
VANIR
2010
PM/CM
21st Annual Conference
The High-Velocity Edge:
Achieving Operational
Excellence
ELECTRICAL

Basic Electrical

Rick Miller, PE, LEED®AP

RNM Engineering, Inc.

Vanir Corp.

November 6, 2010

7:15 - 10:45

11:30 - 2:45

Alternate Title:

Alternate Title:

Electrical Systems: From a Dream to Reality

Alternate Title:

Electrical Systems: From a Dream to Reality

-or-

Alternate Title:

Electrical Systems: From a Dream to Reality

-or-

“From the Utility Pole to the Outlet”®

Electrical Systems - Agenda

- Design Phase
- Construction Phase
- Post Occupancy - (Building Facilities)
- Electrical Equipment

Design Phase

- OPR – Owner's Project Requirements
- BOD – Basis of Design
- BIM – Building Information Modeling

Design Phase

- Codes
- National Electrical Code (NEC)
- NFPA-70, -70E, -72, -110, -111
- Energy Codes: IECC, ASHRAE/IES, T24
- USGBC - LEED

Design Phase

- Schematic Design - OPR
- Design Development - BOD
- Construction Documents
  - Specifications:
    - AIA, CSI, MasterSpec
  - Drawings:
    - Plans, Diagrams, Schedules
  - Lighting Calculations
  - Calculations: Load, Short Circuit, Arc Flash

Specifications: Electrical

- 260500 COMMON WORK RESULTS FOR ELECTRICAL
- 260513 MEDIUM-VOLTAGE CABLES
- 260519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
- 260519.13 UNDERCARPET ELECTRICAL POWER CABLES
- 260523 CONTROL-VOLTAGE ELECTRICAL POWER CABLES UTP
- 260526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
- 260529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
- 260533 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS
- 260536 CABLE TRAYS FOR ELECTRICAL SYSTEMS
- 260539 UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS
- 260543 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
- 260548 VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS
- 260553 IDENTIFICATION FOR ELECTRICAL SYSTEMS
- 260573 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY
- 260913 ELECTRICAL POWER MONITORING AND CONTROL
- 260923 LIGHTING CONTROL DEVICES
- 260933 CENTRAL DIMMING CONTROLS
- 260936 MODULAR DIMMING CONTROLS
- 260943 NETWORK LIGHTING CONTROLS
- 261116 SECONDARY UNIT SUBSTATIONS
- 261200 MEDIUM-VOLTAGE TRANSFORMERS
- 261300 MEDIUM-VOLTAGE SWITCHGEAR
- 262200 LOW-VOLTAGE TRANSFORMERS
- 262300 LOW-VOLTAGE SWITCHGEAR

Specifications: Electrical

- 262313 PARALLELING LOW-VOLTAGE SWITCHGEAR
- 262413 SWITCHBOARDS
- 262416 PANELBOARDS
- 262419 MOTOR-CONTROL CENTERS
- 262500 ENCLOSED BUS ASSEMBLIES
- 262600 POWER DISTRIBUTION UNITS
- 262713 ELECTRICITY METERING
- 262726 WIRING DEVICES
- 262813 FUSES
- 262816 ENCLOSED SWITCHES AND CIRCUIT BREAKERS
- 262913 ENCLOSED CONTROLLERS
- 262923 VARIABLE-FREQUENCY MOTOR CONTROLLERS
- 263213 ENGINE GENERATORS
- 263323 CENTRAL BATTERY EQUIPMENT
- 263353 STATIC UNINTERRUPTIBLE POWER
- 263533 POWER FACTOR CORRECTION EQUIPMENT
- 263600 TRANSFER SWITCHES
- 264113 LIGHTNING PROTECTION FOR STRUCTURES
- 264200 CATHODIC PROTECTION
- 264313 TRANSIENT-VOLTAGE SUPPRESSION
- 265100 INTERIOR LIGHTING
- 265561 THEATRICAL LIGHTING
- 265600 EXTERIOR LIGHTING
- 265668 EXTERIOR ATHLETIC LIGHTING

Specifications: Format

SECTION 260000 - TITLE OF SPEC SECTION

PART 1 - GENERAL

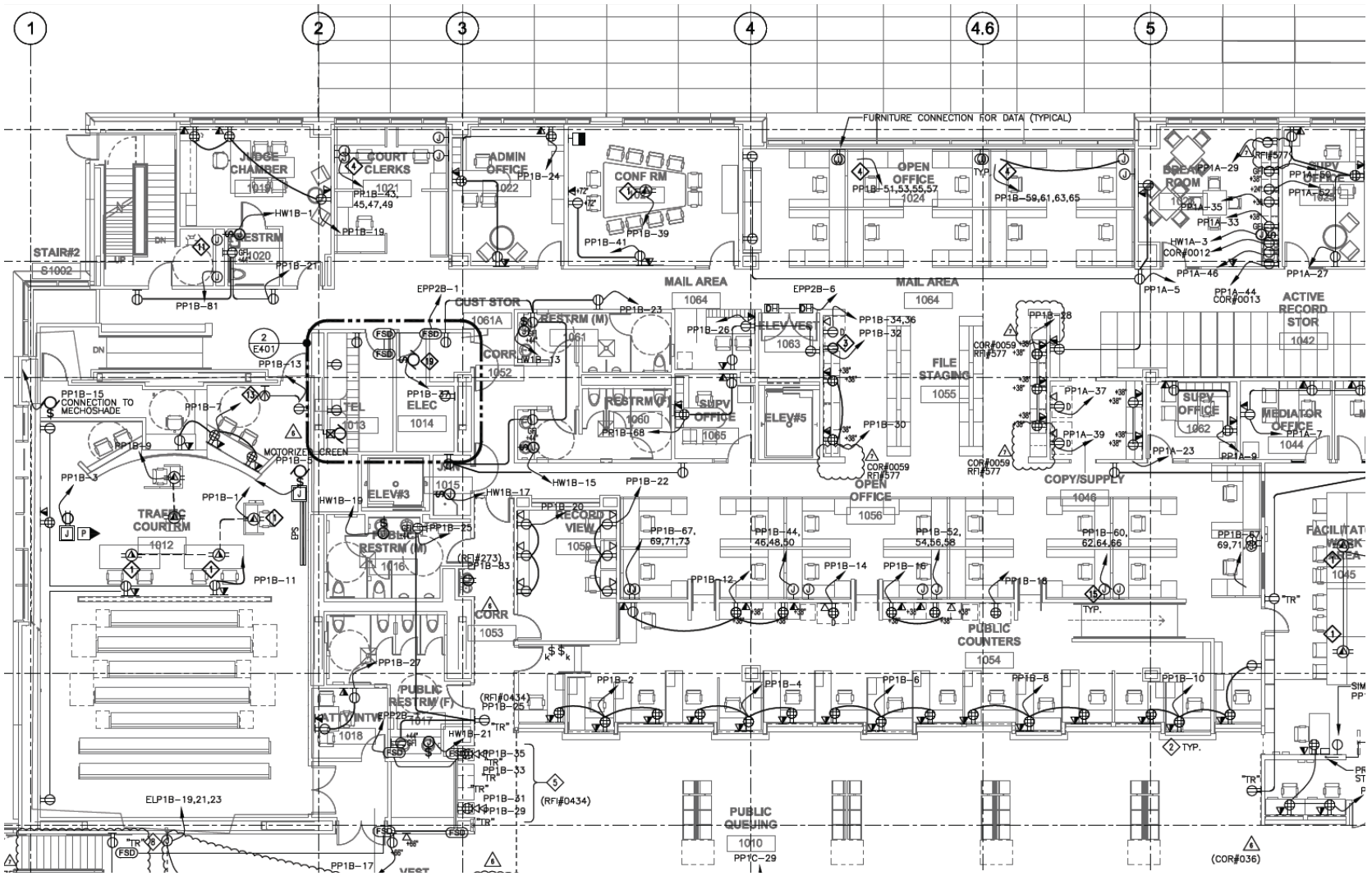
- 1.1 Related Documents
- 1.2 Summary
- 1.3 Submittals
- 1.4 Quality Assurance
- 1.5 Coordination

