

**E<sup>2</sup> Power Systems, Inc. expertise includes...****ELECTRICAL SYSTEM DESIGN**

- Hydro, ST & GT Generating Systems
- Emergency Backup Systems
- System Power Factor Correction
- Power Distribution Systems
- Automation Control (PLC & PC Based)
- System Protection
- Ground Mat Systems (IEEE Std 80-1986)
- Machine Tool Retrofit
- Drive Systems Application
- SCADA & DCS Control Systems
- Diesel GenSet Control Retrofit
- Synchronous Motor System & Controls
- Synchronous Condenser System & Controls

**GENERATING SYSTEM UPGRADE PACKAGES**

- Excitation System Upgrades (DECS-300N, EX2000)
- Voltage Regulator Upgrades (DECS, EX2000)
- Power System Stabilizer Installations
- Auto/Manual Synchronizing System Upgrades
- Generator & Line Protection Upgrades
- Interface to Plant Control (Fanuc, A-B, Bailey,...)
- System Control Monitoring & Trending
- Design Interface & Technical Direction Projects
- Turnkey Installation Projects
- System O&M Training

**APPRAISAL TESTING & MAINTENANCE**

- Protective Relay & Meter Calibration
- Demand Power Analysis
- Insulation Power Factor & Resistance Testing
- Step-Up & Auxillary Transformers
- Breakers, Switchgear & Motor Controls
- Ground System Testing
- Adjustable Frequency & LCI Drive Systems
- Machine Tool Controls
- IPP / Utility Interface Acceptance Testing

**CONSULTING**

- Short Circuit Analysis
- Watt & VAR Load Flow Studies
- Stability Studies
- Protective Device Coordination
- PE Reviews & Inspections
- Evaluation & Enhancement Studies
- Life Extension
- System Feasibility
- Specification Development
- Expert Witness
- Procedure Development

**GENERATING SYSTEM MAINTENANCE**

- System Component Inspection & Cleaning
- Protective Relay Calibration & Testing
- Power System Stabilizer Testing
- Excitation System Tuneups
- Voltage Regulator System Tuneups
- Performance Criteria Testing
- SCT-PPT, ALTERREX, AMPLIDYNE
- GENERREX, EX2000, BUS-FED,
- TRINISTAT, MAGASTAT, SILVERSTAT, PRX
- SSE, DECS-300, SSR/SR8A, REGULEX

**Excitation System Expertise On:**

**Alsthom Basler Brush EMC  
General Electric Westinghouse Siemens**

**ON-SITE MANAGEMENT**

- Construction Management
- Technical Direction
- Startup & Testing Services
- Safety Appraisals
- Third Party Technical Representative
- Technical Training Seminars
- GRAHAM Drive Systems Service Rep.
- DANFOSS Drive Systems Service Rep.

*Established in 1986, **E<sup>2</sup>PSI** is a leading electrical engineering services company in the power generation, power distribution, and controls market, internationally recognized for its superior quality and enthusiastic clients.*

***E<sup>2</sup>PSI** is fully bondable and will undertake total project responsibility or supply specific, electrical engineering and technical services such as listed - we will tailor our services to exactly fit your needs.*

*Consider us as the support source for all of your Electrical Systems Technical Requirements.*

**E<sup>2</sup>PSI**

**E<sup>2</sup> Power Systems, Inc.**

7961 Shaffer Pkwy, Unit 2

Littleton, CO 80127

TEL 303/988-6659 FAX 303/988-5714

E-mail Address: [esquared@e2psi.com](mailto:esquared@e2psi.com)

Web Site: [www.e2psi.com](http://www.e2psi.com)

Allowable Ampacities of Insulated Conductors Rated 0-2000 Volts, Not More Than Three Conductors in Raceway or Cable or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F) - Reference Only. See NEC Table 310-16 For Details.

SIZE	TEMPERATURE RATING OF CONDUCTOR	
	75°C (167°F)	90°C (194°F)
AWG kcmil	TYPES FEPW, RH, RHW, THHW THW THWN, XHHW, USE, ZW	TYPES TBS, SA SIS, FEB, FEPB, MI RHH, RHW-2 THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2
	COPPER	
18	....	14
16	....	18
14	20	25
12	25	30
10	35	40
8	50	55
6	65	75
4	85	95
3	100	110
2	115	130
1	130	150
1/0	150	170
2/0	175	195
3/0	200	225
4/0	230	260
250	255	290
300	285	320
350	310	350
400	335	380
500	380	430
600	420	475
700	460	520
750	475	535
800	490	555
900	520	585
1000	545	615
1250	590	665
1500	625	705
1750	650	735
2000	665	750

**Ohms Law:**

$$E = I \times R$$

E = Voltage I = Amperes R = Resistance

**Conversion Factors:**

C° = 5/9 (F° - 32) F° = 9/5C° + 32  
 1 Centimeter = .3937 Inches 1 Inch = 2.54 Centimeters  
 1 Meter = 3.281 Feet 1 Foot = .3048 Meters  
 1 Meter = 1.0936 Yards 1 Yard = .9144 Meters  
 1 Kilometer = .6214 Miles 1 Mile = 1.6093 Kilometers  
 1 Horsepower = .7457 Kilowatts 1 Kilowatt = 1.341 Horsepower  
 1 Kilogram = 2.20 Pounds 1 Year = 8,766 Hours

**Hydropower Potential:**

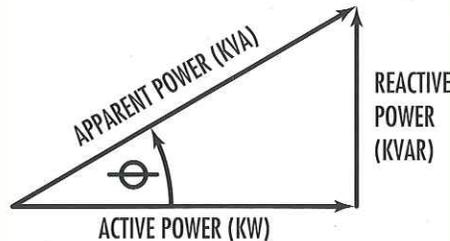
$$P = QHE/11.6$$

H = Gross Head in Ft. Q = Flow in Cubic Ft./Sec.  
 E = System Efficiency P = Capacity in KW

**Transformer Formulas:**

FLA = Full Load Amps  
 $FLA (1\phi) = \frac{KVA \times 1000}{Circuit Volts}$   $FLA (3\phi) = \frac{KVA \times 1000}{(1.732)(Volts)}$   
 Isca = Short Circuit Amps  $Isca = \frac{FLA \times 1000}{Unit Impedance}$

**Power Factor - Power Triangle**



POWER FACTOR = PF = COS Ø =  $\frac{ACTIVE POWER}{APPARENT POWER} = \frac{KW}{KVA}$   
 SIN Ø =  $\frac{REACTIVE POWER}{APPARENT POWER} = \frac{KVAR}{KVA}$   
 $KW = (KVA)(PF) = (KVA)(COS Ø)$   $KVAR = (KVA)(SIN Ø)$   
 $(KVA)^2 = (KW)^2 + (KVAR)^2$   
 $KVA = \sqrt{(KVA COS Ø)^2 + (KVA SIN Ø)^2}$

**LAGGING PF:**

Active & Reactive Power Flow in Same Direction

**LEADING PF:**

Active & Reactive Power Flow in Opposite Directions

**Useful Electrical Formulas for Determining Amperes, Horsepower, Kilowatts, and KVA**

To Find	Direct Current	Alternating Current	
		Single Phase	Three Phase
Amperes when Horsepower is known	$\frac{HP \times 746}{E \times Eff}$	$\frac{HP \times 746}{E \times Eff \times PF}$	$\frac{HP \times 746}{1.73 \times E \times Eff \times PF}$
Amperes when Kilowatts are known	$\frac{KW \times 1000}{E}$	$\frac{KW \times 1000}{E \times PF}$	$\frac{KW \times 1000}{1.73 \times E \times PF}$
Amperes when KVA is known		$\frac{KVA \times 1000}{E}$	$\frac{KVA \times 1000}{1.73 \times E}$
Kilowatts	$\frac{I \times E}{1000}$	$\frac{I \times E \times PF}{1000}$	$\frac{I \times E \times 1.73 \times PF}{1000}$
KVA		$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$
Horsepower—(output)	$\frac{I \times E \times Eff}{746}$	$\frac{I \times E \times Eff \times PF}{746}$	$\frac{I \times E \times 1.73 \times Eff \times PF}{746}$

E = Volts  
 I = Amperes  
 KVA = Kilovolt-amperes  
 HP = Horsepower  
 PF = Power Factor  
 Eff = Per Cent Efficiency  
 KW = Kilowatts  
 Eff =  $\frac{Output}{Input}$

**E<sup>2</sup>PSI** is fully bondable and will undertake total project responsibility or supply specific, electrical engineering and technical services.

We will tailor our services to exactly fit your needs.

Consider us as the support source for all of your Electrical Systems Technical Requirements. Feel free to call with any of your technical questions.



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POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

Turbine Technologies Construction

10/01/01

CUSTOMER

DATE

001044

2138T1835

CUSTOMER PURCHASE ORDER NUMBER

E SQUARED CONTRACT NUMBER

120 kV Switchyard

Fellows, CA

PT LOCATION

CUSTOMER SITE

Westinghouse Electric Co.

ISO Metering C Phase

PT MANUFACTURER

CIRCUIT IDENTIFICATION

PREVIOUS INSPECTION DATE

INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA			
Type:	AMU 550	Serial #	Nameplate missing
Ratio	600:1 and 1000:1	BIL	550 kV
Class	0.3	Weight	2360 lbs.
Primary	69 kV	Style	550M0103AP
Hertz	60	VA	6000

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39			
RATIO	RESULT	mA During Test	
X1-X3	600.62:1	2 mA	
X2-X3	1000.4:1	2 mA	
Y1-Y3	600.37:1	2 mA	
Y2-Y3	1000.7:1	2 mA	

Megger Tests performed with Amprobe Model # AMB-5kV		
Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
H1 Primary to Ground (H2 lifted)	> 100 Giga $\Omega$	5000 Volts
H1 to PT X winding	100 Giga $\Omega$	1000 Volts
H1 to PT Y winding	100 Giga $\Omega$	1000 Volts
H1 to CT X winding	100 Giga $\Omega$	1000 Volts
H1 to CT Y winding	100 Giga $\Omega$	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

<b>Turbine Technologies Construction</b>	10/01/01
CUSTOMER <b>001044</b>	DATE <b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER <b>120 kV Switchyard</b>	E SQUARED CONTRACT NUMBER <b>Fellows, CA</b>
PT LOCATION <b>Westinghouse Electric Co.</b>	CUSTOMER SITE <b>ISO Metering B Phase</b>
PT MANUFACTURER	CIRCUIT IDENTIFICATION
PREVIOUS INSPECTION DATE	INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA			
Type:	AMU 550	Serial #	C0733089
Ratio	600:1 and 1000:1	BIL	550 kV
Class	0.3	Weight	2360 lbs.
Primary	69 kV	Style	550M0103AP
Hertz	60	VA	6000

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39			
RATIO	RESULT	mA During Test	
X1-X3	600.90:1	2 mA	
X2-X3	1001.2:1	2 mA	
Y1-Y3	600.72:1	2 mA	
Y2-Y3	1001.0:1	2 mA	

Megger Tests performed with Amprobe Model # AMB-5kV		
Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
H1 Primary to Ground (H2 lifted)	> 100 Giga $\Omega$	5000 Volts
H1 to PT X winding	100 Giga $\Omega$	1000 Volts
H1 to PT Y winding	100 Giga $\Omega$	1000 Volts
H1 to CT X winding	100 Giga $\Omega$	1000 Volts
H1 to CT Y winding	100 Giga $\Omega$	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

**9/27/01**

CUSTOMER
<b>001044</b>
CUSTOMER PURCHASE ORDER NUMBER
<b>120kV Switchyard</b>
CT LOCATION
<b>Westinghouse</b>
CT MANUFACTURER
PREVIOUS INSPECTION DATE

DATE
<b>2138T1835</b>
E SQUARED CONTRACT NUMBER
<b>Fellows, CA</b>
CUSTOMER SITE
<b>ISO Metering A Phase</b>
CIRCUIT IDENTIFICATION
INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
Style	550M0103AP	Serial #	C0732089
Ratio	150:5 and 300:5 X1-X3/X2-X3	BIL	550 kV
Type	AMU 550	NSV	
Relay Class	380.1-.382.0	Insulation Class	
Hertz	60	R.F.	@30 Degrees C = 1.5

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Good	Connections Tight	Yes
Secondary wires	Solid		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39			
RATIO	RESULT	mA During Test	
X1-X3	59.934:1	20 mA	
X2-X3	29.942:1	103 mA	
Y1-Y3	59.934:1	12 mA	
Y2-Y3	29.940:1	45 mA	

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

Turbine Technologies Construction

9/27/01

CUSTOMER

DATE

001044

2138T1835

CUSTOMER PURCHASE ORDER NUMBER

E SQUARED CONTRACT NUMBER

120kV Switchyard

Fellows, CA

CT LOCATION

CUSTOMER SITE

Westinghouse

ISO Metering B Phase

CT MANUFACTURER

CIRCUIT IDENTIFICATION

PREVIOUS INSPECTION DATE

INSTRUCTION BOOK

#### CURRENT TRANSFORMER NAMEPLATE DATA

Style	550M0103AP	Serial #	C0733089
Ratio	150:5 and 300:5 X1-X3/X2-X3	BIL	550 kV
Type	AMU 550	NSV	
Relay Class	380.1-382.0	Insulation Class	
Hertz	60	R.F.	@30 Degrees C = 1.5

#### VISUAL & MECHANICAL INSPECTION

OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Good	Connections Tight	Yes
Secondary wires	Solid		
Overheating	None		

#### Tests Performed with Bidle Three Phase TTR Model #550100-39

RATIO	RESULT	mA During Test
X1-X3	59.941:1	16 mA
X2-X3	29.942:1	100 mA
Y1-Y3	59.934:1	53 mA
Y2-Y3	29.940:1	97 mA

Comments CT testing was performed with the Bidle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

Turbine Technologies Construction

9/27/01

CUSTOMER

DATE

001044

2138T1835

CUSTOMER PURCHASE ORDER NUMBER

E SQUARED CONTRACT NUMBER

120kV Switchyard

Fellows, CA

CT LOCATION

CUSTOMER SITE

Westinghouse

ISO Metering C Phase

CT MANUFACTURER

CIRCUIT IDENTIFICATION

PREVIOUS INSPECTION DATE

INSTRUCTION BOOK

#### CURRENT TRANSFORMER NAMEPLATE DATA

Style	550M0103AP	Serial #	Nameplate Missing
Ratio	150:5 and 300:5 X1-X3/X2-X3	BIL	550 kV
Type	AMU 550	NSV	
Relay Class	380.1-.382.0	Insulation Class	
Hertz	60	R.F.	@30 Degrees C = 1.5

#### VISUAL & MECHANICAL INSPECTION

OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Good	Connections Tight	Yes
Secondary wires	Solid		
Overheating	None		

#### Tests Performed with Biddle Three-Phase TTR Model #550100-39

RATIO	RESULT	mA During Test
X1-X3	59.934:1	12 mA
X2-X3	29.942:1	71 mA
Y1-Y3	59.934:1	15 mA
Y2-Y3	29.940:1	41 mA

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



ENGINEERING APPRAISAL

120 kV Circuit Switcher Inspection/Test Report  
Siemens Line Backer Circuit Switcher

Circuit Switcher Nameplate Data/Information		DATE: 10/04/01
Customer: TTSC	KV Nom.: 38-169	Close and latch current: 30 kA
Project: Mid Sun Co-Gen	Interrupter BIL: 550 kV	Interrupting time: 5 cycle
Location: 120 kV Switchyard	Cont. amps: 1200	Interrupter Units S/N Couldn't locate
Mfg.: Siemens	Short Circuit current: 10 kA	
Serial No: Couldn't locate	Thru Fault current: 70 kA	
Type: MFB	Inst. Book: PS33208-03	

Electrical Tests	Recommended	A φ	B φ	C φ
Ductor across SF6 Interrupter	< 200 μΩ	109 μΩ	86 μΩ	106 μΩ
Megger (see sheets)				

Close and Trip coil Pickup tests				
	Rated Voltage/Current	Minimum Voltage Pickup Test	Time to Close main contacts test	Time to Open main contacts test
Close coil	125 VDC	VDC pickup		
Trip coil	125 VDC @ 24 ADC	VDC pickup		

**Comments:**

The circuit switcher was inspected/tested. No nameplate data could be located for this unit. The data on this form was taken from the instruction book located on-site. There is zero SF6 gas pressure inside each of the interrupter bottles. This is based on gauge readings taken on the ends of the interrupters. The switcher can not be operated in this condition. A complete service call from the factory is needed to return this switcher to operational status. The insulators are very dirty/rusty and need to be cleaned.

