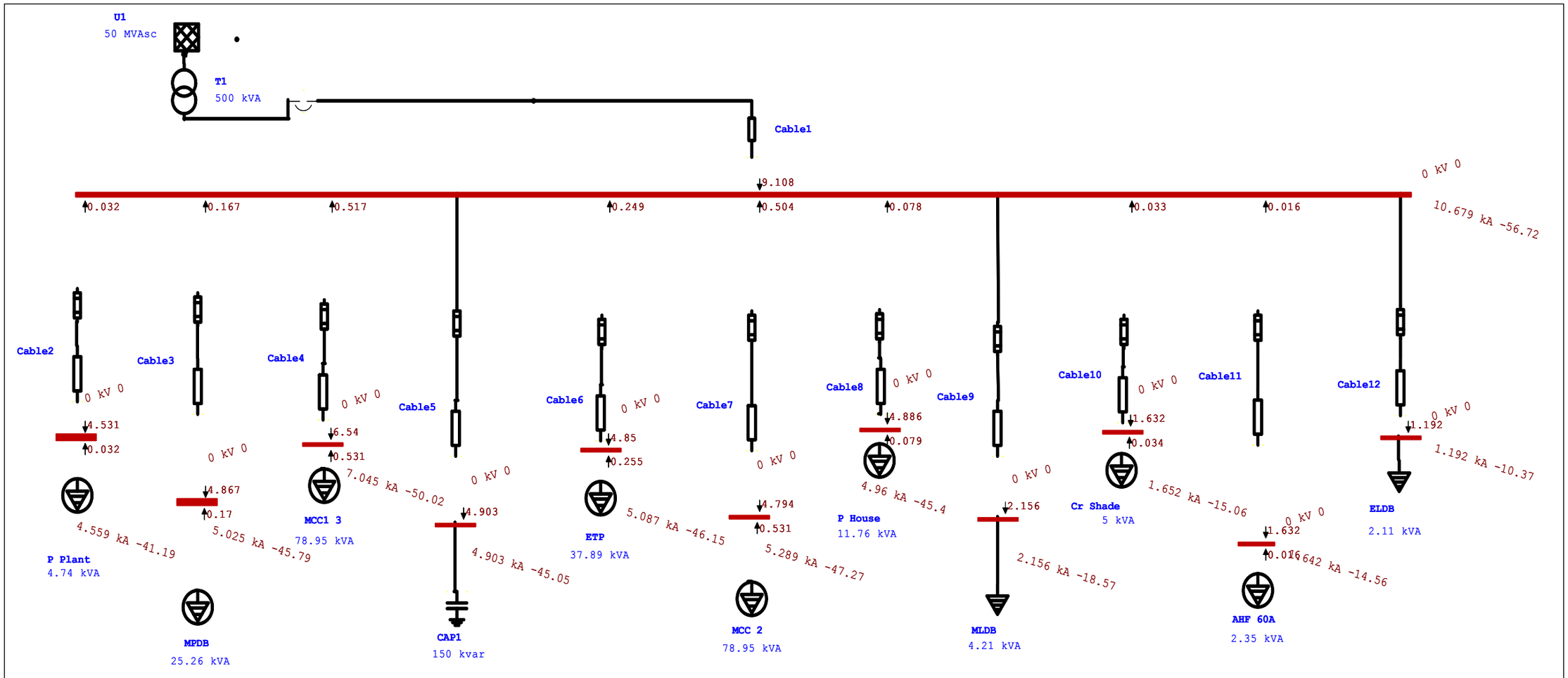
This plant works on a 11KV/433V – 500KVA transformer. An OLD LT Panel with SFUS supplies 11 individual feeders, which supply to individual loads. 11Kv is available from 50MVAC fault level source from MCEDCL and plant incomer is a load break switch. The panel being old, we have considered the same in "Switchboard Category" for deciding equipment type for ETAP Arc flash analysis, which assumes minimum 32mm gap between busbars.

Executive summary and recommendations from arc flash study.