PART 2 - PRODUCTS

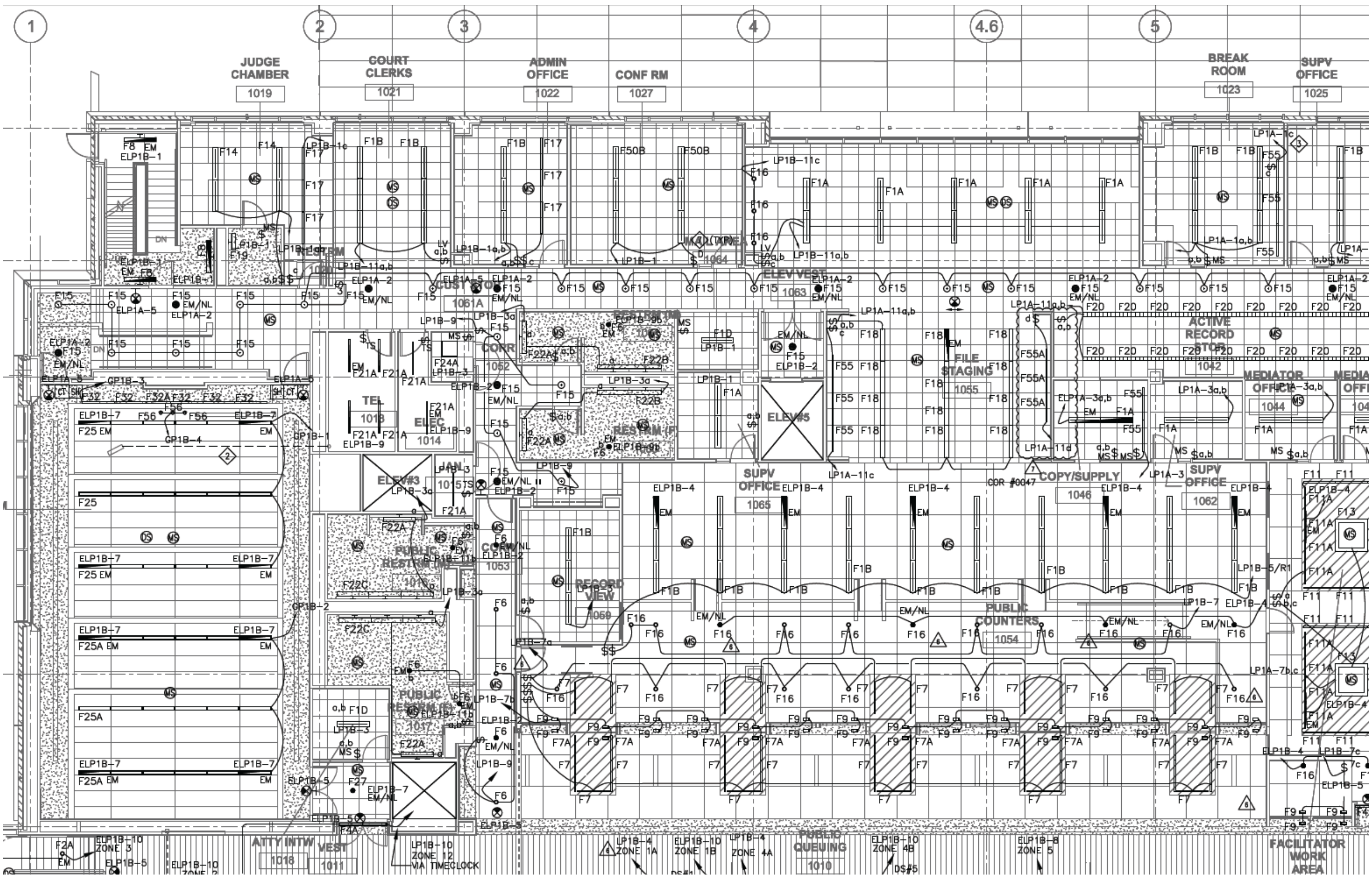
PART 3 - EXECUTION

- 3.1 Installation
- 3.2 Field Quality Control
- 3.3 Training

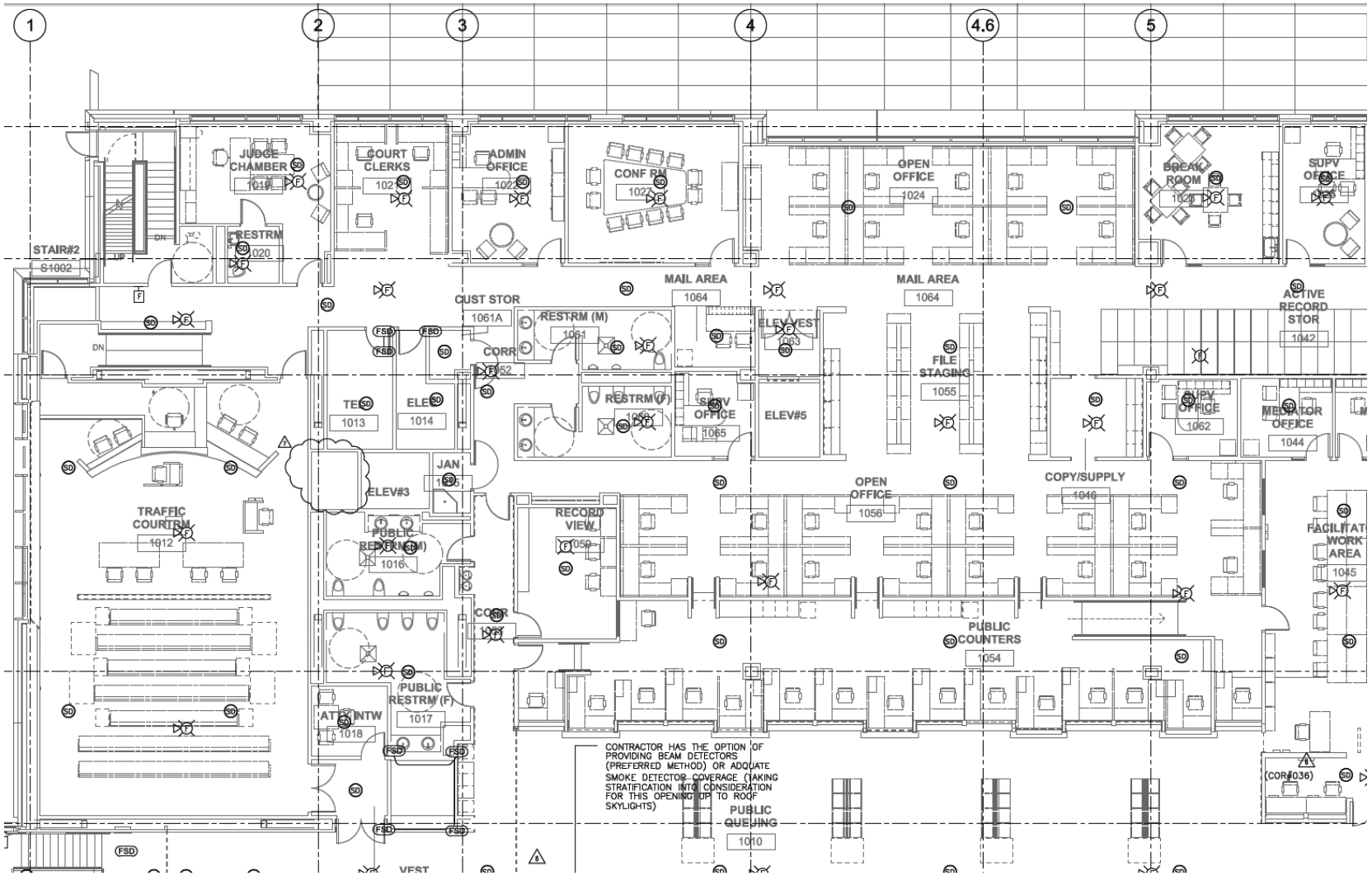
Drawings: Power Plans



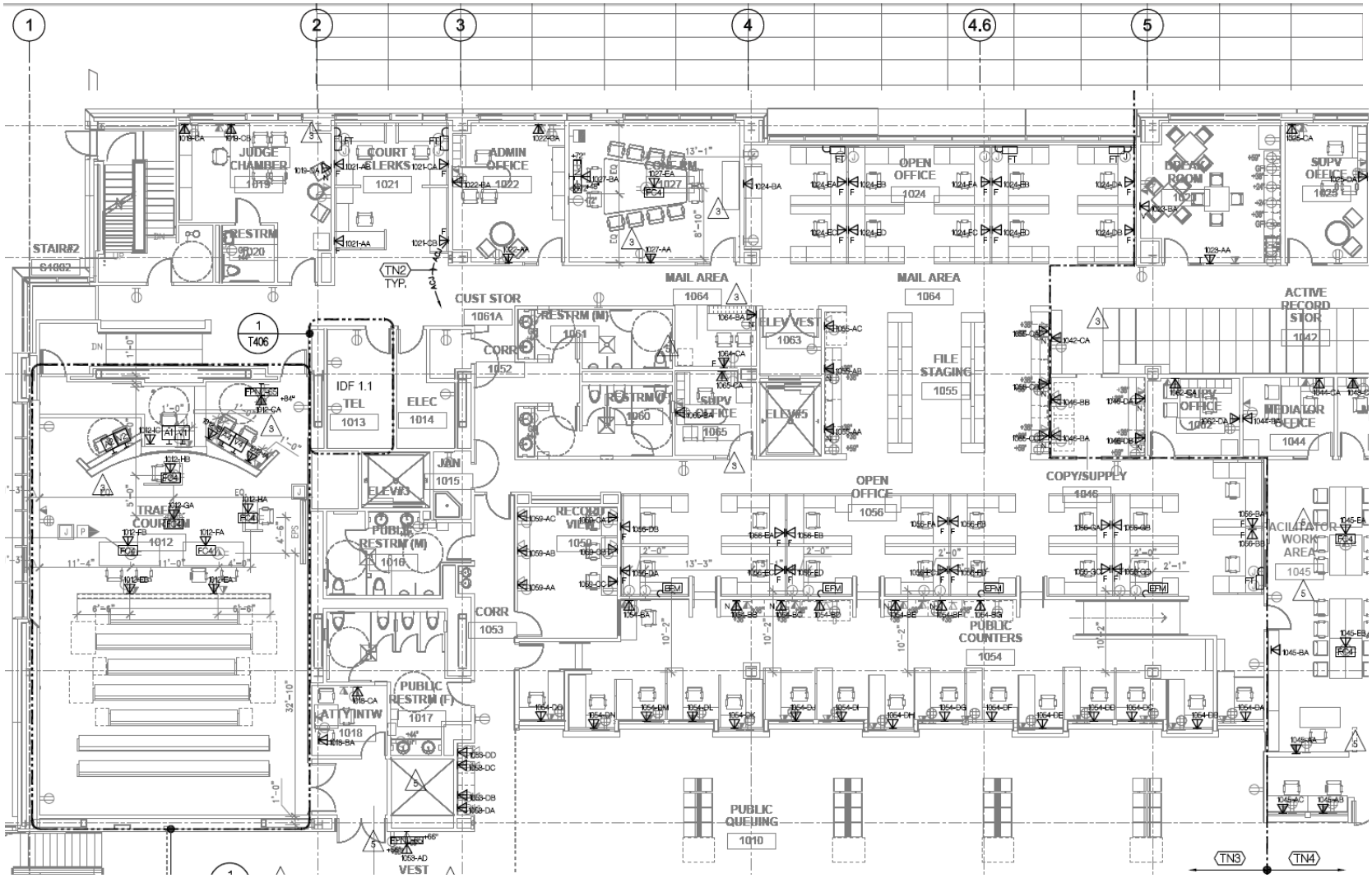
Drawings: Lighting Plans



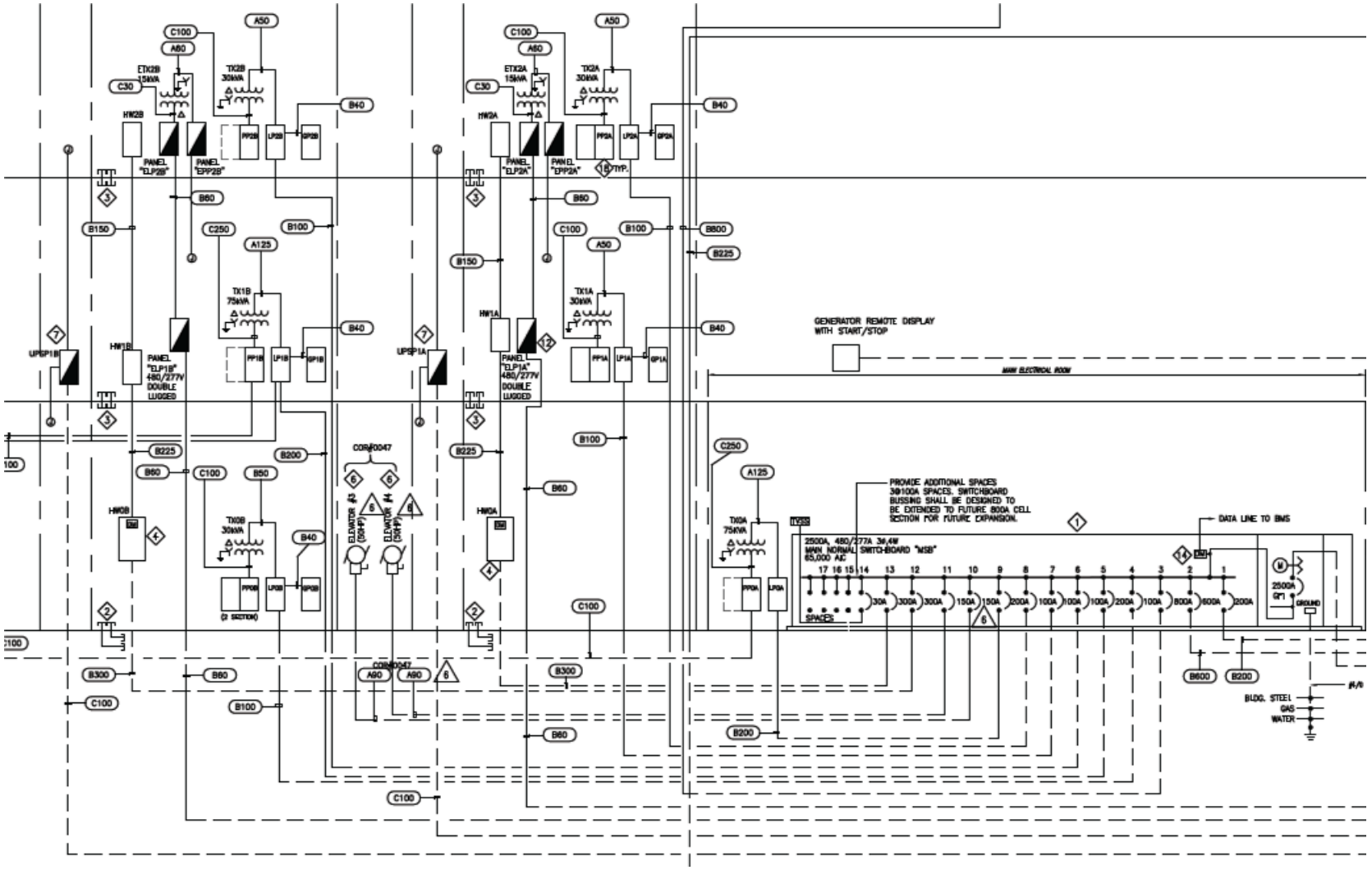
Drawings: Fire Alarm Plans



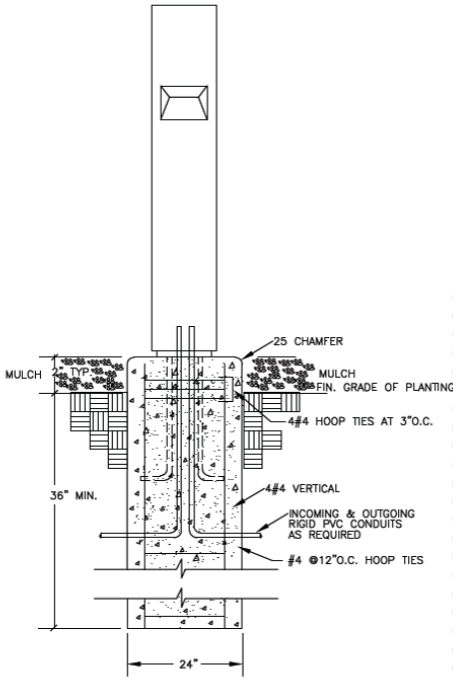
Drawings: Communication Plans



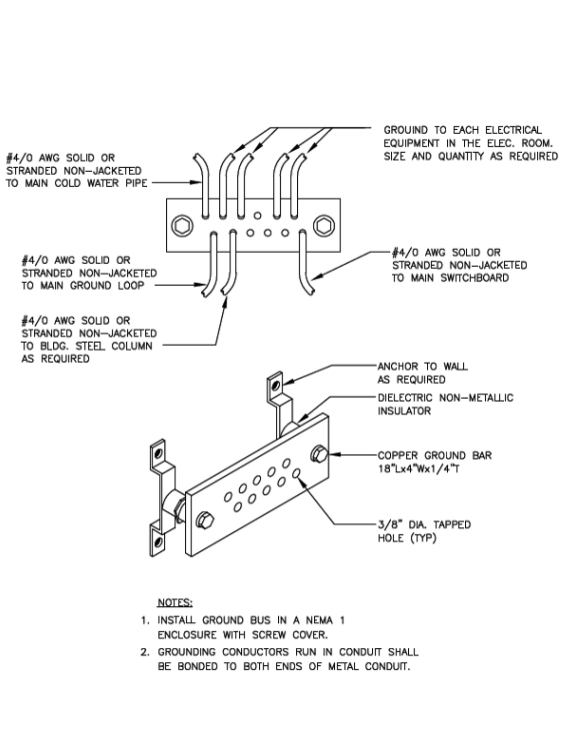
Drawings: Diagrams



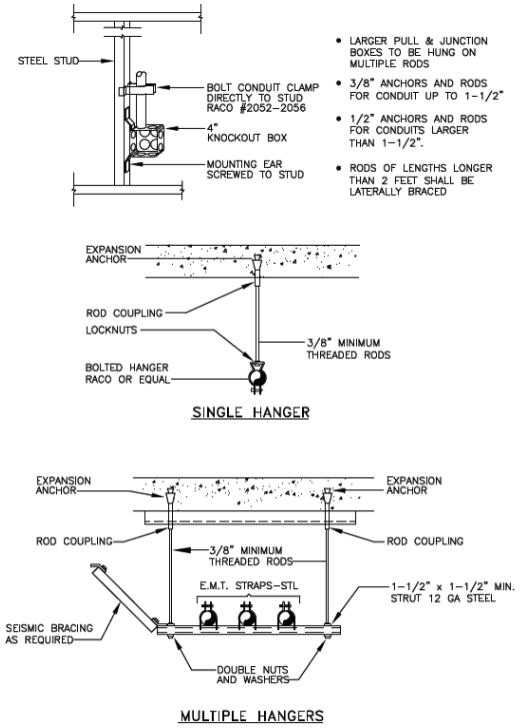
Drawings: Details



Bollard Base Detail



Ground Bus Detail



Conduit Support Method

Drawings: Schedules

DIMMING PANEL "GP2A" (277V) GP12–2774ML–20 (14 KAIC)										
CIRCUITING										
DIMMING PANEL	CIRCUIT #	Zone	Room	Lighting	Type	QTY	Load Type	Watts	Total	CKT LOAD
DIMMING PANEL "GP2A"	1	1	COURTROOM 2032	24' RECESSED @ DESK	F25	3	FL HI-LUME	384	1152	1152
	2	2	COURTROOM 2032	24' RECESSED @ SEATING	F25A	2	FL HI-LUME	192	384	384
	3	3	COURTROOM 2032	4' LINEAR COVE @ REAR WALL	F32	5	FL HI-LUME	32	160	185
				3' LINEAR COVE @ REAR WALL	F32A	1	FL HI-LUME	25	25	
	4	4	COURTROOM 2032	RECESSED (LOGO)	F56	3	MLV	50	150	150
	5	1	COURTROOM 2052	24' RECESSED @ DESK	F25	3	FL HI-LUME	384	1152	1152
	6	2	COURTROOM 2052	24' RECESSED @ SEATING	F25A	2	FL HI-LUME	192	384	384
	7	3	COURTROOM 2052	4' LINEAR COVE @ REAR WALL	F32	5	FL HI-LUME	32	160	185
				3' LINEAR COVE @ REAR WALL	F32A	1	FL HI-LUME	25	25	
	8	4	COURTROOM 2052	RECESSED (LOGO)	F56	3	MAG. LV	50	150	150
	9	-	SPARE							
	10	-	SPARE							
	11	-	SPARE							
	12	-	SPARE							
TOTAL PANEL CONNECTED LOAD (WATTS)										3742
TOTAL PANEL CONNECTED LOAD (AMPS @480V, 3 PHASE, 4W + G)										4.5

COPPER FEEDER SCHEDULE A

TAG									
				PHASE		NEUTRAL		GND	
AMPS	QTY	SIZE	QTY	AWG (MM²)	QTY	AWG (MM²)	QTY	AWG (MM²)
100	1	1/0	3	1/0	1	1/0	1	1/0
125	1	1/0	3	1/0	1	1/0	1	1/0
150	1	2/0	3	2/0	1	2/0	1	1/0
175	1	3/0	3	3/0	1	3/0	1	1/0
200	1	4/0	3	4/0	1	4/0	1	1/0
225	1	250	3	250	1	250	1	2/0
250	1	300	3	300	1	300	1	2/0
300	1	350	3	350	1	350	1	3/0
350	1	400	3	400	1	400	1	3/0
400	1	500	3	500	1	500	1	4/0
450	1	600	3	600	1	600	1	250
500	1	700	3	700	1	700	1	350
600	1	800	3	800	1	800	1	400

COPPER FEEDER SCHEDULE B

TAG									
				PHASE		NEUTRAL		GND	
AMPS	QTY	SIZE	QTY	AWG (MM²)	QTY	AWG (MM²)	QTY	AWG (MM²)
100	1	1/0	3	1/0	1	1/0	1	1/0
125	1	1/0	3	1/0	1	1/0	1	1/0
150	1	1	3	1	1	1	1	1
175	1	1-1/0	3	1/0	1	1/0	1	1
200	1	1-1/0	3	1/0	1	1/0	1	1
225	1	1-1/0	3	1/0	1	1/0	1	1
250	1	1-1/0	3	1/0	1	1/0	1	1
300	1	1-1/0	3	1/0	1	1/0	1	1
350	1	1-1/0	3	1/0	1	1/0	1	1
400	1	1-1/0	3	1/0	1	1/0	1	1
450	1	1-1/0	3	1/0	1	1/0	1	1
500	1	1-1/0	3	1/0	1	1/0	1	1
600	1	1-1/0	3	1/0	1	1/0	1	1
700	1	1-1/0	3	1/0	1	1/0	1	1
800	1	1-1/0	3	1/0	1	1/0	1	1
900	1	1-1/0	3	1/0	1	1/0	1	1
1000	1	1-1/0	3	1/0	1	1/0	1	1
1100	1	1-1/0	3	1/0	1	1/0	1	1
1200	1	1-1/0	3	1/0	1	1/0	1	1
1300	1	1-1/0	3	1/0	1	1/0	1	1
1400	1	1-1/0	3	1/0	1	1/0	1	1
1500	1	1-1/0	3	1/0	1	1/0	1	1
1600	1	1-1/0	3	1/0	1	1/0	1	1
1700	1	1-1/0	3	1/0	1	1/0	1	1
1800	1	1-1/0	3	1/0	1	1/0	1	1
1900	1	1-1/0	3	1/0	1	1/0	1	1
2000	1	1-1/0	3	1/0	1	1/0	1	1
2100	1	1-1/0	3	1/0	1	1/0	1	1
2200	1	1-1/0	3	1/0	1	1/0	1	1
2300	1	1-1/0	3	1/0	1	1/0	1	1
2400	1	1-1/0	3	1/0	1	1/0	1	1
2500	1	1-1/0	3	1/0	1	1/0	1	1
2600	1	1-1/0	3	1/0	1	1/0	1	1
2700	1	1-1/0	3	1/0	1	1/0	1	1
2800	1	1-1/0	3	1/0	1	1/0	1	1
2900	1	1-1/0	3	1/0	1	1/0	1	1
3000	1	1-1/0	3	1/0	1	1/0	1	1
3100	1	1-1/0	3	1/0	1	1/0	1	1
3200	1	1-1/0	3	1/0	1	1/0	1	1
3300	1	1-1/0	3	1/0	1	1/0	1	1
3400	1	1-1/0	3	1/0	1	1/0	1	1
3500	1	1-1/0	3	1/0	1	1/0	1	1
3600	1	1-1/0	3	1/0	1	1/0	1	1
3700	1	1-1/0	3	1/0	1	1/0	1	1
3800	1	1-1/0	3	1/0	1	1/0	1	1
3900	1	1-1/0	3	1/0	1	1/0	1	1
4000	1	1-1/0	3	1/0	1	1/0	1	1

SYMBOL LIST

WIRING DEVICES

- Single pole toggle switch (Numeral or alpha- numeral, when shown denotes circuit or portion of circuit controlled by switch)
- Dimmer switch- Rating as noted
- Three-way switch
- Four-way switch
- Key-operated switch
- Combination wall switch/ occupancy sensor
- Weatherproof switch
- Low voltage switch
- Momentary contact switch
- Duplex receptacle outlet, wall mounted
- Duplex receptacle with Ground Fault Interrupter, wall mounted
- Weatherproof duplex receptacle, wall mounted
- Duplex receptacle wall mounted above counter height
- Copier receptacle, wall mounted
- Dishwasher receptacle, wall mounted
- Garbage disposal receptacle, wall mounted
- Hot water heater receptacle, wall mounted
- Refrigerator receptacle, wall mounted
- Vending machine receptacle, wall mounted
- Double duplex receptacle outlet, wall mounted
- Double duplex receptacle, recess mounted
- Floor mounted duplex outlet
- Single receptacle outlet, wall mounted
- Special receptacle as denoted, wall mounted
- Flush floor mounted power and tele/data outlet
- Occupancy sensor, ceiling mounted

EQUIPMENT

- SWBD NO. 1 — Major equipment such as Switchgear, Switchboard, or Power Control Center, Unit Substation or Rapid
- MCC-1 — Motor Control center
- T1 — Transformer, rating as indicated or scheduled

PANELBOARDS

- Power Distribution System
- Distribution Type

PANELBOARD DESIGNATION

- Equipment tag
- Fused disconnect switch, rating as indicated or scheduled
- Non-fused disconnect switch, rating as noted or scheduled
- Circuit breaker with enclosure, rating as indicated or scheduled
- Combination magnetic starter, rating as noted or scheduled
- Ground bus
- Multi-outlet assembly ("Raceway") with built-in receptacles (Type and spacing as indicated or specified)