Tested By: S. Mills

Witnessed \_\_\_\_\_



**ENGINEERING APPRAISAL**

**Megaohm Insulation Resistance Testing Data**

<b>Turbine Technologies Construction</b>	<b>10/02/01</b>
CUSTOMER	DATE
<b>Midsun Co-Gen</b>	<b>120 kV Switchyard</b>
PROJECT	LOCATION
<b>52T 120 kV Circuit Switcher</b>	<b>Fellows, CA</b>
UNIT UNDER TEST	CUSTOMER SITE
<b>001044</b>	<b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER	E SQUARED CONTRACT NUMBER

GENERAL: This Appraisal Standard provides a checklist of tests to be performed during an appraisal and serves as a permanent record of data taken during the appraisal upon which recommendations for corrective action will be made. *Refer to applicable instruction books for details.*

**Environment:** Temperature = 85 °F Relative Humidity = Dry  
**Test Equipment:** Amprobe Model # AMB-5kV

TESTING RESULTS				
Test Connection	Resistance in $\Omega$		Test Connection	Resistance in $\Omega$
Breaker Open	1 Minute		Breaker Closed	1 Minute
Pole 1 to ground	> 100 Giga $\Omega$		Pole 1 to ground	> 100 Giga $\Omega$
Pole 2 to ground	> 500 Giga $\Omega$		Pole 2 to ground	> 100 Giga $\Omega$
Pole 3 to ground	> 100 Giga $\Omega$		Pole 3 to ground	> 100 Giga $\Omega$
Pole 4 to ground	> 500 Giga $\Omega$			
Pole 5 to ground	> 100 Giga $\Omega$			
Pole 6 to ground	> 500 Giga $\Omega$			
Pole 1 to Pole 2	> 500 Giga $\Omega$			
Pole 3 to Pole 4	> 500 Giga $\Omega$			
Pole 5 to Pole 6	> 500 Giga $\Omega$			

**Comments** Tests were performed @ 5000 volts. Results are satisfactory.

Tested By: S. Mills

Witnessed By: \_\_\_\_\_



120KV Circuit Switcher  
Midsun Cogen  
November 15, 2001

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Due to the deteriorated state of the existing circuit switcher, Hanover Group contracted its replacement/refurbishment. This replacement/refurbishment was performed by:

Southern States, Inc.  
30 Georgia Ave.  
Hampton, GA 30228  
PH(770) 946-4562

Following is the field service report detailing the timing test(s) performed by Kerry Bjorn (Southern States, Inc.) as well as the factory tests performed on the parts furnished by Southern States, Inc.

# FIELD SERVICE REPORT

FOR: HANOVER ENERGY  
FELLOWS, CA 11/28/01

## EQUIPMENT:

ORIGINAL SIEMENS CIRCUIT SWITCHER INSTALLED 1988.  
SOUTHERN STATES PROVIDED NEW INTERRUPTER/DRIVER UNITS (3)  
AND NEW SWITCH HINGE ASSEMBLIES AND BLADES. ORIGINAL  
SWITCH OPEN CONTACTS WERE USED.

## WORK SUMMARY:

REMOVED INTERRUPTER/DRIVER MODULES, HINGES, AND  
BLADE ASSEMBLIES AT TOP OF STATIONARY AND ROTATING  
POST INSULATORS. REPLACED WITH NEW EQUIPMENT LISTED  
ABOVE.

1. ADJUSTED INTERPHASE LINKAGE TO PROVIDE FOR CLOSING  
OF INTERRUPTERS WITHIN MANUFACTURERS REQUIREMENTS  
(12 MS RANGE FOR 3 PHASES) SEE DATA
2. CHECKED OPENING TIMING TO MEET MANUFACTURERS  
REQUIREMENT (8 MS RANGE FOR 3 PHASES)
3. RESET MOTOR OPERATOR LIMIT SWITCHES FOR OPEN AND  
CLOSED POSITIONS
4. CHECKED AND ADJUSTED SHUNT TRIPS TO OPEN POSITION  
CAM / ROLLER GAP DIMENSION ( $1/8$  IN  $\pm 1/32$ )

PAGE 2/3

5. JACKED CONTACT END INSULATORS TO PROVIDE PROPER CLOSING AND CONTACT ENGAGEMENT OF THE DISCONNECTING SWITCH.
6. ADJUSTED SWITCH HINGE AND BLADE ASSEMBLIES FOR UNIFORM CLOSING AND OPENING OF THE SWITCH.

TIMING TEST DATA

11/27/01	PHASE	A	B	C
	MANUAL CLOSE	0.4	0.0	1.7
	MOTOR CLOSE	0.0	2.4	2.1
	OPEN	13.0	0.0	8.5
	CLOSE	0	7.8	2.8
	OPEN	5.9	0	7.2
	CLOSE	0	5.1	3.1
	OPEN	0	2.4	9.6
	CLOSE	0	4.4	4.5
	OPEN	3.0	0.0	1.7
	OPEN	1.6	0	2.8
	CLOSE	0	4.0	4.3
	OPEN	1.2	0	2.7
	OPEN <del>CLOSE</del>	0.9	0	1.6
	CLOSE	0	1.5	4.7

(INSPECTED SHUNT TRIP MODIFIED TRIGGER)

(CONTINUE NEXT PAGE)

11/28/01

TIMING TEST DATA

ADJUSTED SWITCH HINGES AND PLATES

PHASE	A	B	C	
CLOSE	0	5.1	8.8	
OPEN	5.2	1.5	0.0	ADJUSTED Aφ
CLOSE	0	3.1	4.5	
OPEN	2.6	0	3.2	
CLOSE	0.7	0	5.9	
OPEN	1.4	1.0	0	
CLOSE	0	4.5	5.4	
OPEN	0.5	0.0	0.3	ADJUSTED Aφ
CLOSE	0	0.8	3.6	
OPEN	0	3.1	0.3	
CLOSE	0.0	2.4	3.3	
OPEN	0.8	0.9	0.0	

SUMMARY

THE CIRCUIT SWITCHER WAS LEFT IN THE OPEN POSITION. CONDUCTORS ARE TO BE REPLACED BY THE CUSTOMER. THE CIRCUIT SWITCHER AS INSTALLED EXCEEDS THE REQUIREMENTS ESTABLISHED BY THE MANUFACTURER AND IS IN VERY GOOD CONDITION. I WOULD RECOMMEND PAINT TOUCH UP ON THE STRUCTURE AT THE CUSTOMERS CONVENIENCE.

FIELD SERVICE ENGINEER  
SOUTHERN STATES INC.

KERRY BJORN  
Kerry Bjorn

TYPE	CSH--B	CIRCUIT SWITCHER	35
KV, MAX.	121	BIL	550
CONTINUOUS CURRENT	1200	A	
FREQ.	60	Hz	MFR. DATE
STYLE	B10A010B	J.O.	60089
SHORT-TIME CURRENT			20 KA
NORMAL OPERATING PRESS. AT 20° C			81 PSIG
INTERRUPTING TIME			6 CYCLES

**SS** Southern States, Inc.  
 30 GEORGIA AVENUE  
 HUNTSVILLE, GEORGIA 35894-8189  
 (770) 944-4882 FAX (770) 944-8104

NOTE: ONLY INTERRUPTER/DRIVER, HINGE ASSEMBLY AND BLADE ASSEMBLY (3 PHASES) WERE SUPPLIED ON THIS ORDER.

INTERRUPTER/DRIVER	08126260	3
HINGE ASSEMBLY	08125928	3
BLADE ASSEMBLY	08124621	3
SF6 GAS FILL KIT	81050101	1

# Circuit Switcher Application Guide

## Type CSH and CSH-B Interrupting Ratings

Application		Qualifications	Maximum Amperes Interrupting RMS Symm.
Transformer Switching and Protection	Parallel Switching	---	1200
	Load Dropping ①	---	1200
	Fault Interrupting ②	Primary Faults Secondary Faults	20,000 ③④ 4,000 ⑤
Line or Cable Switching and Protection	Load Splitting (Parallel or Loop Switching)	---	1200
	Load Dropping	---	1200
	Line, Cable Dropping (Charging Current)	72.5 kV thru 145 kV 169kV	400 320
	Fault Interrupting ②	---	20,000 ③④
Single Shunt Capacitor-Bank Switching and Protection	Bank Current Switching	Grounded capacitor banks applied on solidly grounded systems only, thru 145 kV Ungrounded capacitor banks thru 145 kV	550 400
	Fault Interrupting ②	---	20,000 ③④
Series Reactor Switching		Refer to your Southern States Representative	
Shunt Reactor Sw. & Protection (Line-Conn or Tertiary-Connected Reactors)	Reactor Current Switching	Grounded reactors applied on solidly grounded systems only thru 145 kV Ungrounded reactors 72.5 kV only	600 600
	Fault Interrupting ②	---	20,000 ③④

① Southern States circuit switchers can close, carry and interrupt the magnetizing current of the protected transformer.

② The interrupting ratings shown are applicable for the following duty cycles: O or OO.

③ Tripping of Southern States Circuit Switchers must be coordinated with source-side protective equipment for short-circuit currents in excess of this value.

④ Rating is based on transient-recovery-voltage parameters defined in Table 2 of

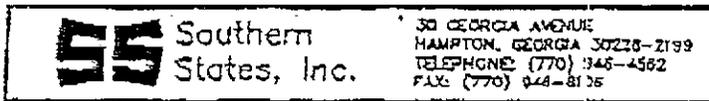
ANSI standard C37.06-1987 for Southern States Circuit Switchers rated 72.5 kV and Table 3 for 121 kV through 242 kV.

⑤ Southern States Circuit Switchers are suitable for transformer-primary applications where the *inherent* secondary-fault current as reflected on the primary side of the transformer, assuming an infinite zero impedance-source does not exceed 4000 amperes. The *inherent* secondary-fault current may be calculated as follows. (Inherent is defined as secondary-side fault current as reflected through to the primary side of the transformer.):

$$I = \frac{KVA \times 100}{\sqrt{3} E \times Z}$$

I = Inherent Secondary Fault Current  
KVA = Transformer Self-cooled 3-Phase Rating  
E = System Voltage (kV)  
Z = Impedance Primary-to Secondary in Percent

For applications where the inherent secondary-fault current exceeds the above limits, but where the maximum expected fault current, based on transformer impedance plus source impedance is within these limits, refer to your Southern States Representative.



PRODUCTION LEAK TEST AND HI-POT DATA

EVACUATE TO 2mm hg.

FILL UNIT TO 81 PSIG, SFG AT 68 DEG. F. [RECORD ACTUAL] 81 PSIG

PLACE UNIT IN LEAK CHAMBER AND PERFORM (50) "CLOSE/OPEN" OPERATIONS.

a. DURING MECHANICAL OPERATION TEST, PERFORM LEAK TEST. (< 250 MICRO-LITER / HR.) [ANSI C37.09-5.7]

b. AFTER MECHANICAL OPERATION TEST, PERFORM LEAK TEST WITH HAND HELD DETECTOR INSIDE THE DRIVER FOR BELLOWS LEAK.

c. ACCEPT OR REJECT BASED ON DETECTION RESULTS.

ACCEPT: BJSB

d. VERIFY TRIPPING TIME USING TIMING RECORD BY ENERGIZING TRIP COIL AFTER CLOSE OPERATION.  
[MAX. ALLOWABLE TRIP TIME: 65 ms]

RECORD ACTUAL: 46.0

e. STAMP SERIALIZED DATE ON POLE UNIT COVERS.

RECORD: 11/00/01 S I

RESISTANCE TEST [ANSI C37.09-5.14]

1. 72/121 kV Max. ALLOWABLE RESISTANCE, 75 micro ohms.

RECORD ACTUAL: 59.0

2. 145/169 kV Max. ALLOWABLE RESISTANCE, 85 micro ohms.

RECORD ACTUAL: N/A

3. 242 kV Max. ALLOWABLE RESISTANCE, 90 micro ohms.

RECORD ACTUAL: N/A

WITHSTAND (PHASE) HZ - 1 minute [ANSI C37.09-5.12]

CHECK ONE BOX

72 kV RATING - TEST VOLTAGE 160 kV RMS

121 kV RATING - TEST VOLTAGE 260 kV RMS

145 kV RATING - TEST VOLTAGE 310 kV RMS

169 kV RATING - TEST VOLTAGE 365 kV RMS

242 kV RATING - TEST VOLTAGE 425 kV RMS

TEST SIGNATURE [Signature]

DATE 11/12/01

JO. 60089-001

 <b>Southern States, Inc.</b>	30 GEORGIA AVENUE
	HAMPTON, GEORGIA 30228-2100
	TELEPHONE: (770) 946-4562
	FAX: (770) 946-8106

PRODUCTION LEAK TEST AND HI-POT DATA

EVACUATE TO 2mm.hg.

FILL UNIT TO 81 PSIG, SF6 AT 68 DEG. F. [RECORD ACTUAL] 81 PSIG

PLACE UNIT IN LEAK CHAMBER AND PERFORM (50) "CLOSE/OPEN" OPERATIONS.

a. DURING MECHANICAL OPERATION TEST, PERFORM LEAK TEST. (< 250 MICRO-LITER / HR.) [ANSI C37.09-5.7]

b. AFTER MECHANICAL OPERATION TEST, PERFORM LEAK TEST WITH HAND HELD DETECTOR INSIDE THE DRIVER FOR BELLOW LEAK.

c. ACCEPT OR REJECT BASED ON DETECTION RESULTS. ACCEPT: BTR

d. VERIFY TRIPPING TIME USING TIMING RECORD BY ENERGIZING TRIP COIL AFTER CLOSE OPERATION. (MAX. ALLOWABLE TRIP TIME: 65 ms) RECORD ACTUAL: 47.8

e. STAMP SERIALIZED DATE ON POLE UNIT COVERS. RECORD: 11/10/02 ST

RESISTANCE TEST [ANSI C37.09-5.14]

1. 72/121 KV Max. ALLOWABLE RESISTANCE, 75 micro ohms. RECORD ACTUAL: 59

2. 145/165 KV Max. ALLOWABLE RESISTANCE, 85 micro ohms. RECORD ACTUAL: N/A

3. 242 KV Max. ALLOWABLE RESISTANCE, 90 micro ohms. RECORD ACTUAL: N/A

W STAND (PHASE) HZ - 1 minute (ANSI C37.09-5.12) CHECK ONE BOX

72 KV RATING - TEST VOLTAGE 160 KV RMS

121 KV RATING - TEST VOLTAGE 260 KV RMS

145 KV RATING - TEST VOLTAGE 310 KV RMS

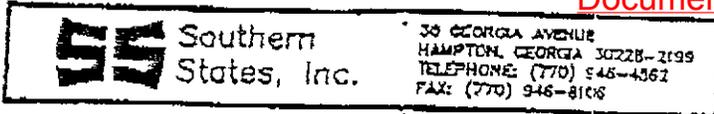
165 KV RATING - TEST VOLTAGE 365 KV RMS

242 KV RATING - TEST VOLTAGE 425 KV RMS

TEST SIGNATURE [Signature]

DATE 11/12/01

J.O. 50089-001



PRODUCTION LEAK TEST AND HI-POT DATA

EVACUATE TO 2mm.hg.

FILL UNIT TO 81 PSIG, SF6 AT 68 DEG. F. [RECORD ACTUAL] 81 PSIG

PLACE UNIT IN LEAK CHAMBER AND PERFORM (50) "CLOSE/OPEN" OPERATIONS.

a. DURING MECHANICAL OPERATION TEST, PERFORM LEAK TEST. (< 250 MICRO-LITERS / HR.) [ANSI C37.09-5.7]

b. AFTER MECHANICAL OPERATION TEST, PERFORM LEAK TEST WITH HAND HELD DETECTOR INSIDE THE DRIVER FOR BELLOWS LEAK.

c. ACCEPT OR REJECT BASED ON DETECTION RESULTS.

ACCEPT: BTB

d. VERIFY TRIPPING TIME USING TIMING RECORD BY ENERGIZING TRIP COIL AFTER CLOSE OPERATION.

[MAX. ALLOWABLE TRIP TIME: 65 ms]

RECORD ACTUAL: 46.3

e. STAMP SERIALIZED DATE ON POLE UNIT COVERS.

RECORD: 11/06/03 ST

RESISTANCE TEST [ANSI C37.09-5.14]

1. 72/121 kV Max. ALLOWABLE RESISTANCE, 75 micro ohms.

RECORD ACTUAL: 57

2. 145/169 kV Max. ALLOWABLE RESISTANCE, 85 micro ohms.

RECORD ACTUAL: N/A

3. 242 kV Max. ALLOWABLE RESISTANCE, 90 micro ohms.

RECORD ACTUAL: N/A

STAND (PHASE) HZ - 1 minute [ANSI C37.09-5.13]

CHECK ONE BOX

- 72 kV RATING - TEST VOLTAGE 160 kV RMS
- 121 kV RATING - TEST VOLTAGE 260 kV RMS
- 145 kV RATING - TEST VOLTAGE 310 kV RMS
- 169 kV RATING - TEST VOLTAGE 365 kV RMS
- 242 kV RATING - TEST VOLTAGE 425 kV RMS

TEST SIGNATURE

[Signature]

DATE

11/12/01

J.O. 60089-001



TTS CONSTRUCTION  
MIDSUN COGEN PROJECT, FELLOWS, CA  
STEP UP TRANSFORMER TESTING

AUGUST 13, 2001

**STEP UP TRANSFORMER-**

**TTR RESULTS:**

A Transformer Turns Ratio test was performed on all three windings and on all taps of the **Main Transformer**. The results compared to the calculated expectations with no indication of problems. Specified tolerances are typically 0.5% maximum error.

Biddle 550005-TTR, Single Phase,  
Oil Temperature 34° C  
Ambient Temperature 90° F  
Relative Humidity 20%  
Liquid Level at 25° C Mark (high edge)

**AS FOUND:** Tap Position 3  
**AS LEFT:** Tap Position 3

			<b>MAIN TRANSFORMER TTR</b>		8-2001
TAP		PHASE A	PHASE B	PHASE C	
<b>1</b>	Ratio	5.2720	5.2722	5.2715	
5.27146					
<b>2</b>	Ratio	5.1455	5.1460	5.1455	
5.14595					
<b>3</b>	Ratio	5.0200	5.0205	5.0200	
5.02044					
<b>4</b>	Ratio	4.8945	4.8950	4.8945	
4.89493					
<b>5</b>	Ratio	4.7690	4.7695	4.7690	
4.76942					



TTS CONSTRUCTION  
MIDSUN COGEN PROJECT, FELLOWS, CA  
STEP UP TRANSFORMER TESTING

AUGUST 13, 2001

**MEGGER RESULTS:**

**ENGINEERING APPRAISAL**

**MEGOHM INSULATION RESISTANCE  
TESTING DATA**

DATE 8-14-01

REF. NO. 2127T1794

CUSTOMER TTS Construction

CUSTOMER P.O. NO. \_\_\_\_\_

PROJECT Midsun Cogen

LOCATION Fellows, CA

SUBSTATION NAME Step-Up Transformer

UNIT UNDER TEST SUT

GENERAL: This Appraisal Standard provides a checklist of tests to be performed during an appraisal and serves as a permanent record of data taken during the appraisal upon which recommendations for corrective action will be made.