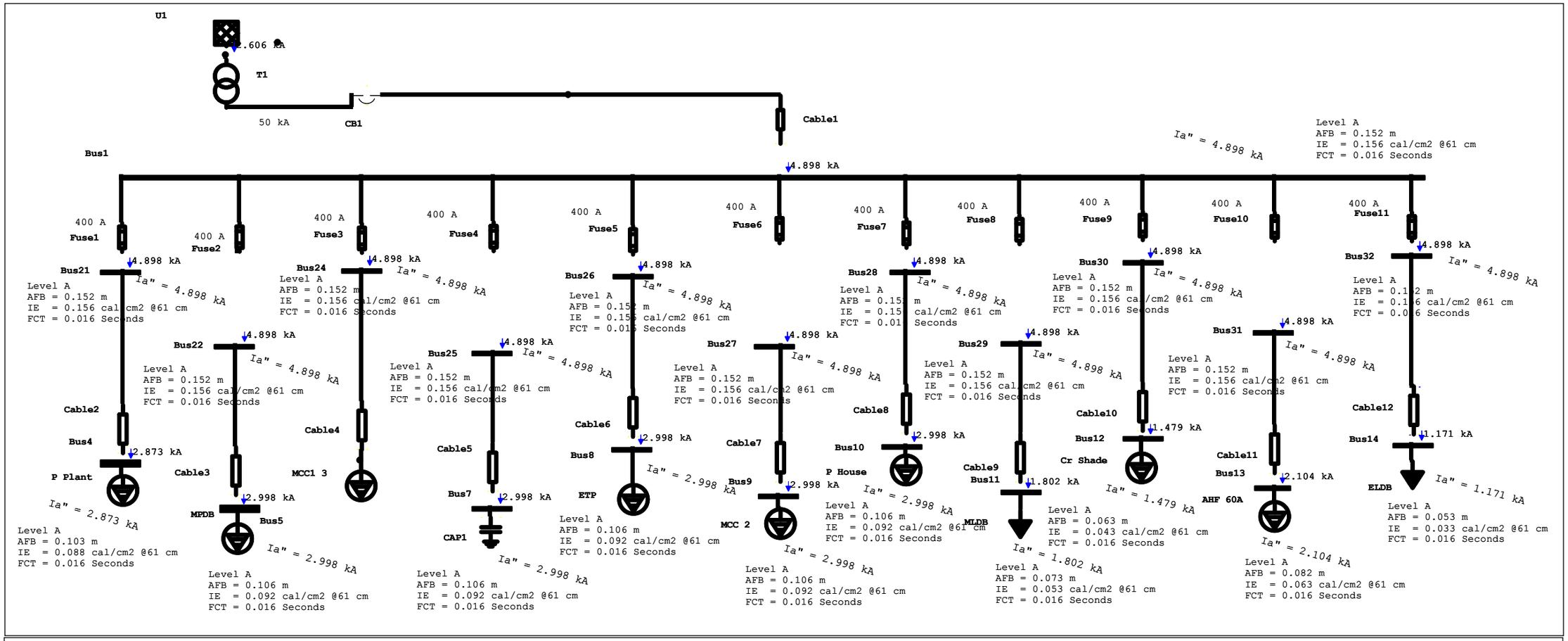
- The main LT Panel is old and provides only one ACB at input and Switch fuse units for individual feeders.The present cable and fuses are grossly overrated for the purpose. Under Arc Fault conditions on any of these LT panel out going / incoming the INCIDENT ENERGY level is LEVEL A but any downstream ARC Fault will be cleared only by ACB and not by Fuses.
- The fuse and cable ratings are too high compared to actual feeder requirements in case of most of the feeders. (Ref SLD simulation output on page 5).
- This report recommends appropriate fuse ratings to reduce arc energies by reducing fault clearing time. It may not be possible to accommodate these fuses in existing SFUs. This recommendation also will ensure individual fuse blowing under downstream ARC Fault – avoiding main ACB trip and total supply interruption.
- For any Arc fault in fuses, however the backup fault clearing protection would be ACB.
- The individual MCCS and PDBS may clear the faults at that level depending upon their ratings.