Drawings: Panel Schedules

PB1

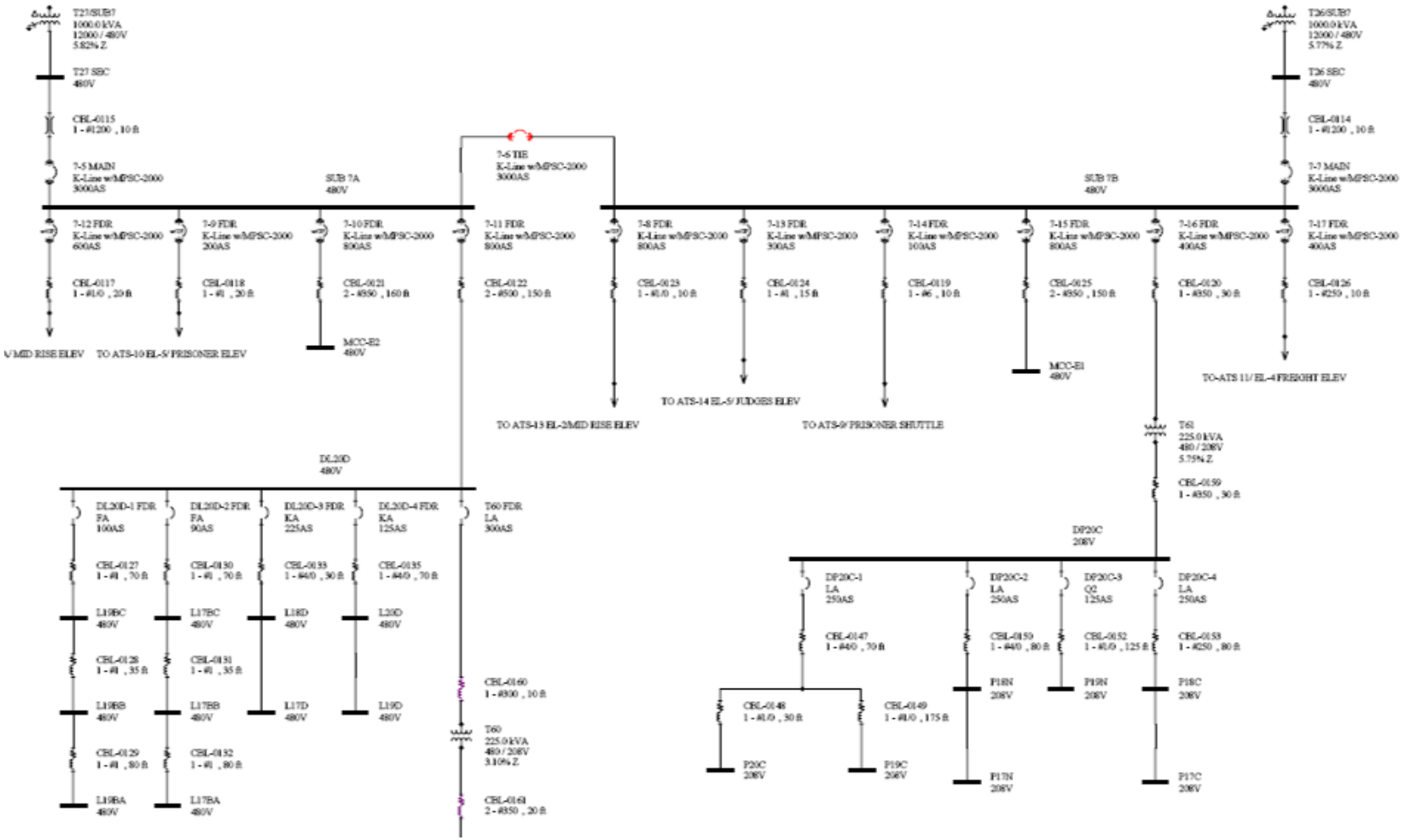
ROOM	VOLTS 240/120V 2P 3W	AIC 10,000
MOUNTING SURFACE	BUS AMPS 200	MAIN BKR MLO
FED FROM SWBD	NEUTRAL 100%	LUGS STANDARD
NOTE		

CKT #	CKT BKR	CIRCUIT DESCRIPTION	KVA LOAD A	KVA LOAD B	CKT #	CKT BKR	CIRCUIT DESCRIPTION	KVA LOAD A	KVA LOAD B
1	20/1	BOILER-1, HEATING PUMP P-1, ROOM 009	1.06		2	20/1	RECEP, ROOM 005	1.44	
3	20/1	BOILER-2, HEATING PUMP P-2, ROOM 009		1.06	4	20/1	RECEP, ROOM 005		0.72
5	20/1	PRIMARY CIRC PUMP P-3, ROOM 009	1.66		6	20/1	RECEP, EF-5, ROOM 008	0.77	
7	20/1	DOMES WATER HEATER P-4, WH-1, ROOM 009		0.628	8	20/1	RECEP, ROOM 013		1.26
9	20/1	HYDRONIC CIRC PUMP P-5, ROOM 009	0.528		10	20/1	RECEP, ROOM 014	0.18	
11	20/1	RECEP, ROOM 009		0.36	12	20/1	RECEP, EF-4, ROOM 014, 015		0.28
13	20/1	RECEP, ROOM 009	0.9		14	20/1	RECEP, ROOM 003, 004, 011, 017	0.72	
15	20/1	RECEP, EF-2, ROOM 018		0.82	16	20/1	SPACE		0
17	20/1	RECEP, ROOM 018	0.54		18	20/1	SPACE	0	
19	30/2	DRYER-1, ROOM 019		2.75	20	20/1	SPACE		0
21	|		2.75		22	20/1	SPACE	0	
23	20/1	WASHER-1, ROOM 019		1.18	24	20/1	SPACE		0
25	20/1	RECEP, RECEP-TV, ROOM 019	1.26		26	20/1	SPACE	0	
27	20/1	RECEP, ROOM 019		1.18	28	20/1	SPACE		0
29	20/1	EF-3, ROOM 016	0.1		30	20/1	SPACE	0	
31	20/1	RECEP, ROOM 016		0.75	32	20/1	LIGHTS		0
33	20/1	ELEV, ROOM 012	1.66		34	20/1	LIGHTS	0	
35	20/1	SPACE		0	36	20/1	LIGHTS		0
37	20/1	SPACE	0		38	20/1	LIGHTS	0	
39	20/1	SPACE		0	40	20/1	LIGHTS		0
41	20/1	SPACE	0		42	20/1	LIGHTS	0	
							TOTAL KVA	13.6	11

	CONN. KVA	CALC. KVA			CONN. KVA	CALC. KVA	
LIGHTING	0	0	(125%)	CONTINUOUS	0	0	(125%)
LARGEST MOTOR	1.66	2.07	(125%)	HEATING	0	0	(100%)
OTHER MOTORS	5.07	5.07	(100%)	NONCONTINUOUS	0.2	0.2	(100%)
RECEPTACLES	10.9	10.5	(50%>10)	KITCHEN EQUIP	0	0	(N/A)
				NONCOIN/DIVERSE	6.68	0	(0%)
				TOTAL KVA	24.5	17.8	

BALANCED PHASE AMPS 74.2

Short Circuit Diagram

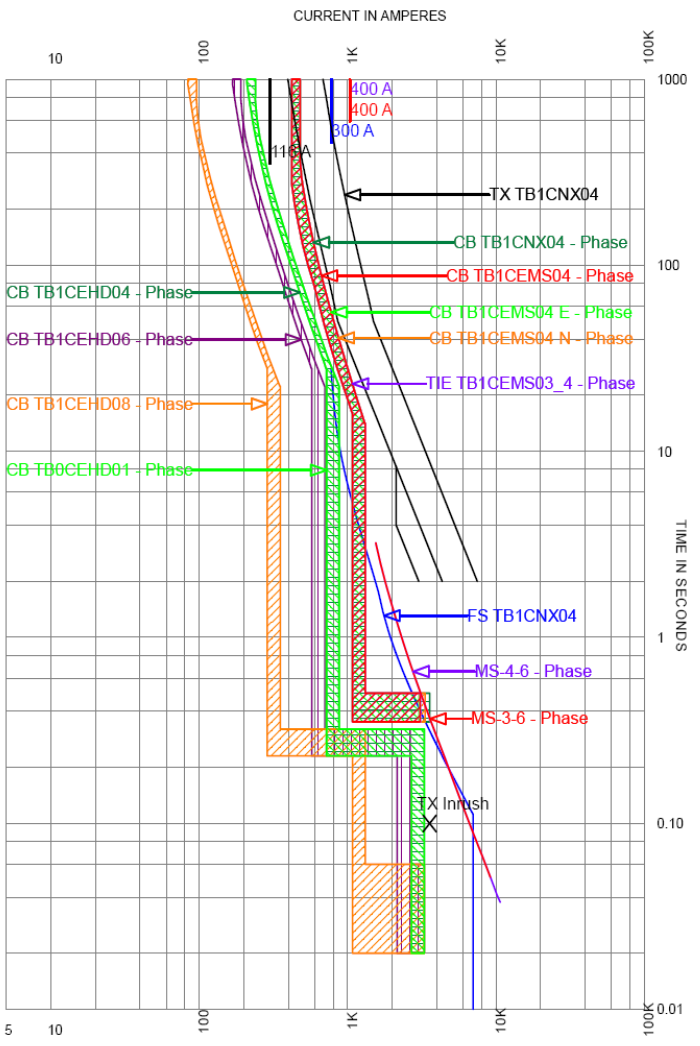


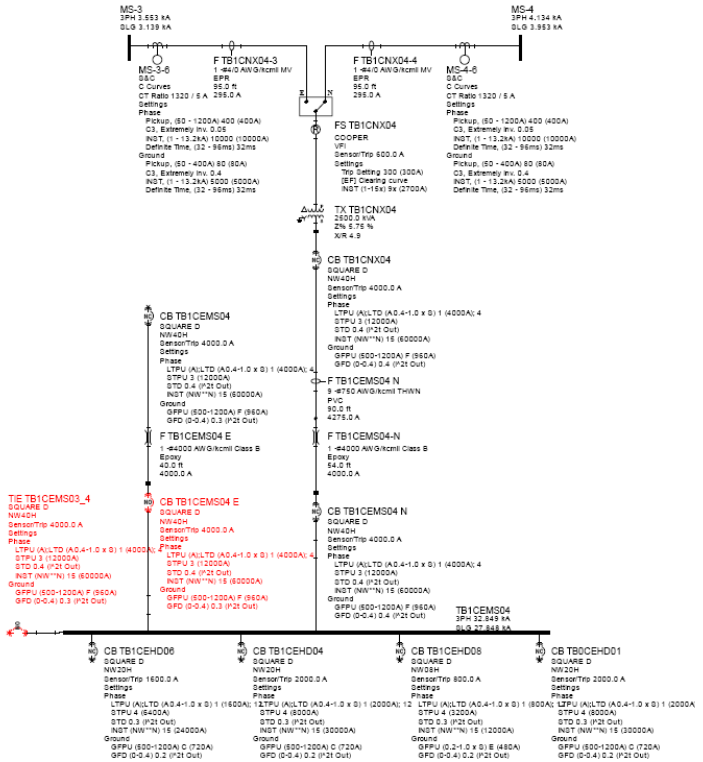
Short Circuit Calculations

U N B A L A N C E D F A U L T R E P O R T
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

LOCATION VOLTAGE	FAULT DUTIES	KA (RMS)	X/R	EQUIVALENT (PU) FAULT IMPEDANCE	ASYM. KA AT 0.5 CYCLES * MAX. RMS	AVG. RMS *
PSBC	3 PHASE:	4.836	3.	Z1= 57.3992	5.406	5.125
	SLG DUTY:	5.019	3.	Z2= 57.3992	5.596	
208. VOLTS	LN/LN	4.188		Z0= 51.1114		
	LN/LN/GND	4.951	(5.217 GND RETURN KA)			
SUB 2A	3 PHASE:	19.457	5.	Z1= 6.1819	24.250	21.923
	SLG DUTY:	19.008	4.	Z2= 6.1819	22.574	
480. VOLTS	LN/LN	16.850		Z0= 6.6557		
	LN/LN/GND	19.937	(18.545 GND RETURN KA)			
SUB 2B	3 PHASE:	20.003	5.	Z1= 6.0132	24.895	22.519
	SLG DUTY:	19.476	4.	Z2= 6.0132	23.082	
480. VOLTS	LN/LN	17.323		Z0= 6.5372		
	LN/LN/GND	20.471	(18.939 GND RETURN KA)			
SUB 3A	3 PHASE:	19.489	5.	Z1= 6.1719	24.289	21.958
	SLG DUTY:	19.039	4.	Z2= 6.1719	22.607	
480. VOLTS	LN/LN	16.878		Z0= 6.6457		
	LN/LN/GND	19.970	(18.573 GND RETURN KA)			
SUB 3B	3 PHASE:	19.648	5.	Z1= 6.1219	24.480	22.134
	SLG DUTY:	19.190	4.	Z2= 6.1219	22.774	
480. VOLTS	LN/LN	17.015		Z0= 6.5964		
	LN/LN/GND	20.136	(18.717 GND RETURN KA)			
SUB 4A	3 PHASE:	19.190	5.	Z1= 6.2678	23.851	21.587
	SLG DUTY:	18.566	4.	Z2= 6.2678	22.047	
480. VOLTS	LN/LN	16.619		Z0= 6.9323		
	LN/LN/GND	19.532	(17.951 GND RETURN KA)			

Overcurrent Coordination





Arc Flash Analysis

Table 6.1 – Arc-Flash Analysis Summary Table

Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Gnd	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm^2)	Hazard Risk Category
ALT-1 L	ATS-1 E FDR	0.48	17.67	17.67	10.67	0.017	0	Yes	PNL	25	12	18	0.59	#0
ATS 17 L	6-15 FDR	0.48	4.1	4.1	2.6	0.32	0	Yes	PNL	25	28	18	2.5	#1
ATS 8 L	6-8 FDR	0.48	15.95	15.95	9.77	0.05	0	Yes	PNL	25	22	18	1.6	#1
ATS-1 L	2-15 FDR	0.48	12.19	12.19	7.76	2	0	Yes	PNL	25	101	18	20	#3
ATS-10 L	7-9 FDR	0.48	19.2	18.85	11.24	0.051	0	Yes	PNL	25	24	18	1.9	#1
ATS-11 L	7-17 FDR	0.48	4.26	4.26	3.16	2	0	Yes	PNL	25	98	18	19	#3
ATS-12 L	7-12 FDR	0.48	13.16	11.61	7.32	2	0	Yes	PNL	25	101	18	20	#3
ATS-13 L	7-8 FDR	0.48	14.56	13.01	8.08	2	0	Yes	PNL	25	103	18	21	#3
ATS-14 L	7-13 FDR	0.48	4.22	4.22	3.14	0.5	0	Yes	PNL	25	42	18	4.7	#2
ATS-18 N DISC	2-9 FDR	0.48	11.85	11.85	7.58	2	0	Yes	PNL	25	101	18	20	#3
ATS-19 L	2-16 FDR	0.48	4.25	4.25	2.68	0.23	0	Yes	PNL	25	23	18	1.8	#1
ATS-19 N FDR BOX	SUB 2B FDR	0.48	12.45	12.18	7.74	2	0	Yes	PNL	25	102	18	21	#3
ATS-20 E FDR BOX	GEN BKR	0.48	17.23	9.12	5.52	2	0	Yes	PNL	25	108	18	22	#3
ATS-3 L	3-13 FDR99	0.48	4.22	4.22	3.14	2	0	Yes	PNL	25	97	18	19	#3
ATS-3 N FDR BOX	SUB 3B FDR	0.48	12.15	12.15	7.75	2	0	Yes	PNL	25	102	18	20	#3
ATS-4 L	4-11 FDR	0.48	4.13	4.13	3.08	2	0	Yes	PNL	25	96	18	19	#3
ATS-5 L	4-9 FDR	0.48	18.22	17.2	10.34	0.052	0	Yes	PNL	25	24	18	1.9	#1
ATS-6 L	6-14 FDR	0.48	4.24	4.24	3.15	2	0	Yes	PNL	25	97	18	19	#3
ATS-7 L	6-9 FDR	0.48	4.23	4.23	3.15	2	0	Yes	PNL	25	97	18	19	#3
ATS-9 L	7-14 FDR	0.48	19.39	19.39	11.55	0.05	0	Yes	PNL	25	24	18	1.9	#1
BASEMENT SHUTTLE 21	2-11 FDR	0.48	13.02	13.02	8.22	0.05	0	Yes	PNL	25	19	18	1.3	#1
BASEMENT SHUTTLE 24/25	7-14 FDR	0.48	2.67	2.67	2.12	0.056	0	Yes	PNL	25	8	18	0.35	#0
BUS-1A	Y1108 PHASE	12.00	32.19	32.04	30.48	0.322	0.05	Yes	SWG	153	505	36	16	#3

Arc Flash Warning Labels

CAUTION

Arc Flash and Shock Hazard

Appropriate PPE Required

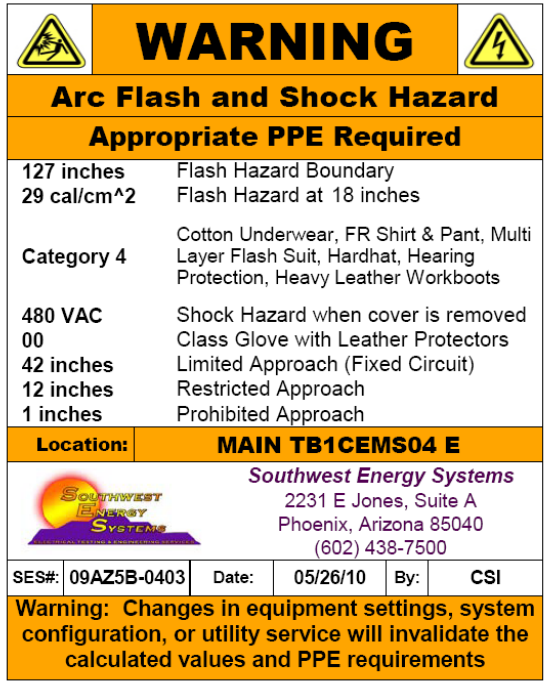
31 inches	Flash Hazard Boundary
1.0 cal/cm^2	Flash Hazard at 36 inches
Category 0	Untreated Cotton, Hardhat, Safety Glasses, Hearing Protection, Leather Workboots
12470 VAC	Shock Hazard when cover is removed
2	Class Glove with Leather Protectors
60 inches	Limited Approach (Fixed Circuit)
26 inches	Restricted Approach
7 inches	Prohibited Approach

Location: PME-9-4

Southwest Energy Systems
2231 E Jones, Suite A
Phoenix, Arizona 85040
(602) 438-7500

SES#:	09AZ5B-0403	Date:	05/26/10	By:	CSI

Warning: Changes in equipment settings, system configuration, or utility service will invalidate the calculated values and PPE requirements