REFER TO APPLICABLE INSTRUCTION BOOKS FOR DETAILS.

WARNING: Comply with all applicable safety precautions when working in and around high-voltage equipment.

ENVIRONMENT: Temperature 90°F Relative Humidity 20%

SPECIAL TEST EQUIPMENT: BIDDLE MEGGER (2500 V)

Test Connection	RESISTANCE (Ohms)			
	30 Sec.	1 Min.	2 Min.	10 Min.
H1—GND		1000 MΩ		
H2—GND		1000 MΩ		
H3—GND		1000 MΩ		
X1—GND		600 MΩ		
X2—GND		600 MΩ		
X3—GND		600 MΩ		
H1--X1		1000 MΩ		
H2--X2		1000 MΩ		
H3--X3		1000 MΩ		
Core Ground @ 1KV		N/A		

COMMENTS: NEUTRAL REMOVED FROM GROUND BUS WHILE MEASURING H1, H2, H3.

CORE GROUND WAS NOT ACCESSIBLE FOR TESTING

Tested By: Barry Poste



TTS CONSTRUCTION  
MIDSUN COGEN PROJECT, FELLOWS, CA  
STEP UP TRANSFORMER TESTING

---

AUGUST 13, 2001

### **POWER FACTOR TESTING RESULTS:**

Power factor insulation testing was performed on the windings, bushings and station arresters associated with the main Step Up Transformer of the Midsun Cogen Substation. Excitation current testing was also performed on all taps of the high voltage winding.

The power factor testing showed results classified as **GOOD** for a transformer of this class and rating. This **GOOD** classification was also applicable to the station arresters and the bushings of this transformer.

### **OIL TESTING RESULTS:**

A comprehensive test with additional power factor testing of an oil sample from the Midsun Cogen Step Up Transformer was performed by the General Electric Insulating Liquids Laboratory.

All results of this testing showed the oil to be **GOOD** and within the specifications for in-service oil.

Preventative maintenance including annual testing of the condition of this transformer's insulating oil is recommended.

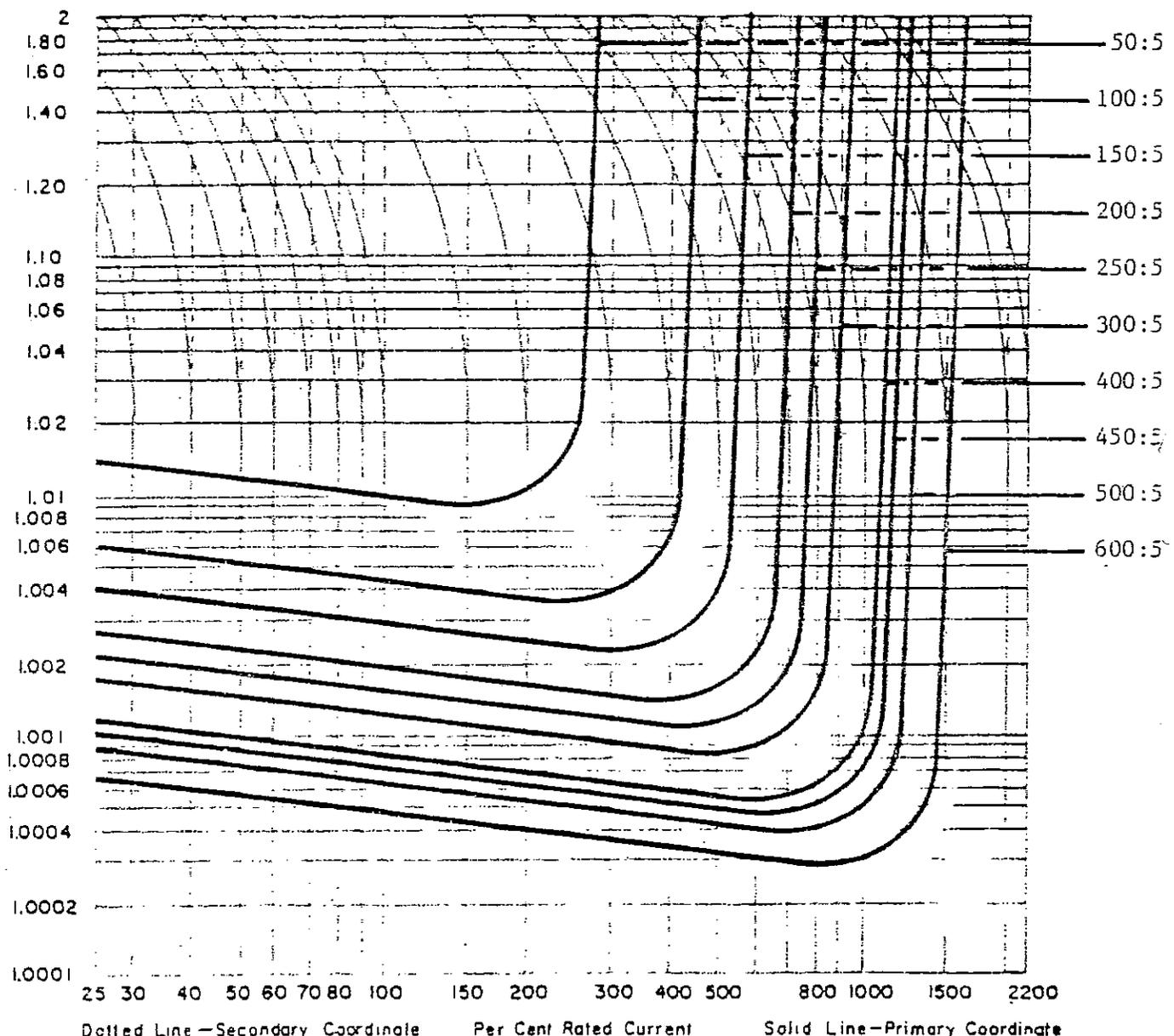
### **SUMMARY**

1. Winding ratios from the test results verify calculated values based on Nameplate Data. All results were within the 0.5 % tolerance limits.
2. The insulation resistance testing performed showed all resistance within expected levels.
3. The power factor testing results classified this transformer in the **GOOD** rating.
4. The results of the analysis of the insulating oil of this transformer also showed it to be **GOOD**, within the specifications for in-service oil.

All testing that was performed on the Step Up Transformer showed it to be in **GOOD** condition and ready for operation at this Midsun Cogen Project.

MARKED RATIO	SEC. TURNS	SEC. TAPS
50:5	10	X2 - X3
100:5	20	X1 - X2
150:5	30	X1 - X3
200:5	40	X4 - X5
250:5	50	X3 - X4
300:5	60	X2 - X4
400:5	80	X1 - X4
450:5	90	X3 - X5
500:5	100	X2 - X5
600:5	120	X1 - X5

FREQUENCY 60 HZ.  
 MAXIMUM RATIO 600:5  
 TOTAL SEC. TURNS 120  
 SEC. RES. 0.0030 OHMS/TURN @85° CENTIGRADE  
 ANSI ACCURACY C200  
 BURDEN 2.0 (2.0 OHMS, 50 PERCENT P. F. LAG)



			H.K. Porter Co., Inc. Belmont, California 94002
			C.T. # R-062-179528-M
		DWN. <i>R.M.</i>	CHK
		ISSUED	
SHEET	2	2	P.O. 4772

TYPICAL

Document Control# TSM09-2215-09

MARKED RATIO	SEC. TURNS	SEC. TAPS
50:5	10	X2-X3
100:5	20	X1-X2
150:5	30	X1-X3
200:5	40	X4-X5
250:5	50	X3-X4
300:5	60	X2-X4
400:5	80	X1-X4
450:5	90	X3-X5
500:5	100	X2-X5
600:5	120	X1-X5

BTCT EXCITING CURRENT CURVES

TYPE: BUSHING

FREQUENCY 60 HZ.

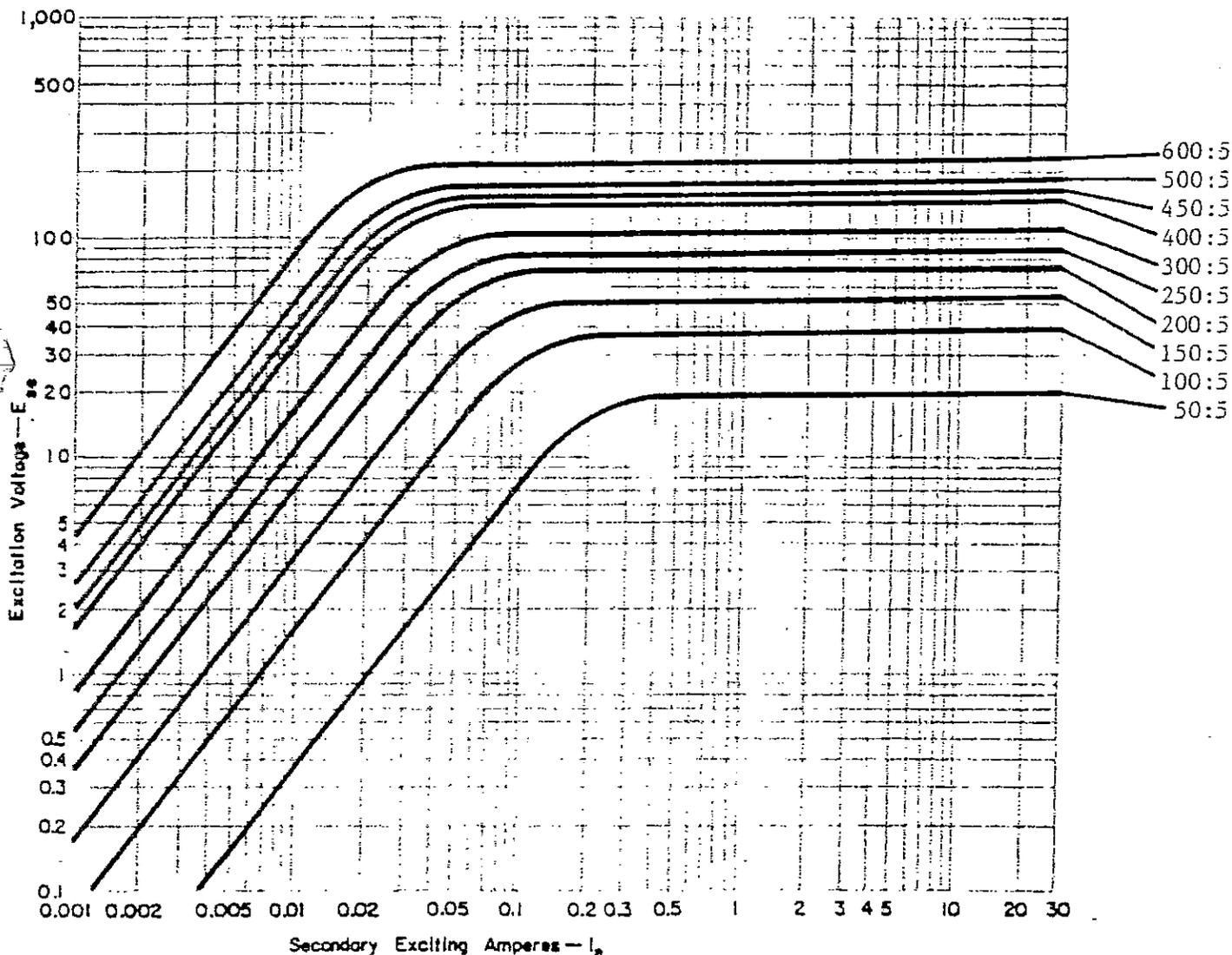
MAXIMUM RATIO 600:5

TOTAL SEC. TURNS 120

SEC. RES. 0.0030 OHMS/TURN @ 85° CENTIGRADE

ANSI ACCURACY C200

BURDEN 2.0 ( 2.0 OHMS, 50 PERCENT P. F. LAG)



H.K. Porter Co., Inc.  
Belmont, California 94002

C.T. # R-062-179528-M

DWN. <i>R.M.</i>	CHK	ISSUED
SHEET 1	2	P.O. 4772

1011-1



**ENGINEERING APPRAISAL**

**15 kV Breaker Test Report  
52M Main Bus Vacuum Circuit Breaker**

Breaker Nameplate Data/Information:		DATE: 10/03/01
Customer: TTSC	Rated Int. MVA: 750	Mech Code: M3
Project: MidSun Co-Gen	Int. amps at rated volts: 28 kA	Close coil volts: 90-130 DC
Location: 15 kV switchgear	Maximum Int.amps: 36 kA	Close coil current: 6.0 amps
Mfg.: Industrial Electric MFG.	Momentary amps: 58 kA	Close coil #: 2-15-CP
Serial No: 830519	Rated max volts: 15 kV	Trip coil volts: 70-140 DC
Type: HVD-1575-20	Rated amps: 2000 @ 60 Hz	Trip coil current: 6.0 amps
Inst. Book:	Interrupting time: 3 cycle	Trip coil #: 2-15-CP
Designation: 52M	BIL 95kV	Trip Count: As Found: 2113
Date of Mfg.: 05-83	Weight: 500 lbs.	Trip Count: As Left: 2115

Measurements	Tolerance	A φ	B φ	C φ

Electrical Tests	Recommended	A φ	B φ	C φ
Ductor	< 50 μ Ω	20 μ Ω	20 μ Ω	21 μ Ω
Megger (see sheets)				

Close and Trip coil pickup tests	Actual	
	Close coil	90-130volts
Trip coil	70-140 volts	VDC pickup

**Comments:**

Upon initial inspection the breaker was found to be in good overall condition. Measurements were not taken as part of this inspection.

The primary and secondary contacts stabs appeared to be very dry and lacking grease. These should be regreased with a High Voltage type grease before the unit is placed in service.

Tested By: S. Mills

Witnessed \_\_\_\_\_



**ENGINEERING APPRAISAL**

**Megaohm Insulation Resistance Testing Data**

<b>Turbine Technologies Construction</b>	<b>10/02/01</b>
CUSTOMER	DATE
<b>Midsun Co-Gen</b>	<b>15 kV Switchgear</b>
PROJECT	LOCATION
<b>52M Main Bus Breaker/Serial # 830519</b>	<b>Fellows, CA</b>
UNIT UNDER TEST	CUSTOMER SITE
<b>001044</b>	<b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER	E SQUARED CONTRACT NUMBER

GENERAL: This Appraisal Standard provides a checklist of tests to be performed during an appraisal and serves as a permanent record of data taken during the appraisal upon which recommendations for corrective action will be made. *Refer to applicable instruction books for details.*

**Environment:** Temperature = 85 °F Relative Humidity = Dry  
**Test Equipment:** Amprobe Model # AMB-5kV

TESTING RESULTS				
Test Connection	Resistance in $\Omega$		Test Connection	Resistance in $\Omega$
Breaker Open	1 Minute		Breaker Closed	1 Minute
Pole 1 to ground	500 Giga $\Omega$		Pole 1 to ground	500 Giga $\Omega$
Pole 2 to ground	500 Giga $\Omega$		Pole 2 to ground	500 Giga $\Omega$
Pole 3 to ground	500 Giga $\Omega$		Pole 3 to ground	500 Giga $\Omega$
Pole 4 to ground	500 Giga $\Omega$			
Pole 5 to ground	500 Giga $\Omega$			
Pole 6 to ground	500 Giga $\Omega$			
Pole 1 to Pole 2	> 500 Giga $\Omega$			
Pole 3 to Pole 4	> 500 Giga $\Omega$			
Pole 5 to Pole 6	> 500 Giga $\Omega$			

**Comments** Tests were performed @ 5000 volts. Results are satisfactory. The secondaries were tested at 500 volts to ground results were better than 10 Giga  $\Omega$ .

Tested By: S. Mills

Witnessed By: \_\_\_\_\_



**15KV Switchgear-Timing and Trip tests of Breakers  
Midsun Cogen  
November 15, 2001**

---

**Timing and 70% control voltage trip testing-  
Breaker 52M-**

Testing was performed on this breaker to determine the amount of time between a trip signal being given to the trip coil of the breaker and the main contacts actually coming to a closed position. The nameplate of this breaker denotes it as a 3-cycle breaker. On a 60 Hz system, this is equivalent to 0.05 seconds. Therefore, this breaker should trip (and close) the main contacts, after receiving a trip (or close) signal, in 0.05 seconds or less.

To perform this test, it was necessary to implement an interposing relay. In this case, a simple two (2) contact GE relay was used (type HGA auxiliary relay). Since the use of this relay would add more delay into the overall system, a timing test of this relay alone was performed. The average of 25 trials was found to be 24.51 milliseconds. This time will be subtracted from all times taken from the breaker timing tests.

Also, in order to initiate a trip or close signal to the breaker, it will be necessary to simply connect two terminal points, thereby bypassing the various lockouts, control switches, etc. in the breaker control scheme.