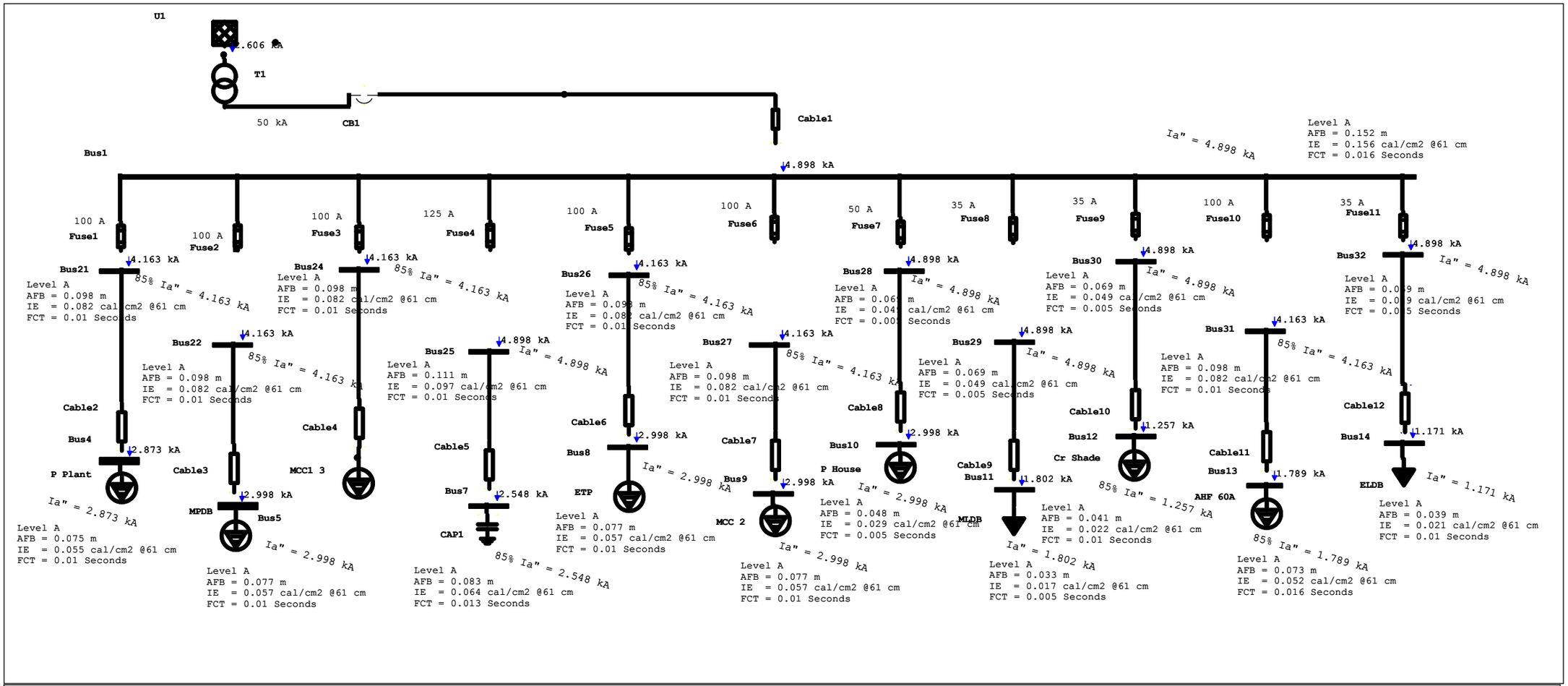
Existing Load flow results showing currents handled by respective feeders.



Short circuit analysis simulation results with existing component ratings



Arc flash analysis results with original fuse ratings and cables.



Arc flash analysis results with modified fuse ratings to suit present load.