WARNING

Arc Flash and Shock Hazard

Appropriate PPE Required

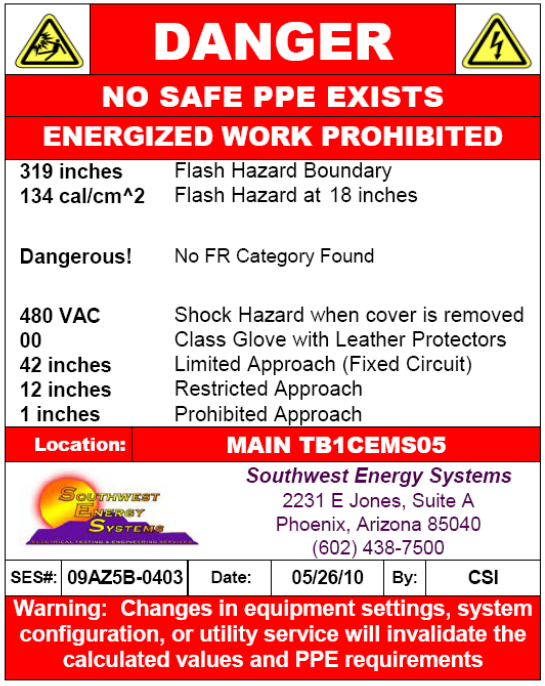
127 inches	Flash Hazard Boundary
29 cal/cm^2	Flash Hazard at 18 inches
Category 4	Cotton Underwear, FR Shirt & Pant, Multi Layer Flash Suit, Hardhat, Hearing Protection, Heavy Leather Workboots
480 VAC	Shock Hazard when cover is removed
00	Class Glove with Leather Protectors
42 inches	Limited Approach (Fixed Circuit)
12 inches	Restricted Approach
1 inches	Prohibited Approach

Location: MAIN TB1CEMS04 E

Southwest Energy Systems
2231 E Jones, Suite A
Phoenix, Arizona 85040
(602) 438-7500

SES#:	09AZ5B-0403	Date:	05/26/10	By:	CSI

Warning: Changes in equipment settings, system configuration, or utility service will invalidate the calculated values and PPE requirements



DANGER

NO SAFE PPE EXISTS

ENERGIZED WORK PROHIBITED

319 inches	Flash Hazard Boundary
134 cal/cm^2	Flash Hazard at 18 inches
Dangerous!	No FR Category Found
480 VAC	Shock Hazard when cover is removed
00	Class Glove with Leather Protectors
42 inches	Limited Approach (Fixed Circuit)
12 inches	Restricted Approach
1 inches	Prohibited Approach

Location: MAIN TB1CEMS05

Southwest Energy Systems
2231 E Jones, Suite A
Phoenix, Arizona 85040
(602) 438-7500

SES#:	09AZ5B-0403	Date:	05/26/10	By:	CSI

Warning: Changes in equipment settings, system configuration, or utility service will invalidate the calculated values and PPE requirements

LEED® Design Process

- LEED
  - Outdoor Lighting
  - Indoor Lighting Energy (daylight harvesting)
  - Daylight Factor
  - Views
- LEED Certification Levels:
  - **Certified** 40–49 points
  - **Silver** 50–59 points
  - **Gold** 60–79 points
  - **Platinum** 80 points and up

Construction Phase

- Skyer (Prolog, BuzzSaw)
- BIM
- Product Submittals
- Requests for Information
- Change Orders
- Observations vs Inspections
  - Observations by the Designers
  - Inspections by AHJ

Construction Process

- Prepare Bid & Cost Estimate
- Assemble Team (Management & Labor)
- Order Products
- Layout Work
  - Use BIM
  - Coordinate with General, Mechanical, Others
- Install Products & Make Connections
- Test Installation
  - by EC or Manufacturer or Third Party

LEED® Commissioning

- Fundamental Cx is a Prerequisite
  - for Electrical, this means Lighting Control
- Enhanced Cx is Optional (worth 2 points)
  - Lighting Control is still required
  - Electrical Distribution, Generators, etc
- Materials

LEED® CX Process

- Design reviews
- Product reviews
- Construction reviews
- Installation Verification
- Prefunctional Check (Start up)
- Function Performance Test

Post Occupancy

- Facility Management
- BIM
- Remodeling
- BOMA Documentation

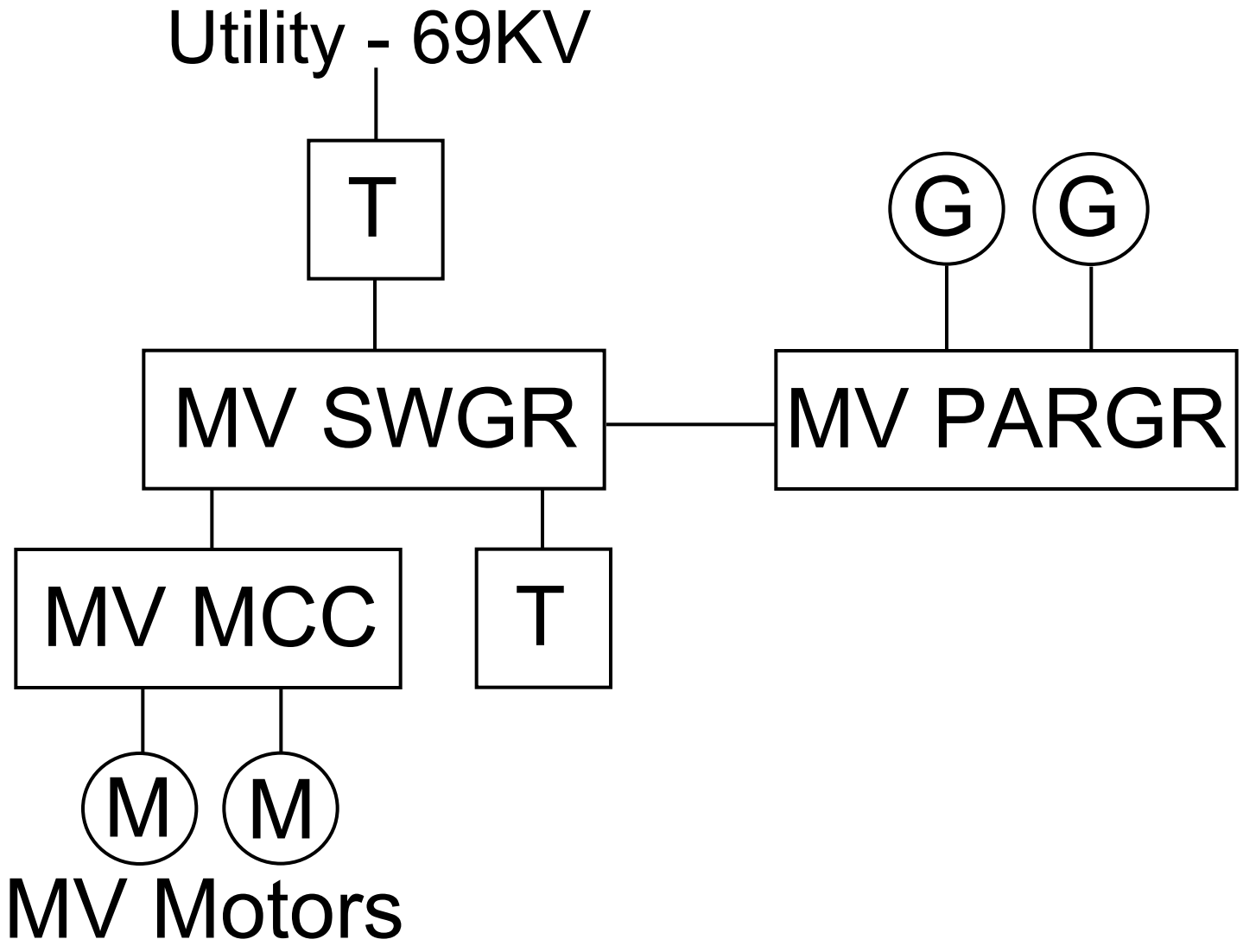
Electrical Equipment

- Utility Transformer
- Switchgear
- Switchboard
- Meter Sockets
- Distribution Panelboard
- Panelboard
- Motor Control Center
- Disconnect Switch

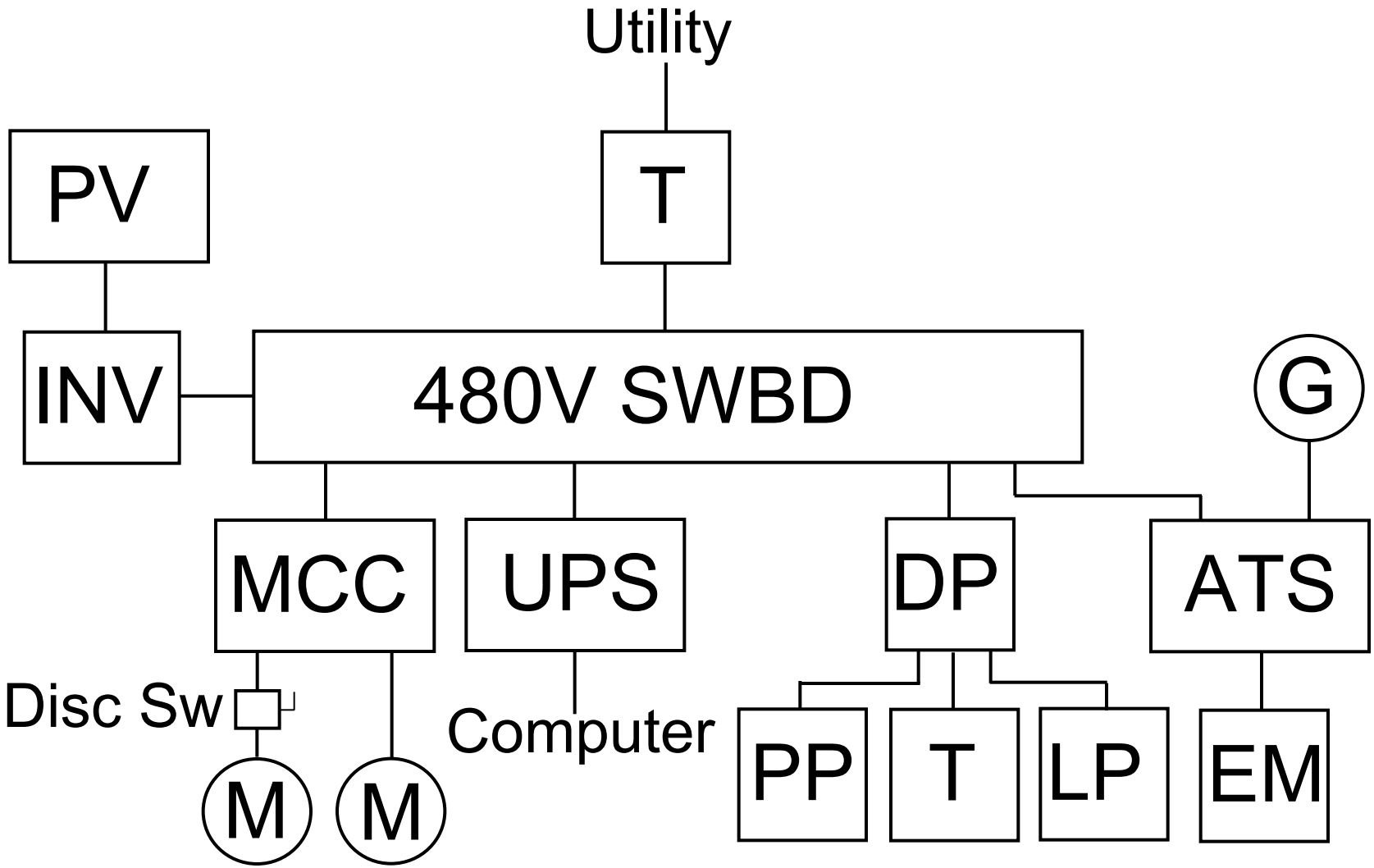
Electrical Equipment

- Busway, Pipe and Wire
- Transformers
- Generator, UPS, PV, Fuel Cell, Battery
- Computer Rooms
- Communication Systems
- Lighting
- Lighting Controls
- Wiring Devices