For the trip signal to the 52M breaker, terminal points TBC2(4) and TBC2(9) were connected. This connection was made through the interposing relay. By using this setup, the Doble test set could be used to both give the output necessary to actuate the interposing relay and also to sense the opening of the main contacts on the breaker. The following data was taken:

<u>Trail</u>	<u>Time</u>
1	47.60 msec
2	47.79 msec
3	48.12 msec

After subtracting the time delay from the interposing relay, the results would be thus:

<u>Trial</u>	<u>Time</u>
1	23.09 msec
2	23.28 msec
3	23.61 msec

These times indicate that the breaker trip time is well within its rated time of 3 cycles.



**15KV Switchgear-Timing and Trip tests of Breakers**  
**Midsun Cogen**  
**November 15, 2001**

The next test performed on this breaker was the closing time test. The same setup mentioned above was used for this test, however, terminal points TBC2(6) and TBC2(7) were connected instead. The following data was taken:

<u>Trial</u>	<u>Time</u>
1	88.04 msec
2	88.10 msec
3	86.97 msec

After subtracting the interposing relay time delay, the closing time is thus:

<u>Trial</u>	<u>Time</u>
1	63.53 msec
2	63.59 msec
3	62.46 msec

These times indicate a close time of less than 4 cycles. This is acceptable.

The last test performed on this breaker was a 70% control power trip test. To perform this test, the 125 VDC batteries were reconfigured so as to supply a maximum of 87.5 VDC (70% of 125 VDC). Since a properly functioning battery charging system was not installed at the time of this test, the actual battery voltage was found to be 85 VDC. Since the PG&E requirements state that breaker must have the ability to trip at 70% or less, this lower voltage is fine.

After the 85 VDC was applied to the breaker control system (and the breaker being closed beforehand) terminal points TBC2(4) and TBC2(9) were jumpered to initiate the trip coil. This breaker tripped satisfactorily at less than 70% control voltage.



**ENGINEERING APPRAISAL**

**15 kV Breaker Test Report  
52G Generator Vacuum Circuit Breaker**

Breaker Nameplate Data/Information		DATE: 10/03/01
Customer: TTSC	Rated Int. MVA: 750	Mech Code: M3
Project: MidSun Co-Gen	Int. amps at rated volts: 28 kA	Close coil volts: 90-130 DC
Location: 15 kV switchgear	Maximum Int.amps: 36 kA	Close coil current: 6.0 amps
Mfg.: Industrial Electric MFG.	Momentary amps: 58 kA	Close coil #: 2-15-CP
Serial No: 830520	Rated max volts: 15 kV	Trip coil volts: 70-140 DC
Type: HVD-1575-20	Rated amps: 2000 @ 60 Hz	Trip coil current: 6.0 amps
Inst. Book:	Interrupting time: 3 cycle	Trip coil #: 2-15-CP
Designation: 52G	BIL 95kV	Trip Count: As Found: 414
Date of Mfg.: 05-83	Weight: 500 lbs.	Trip Count: As Left: 416

Measurements	Tolerance	A φ	B φ	C φ

Electrical Tests	Recommended	A φ	B φ	C φ
Ductor	< 50 μ Ω	23 μ Ω	26 μ Ω	27 μ Ω
Megger (see sheets)				

Close and Trip coil pickup tests	Actual			
	Close coil	90-130volts	VDC pickup	
Trip coil	70-140 volts	VDC pickup		

**Comments:**

Upon initial inspection the breaker was found to be in good overall condition. Measurements were not taken as part of this inspection.

The primary and secondary contacts stabs appeared to be very dry and lacking grease. These should be regreased with a High Voltage type grease before the unit is placed in service.

Tested By: S. Mills

Witnessed \_\_\_\_\_



**ENGINEERING APPRAISAL**

**Megaohm Insulation Resistance  
Testing Data**

**Turbine Technologies Construction**  
 \_\_\_\_\_  
 CUSTOMER  
**Midsun Co-Gen**  
 \_\_\_\_\_  
 PROJECT  
**52G Generator Breaker/Serial # 830520**  
 \_\_\_\_\_  
 UNIT UNDER TEST  
**001044**  
 \_\_\_\_\_  
 CUSTOMER PURCHASE ORDER NUMBER

**10/02/01**  
 \_\_\_\_\_  
 DATE  
**15 kV Switchgear**  
 \_\_\_\_\_  
 LOCATION  
**Fellows, CA**  
 \_\_\_\_\_  
 CUSTOMER SITE  
**2138T1835**  
 \_\_\_\_\_  
 E SQUARED CONTRACT NUMBER

GENERAL: This Appraisal Standard provides a checklist of tests to be performed during an appraisal and serves as a permanent record of data taken during the appraisal upon which recommendations for corrective action will be made. *Refer to applicable instruction books for details.*

**Environment:** Temperature = 85 °F Relative Humidity = Dry  
**Test Equipment:** Amprobe Model # AMB-5kV

TESTING RESULTS				
Test Connection	Resistance in Ω		Test Connection	Resistance in Ω
Breaker Open	1 Minute		Breaker Closed	1 Minute
Pole 1 to ground	500 Giga Ω		Pole 1 to ground	500 Giga Ω
Pole 2 to ground	500 Giga Ω		Pole 2 to ground	500 Giga Ω
Pole 3 to ground	500 Giga Ω		Pole 3 to ground	500 Giga Ω
Pole 4 to ground	500 Giga Ω			
Pole 5 to ground	500 Giga Ω			
Pole 6 to ground	500 Giga Ω			
Pole 1 to Pole 2	> 500 Giga Ω			
Pole 3 to Pole 4	> 500 Giga Ω			
Pole 5 to Pole 6	> 500 Giga Ω			

**Comments** Tests were performed @ 5000 volts. Results are satisfactory. The secondaries were tested at 500 volts to ground results were better than 10 Giga Ω.

Tested By: S. Mills

Witnessed By: \_\_\_\_\_



15KV Switchgear-Timing and Trip tests of Breakers  
Midsun Cogen  
November 15, 2001

---

**Timing and 70% control voltage trip testing-  
Breaker 52G-**

Testing was performed on this breaker to determine the amount of time between a trip signal being given to the trip coil of the breaker and the main contacts actually coming to a closed position. The nameplate of this breaker denotes it as a 3-cycle breaker. On a 60 Hz system, this is equivalent to 0.05 seconds. Therefore, this breaker should trip (and close) the main contacts, after receiving a trip (or close) signal, in 0.05 seconds or less.

To perform this test, it was necessary to implement an interposing relay. In this case, a simple two (2) contact GE relay was used (type HGA auxiliary relay). Since the use of this relay would add more delay into the overall system, a timing test of this relay alone was performed. The average of 25 trials was found to be 24.51 milliseconds. This time will be subtracted from all times taken from the breaker timing tests.

Also, in order to initiate a trip or close signal to the breaker, it will be necessary to simply connect two terminal points, thereby bypassing the various lockouts, control switches, etc. in the breaker control scheme.

For the trip signal to the 52M breaker, terminal points TBC3(12) and TBC3(22) were connected. This connection was made through the interposing relay. By using this setup, the Doble test set could be used to both give the output necessary to actuate the interposing relay and also to sense the opening of the main contacts on the breaker. The following data was taken:

<u>Trail</u>	<u>Time</u>
1	54.11 msec
2	52.92 msec
3	53.15 msec

After subtracting the time delay from the interposing relay, the results would be thus:

<u>Trial</u>	<u>Time</u>
1	29.60 msec
2	28.41 msec
3	28.64 msec

These times indicate that the breaker trip time is well within its rated time of 3 cycles.



## 15KV Switchgear-Timing and Trip tests of Breakers

Midsun Cogen

November 15, 2001

The next test performed on this breaker was the closing time test. The same setup mentioned above was used for this test, however, terminal points TBC3(19) and TBC3(21) were connected instead. The following data was taken:

<u>Trial</u>	<u>Time</u>
1	91.24 msec
2	81.13 msec
3	79.86 msec

After subtracting the interposing relay time delay, the closing time is thus:

<u>Trial</u>	<u>Time</u>
1	66.73 msec
2	56.62 msec
3	55.35 msec

These times indicate a close time of 4 cycles or less. This is acceptable. This closing time data will be used to calculate the breaker compensation time setting of the Automatic Synchronizer (device 25AS).

The last test performed on this breaker was a 70% control power trip test. To perform this test, the 125 VDC batteries were reconfigured so as to supply a maximum of 87.5 VDC (70% of 125 VDC). Since a properly functioning battery charging system was not installed at the time of this test, the actual battery voltage was found to be 85 VDC. Since the PG&E requirements state that breaker must have the ability to trip at 70% or less, this lower voltage is fine.

After the 85 VDC was applied to the breaker control system (and the breaker being closed beforehand) terminal points TBC3(12) and TBC3(22) were jumpered to initiate the trip coil. This breaker tripped satisfactorily at less than 70% control voltage.



**ENGINEERING APPRAISAL**

**15 kV Breaker Test Report  
52P Station Service Vacuum Circuit Breaker**

Breaker Nameplate Data/Information		DATE: 10/03/01
Customer: TTSC	Rated Int. MVA: 750	Mech Code: M3
Project: MidSun Co-Gen	Int. amps at rated volts: 28 kA	Close coil volts: 90-130 DC
Location: 15 kV switchgear	Maximum Int.amps: 36 kA	Close coil current: 6.0 amps
Mfg.: Industrial Electric MFG.	Momentary amps: 58 kA	Close coil #: 2-15-CP
Serial No: 830518	Rated max volts: 15 kV	Trip coil volts: 70-140 DC
Type: HVD-1575-12	Rated amps: 1200 @ 60 Hz	Trip coil current: 6.0 amps
Inst. Book:	Interrupting time: 3 cycle	Trip coil #: 2-15-CP
Designation: 52P	BIL 95kV	Trip Count: As Found: 154
Date of Mfg.: 05-83	Weight: 500 lbs.	Trip Count: As Left: 156

Measurements	Tolerance	A φ	B φ	C φ

Electrical Tests	Recommended	A φ	B φ	C φ
Ductor	< 50 μ Ω	29 μ Ω	30 μ Ω	28 μ Ω
Megger (see sheets)				

Close and Trip coil pickup tests	Actual			
	Close coil	90-130volts	VDC pickup	
Trip coil	70-140 volts	VDC pickup		

**Comments:**

Upon initial inspection the breaker was found to be in good overall condition. Measurements were not taken as part of this inspection.

The primary and secondary contacts stabs appeared to be very dry and lacking grease. These should be regreased with a High Voltage type grease before the unit is placed in service.

Tested By: S. Mills

Witnessed \_\_\_\_\_



**ENGINEERING APPRAISAL**

**Megaohm Insulation Resistance Testing Data**

<b>Turbine Technologies Construction</b>	<b>10/02/01</b>
CUSTOMER	DATE
<b>Midsun Co-Gen</b>	<b>15 kV Switchgear</b>
PROJECT	LOCATION
<b>52P Station Service Breaker/Serial # 830518</b>	<b>Fellows, CA</b>
UNIT UNDER TEST	CUSTOMER SITE
<b>001044</b>	<b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER	E SQUARED CONTRACT NUMBER

GENERAL: This Appraisal Standard provides a checklist of tests to be performed during an appraisal and serves as a permanent record of data taken during the appraisal upon which recommendations for corrective action will be made. *Refer to applicable instruction books for details.*

**Environment:** Temperature = 85 °F      Relative Humidity = Dry  
**Test Equipment:** Amprobe Model # AMB-5kV

TESTING RESULTS				
Test Connection	Resistance in $\Omega$		Test Connection	Resistance in $\Omega$
Breaker Open	1 Minute		Breaker Closed	1 Minute
Pole 1 to ground	500 Giga $\Omega$		Pole 1 to ground	500 Giga $\Omega$
Pole 2 to ground	500 Giga $\Omega$		Pole 2 to ground	500 Giga $\Omega$
Pole 3 to ground	500 Giga $\Omega$		Pole 3 to ground	500 Giga $\Omega$
Pole 4 to ground	500 Giga $\Omega$			
Pole 5 to ground	500 Giga $\Omega$			
Pole 6 to ground	500 Giga $\Omega$			
Pole 1 to Pole 2	> 500 Giga $\Omega$			
Pole 3 to Pole 4	> 500 Giga $\Omega$			
Pole 5 to Pole 6	> 500 Giga $\Omega$			

**Comments** Tests were performed @ 5000 volts. Results are satisfactory. The secondaries were tested at 500 volts to ground results were better than 10 Giga  $\Omega$ .

Tested By: S. Mills

Witnessed By: \_\_\_\_\_



15KV Switchgear-Timing and Trip tests of Breakers  
Midsun Cogen  
November 15, 2001

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**Timing and 70% control voltage trip testing-  
Breaker 52P-**

Testing was performed on this breaker to determine the amount of time between a trip signal being given to the trip coil of the breaker and the main contacts actually coming to a closed position. The nameplate of this breaker denotes it as a 3-cycle breaker. On a 60 Hz system, this is equivalent to 0.05 seconds. Therefore, this breaker should trip (and close) the main contacts, after receiving a trip (or close) signal, in 0.05 seconds or less.

To perform this test, it was necessary to implement an interposing relay. In this case, a simple two (2) contact GE relay was used (type HGA auxiliary relay). Since the use of this relay would add more delay into the overall system, a timing test of this relay alone was performed. The average of 25 trials was found to be 24.51 milliseconds. This time will be subtracted from all times taken from the breaker timing tests.

Also, in order to initiate a trip or close signal to the breaker, it will be necessary to simply connect two terminal points, thereby bypassing the various lockouts, control switches, etc. in the breaker control scheme.

For the trip signal to the 52M breaker, terminal points TBC1(7) and TBC1(11) were connected. This connection was made through the interposing relay. By using this setup, the Doble test set could be used to both give the output necessary to actuate the interposing relay and also to sense the opening of the main contacts on the breaker. The following data was taken:

<u>Trail</u>	<u>Time</u>
1	45.67 msec
2	45.38 msec
3	47.45 msec

After subtracting the time delay from the interposing relay, the results would be thus:

<u>Trial</u>	<u>Time</u>
1	21.16 msec
2	20.87 msec
3	22.94 msec

These times indicate that the breaker trip time is well within its rated time of 3 cycles.



**15KV Switchgear-Timing and Trip tests of Breakers  
Midsun Cogen  
November 15, 2001**

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The next test performed on this breaker was the closing time test. The same setup mentioned above was used for this test, however, terminal points TBC1(8) and TBC1(9) were connected instead. The following data was taken:

<u>Trial</u>	<u>Time</u>
1	73.47 msec
2	74.70 msec
3	71.94 msec

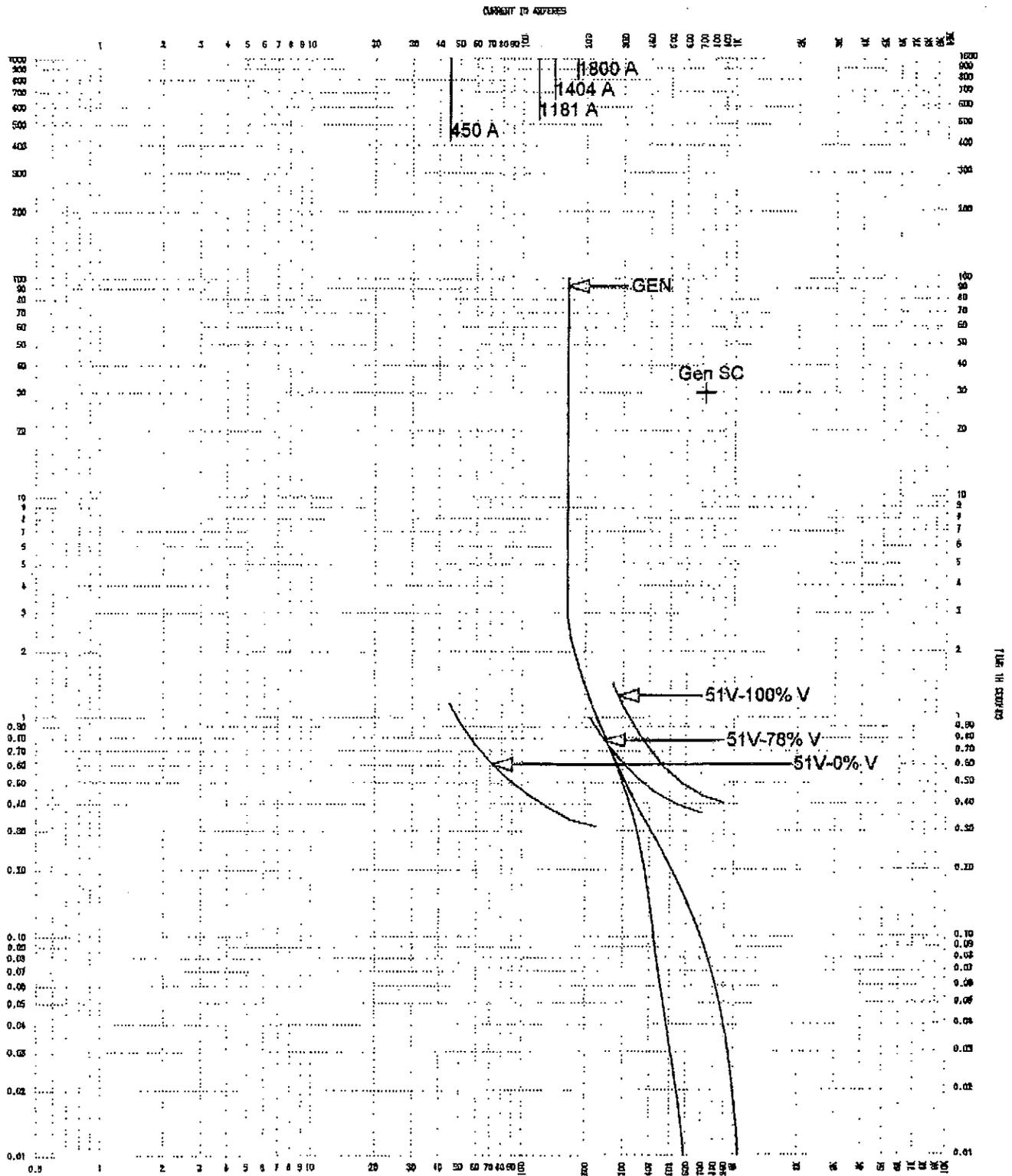
After subtracting the interposing relay time delay, the closing time is thus:

<u>Trial</u>	<u>Time</u>
1	48.96 msec
2	50.19 msec
3	47.43 msec

These times indicate a close time of less than 4 cycles. This is acceptable.