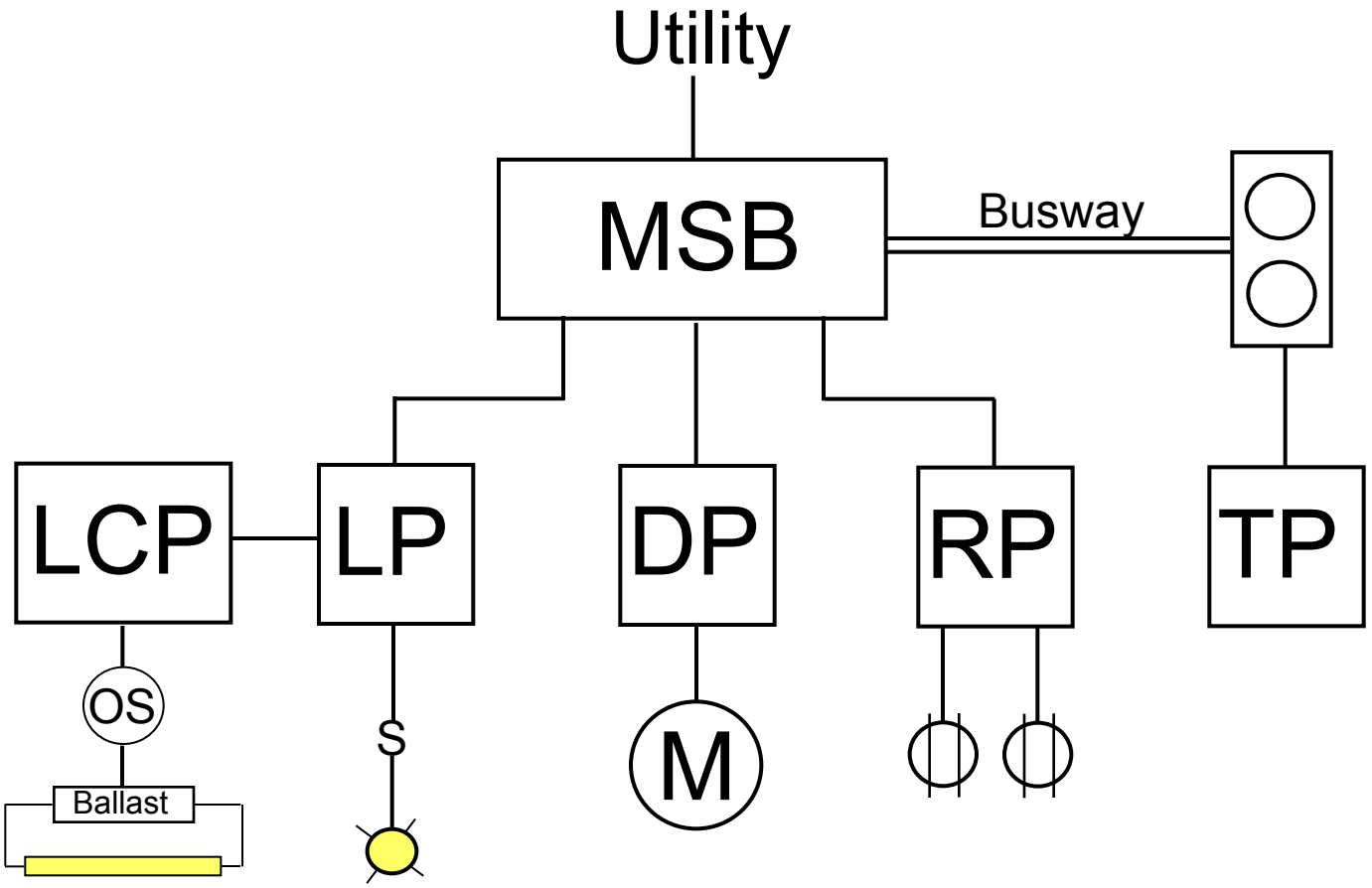
One Line - 12KV or 4160V



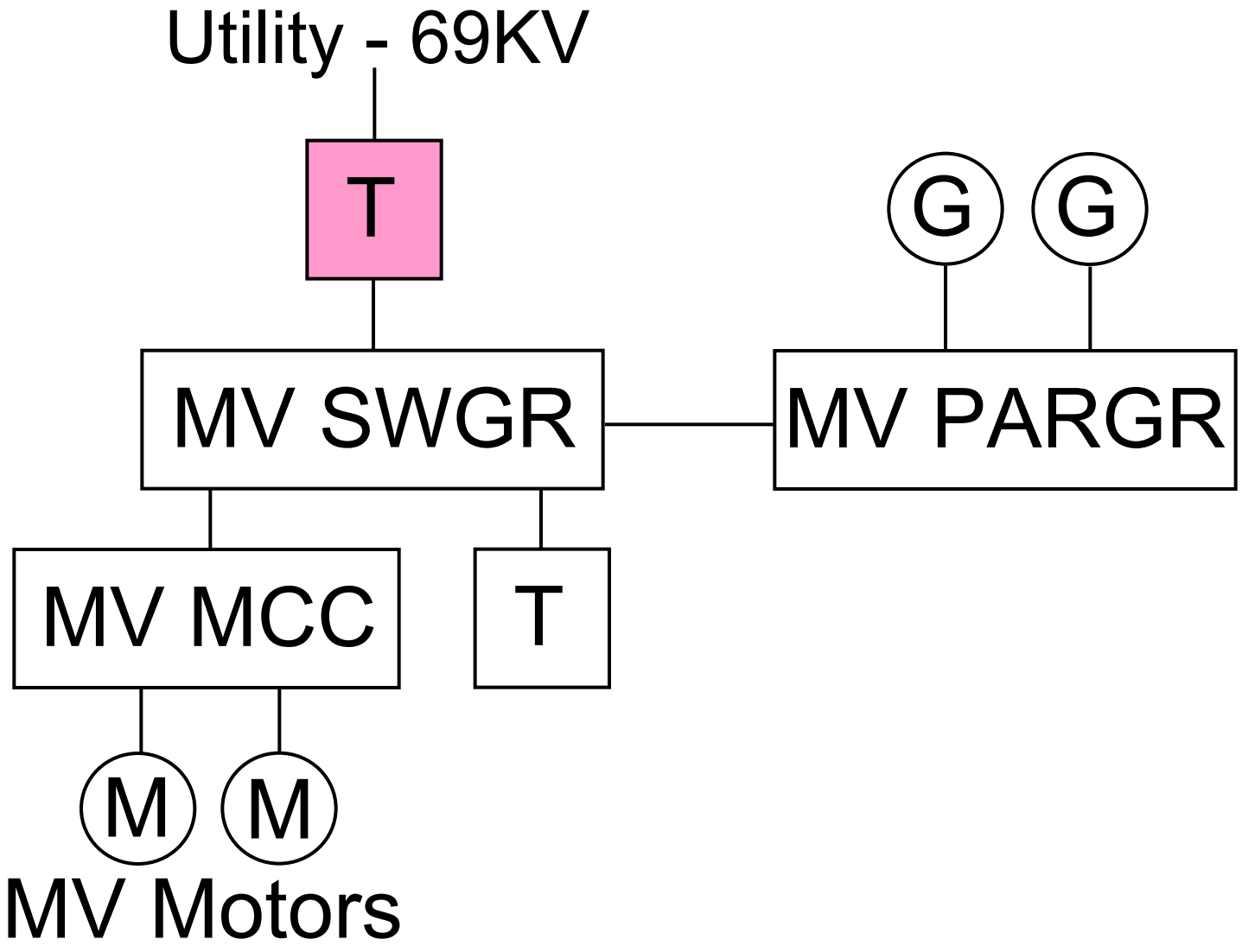
One Line - 480/277V



One Line - 208/120V



Utility Transformer



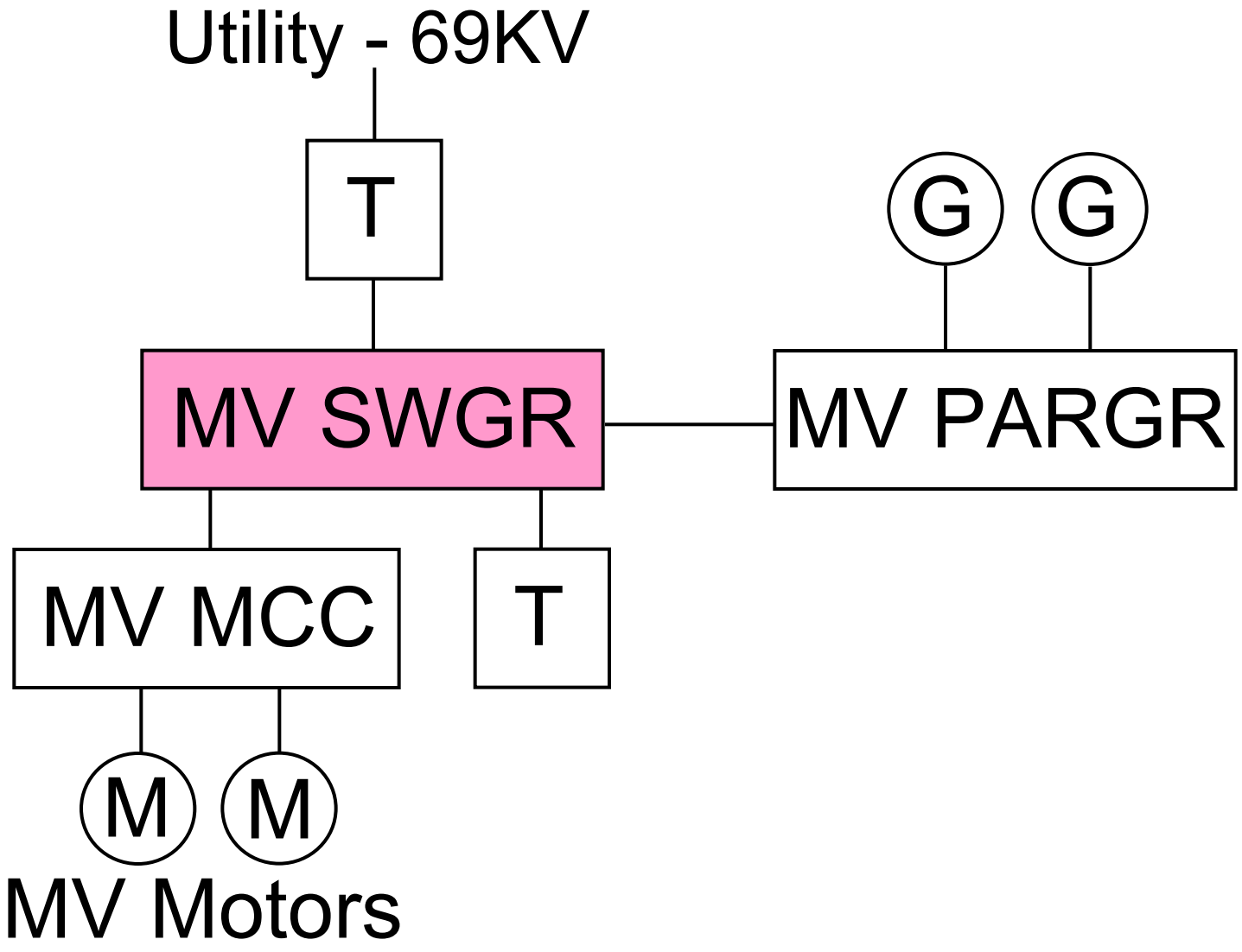
Utility Transformer

- Compartment Pad Mount
- Pole Mount

Utility Transformer

- Compartment Pad Mount
- Pole Mount

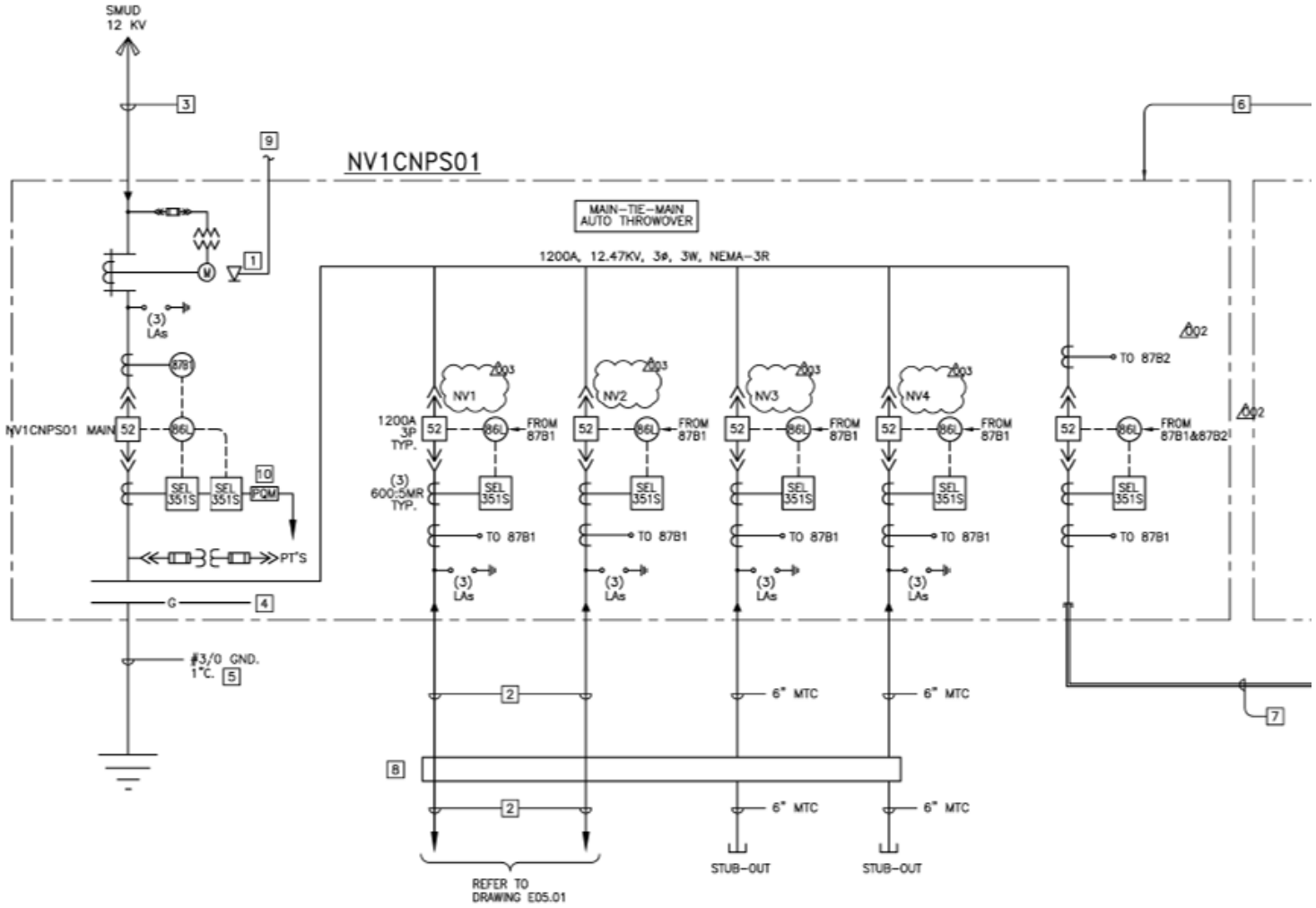
Switchgear



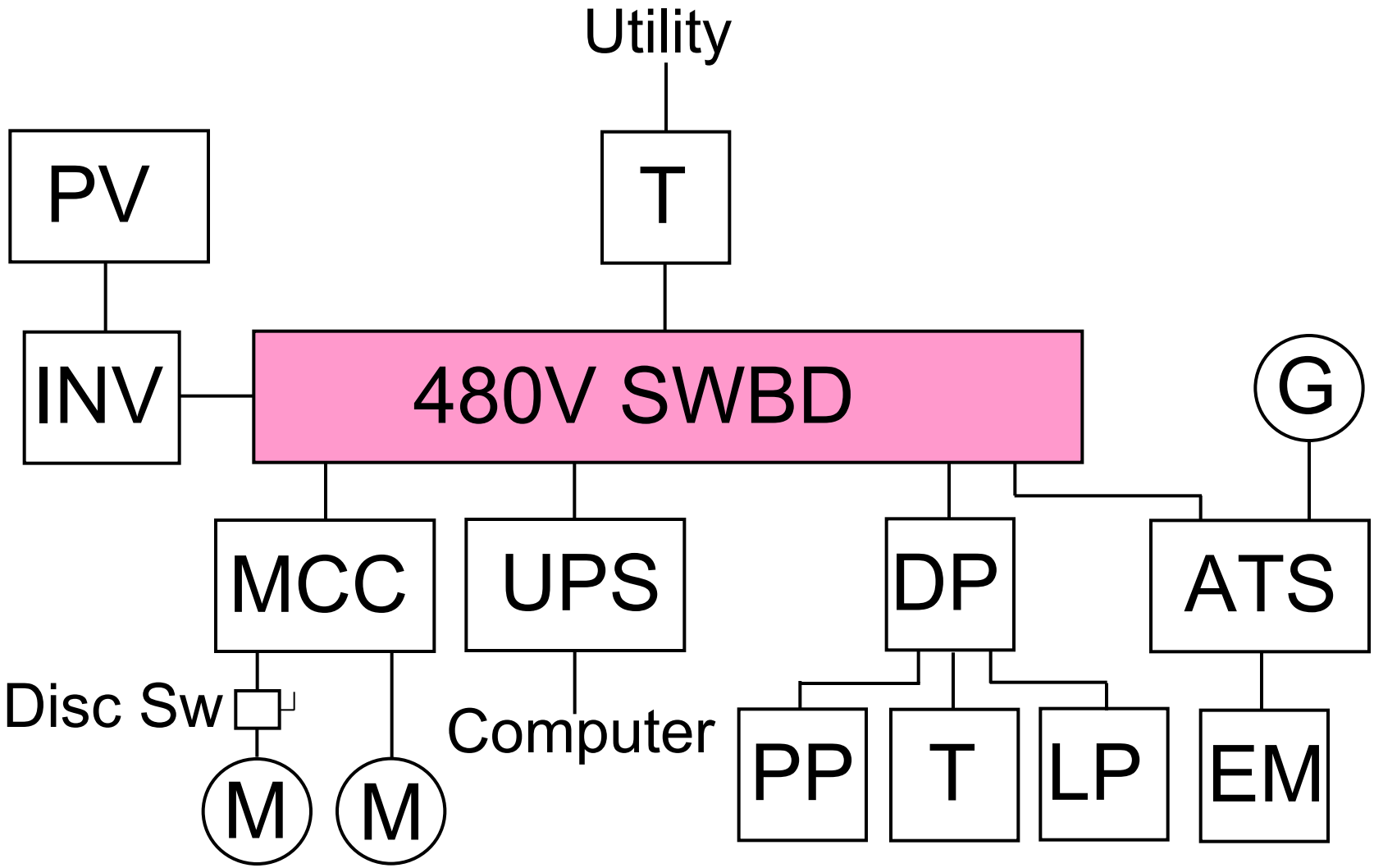
Switchgear

- 5’,6’D x 90”H x ??’L
- 480V, 5kV, 15kV
- Drawout CB
- Meters & Relays

Switchgear


SMUD
12 KV
NV1CNPS01
MAIN–TIE–MAIN
AUTO THROWOVER
1200A, 12.47KV, 3ø, 3W, NEMA–3R
NV1CNPS01 MAIN
(3)
LAs
87B1
52
86L
SEL
351S
PQM
PT'S
#3/0 GND.
1"C.
NV1
NV2
NV3
NV4
1200A
3P
TYP.
(3)
600:5MR
TYP.
FROM
87B1
TO 87B1
TO 87B2
FROM
87B1&87B2
6" MTC
REFER TO
DRAWING E05.01
STUB–OUT

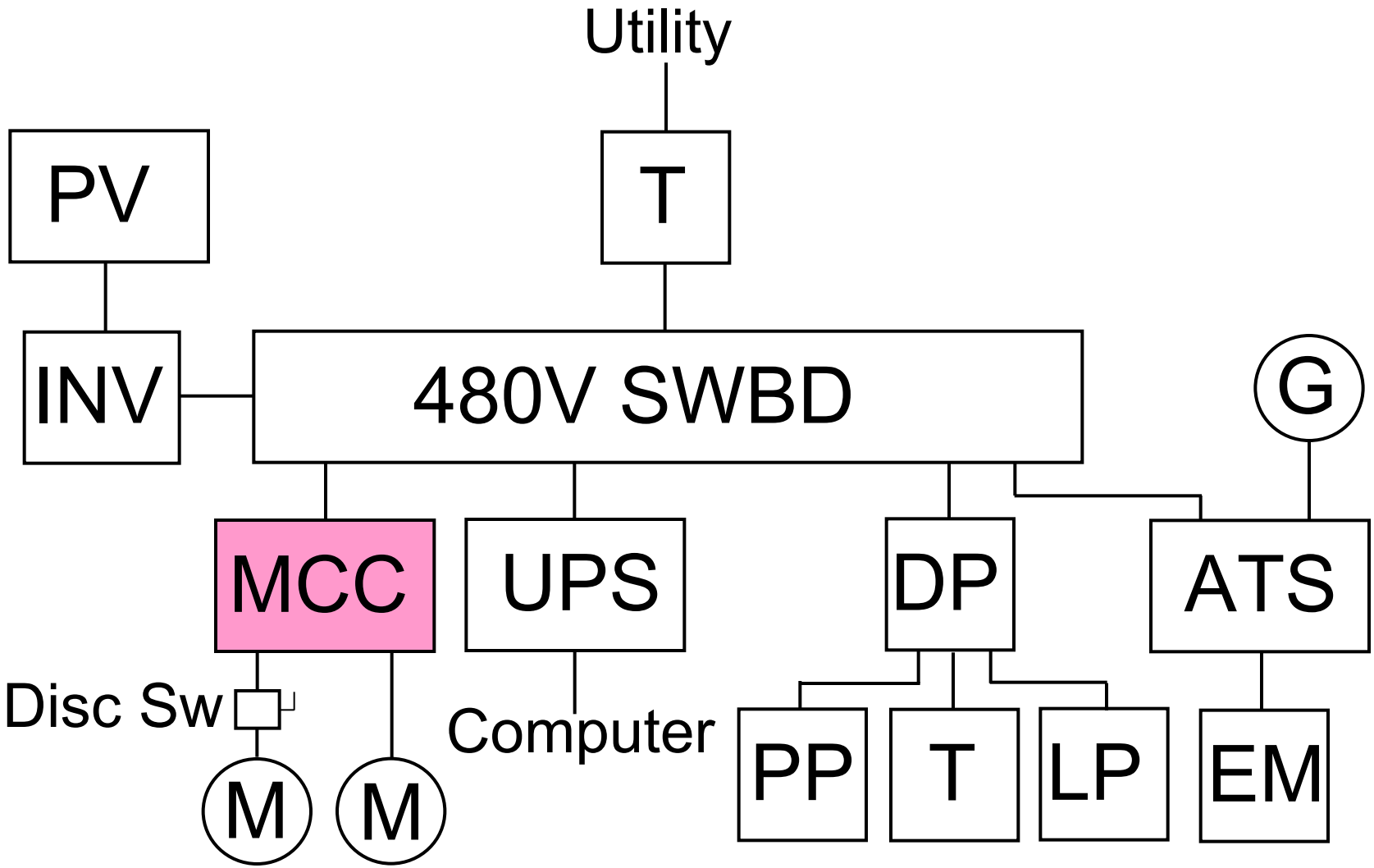
Switchboard



Switchboard

- 12”,24”,36”D x 90”H x ??”L
- Voltages:
  - 120/240V,1P,3W
  - 208Y/120V, 3P,4W
  - 480Y/277V,3P,4W
  - 480V,3P,3W
- Current: 400A-2000A
- CB or Sw&Fu

Motor Control Center



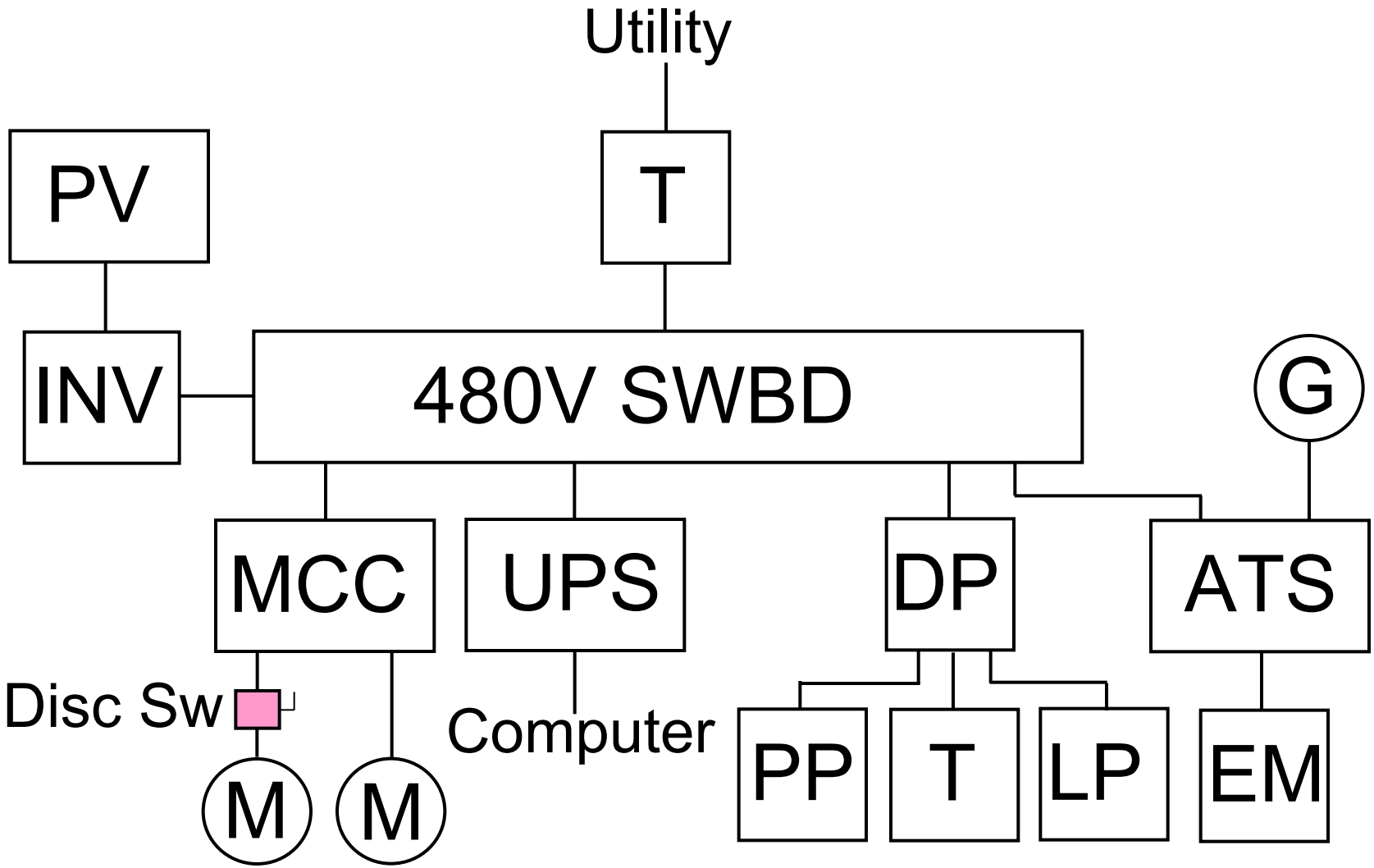
Motor Control Center

- Grouped motor starters
- 90”H x 20”D x 20”W per section
- “Buckets”
- VFDs

Motor Control Center

- Grouped motor starters
- 90”H x 20”D x 20”W per section
- “Buckets”
- VFDs

Disconnect Switch



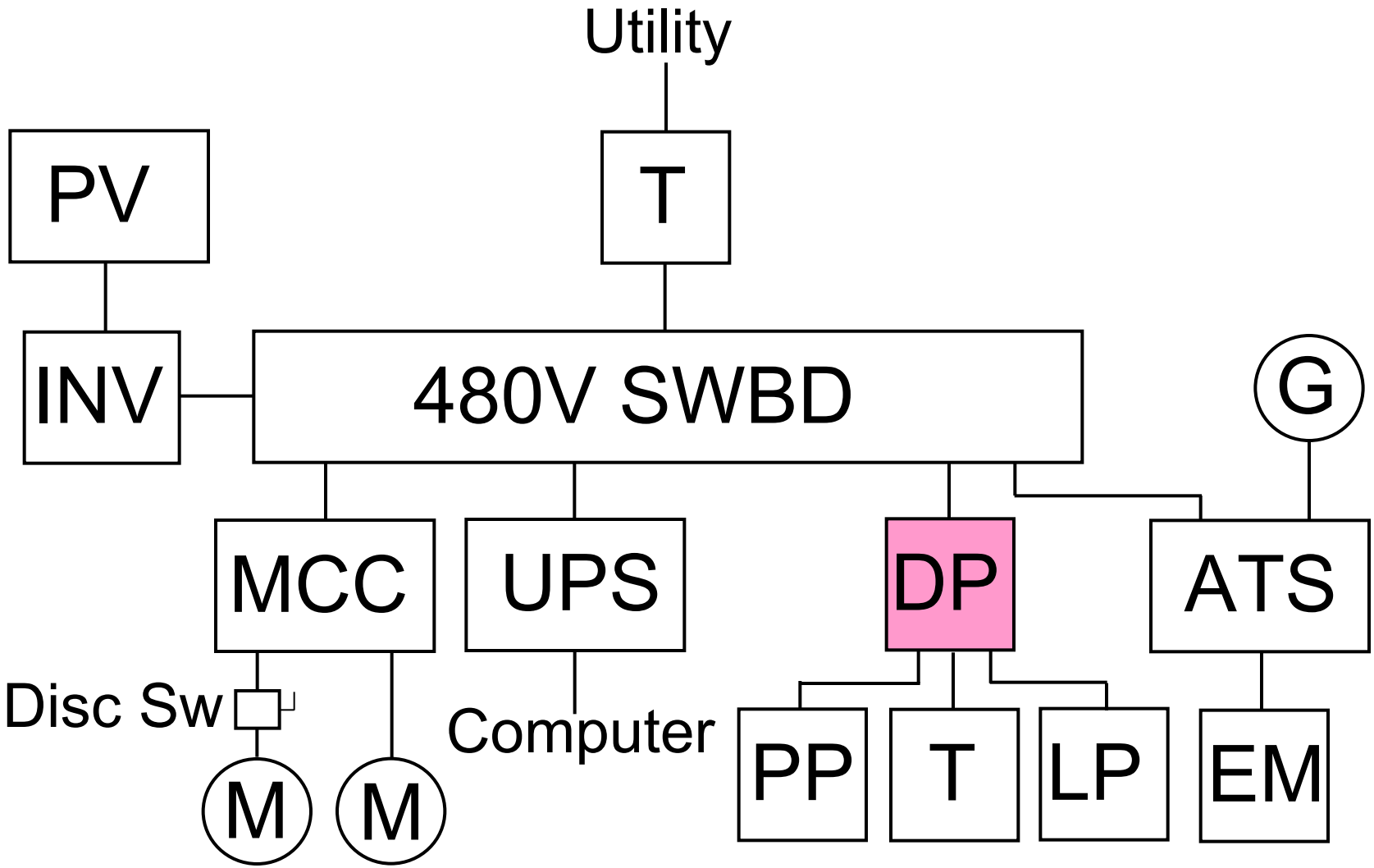
Disconnect Switch

- Voltage rating: Normal Duty 250V
  Heavy Duty 600V (480V)
- Current rating: 30A, 60A, 100A, 200A, 400A, 600A, 800A, 1000A
- Switch and Fuse
- Non-fused (switch only)
- Safety interlock

Disconnect Switch

- Voltage rating: Normal Duty 250V
  Heavy Duty 600V (480V)
- Current rating: 30A, 60A, 100A, 200A, 400A, 600A, 800A, 1000A
- Switch and Fuse
- Non-fused (switch only)
- Safety interlock

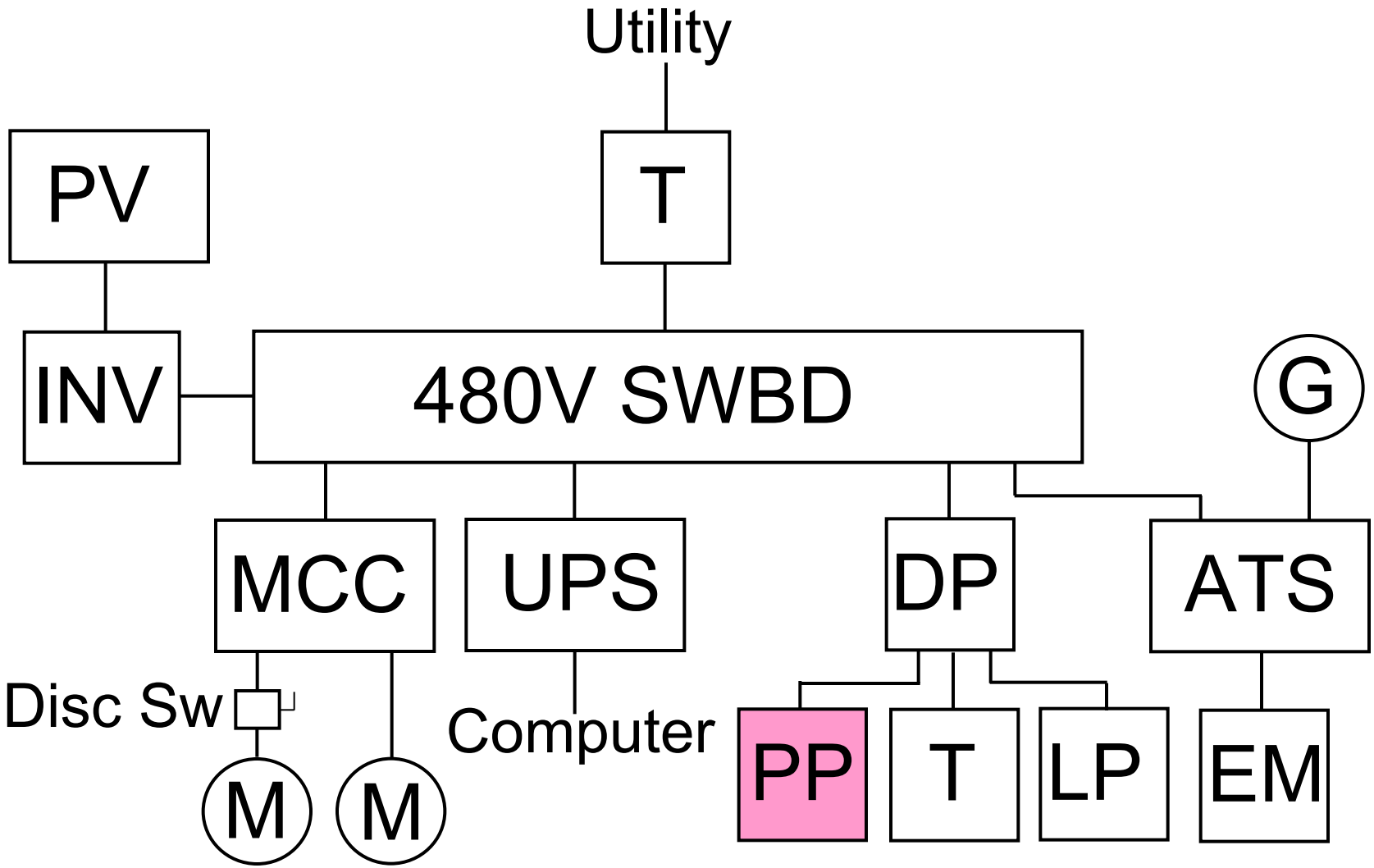
Distribution Panelboard



Distribution Panelboard

- 30-42”W x 6-10”D x ??”H
- Voltages:
  - 208Y/120V, 3P,4W
  - 480Y/277V,3P,4W
  - 480V,3P,3W
- Current: 400A-1000A
- Main CB or MLO
- CB or Sw&Fu

Panelboard


Utility
PV
T
INV
480V SWBD
G
MCC
UPS
DP
ATS
Disc Sw
Computer
PP
T
LP
EM
M
M

Panelboard

- 20”W x 6”D x ??”H
- Voltages:
  - 120/240V,1P,3W
  - 208Y/120V, 3P,4W
  - 480Y/277V,3P,4W
  - 480V,3P,3W
- Current: 100A-400A
- Main CB or MLO

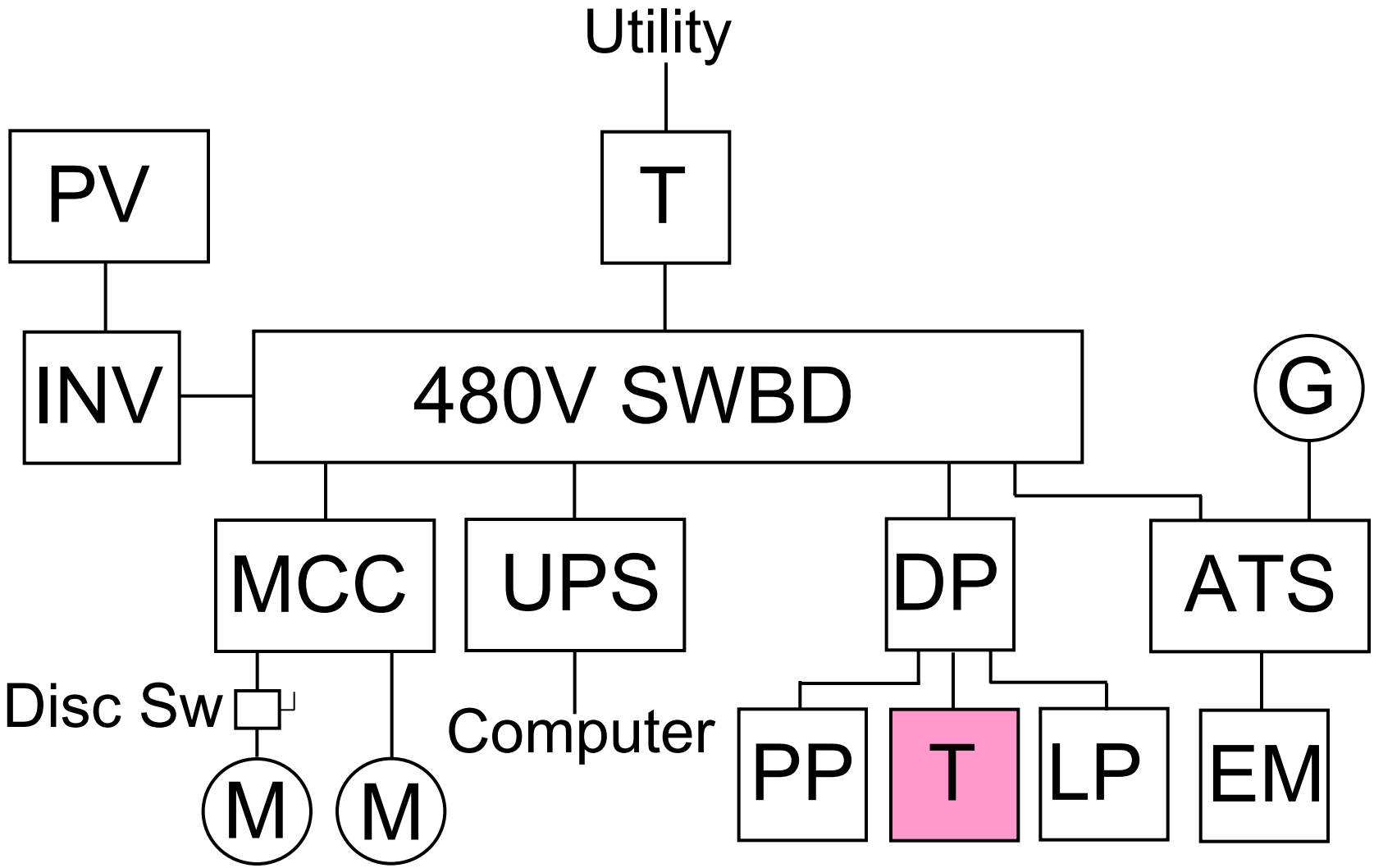
Panelboard

- 20”W x 6”D x ??”H
- Voltages:
  - 120/240V,1P,3W
  - 208Y/120V, 3P,4W
  - 480Y/277V,3P,4W
  - 480V,3P,3W
- Current: 100A-400A
- Main CB or MLO

Pipe and Wire

- Conduit
  - Rigid, Intermediate IMC, Tubing EMT, Flex, Liquidtight, PVC, Wireway (Gutter, Trough)
- Wire
  - Copper, Aluminum
  - Size: #14 AWG, #1, even larger 750kcmil
  - Temperature Rating: 60C, 75C,
  - Voltage rating: 300V, 600V, 5kV, 15kV,…

Transformers



Transformers

- Power transformers (liquid filled)
- Dry-Type transformers
- Efficiency Rating
- Power Rating
- Voltages

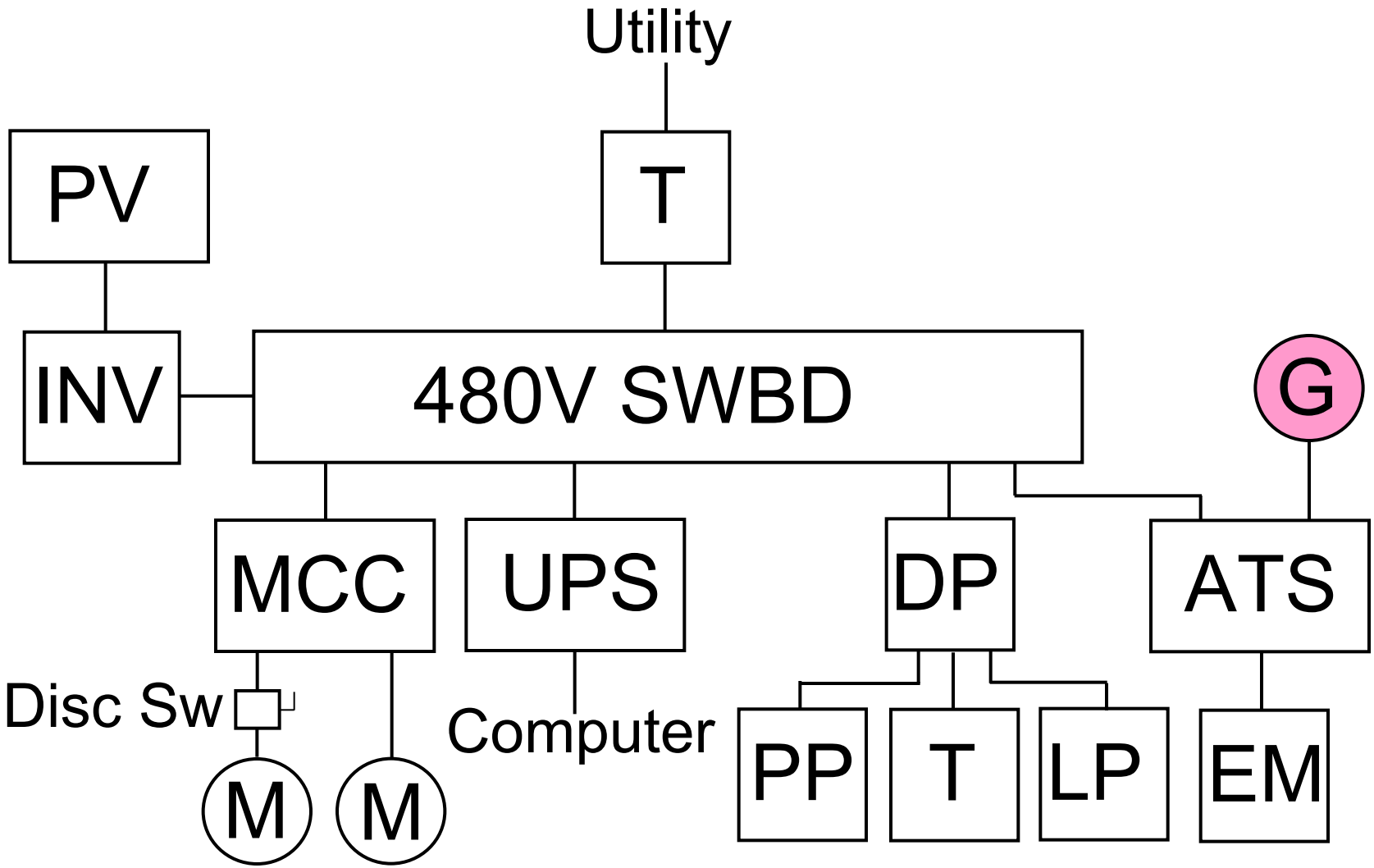
Transformers

- Power transformers (liquid filled)
- Dry-Type transformers
- Efficiency Rating
- Power Rating
- Voltages