The last test performed on this breaker was a 70% control power trip test. To perform this test, the 125 VDC batteries were reconfigured so as to supply a maximum of 87.5 VDC (70% of 125 VDC). Since a properly functioning battery charging system was not installed at the time of this test, the actual battery voltage was found to be 85 VDC. Since the PG&E requirements state that breaker must have the ability to trip at 70% or less, this lower voltage is fine.

After the 85 VDC was applied to the breaker control system (and the breaker being closed beforehand) terminal points TBC1(7) and TBC1(11) were jumpered to initiate the trip coil. This breaker tripped satisfactorily at less than 70% control voltage.



TCC Name: Gen 51V  
Online: Generator Voltage Restraint Protection  
7 November, 2001 9:34 AM

Current Scale X10

Reference Voltage: 13800

E Squared Power Systems, Inc.

TCC Name: Gen 51V.tcc  
 Reference Voltage: 13800  
 Current Scale X 10^4

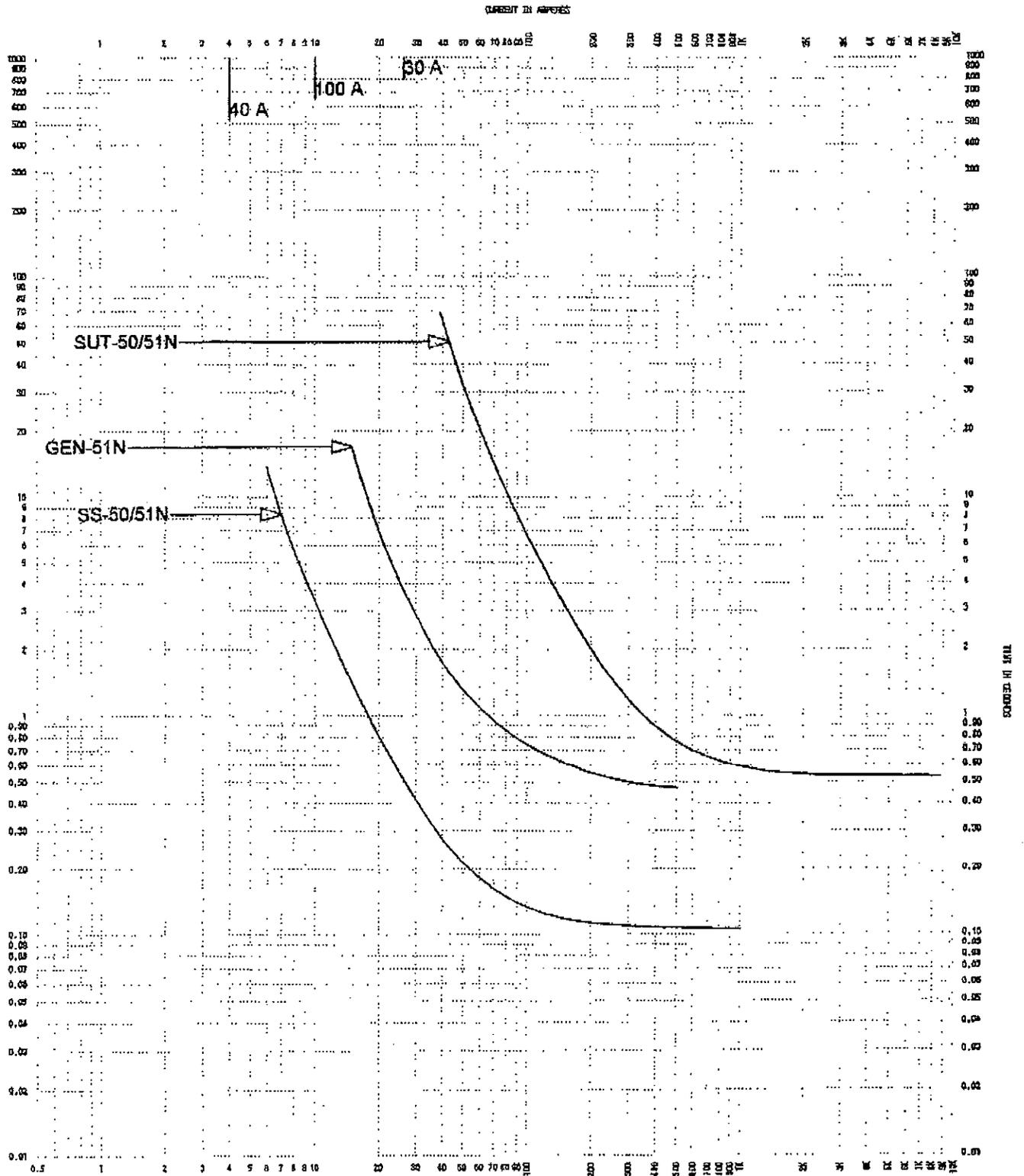
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 AND APPLICATION BY A REGISTERED ENGINEER ONLY.  
 CAPTOR (Computer Aided Plotting for Time Overcurrent Reporting)  
 COPYRIGHT SKM SYSTEMS ANALYSIS, INC. 1998  
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Device Name:	GEN	Bus Name:	
Description:	Generator Decrement Curve	Bus Voltage:	13800V
Sized:	28229.0KVA	Fault Duty:	200000.0A
Power Factor:	0.800 Lead		
Xd':	0.1620	Td':	0.0260
Xd'':	0.2220	Td'':	0.6400
Xd:	2.18	Ta:	0.2000
		Irg:	1.0000
		If:	3.0000

Device Name:	51V-100% V	Bus Name:	
Description:	GE-IJCV 100%-50/51V	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	20000.0A
Current Rating:	1500A / 5A	Curve Multiplier:	1.00000
Setting: 1) LTPU	8.0	Test Points:	
2) Time Dials	<del>2.18</del> 1.0	e2.OX, 0.831s	
		e5.OX, 0.403s	

Device Name:	51V-70% V	Bus Name:	
Description:	GE-IJCV 70%-50/51V	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	20000.0A
Current Rating:	1500A / 5A	Curve Multiplier:	1.00000
Setting: 1) LTPU	4.88	Test Points:	
2) Time Dials	<del>2.18</del> 1.0	e2.OX, 0.664s	
		e5.OX, 0.383s	

Device Name:	51V-0% V	Bus Name:	
Description:	GE-IJCV 0%-50/51V	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	20000.0A
Current Rating:	1500A / 5A	Curve Multiplier:	1.00000
Setting: 1) LTPU	1.5	Test Points:	
2) Time Dials	<del>2.18</del> 1.0	e2.OX, 0.488s	
		e5.OX, 0.312s	



TCC Name: 50/51N  
 Online: Ground Protection Coordination  
 7 November, 2001 2:21 PM

Current Scale X10

Reference Voltage: 13800

E Squared Power Systems, Inc.

TCC Name: 50/51N.tcc  
 Reference Voltage: 13800  
 Current Scale X 10A1

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 -----

Device Name:	SS-50/51N	Bus Name:	
Description:	SEL-501-M,I,V,E	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	200A / 5A	Curve Multiplier:	1.00000
Setting: 1) Tap	1.0	Test Points:	
2) [E] EXTREMELY	3.0	2.0X, 5.778s	
		5.0X, 0.814s	

Device Name:	GEN-51N	Bus Name:	
Description:	GE-IAC 53-50/51	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	100A / 5A	Curve Multiplier:	1.00000
Setting: 1) LTPU	5.0	Test Points:	
2) Time Dial	5.0	2.0X, 7.000s	
		5.0X, 1.310s	

Device Name:	SUT-50/51N	Bus Name:	
Description:	SEL-601-M,I,V,E	Bus Voltage:	120000.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	300A / 5A	Curve Multiplier:	1.00000
Setting: 1) Tap	0.5	Test Points:	
2) [E] EXTREMELY	15.0	2.0X, 28.878s	
		5.0X, 4.072s	



MIDSUN COGEN PROJECT  
 LM2500 TG UNIT NO. 1, FELLOWS, CA  
 PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

## Protective Relay Setting Review

### *Beckwith M-3420-*

This relay is utilized for generator protection. The generator has the following rating:

28.23 MVA, 22.575 Mega-watts, 0.8 Power Factor, 13,800 Volts, 1181 Amperes (This rating is based on 15°C Cold Air Temperature)

### 24 Volts per Hertz

Volts per hertz protection is used to protect the generator, generator terminal connected transformers and step-up transformer from excessive magnetic flux density levels. The protection settings are based on the combined typical limiting curves for V/Hz operation of the generator and of the transformer.

Recommended setting:	Trip	DT #1	Pickup 118%, Time Delay 150 cycles
	Alarm	DT #2	Pickup 110%, Time Delay 300 cycles
	Trip	Inverse Pickup	110%, Curve 1, TD 10
		Reset Time	240 seconds

### 27 RMS Under-voltage

Under-voltage protection is supplied as a backup to the 40-Loss of Excitation function. The input to this function will be the generator potential transformers rated 14,400 to 120 volts. This protection should trip the generator breaker on the occurrence of 80% generator voltage while loaded, therefore, this function should be blocked until the generator breaker is closed.

Recommended setting:	Trip	27 #1	Pickup 92 volts, Time Delay 180 cycles
		27 #2	Disabled



MIDSUN COGEN PROJECT  
 LM2500 TG UNIT NO. 1, FELLOWS, CA  
 PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

### 32 Directional Power

The reverse power protection should protect the prime mover in the event of loss of fuel and the resultant motoring of the generator. Typical gas turbine prime movers will require approximately 50% of the generator rating to continue rated rotation speeds. This reverse power requirement should provide sensing at levels 5 to 10 times the minimum pickup setting of the protective relaying. Typical time delays are approximately 10-15 seconds. (ANSI/IEEE Std. 242-1986, 11.4.4) The CT ratio is 300:1 and PT ratio is 120:1.

22.575 MW gen = 11.29 MW to motor turbine = 313.5 secondary watts  
 Relay sensitivity = 31.4 – 62.7 secondary watts = 0.1 – 0.05 PU.

The second element of the directional power function can be set to alarm overloading conditions on the generator.

Recommended setting:	Trip 32 #1	Pickup -0.05 PU, Time Delay 600 cycles
	Alarm 32 #2	Pickup 1.1 PU, Time Delay 600 cycles

### 40 Loss of Field

This function is set per the recommendations of ANSI/IEEE Std. 242-1986, 11.4.6 and Beckwith M-3420 first approach.

Generator impedance data was supplied on 26.275 MVA base, 12.47 KV base. This equates to 5.92 ohms base primary. The new base is 28.22 MVA and 13.8 KV. This equates to 6.75 ohms base primary = 16.87 ohms secondary

$$x'd = 0.254 \text{ PU} = 3.75 \text{ ohms}$$

$$x'd \div 2 = 1.88 \text{ ohms}$$

$$x_d = 2.47 \text{ PU} = 36.56 \text{ ohms}$$

Recommended settings:	Lockout 40 #1	Diameter 16.9 ohms, Offset -1.9 ohms, Time Delay 15 cycles
	Lockout 40 #2	Diameter 36.6 ohms, Offset -1.9 ohms, Time Delay 45 cycles



MIDSUN COGEN PROJECT  
 LM2500 TG UNIT NO. 1, FELLOWS, CA  
 PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

### 46 Negative Sequence Over-current

This generator is of type indirectly air cooled, revolving field, cylindrical rotor, brushless excitation. The ability to withstand these negative sequence currents is defined by ANSI C50.13-1977 as  $I_2t = K$ . K will be 30 for this type of generator. Damages are possible at negative sequence currents above 0.15 PU.

Recommended settings:	Alarm	46DT	Pickup 7%, Time Delay 3600 cycles
	Trip	46IT	Pickup 12%, Time Dial 30
	Lockout		Max Time 36000 cycles

### 50/50N Instantaneous Over-current, Phase and Neutral Circuits

These functions are disabled.

### 50/27 Inadvertent Energization

Recommended setting:	Trip	50/27 Pickup 1.0 A, Time Delay 3 cycles
		50/27 Voltage Control 80 V

### 50BF Generator Breaker Failure / HV Breaker Flashover

This function should be initiated by the operation of the generator breaker 52G/b contact into Input 1.

Recommended setting:	Lockout	50BF	Neutral Element Enabled
		50BF	Neutral Pickup 0.5 A
		50BF	Phase Element Enabled
		50BF	Phase Pickup 0.5 A, Time Delay 30 cycles





MIDSUN COGEN PROJECT  
 LM2500 TG UNIT NO. 1, FELLOWS, CA  
 PROTECTIVE RELAY SETTING SELECTION

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NOVEMBER 7, 2001

### 60FL VT Fuse-Loss Detection

This feature will be utilized for blocking of the functions of 50/27, 27 and 51C (if utilized).

Recommended setting: Alarm 60FL Input Initiate NONE, Delay 25 cycles

### 81 Frequency

Recommended setting:	Trip	81 #1	Pickup 63.00 hertz, Delay 30 cycles
	Trip	81 #2	Pickup 58.0 hertz, Delay 10800 cycles
	Trip	81 #3	Pickup 57.0 hertz, Delay 3600 cycles
	Trip	81 #4	Pickup 55.0 hertz, Delay 30 cycles

### 87 Generator Phase Differential Over-current

Recommended setting:	Trip	87	Pickup 0.2 A, Time Delay 1 cycle
	Lockout	87	Slope 10%

### 87GD Ground Differential Over-current

This function is disabled because it can not be utilized with the existing current transformer ratios. The phase current transformers have a 300:1 ratio and the ground sensing current transformer has a ratio of 20:1. The maximum ratio error compensation available on the M-3420 is 7.99.



MIDSUN COGEN PROJECT  
LM2500 TG UNIT NO. 1, FELLOWS, CA  
GENERATOR PROTECTION RELAYS  
TESTING PROCEDURES AND RESULTS

---

November 25, 2001

## I. Testing Procedures

The following is a list of General Test Equipment required in complete testing of the Beckwith M-3420 generator protection relay (M-3420-BG):

- a. Doble F3S three phase voltage/three phase current supply
- b. Doble test set with variable frequency voltage outputs
- c. Laptop PC with IPScom software installed
- d. Digital Multimeter
- e. Alligator clip jumpers

### Pre-Operational Checks

Conducted visual inspection to ensure wiring was properly connected to pertinent relay inputs. Applied 125VDC control power to both relays and inspected relays performing proper power up checks (as noted by sequence lighting of front panel LED's).

### A. Relay Functional Tests

Functional testing of the Beckwith M-3420 relay (M-3420-BG) was performed per the recommended testing procedures as dictated within the Beckwith M-3420 Instruction Manual. Refer to the Beckwith M-3420 Instruction Manual for details on each functional test. The following pages outline the "as set" relay settings and the corresponding "as tested" values recorded during testing for the relay (M-3420-BG).