Power Producers

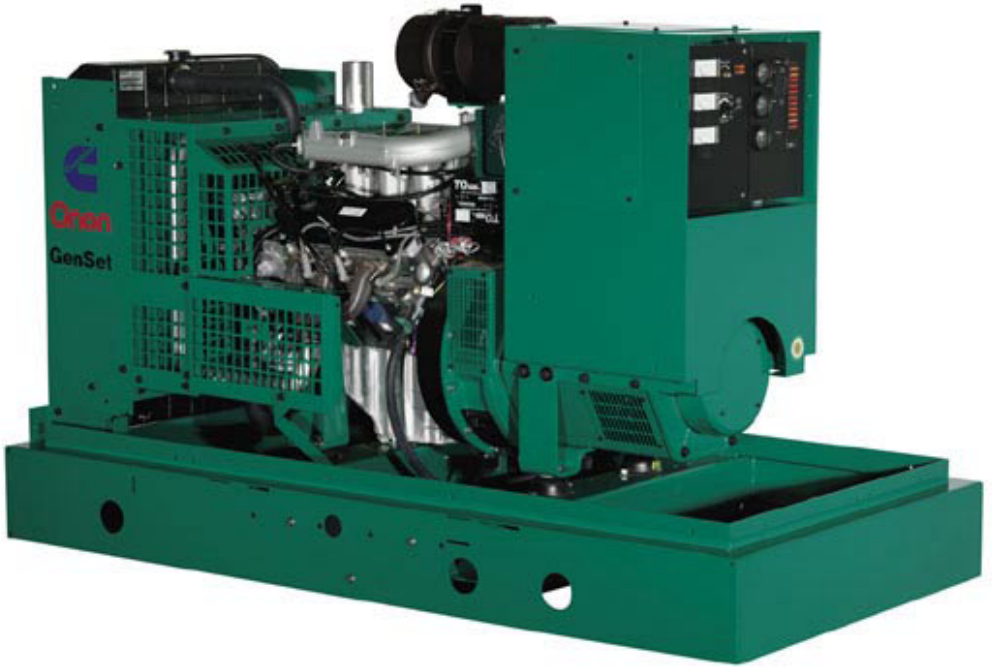
- Generator
- Photovoltaic (PV)
- Fuel Cell
- Battery

Generator


Utility
PV
T
INV
480V SWBD
G
MCC
UPS
DP
ATS
Disc Sw
Computer
PP
T
LP
EM
M
M

Generator

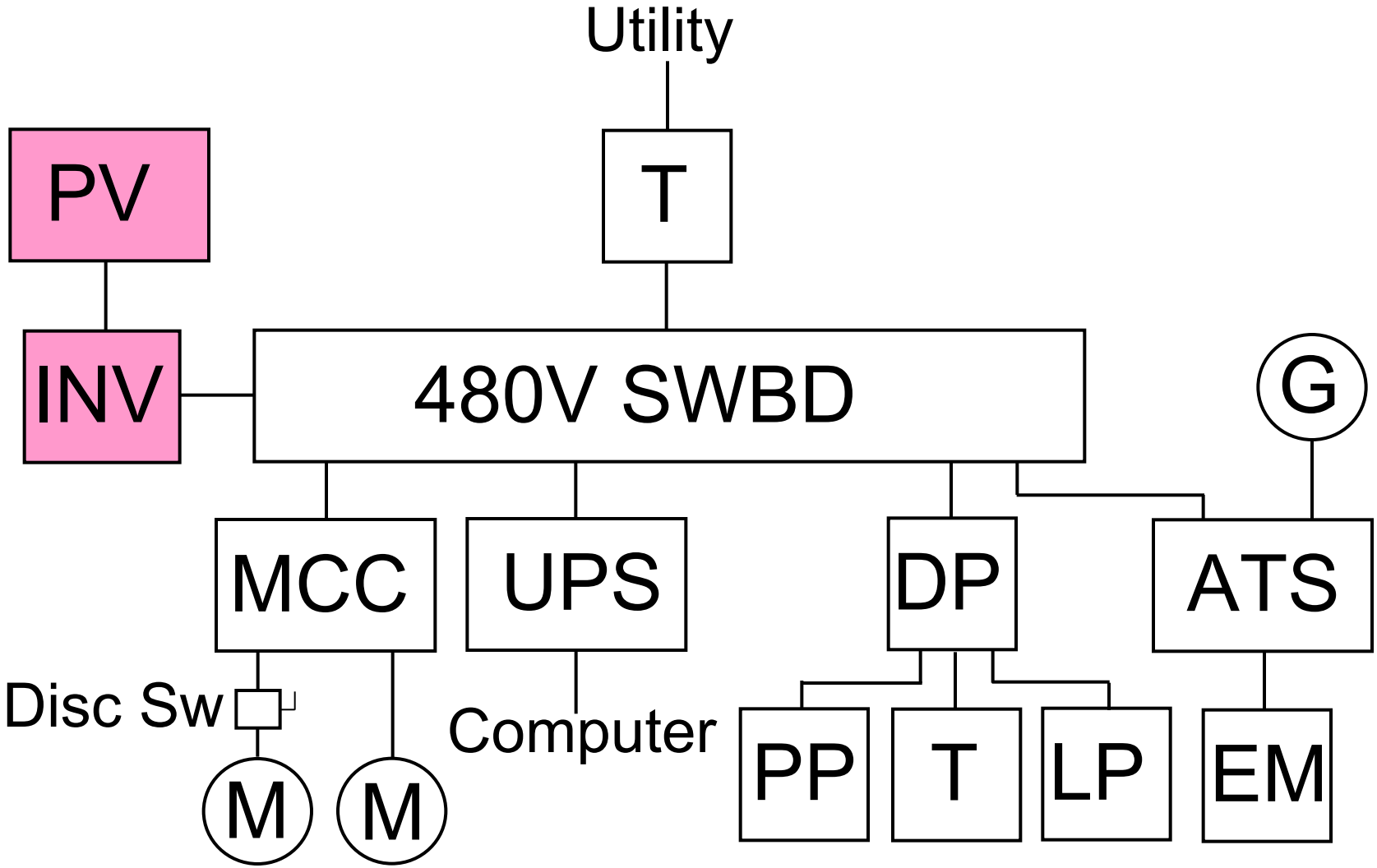
- Fuel - Diesel, Natural Gas
- Combustion Air
- Cooling Air
- Muffler
- Exhaust
- Vibration
- Controls



Generator

- Environmental Enclosure
- Sound Enclosure
- Fuel Tank

Photovoltaic (PV)

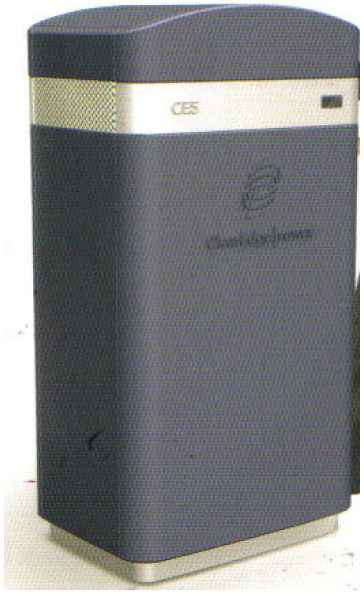


Photovoltaic (PV)

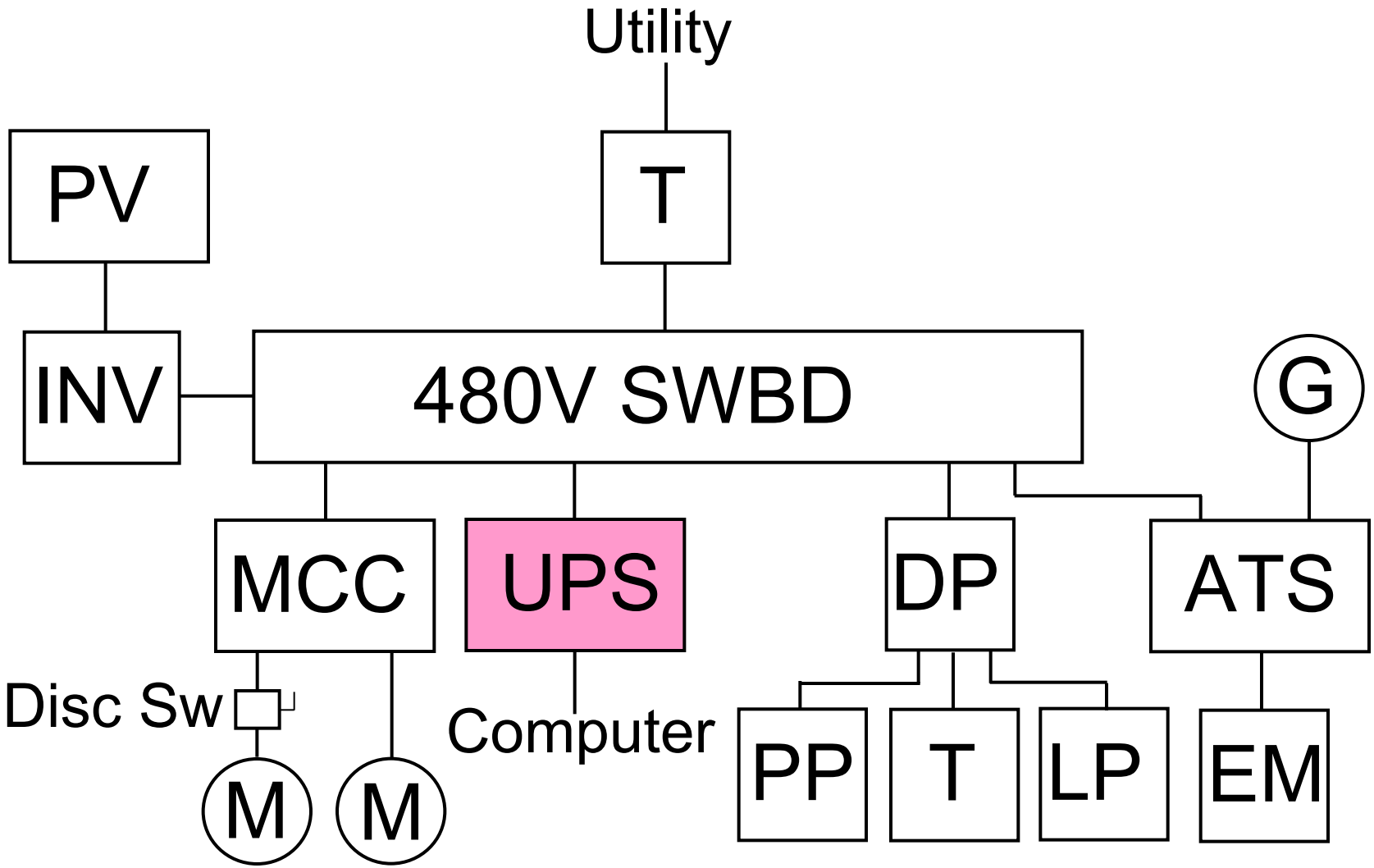
- Utility Permission
- Solar Panel
- DC Disconnets
- Inverter
- AC Disconnect
- Labels

Fuel Cell

- Natural Gas input
- Electricity output
- Heat output



UPS


Utility
PV
T
INV
480V SWBD
G
MCC
UPS
DP
ATS
Disc Sw
Computer
PP
T
LP
EM
M
M

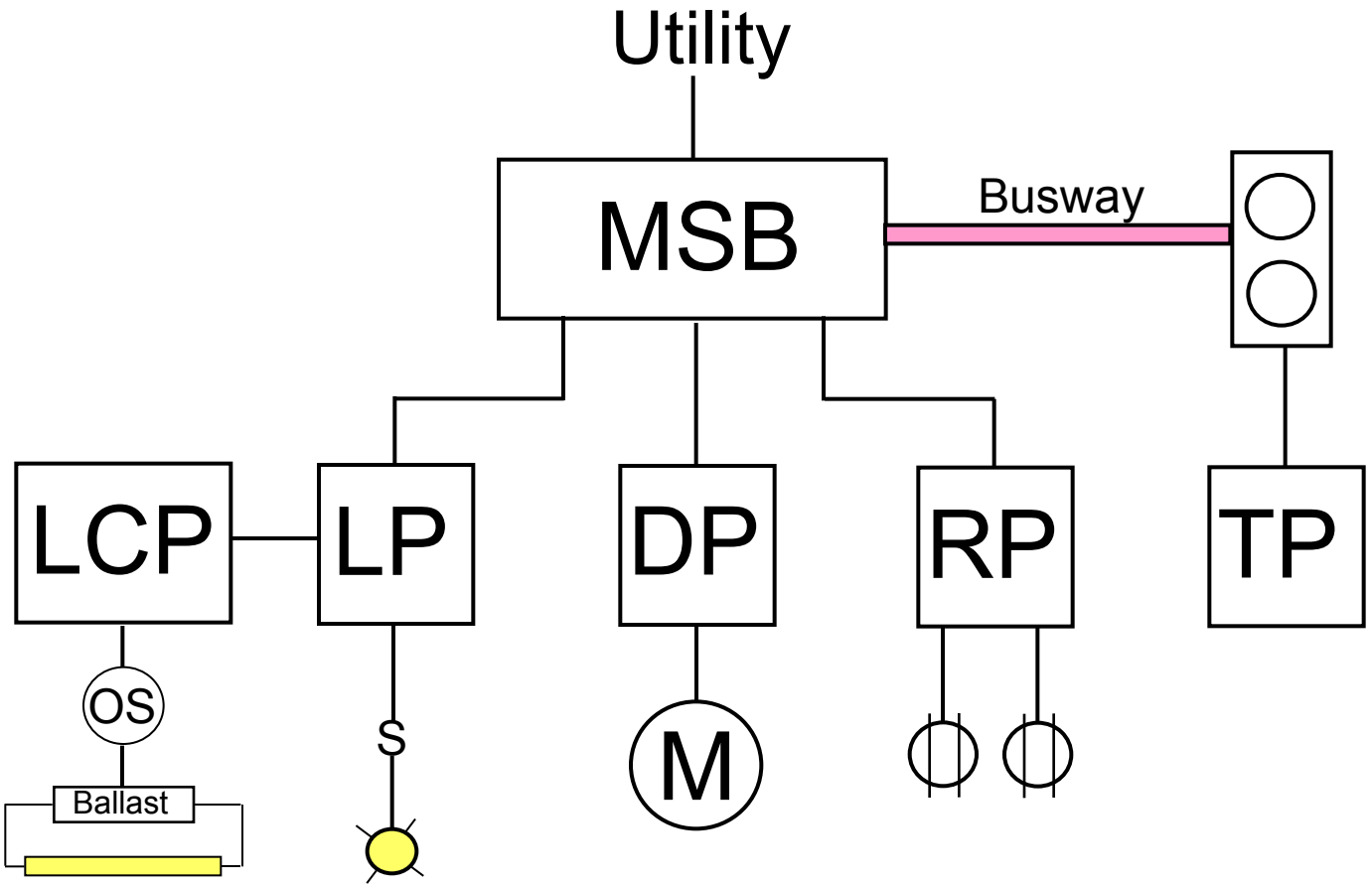
Computer Rooms

- Uninterruptible Power Supply (UPS)
- Power Distribution Unit (PDU)
- Emergency Power Off (EPO)
- Fire Protection
- Fire Alarm

Computer Rooms

- Uninterruptible Power Supply (UPS)
- Power Distribution Unit (PDU)
- Emergency Power Off (EPO)
- Fire Protection
- Fire Alarm

Busway



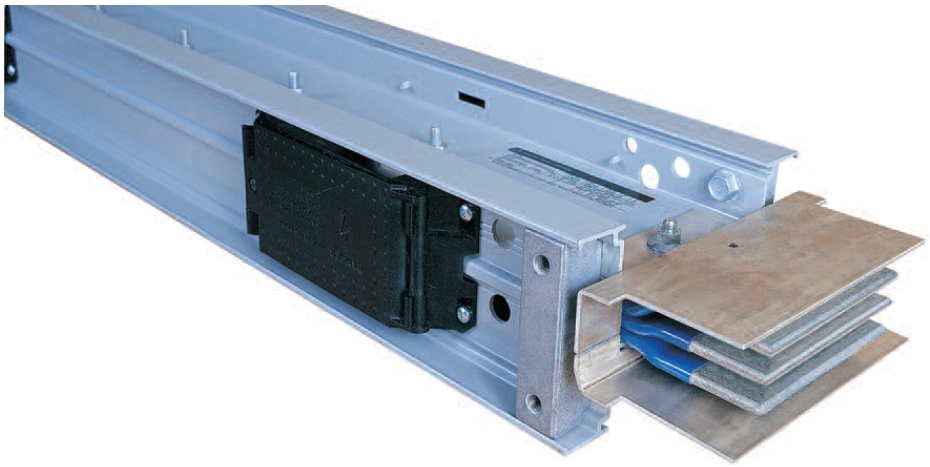
Busway

What’s a bus weigh?