Note: "DT" = Definite Time  
"IT" = Inverse Time  
"pu" = Per Unit  
"P.U." = PickUp



**Test Results of M-3420-BG**

<u>Function (#)</u>	<u>As Set</u>	<u>As Tested</u>	
<u>Volts/Hertz (24)</u>	Trip (52G) DT #1: P.U.=118% Time Delay=150 cycles	Ph. A P.U.=119% Delay=165.6 cycles	
		Ph. B P.U.=119% Delay=160.2 cycles	
		Ph. C P.U.=118% Delay=164.4 cycles	
	Alarm DT #2: P.U.=110% Time Delay=300 cycles	Ph. A P.U.=111% Delay=313 cycles	
		Ph. B P.U.=111% Delay=316 cycles	
		Ph. C P.U.=110% Delay=316 cycles	
	Trip (52G) IT P.U.=110% Curve=1 Time Dial=10 Reset Time=240 sec. Test Points chosen: 120% trips in ~ 45sec 130% trips in ~20.4sec 140% trips in ~11.4sec	Ph. A 120% 46.81 sec 130% 21.26 sec 140% 11.70 sec	
			Ph. B 120% 51.51 sec 130% 22.15 sec 140% 12.32 sec
		<u>Undervoltage (27)</u>	Trip (52G) #1: P.U.=92 volts Time Delay=30 cycles
Ph. B 92 V 0.53 sec			
Ph. C 92 V 0.53 sec			
<u>Directional Power (32)</u>	Trip (52G) #1: P.U.= -0.05 pu = 0.1965A Time Delay=600 cycles Ph. Angle Characteristics: Voltage (Open Delta)  Current (Wye)	0.2A 612 cycles  Ph. A: 0 deg. Ph. B: +60 deg. Ph. A: +150 deg. Ph. B: -30 deg. Ph. C: +90 deg.	
		Alarm #2: P.U.= 1.1 pu = 4.323A Time Delay=600 cycles Voltage (Open Delta)  Current (Wye)	



<u>Loss of Field (40)</u>	Trip (86G)	#1: Diameter=16.9 Ohms Offset= -1.9 Ohms Time Delay=15 cycles	P.U. = 3.53A	3.6A 15.4 cycles
	Trip (86G)	#2: Diameter=36 Offset= -1.9 Ohms Time Delay=45 cycles	P.U. = 1.72A	1.8A 45.3 cycles
<u>Neg. Seq. Overcurrent (46)</u>	Alarm	DT #1: P.U. 7% Time Delay=3600 cycles	P.U.=0.2751A	0.28A 3606 cycles
	Trip (52G) & (86G)	IT P.U.=12% Time Dial=30 Test Points chosen: 100% trips in ~30 sec 200% trips in ~7.5 sec 300% trips in ~3 sec		29.1 sec 7.5 sec 3.4 sec
<u>Breaker Failure (50BF/50N)</u>	Trip (52M)	Neutral P.U.=0.5A Time Delay=30 cycles Phase P.U.=0.5A Time Delay=30 cycles		0.5A 0.52 sec 0.5A 0.52 sec
	Trip (52G)	Tap=0.5 Time Dial=4 Curve=Inverse Test Points (multiples of tap): 2 trips in ~8.5 sec 3 trips in ~3.5 sec 5 trips in ~1.7 sec		8.8 sec 3.5 sec 2.2 sec
<u>IT Ph. OC w/ V Rest. (51V)</u>	Trip (52G) & (86G)	Tap=6A Time Dial=1 Curve=Inverse V control=V Restraint Test Points (multiples of tap): 2 trips in ~2 sec 2.5 trips in ~1.5 sec 3 trips in ~0.85 sec		2.2 sec 1.3 sec 0.9 sec
	Trip (52G)	P.U.=1A Time Delay=3 cycles V control=80V Dropout=60 cycles		1.0A 2.94 cycles 81V 59.28 cycles
<u>Phase Overvoltage (59)</u>	Trip (52G)	#1: P.U.=132V Time Delay=6 cycles		132V 21.6 cycles
	Alarm	#2: P.U.=129V Time Delay=300 cycles		130V 309.6 cycles



Fuse Loss (60FL)

Alarm	Time Delay=25 cycles	Ph. A	25.86 cycles
		Ph. B	26.7 cycles

Frequency (81)

Trip (52G)	#1: P.U.=63Hz Time Delay=30 cycles	63Hz	29.03 cycles
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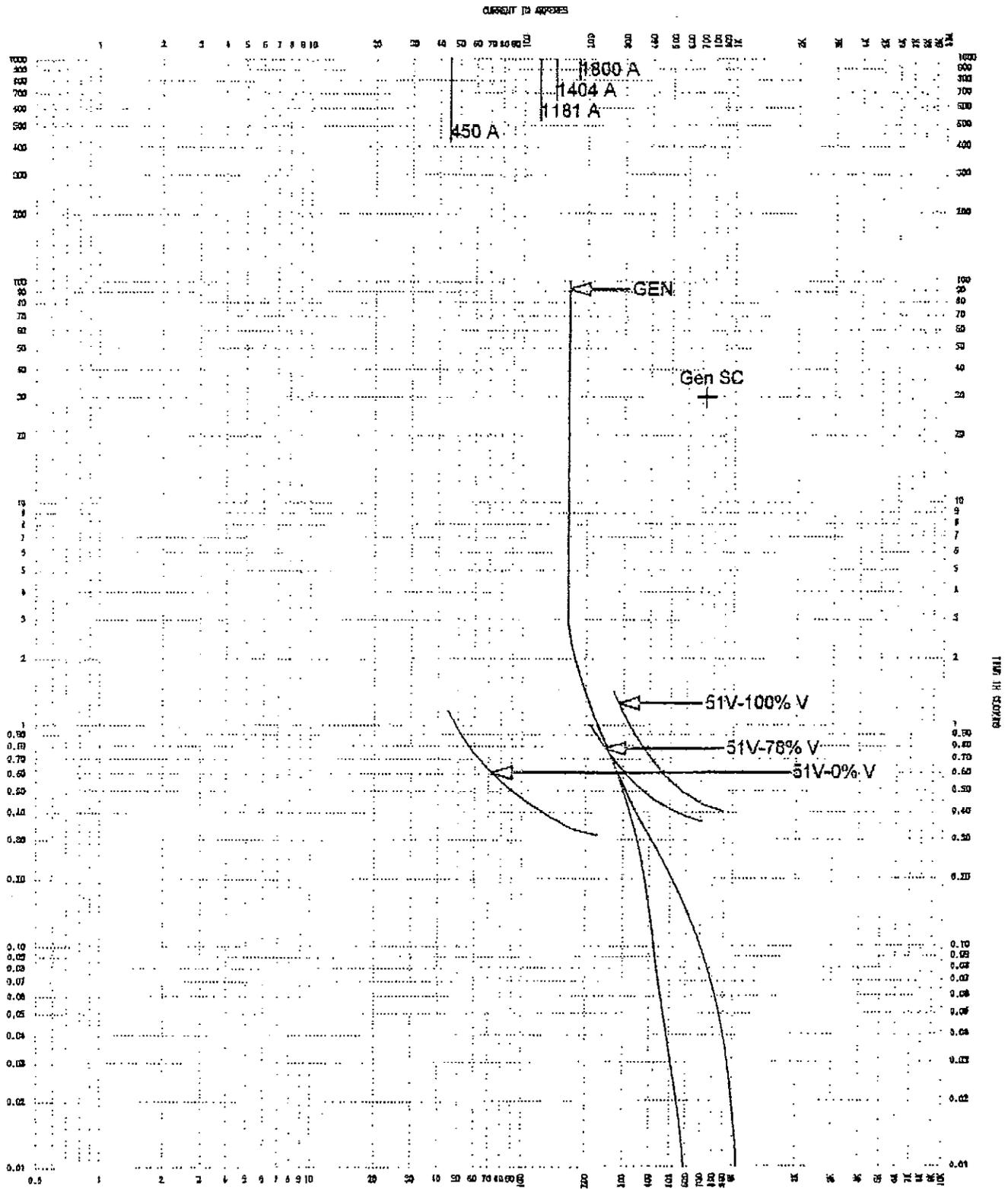
Trip (52G)	#2: P.U.=58Hz Time Delay=10800 cycles	58Hz	10809 cycles
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Trip (52G)	#3: P.U.=57Hz Time Delay=3600Hz	57Hz	3601 cycles
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Trip (52G)	#4: P.U.=55Hz Time Delay=30 cycles	55Hz	27.79 cycles
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Gen. Ph. Diff. OC (87)

Trip (52G) & (86G)	P.U.=0.2A Time Delay=1 cycle Slope=10%	0.18A	1.2 cycles 10%
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TCC Name: Gen 51V

Current Scale X10

Reference Voltage: 13800

Online: Generator Voltage Restraint Protection

7 November, 2001 9:34 AM

E Squared Power Systems, Inc.

TCC Name: Gen 51V.tcc  
Reference Voltage: 13800  
Current Scale X 10^4

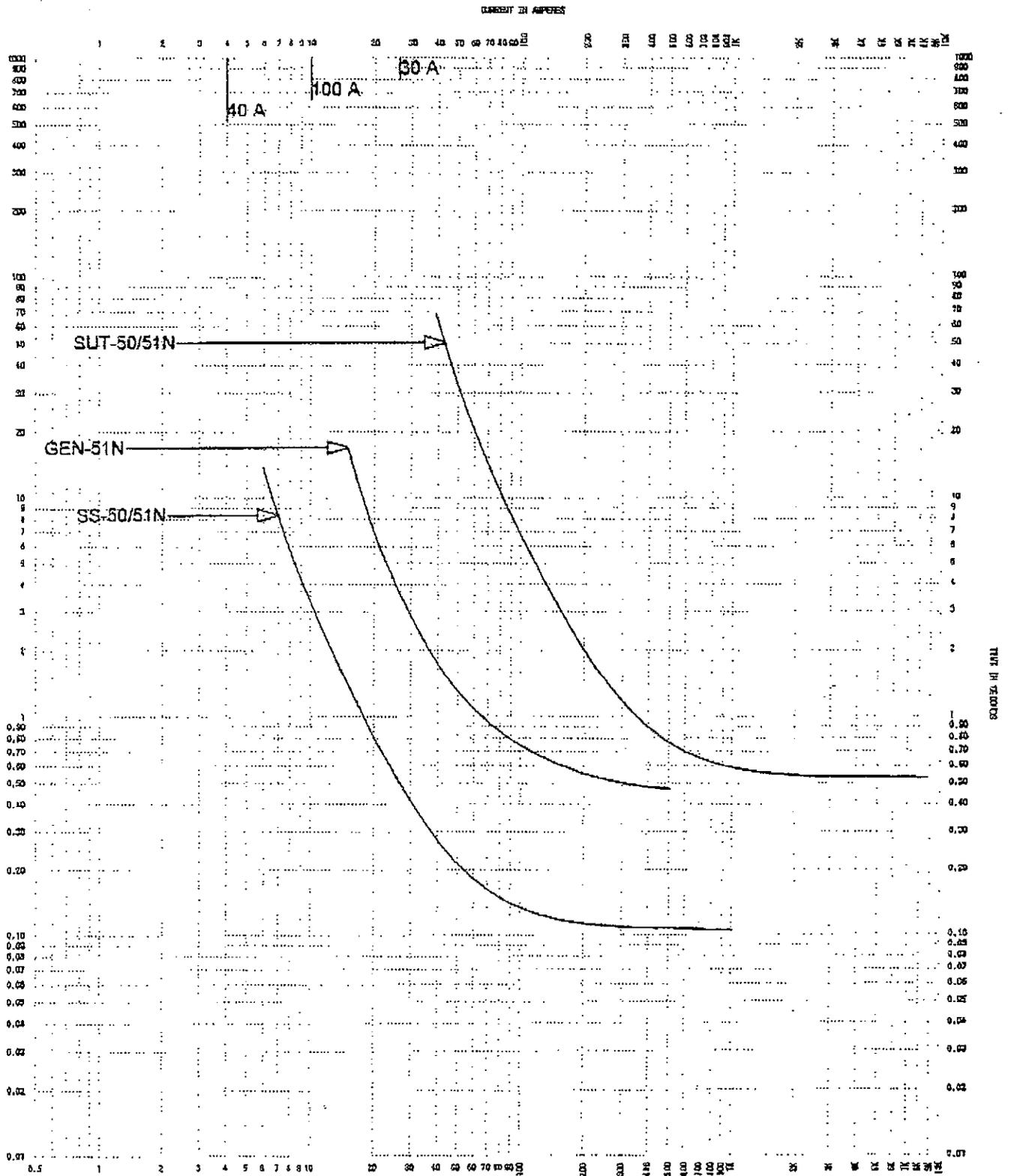
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-----  
Device Name: GEN  
Description: Generator Decrement Curve  
Sized: 29229.0KVA  
Power Factor: 0.800 Lead  
Xd': 0.1620 Td': 0.0260  
Xd': 0.2220 Td': 0.6400  
Xd: 2.18 Ta: 0.2000  
Bus Name:  
Bus Voltage: 13800V  
Fault Duty: 200000.0A  
Ifg: 1.0000  
If: 3.0000  
-----

Device Name: 51V-100% V  
Description: GE-IJCV 100%-50/51V  
AIC Rating: N/A  
Current Rating: 1500A / 5A  
Setting: 1) LTPU 8.0  
2) Time Dials ~~2.75~~ 1.0  
Bus Name:  
Bus Voltage: 13800.0V  
Fault Duty: 20000.0A  
Curve Multiplier: 1.00000  
Test Points:  
e2.0X, 0.831s  
e5.0X, 0.403s  
-----

Device Name: 51V-78% V  
Description: GE-IJCV 78%-50/51V  
AIC Rating: N/A  
Current Rating: 1500A / 5A  
Setting: 1) LTPU 4.88  
2) Time Dials ~~2.75~~ 1.0  
Bus Name:  
Bus Voltage: 13800.0V  
Fault Duty: 20000.0A  
Curve Multiplier: 1.00000  
Test Points:  
e2.0X, 0.664s  
e5.0X, 0.363s  
-----

Device Name: 51V-0% V  
Description: GE-IJCV 0%-50/51V  
AIC Rating: N/A  
Current Rating: 1500A / 5A  
Setting: 1) LTPU 1.5  
2) Time Dials ~~2.75~~ 1.0  
Bus Name:  
Bus Voltage: 13800.0V  
Fault Duty: 20000.0A  
Curve Multiplier: 1.00000  
Test Points:  
e2.0X, 0.498s  
e5.0X, 0.312s  
-----



TCC Name: 50/51N                      Current Scale X10                      Reference Voltage: 13800  
Oneline:                      Ground Protection Coordination  
7 November, 2001 2:21 PM                      E Squared Power Systems, Inc.

TCC Name: 50/51N.tcc  
 Reference Voltage: 13800  
 Current Scale X 10<sup>4</sup>

-----  
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 AND APPLICATION BY A REGISTERED ENGINEER ONLY.  
 CAPTOR (Computer Aided Plotting for Time Overcurrent Reporting)  
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Device Name:	SS-50/51N	Bus Name:	
Description:	SEL-501-M.I.V.E	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	200A / 5A	Curve Multiplier:	1.00000
Setting: 1) Tap	1.0	Test Points:	
2) [E] EXTREMELY	3.0	e2.0X, 5.776s	
		e5.0X, 0.814s	

Device Name:	GEN-51N	Bus Name:	
Description:	GE-IAC 53-50/51	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	100A / 5A	Curve Multiplier:	1.00000
Setting: 1) LTPU	5.0	Test Points:	
2) Time Dials	5.0	e2.0X, 7.000s	
		e5.0X, 1.310s	

Device Name:	SUT-50/51N	Bus Name:	
Description:	SEL-501-M.I.V.E	Bus Voltage:	120000.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	300A / 5A	Curve Multiplier:	1.00000
Setting: 1) Tap	0.5	Test Points:	
2) [E] EXTREMELY	15.0	e2.0X, 28.878s	
		e5.0X, 4.072s	



MIDSUN COGEN PROJECT  
 LM2500 TG UNIT NO. 1, FELLOWS, CA  
 PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

## Protective Relay Setting Review

### ***Beckwith M-3420-***

This relay is utilized for generator protection. The generator has the following rating:

28.23 MVA, 22.575 Mega-watts, 0.8 Power Factor, 13,800 Volts, 1181 Amperes (This rating is based on 15°C Cold Air Temperature)

### **24 Volts per Hertz**

Volts per hertz protection is used to protect the generator, generator terminal connected transformers and step-up transformer from excessive magnetic flux density levels. The protection settings are based on the combined typical limiting curves for V/Hz operation of the generator and of the transformer.

<b>Recommended setting:</b>	<b>Trip</b>	<b>DT #1</b>	<b>Pickup 118%, Time Delay 150 cycles</b>
	<b>Alarm</b>	<b>DT #2</b>	<b>Pickup 110%, Time Delay 300 cycles</b>
	<b>Trip</b>	<b>Inverse Pickup</b>	<b>110%, Curve 1, TD 10</b>
		<b>Reset Time</b>	<b>240 seconds</b>

### **27 RMS Under-voltage**

Under-voltage protection is supplied as a backup to the 40-Loss of Excitation function. The input to this function will be the generator potential transformers rated 14,400 to 120 volts. This protection should trip the generator breaker on the occurrence of 80% generator voltage while loaded, therefore, this function should be blocked until the generator breaker is closed.

<b>Recommended setting:</b>	<b>Trip</b>	<b>27 #1</b>	<b>Pickup 92 volts, Time Delay 180 cycles</b>
		<b>27 #2</b>	<b>Disabled</b>



MIDSUN COGEN PROJECT  
LM2500 TG UNIT NO. 1, FELLOWS, CA  
PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

**32 Directional Power**

The reverse power protection should protect the prime mover in the event of loss of fuel and the resultant motoring of the generator. Typical gas turbine prime movers will require approximately 50% of the generator rating to continue rated rotation speeds. This reverse power requirement should provide sensing at levels 5 to 10 times the minimum pickup setting of the protective relaying. Typical time delays are approximately 10-15 seconds. (ANSI/IEEE Std. 242-1986, 11.4.4) The CT ratio is 300:1 and PT ratio is 120:1.

22.575 MW gen = 11.29 MW to motor turbine = 313.5 secondary watts  
Relay sensitivity = 31.4 –62.7 secondary watts = 0.1 – 0.05 PU.

The second element of the directional power function can be set to alarm overloading conditions on the generator.

Recommended setting:	Trip	32 #1	Pickup -0.05 PU, Time Delay 600 cycles
	Alarm	32 #2	Pickup 1.1 PU, Time Delay 600 cycles

**40 Loss of Field**

This function is set per the recommendations of ANSI/IEEE Std. 242-1986, 11.4.6 and Beckwith M-3420 first approach.

Generator impedance data was supplied on 26.275 MVA base, 12.47 KV base. This equates to 5.92 ohms base primary. The new base is 28.22 MVA and 13.8 KV. This equates to 6.75 ohms base primary = 16.87 ohms secondary

$x'd = 0.254 \text{ PU} = 3.75 \text{ ohms}$   
 $x'd \div 2 = 1.88 \text{ ohms}$   
 $x_d = 2.47 \text{ PU} = 36.56 \text{ ohms}$

Recommended settings:	Lockout	40 #1	Diameter 16.9 ohms, Offset -1.9 ohms, Time Delay 15 cycles
	Lockout	40 #2	Diameter 36.6 ohms, Offset -1.9 ohms, Time Delay 45 cycles



MIDSUN COGEN PROJECT  
LM2500 TG UNIT NO. 1, FELLOWS, CA  
PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

**46 Negative Sequence Over-current**

This generator is of type indirectly air cooled, revolving field, cylindrical rotor, brushless excitation. The ability to withstand these negative sequence currents is defined by ANSI C50.13-1977 as  $I_2t = K$ . K will be 30 for this type of generator. Damages are possible at negative sequence currents above 0.15 PU.

Recommended settings:	Alarm	46DT	Pickup 7%, Time Delay 3600 cycles
	Trip	46IT	Pickup 12%, Time Dial 30
	Lockout		Max Time 36000 cycles

**50/50N Instantaneous Over-current. Phase and Neutral Circuits**

These functions are disabled.

**50/27 Inadvertent Energization**

Recommended setting:	Trip	50/27 Pickup 1.0 A, Time Delay 3 cycles
		50/27 Voltage Control 80 V

**50BF Generator Breaker Failure / HV Breaker Flashover**

This function should be initiated by the operation of the generator breaker 52G/b contact into Input 1.

Recommended setting:	Lockout	50BF	Neutral Element Enabled
		50BF	Neutral Pickup 0.5 A
		50BF	Phase Element Enabled
		50BF	Phase Pickup 0.5 A, Time Delay 30 cycles



MIDSUN COGEN PROJECT  
 LM2500 TG UNIT NO. 1, FELLOWS, CA  
 PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

### 51N Neutral Over-current

This relay should be coordinated with the neutral over-current protection of the downstream neutral over-current devices such as the station service transformer and the step up transformer.

Recommended settings:	Trip	51N Tap 0.5 A
		51N Curve, Inverse, Time Dial 4.0

### 51V Voltage Restraint Over-currents

The setting of this function is based on ANSI/IEEE Std. 242-1986, 11.4.1.2.2. The pickup level should be equal to or greater than 150% of the generator full load current level. The rated full load current of this generator is 1181 amperes. This equates to a secondary amperes of 3.93 amperes.

Recommended settings:	Trip	51V Tap 6.0 A
	Lockout	51V Curve, Inverse, Time Dial 1.0
		51V Voltage Control, v_rstrnt

### 59 RMS Over-voltage (Phase)

This setting is based on the rated voltage of the generator and bus of 13.8 KV and the potential transformer ratio of 14400:120 volts. The M-3420 will alarm at 112% voltage and trip at 115% voltage.

Recommended setting:	Trip	59 #1	Pickup 132 volts, Time Delay 6 cycles
	Alarm	59 #2	Pickup 129 volts, Time Delay 300 cycles

### 59 RMS Over-voltage (Neutral)

This function is disabled due to the existence of low resistance grounding of the generator neutral.



MIDSUN COGEN PROJECT  
 LM2500 TG UNIT NO. 1, FELLOWS, CA  
 PROTECTIVE RELAY SETTING SELECTION

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NOVEMBER 7, 2001

### 60FL VT Fuse-Loss Detection

This feature will be utilized for blocking of the functions of 50/27, 27 and 51C (if utilized).

Recommended setting: Alarm 60FL Input Initiate NONE, Delay 25 cycles

### 81 Frequency

Recommended setting:	Trip	81 #1	Pickup 63.00 hertz, Delay 30 cycles
	Trip	81 #2	Pickup 58.0 hertz, Delay 10800 cycles
	Trip	81 #3	Pickup 57.0 hertz, Delay 3600 cycles
	Trip	81 #4	Pickup 55.0 hertz, Delay 30 cycles

### 87 Generator Phase Differential Over-current

Recommended setting:	Trip	87	Pickup 0.2 A, Time Delay 1 cycle
	Lockout	87	Slope 10%

### 87GD Ground Differential Over-current

This function is disabled because it can not be utilized with the existing current transformer ratios. The phase current transformers have a 300:1 ratio and the ground sensing current transformer has a ratio of 20:1. The maximum ratio error compensation available on the M-3420 is 7.99.



MIDSUN COGEN PROJECT  
LM2500 TG UNIT NO. 1, FELLOWS, CA  
GENERATOR PROTECTION RELAYS  
TESTING PROCEDURES AND RESULTS

November 25, 2001

## I. Testing Procedures

The following is a list of General Test Equipment required in complete testing of the Beckwith M-3420 generator protection relay (M-3420-GG):

- a. Doble F3S three phase voltage/three phase current supply
- b. Doble test set with variable frequency voltage outputs
- c. Laptop PC with IPScom software installed
- d. Digital Multimeter
- e. Alligator clip jumpers

### Pre-Operational Checks

Conducted visual inspection to ensure wiring was properly connected to pertinent relay inputs. Applied 125VDC control power to both relays and inspected relays performing proper power up checks (as noted by sequence lighting of front panel LED's).

### A. Relay Functional Tests

Functional testing of the Beckwith M-3420 relay (M-3420-GG) was performed per the recommended testing procedures as dictated within the Beckwith M-3420 Instruction Manual. Refer to the Beckwith M-3420 Instruction Manual for details on each functional test. The following pages outline the "as set" relay settings and the corresponding "as tested" values recorded during testing for the relay (M-3420-GG).

Note: "DT" = Definite Time  
"IT" = Inverse Time  
"pu" = Per Unit  
"P.U." = PickUp



Test Results of M-3420-GG

<u>Function (#)</u>	<u>As Set</u>	<u>As Tested</u>			
<u>Volts/Hertz (24)</u>	Trip (52G) DT #1: P.U.=118% Time Delay=150 cycles	Ph. A P.U.=119% Delay=167 cycles			
		Ph. B P.U.=119% Delay=159 cycles			
		Ph. C P.U.=119% Delay=160 cycles			
	Alarm DT #2: P.U.=110% Time Delay=300 cycles	Ph. A P.U.=111% Delay=316 cycles			
		Ph. B P.U.=111% Delay=312 cycles			
		Ph. C P.U.=111% Delay=312 cycles			
	Trip (52G) IT P.U.=110% Curve=1 Time Dial=10 Reset Time=240 sec. Test Points chosen: 120% trips in ~ 45sec 130% trips in ~20.4sec 140% trips in ~11.4sec	Ph. A 120% 45.6 sec 130% 20.4 sec 140% 11.9 sec			
			Ph. B 120% 51.9 sec 130% 21.6 sec 140% 12.4 sec		
				Ph. C 120% 48.2 sec 130% 20.4 sec 140% 11.8 sec	
		<u>Undervoltage (27)</u>			Trip (52G) #1: P.U.=92 volts Time Delay=30 cycles
			Ph. B 92 V 0.54 sec		
			Ph. C 92 V 0.53 sec		
<u>Directional Power (32)</u>		Trip (52G) #1: P.U.= -0.05 pu = 0.1965A Time Delay=600 cycles Ph. Angle Characteristics: Voltage (Open Delta)	0.2A		
			612 cycles		
			Ph. A: 0 deg.		
			Ph. B: +60 deg.		
			Ph. A: +150 deg.		
			Ph. B: -30 deg.		
	Ph. C: +90 deg.				
	Alarm #2: P.U.= 1.1 pu = 4.323A Time Delay=600 cycles Voltage (Open Delta)	4.3A			
		612 cycles			
		Ph. A: 0 deg.			
		Ph. B: +60 deg.			
		Ph. A: -30 deg.			
Ph. B: +150 deg.					
Ph. C: -90 deg.					
	Current (Wye)				



<u>Loss of Field (40)</u>	Trip (86G)	#1: Diameter=16.9 Ohms Offset= -1.9 Ohms Time Delay=15 cycles	P.U. = 3.53A	3.6A 15.3 cycles
	Trip (86G)	#2: Diameter=36 Offset= -1.9 Ohms Time Delay=45 cycles	P.U. = 1.72A	1.8A 44.8 cycles
<u>Neg. Seq. Overcurrent (46)</u>	Alarm	DT #1: P.U. 7% Time Delay=3600 cycles	P.U.=0.2751A	0.28A 3606 cycles
	Trip (52G) & (86G)	IT P.U.=12% Time Dial=30 Test Points chosen: 100% trips in ~30 sec 200% trips in ~7.5 sec 300% trips in ~3 sec		26.8 sec 6.7 sec 2.3 sec
<u>Breaker Failure (50BF/50N)</u>	Trip (52M)	Neutral P.U.=0.5A Time Delay=30 cycles Phase P.U.=0.5A Time Delay=30 cycles		0.5A 0.53 sec 0.5A 0.53 sec
	Trip (52G)	Tap=0.5 Time Dial=4 Curve=Inverse Test Points (multiples of tap): 2 trips in ~8.5 sec 3 trips in ~3.5 sec 5 trips in ~1.7 sec		8.78 sec 3.51 sec 1.67 sec
<u>IT Ph. OC w/ V Rest. (51V)</u>	Trip (52G) & (86G)	Tap=6A Time Dial=1 Curve=Inverse V control=V Restraint Test Points (multiples of tap): 2 trips in ~2 sec 2.5 trips in ~1.5 sec 3 trips in ~0.85 sec		2.04 sec 1.32 sec 0.87 sec
	Trip (52G)	P.U.=1A Time Delay=3 cycles V control=80V Dropout=60 cycles		1.0A 4.68 cycles 81V 59.19 cycles
<u>Phase Overvoltage (59)</u>	Trip (52G)	#1: P.U.=132V Time Delay=6 cycles		133V 14.88 cycles
	Alarm	#2: P.U.=129V Time Delay=300 cycles		130V 311 cycles



Fuse Loss (60FL)

Alarm	Time Delay=25 cycles	Ph. A	26.4 cycles
		Ph. B	25.56 cycles

Frequency (81)

Trip (52G)	#1: P.U.=63Hz Time Delay=30 cycles	63Hz 30.01 cycles
Trip (52G)	#2: P.U.=58Hz Time Delay=10800 cycles	58Hz 10810.2 cycles
Trip (52G)	#3: P.U.=57Hz Time Delay=3600Hz	57Hz 3603 cycles
Trip (52G)	#4: P.U.=55Hz Time Delay=30 cycles	55Hz 29.16 cycles

Gen. Ph. Diff. OC (87)

Trip (52G) & (86G)	P.U.=0.2A Time Delay=1 cycle Slope=10%	0.18A 1.45 cycles 11%
--------------------	--	-----------------------------



MIDSUN COGEN PROJECT  
LM2500 TG UNIT NO. 1, FELLOWS, CA  
PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

### ***Schweitzer SEL-501-2-X***

This relay is utilized for Step-Up Transformer protection. The transformer has the following rating:

18.5/24.6/30.8, 20.7/27.5/34.8 MVA, Class OA/FA/FA, 55°C/65°C Rise, 120 Grd Y/69.28 KV-13.8 KV, 7.8% Impedance, Configured Gnd Wye-Delta.

This relay monitors the current in the high voltage winding through current transformers with a 300:5 ratio.

See attached Schweitzer setting sheets for recommended setting.

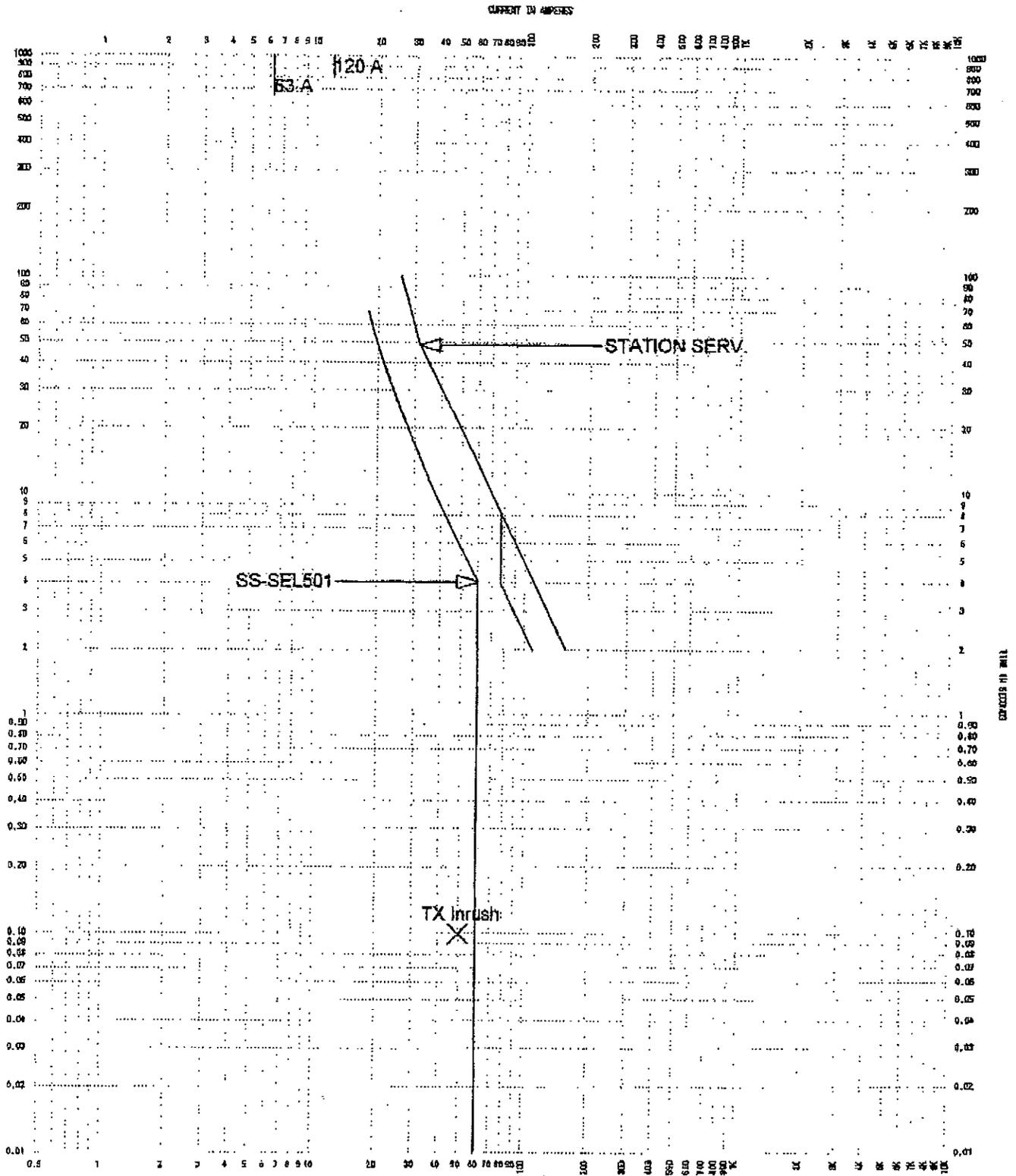
### ***Schweitzer SEL-501-2-Y***

This relay is utilized for Station Service Transformer protection. The transformer has the following rating:

1500 KVA, Class OA, 55°C, 13.8 KV-480/277 Volts, 5.8% Impedance, Configured Delta-Gnd Wye

This relay monitors the current in the high voltage winding through current transformers with a 200:5 ratio.

See attached Schweitzer setting sheets for recommended setting.



TCC Name: SS TRANS  
Oneline: Station Service Transformer Overcurrent Protection  
7 November, 2001 3:55 PM

Current Scale X10

Reference Voltage: 13800

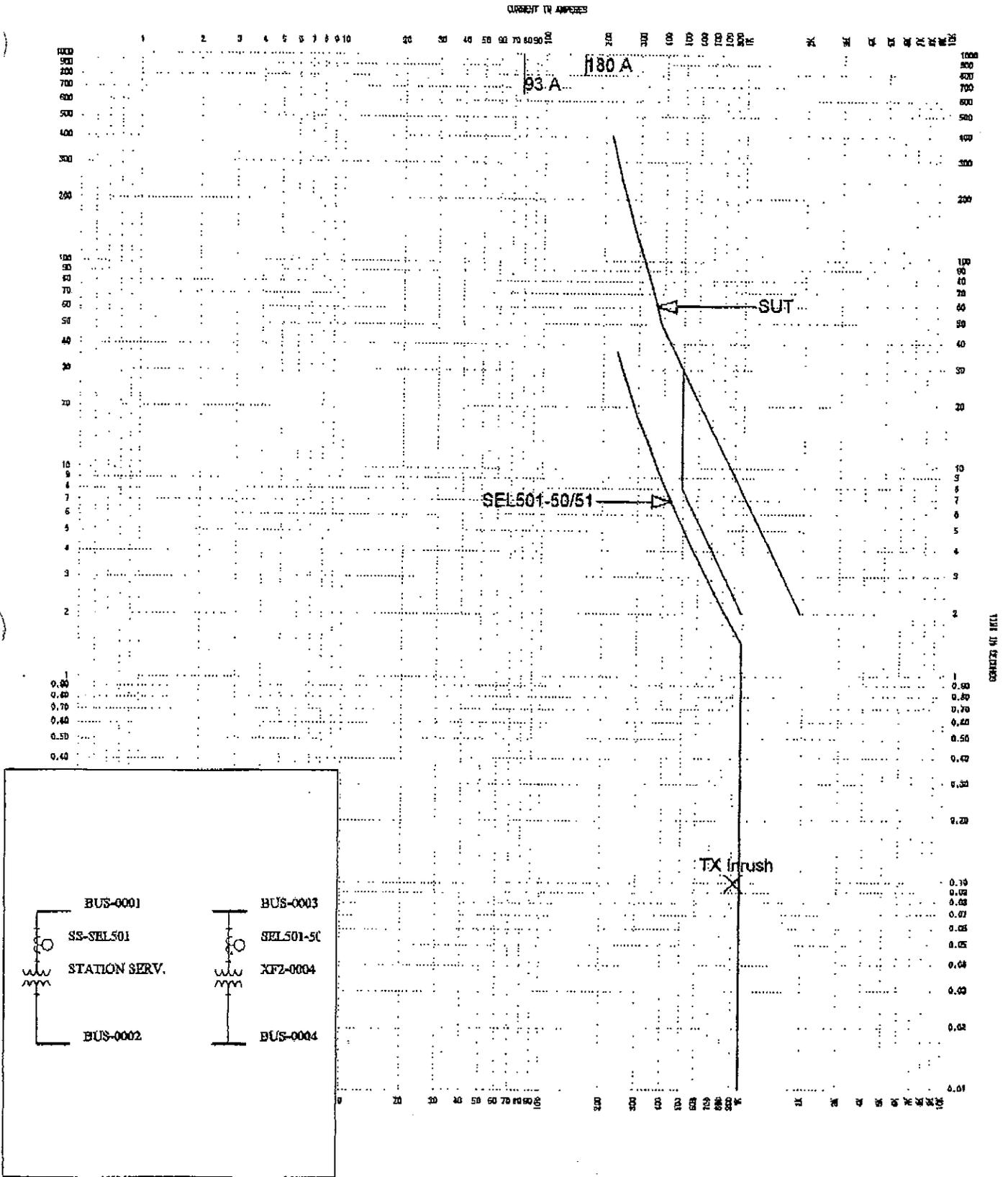
E Squared Power Systems, Inc.