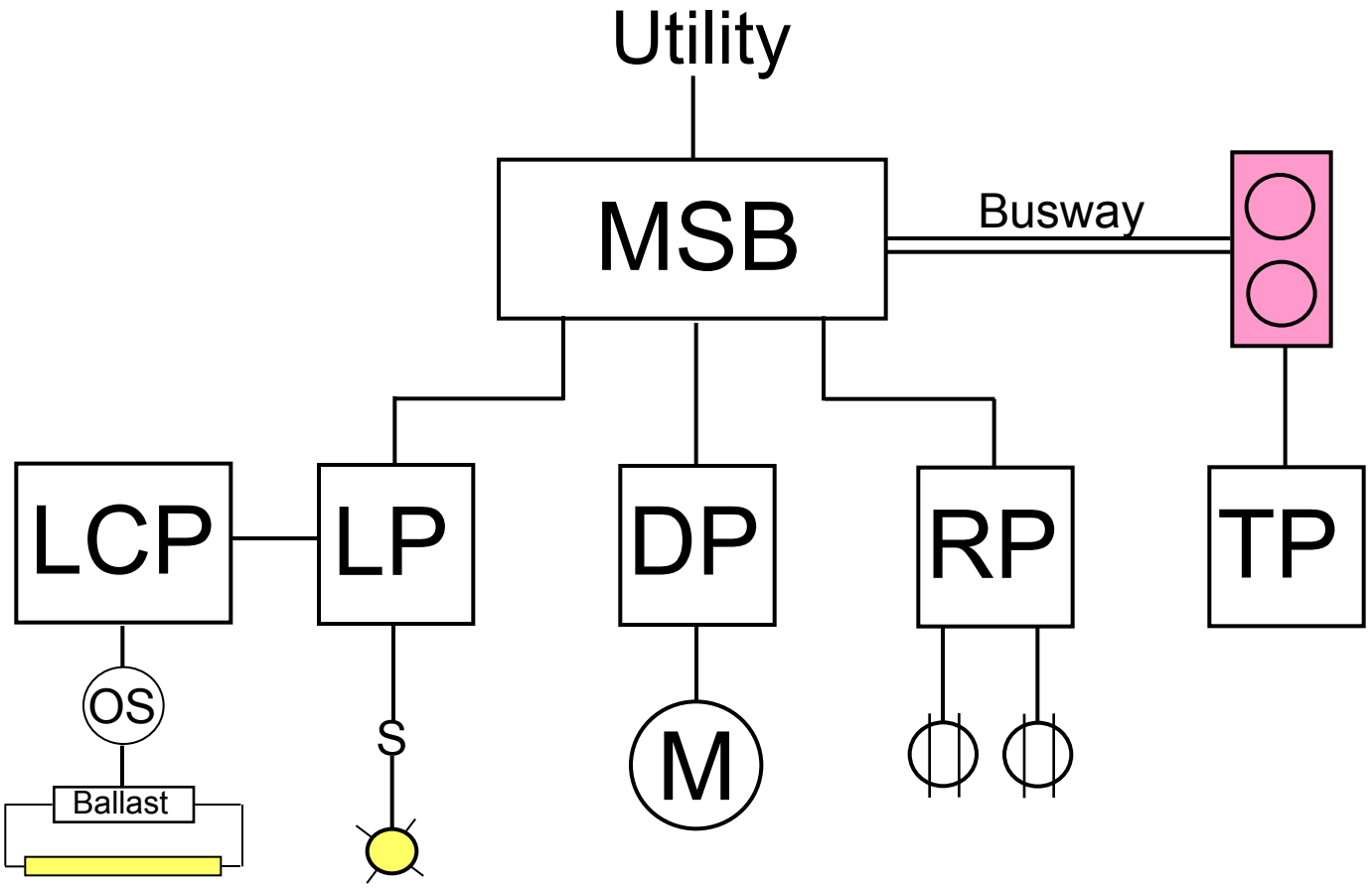
What's a bus weigh?

Busway (aka Bus Duct)

- Bus bars, insulated and enclosed
- Current rating: 100A - 3000A
- 10ft lengths (aka ‘stick’)
- Special fittings



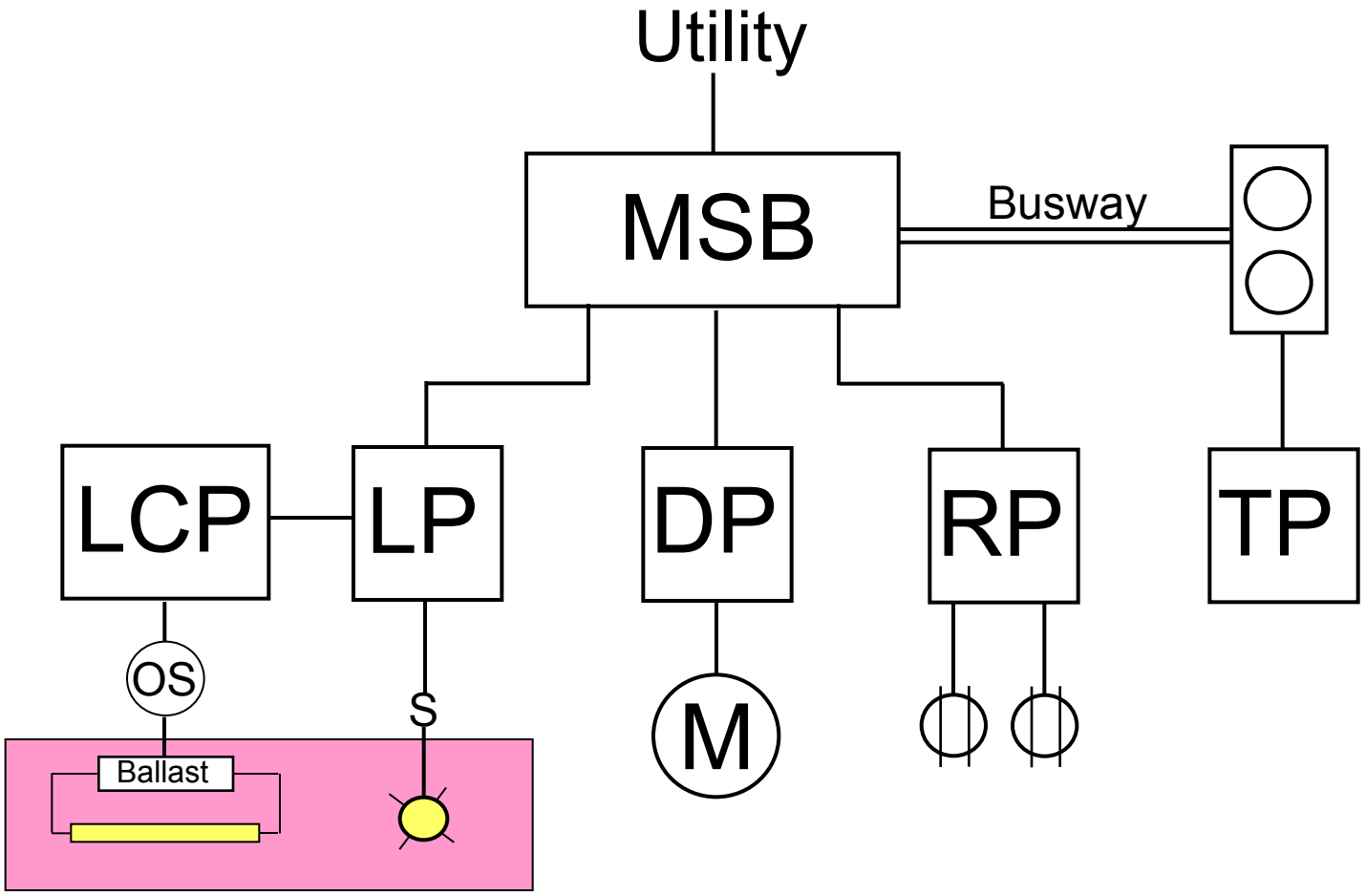
Meter Sockets



Meter Sockets

- Multiple Residential or Commercial
- Voltages:
  - 120/240V,1P,3W
  - 208Y/120V, 3P,4W
  - 480Y/277V,3P,4W
  - 480V,3P,3W
- Current: 100A-320A
- 1⌀ sockets on 3⌀

Lighting

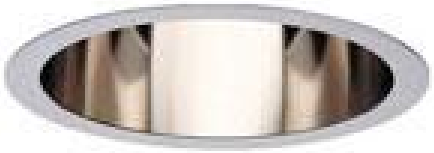


Lighting

- Fixtures



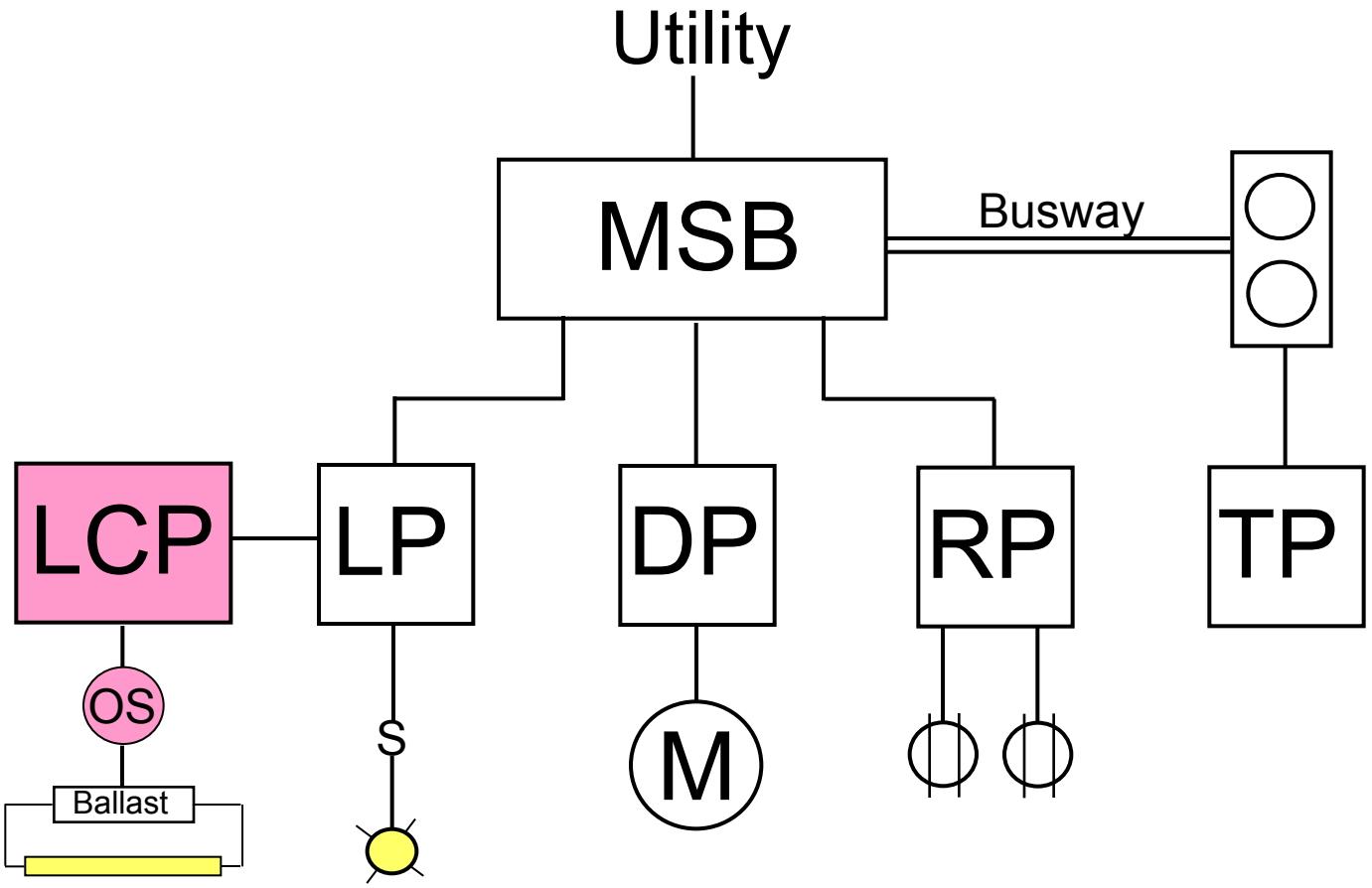





Lamps & Ballasts

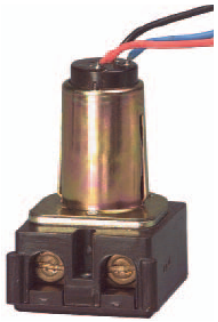
- Lamps
  - Incandescent: Bye Bye
  - Fluorescent: Colors
  - HID: CMH, PS
  - LED: Hello
- Ballasts
  - Electronic: IS, PS
  - Dimming: Step, Cont. 2W, 3W, 0-10VDC, DALI

Lighting Controls

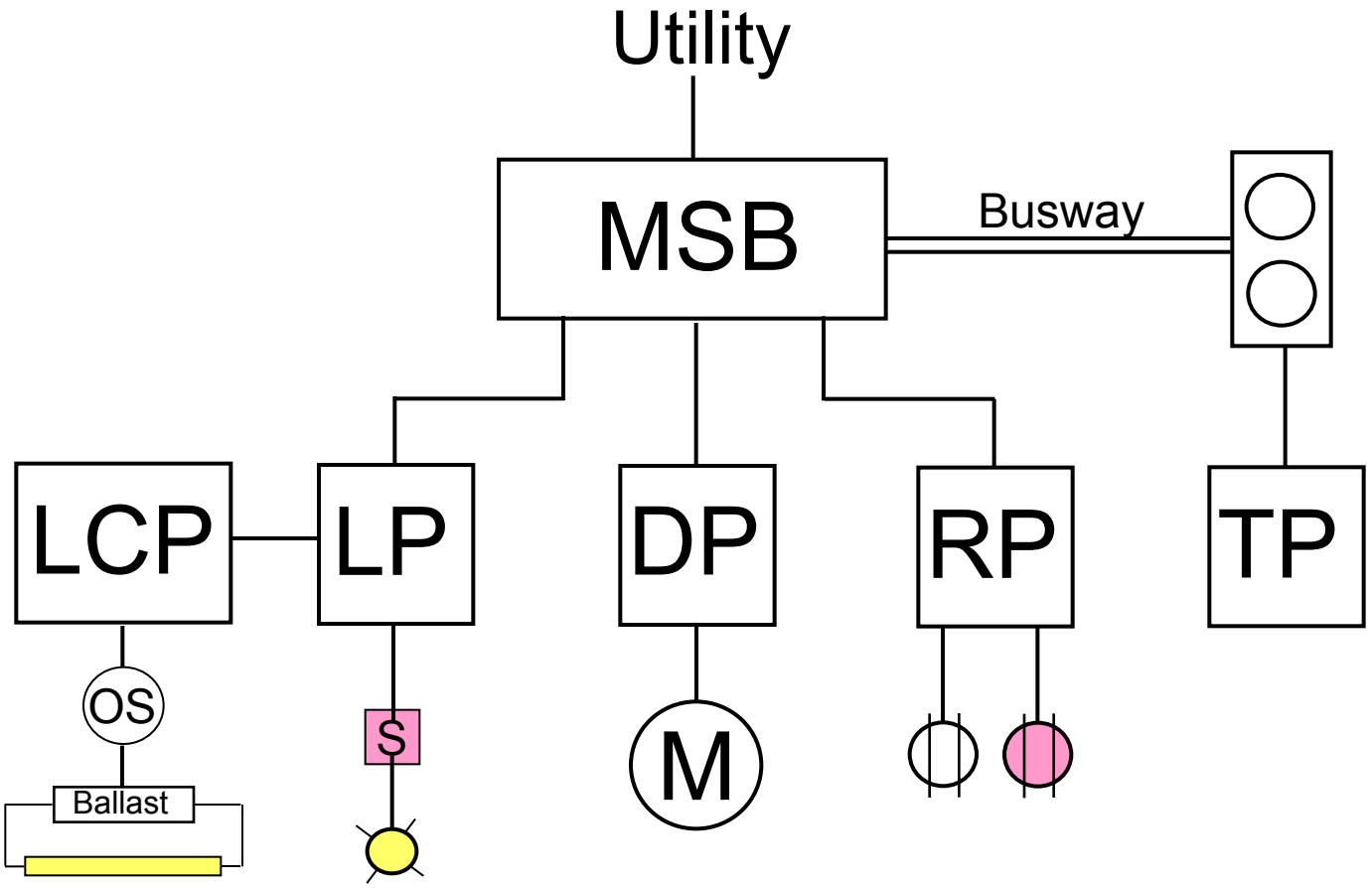


Lighting Controls

- Occupancy Sensors
- Daylight Sensors
- Architectural Dimming
- Central vs Distributed
- Relays
- Digital
- Wireless

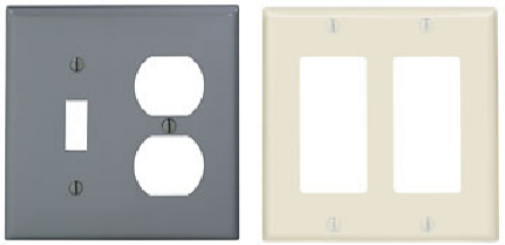


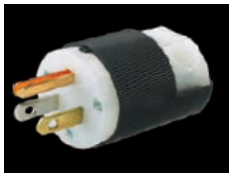
Wiring Devices



Wiring Devices

- Switches
- Receptacles
- Plugs
- Wallplates





In Conclusion

- From a Dream to Reality

  The Design Process

- From the Utility Pole to the Outlet

  The Construction Process

From the Utility Pole to the Outlet

Credits

- Advanced Transformer - Philips
- AIA-MasterSpec
- Bloom Energy
- Cummins/Onan
- General Electric
- HOK, Architects & Engineers
- Hubbell
- Leviton
- Rick Miller
- Smith, Fause McDonald Inc
- Southwest Energy Systems
- The Engineering Enterprise
- Watt Stopper

The End