TCC Name: SS TRANS.tcc  
Reference Voltage: 13800  
Current Scale X 10^1

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-----  
Device Name: STATION SERV. Bus Name: BUS-000?  
Description: 2-Winding Transformer Damage Curve Bus Voltage: 13800V / 480V  
Nominal Size: 1500.0kVA Fault Duty: 200000.0A  
Impedance (%Z): 5.7499 Pri Connection: Delta  
Inrush Factor: 8.0x Sec Connection: Wye-Ground  
-----

Device Name: SS-SEL501 Bus Name: BUS-0001  
Description: SEL-501-M.I.V.E Bus Voltage: 13800.0V  
AIC Rating: N/A Fault Duty: 200000.0A  
Current Rating: 200A / 5A Curve Multiplier: 1.00000  
Setting: 1) INST 3.0 Test Points:  
2) [E] EXTREMELY 15.0 a2.0X, 20.870s  
3) INST 15.0 a5.0X, 4.072s



TCC Name: Midsun SUT  
 Online: 1Line001 Step Up Transformer Overcurrent Protection  
 7 November, 2001 2:40 PM

Current Scale X10

Reference Voltage: 13800

E Squared Power Systems, Inc.

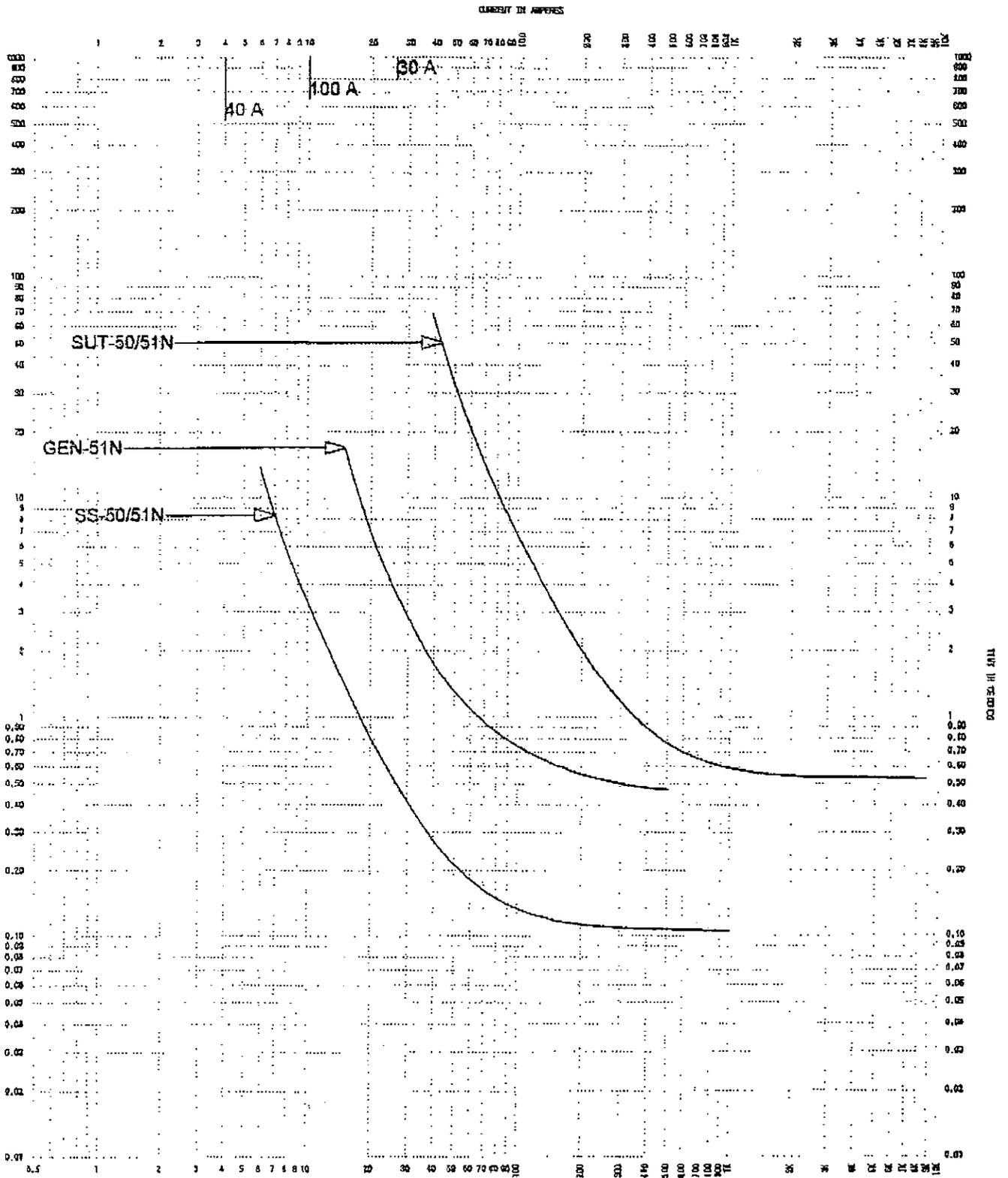
TCC Name: Midson SUT.tcc  
Reference Voltage: 13800  
Current Scale X 10^4

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Device Name:	XF2-0004	Bus Name:	BUS-0003
Description:	2-Winding Transformer Damage Curve	Bus Voltage:	0V / 0V
Nominal Size:	0.0KVA	Fault Duty:	200000.0A
Impedance (%Z):	7.8000	Pri Connection:	Delta
Inrush Factor:	12.0x	Sec Connection:	Wye-Ground

Device Name:	SE1501-50/51	Bus Name:	BUS-0003
Description:	SE1-501-M.I.V.E	Bus Voltage:	120000.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	300A / 5A	Curve Multiplier:	1.00000
Setting:	1) Tap 3.0	Test Points:	
	2) [E] EXTREMELY 8.0		2.0X, 15.402s
	3) INST 19.0		5.0X, 2.172s

Device Name:	SUT	Bus Name:	
Description:	2-Winding Transformer Damage Curve	Bus Voltage:	115000V / 13800V
Nominal Size:	18500.0KVA	Fault Duty:	200000.0A
Impedance (%Z):	7.8000	Pri Connection:	Wye-Ground
Inrush Factor:	12.0x	Sec Connection:	Delta



TCC Name: 50/51N

Current Scale X10

Reference Voltage: 13800

Online: Ground Protection Coordination

7 November, 2001 2:21 PM

E Squared Power Systems, Inc.

TCC Name: 50/51N.tcc  
 Reference Voltage: 13800  
 Current Scale X 10<sup>4</sup>

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Device Name:	SS-50/51N	Bus Name:	
Description:	SEL-501-M.I.V.E	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	200A / 5A	Curve Multiplier:	1.00000
Setting: 1) Tap	1.0	Test Points:	
2) [E] EXTREMELY	3.0	2.0X, 5.776s	
		5.0X, 0.814s	

Device Name:	GEN-51N	Bus Name:	
Description:	GE-IAC 53-50/51	Bus Voltage:	13800.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	100A / 5A	Curve Multiplier:	1.00000
Setting: 1) LTPU	5.0	Test Points:	
2) Time Dials	5.0	2.0X, 7.000s	
		5.0X, 1.310s	

Device Name:	SJT-50/51N	Bus Name:	
Description:	SEL-501-M.I.V.E	Bus Voltage:	120000.0V
AIC Rating:	N/A	Fault Duty:	10000.0A
Current Rating:	300A / 5A	Curve Multiplier:	1.00000
Setting: 1) Tap	0.5	Test Points:	
2) [E] EXTREMELY	15.0	2.0X, 28.878s	
		5.0X, 4.072s	



Test Results of SEL-501-2(SUT Backup)

<u>Function (#)</u>	<u>As Set</u>	<u>As Tested</u>
<u>Phase Instantaneous OC (50)</u>	P.U. = 19A	19A
<u>Phase Time OC (51V)</u>	P.U. = 3A Curve = Extremely Inv. Time Dial = 8 Test Points (multiples of tap): 2 trips in ~15 sec 3 trips in ~6 sec 4 trips in ~3.25 sec	15.28 sec 5.92 sec 3.29 sec
<u>Ground Time OC (51N)</u>	P.U. = 0.5A Curve = Extremely Inv. Time Dial = 15 Test Points (multiples of tap): 2 trips in ~30 sec 3 trips in ~10 sec 4 trips in ~6 sec	27.74 sec 10.98 sec 6.16 sec



Test Results of SEL-501-2(SUT Backup)

<u>Function (#)</u>	<u>As Set</u>	<u>As Tested</u>
<u>Phase Instantaneous OC (50)</u>	P.U. = 19A	19A
<u>Phase Time OC (51V)</u>	P.U. = 3A Curve = Extremely Inv. Time Dial = 8 Test Points (multiples of tap): 2 trips in ~15 sec 3 trips in ~6 sec 4 trips in ~3.25 sec	15.28 sec 5.92 sec 3.29 sec
<u>Ground Time OC (51N)</u>	P.U. = 0.5A Curve = Extremely Inv. Time Dial = 15 Test Points (multiples of tap): 2 trips in ~30 sec 3 trips in ~10 sec 4 trips in ~6 sec	27.74 sec 10.98 sec 6.16 sec

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

General Data

Relay Identifier (13 characters) ID = 50/51 SUT  
 Current Transformer Ratio (CTR:1); (1-6000) CTR = 120  
 Demand Ammeter Time Constant (Off, 5-60 minutes) DATC = OFF  
 Programmable Input Function (EN, BLK, ET)  
 {EN = Enable, BLK = Block, ET = External Trigger} IN = EN

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup  
 (Off, 0.5-80 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50PP = OFF  
 Phase Definite-Time Overcurrent Delay (0-16,000 cycles) 50PD = 0  
 Assign 50PT to trip output contacts (N, 1, 2, B)  
 {N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50PTT = N  
 50PT controlled by input IN or remote bit (N, Y, IN, RB)  
 (N = none, Y = input, IN = input, RB = remote bit) 50PTC = N  
 Phase Instantaneous Overcurrent Pickup  
 (Off, 0.5-80 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50H = 9.5  
 Assign 50H to trip output contacts (N, 1, 2, B)  
 {N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50HT = B  
 50H controlled by input IN or remote bit (N, Y, IN, RB)  
 (N = none, Y = input, IN = input, RB = remote bit) 50HC = IN

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup  
 (Off, 0.5-80 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50QP = OFF  
 Negative-Sequence Definite-Time Overcurrent Delay (1.5-16,000 cycles) 50QD = 1.5  
 Assign 50QT to trip output contacts (N, 1, 2, B)  
 {N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50QTT = N  
 50QT controlled by input IN or remote bit (N, Y, IN, RB)  
 (N = none, Y = input, IN = input, RB = remote bit) 50QTC = N

Ground Definite-Time/Instantaneous Overcurrent Elements

Ground Definite-Time Overcurrent Pickup  
 (Off, 0.5-80 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50NP = OFF  
 Ground Definite-Time Overcurrent Delay (0-16,000 cycles) 50ND = 0  
 Assign 50NT to trip output contacts (N, 1, 2, B)  
 {N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50NTT = N

**SETTINGS SHEET  
FOR THE SEL-501-2 RELAY**

**RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)**

50NT controlled by input IN or remote bit (N, Y, IN, RB) (N = none, Y = input, IN = input, RB = remote bit)	50NTC = <u>  N  </u>
Ground Instantaneous Overcurrent Pickup (Off, 0.5-30 A sec {5 A Model}, 0.1-16 A sec {1 A Model})	50NH = <u>  off  </u>
Assign 50NH to trip output contacts (N, 1, 2, B) (N = none, 1 = TRIP 1, 2 = TRIP2, B = both)	50NHT = <u>  N  </u>
50NH controlled by input IN or remote bit (N, Y, IN, RB) (N = none, Y = input, IN = input, RB = remote bit)	50NHC = <u>  N  </u>

**Phase Time-Overcurrent Element**

Phase Time-Overcurrent Pickup (Off, 0.5-16 A sec {5 A Model}, 0.1-3.2 A sec {1 A Model})	51PP = <u>  1.5  </u>
Phase Time-Overcurrent Operating Curve (U1-U4 {US Curves}, C1-C4 {IEC Curves})	51PC = <u>  U4  </u>
Phase Time-Overcurrent Time-Dial (0.5-15 {US Curves}, 0.05-1.0 {IEC Curves})	51PTD = <u>  8  </u>
Phase Time-Overcurrent EM Reset (Y, N)	51PRS = <u>  N  </u>
Assign 51PT to trip output contacts (N, 1, 2, B) (N = none, 1 = TRIP 1, 2 = TRIP2, B = both)	51PTT = <u>  B  </u>
51PT controlled by input IN or remote bit (N, Y, IN, RB) (N = none, Y = input, IN = input, RB = remote bit)	51PTC = <u>  IN  </u>

**Negative-Sequence Time-Overcurrent Element**

Negative-Sequence Time-Overcurrent Pickup (Off, 0.5-16 A sec {5 A Model}, 0.1-3.2 A sec {1 A Model})	51QP = <u>  off  </u>
Negative-Sequence Time-Overcurrent Operating Curve (U1-U4 {US Curves}, C1-C4 {IEC Curves})	51QC = <u>  -  </u>
Negative-Sequence Time-Overcurrent Time-Dial (0.50-15 {US Curves}, 0.05-1.0 {IEC Curves})	51QTD = <u>  -  </u>
Negative-Sequence Time-Overcurrent Electromechanical Reset (Y, N)	51QRS = <u>  -  </u>
Assign 51QT to trip output contacts (N, 1, 2, B) (N = none, 1 = TRIP 1, 2 = TRIP2, B = both)	51QTT = <u>  N  </u>
51QT controlled by input IN or remote bit (N, Y, IN, RB) (N = none, Y = input, IN = input, RB = remote bit)	51QTC = <u>  N  </u>

SETTINGS SHEET  
FOR THE SEL-501-2 RELAY

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

Ground Time-Overcurrent Element

Ground Time-Overcurrent Pickup  
(Off, 0.5-16 A sec {5 A Model}, 0.1-3.2 A sec {1 A Model}) S1NP = 0.5

Ground Time-Overcurrent Operating Curve  
(U1-U4 {US Curves}, C1-C4 {IEC Curves}) S1NC = U4

Ground Time-Overcurrent Time-Dial  
(0.50-15 {US Curves}, 0.05-1.0 {IEC Curves}) S1NTD = 15.0

Ground Time-Overcurrent Electromechanical Reset (Y, N) S1NRS = N

Assign S1NT to trip output contacts (N, 1, 2, B)  
{N = none, 1 = TRIP 1, 2 = TRIP2, B = both} S1NTT = B

S1NT controlled by input IN or remote bit (N, Y, IN, RB)  
(N = none, Y = input, IN = input, RB = remote bit) S1NTC = IN

TRIP Output Contact Timers/Latch

TRIP1 time-delay pickup (0-16,000 cycles) TRPU1 = 0

Minimum TRIP1 duration (0-16,000 cycles) TDUR1 = 30

TRIP2 time-delay pickup (0-16,000 cycles) TRPU2 = 0

Minimum TRIP2 duration (0-16,000 cycles) TDUR2 = 30

Enable phase current latch condition for trip output contacts (Y, N) ELTCH = N

**SETTINGS SHEET**  
**FOR THE SEL-501-2 RELAY**  
**RELAY SETTINGS (SERIAL PORT COMMAND SET P AND FRONT PANEL)**

**Protocol Setting (see below)**

Protocol (SEL, LMD, MOD)

PROTOCOL = \_\_\_\_\_

**Protocol Settings.**

Set PROTOCOL = SEL for standard SEL ASCII protocol.

Set PROTOCOL = LMD for SEL Distributed Port Switch Protocol (LMD).

Set PROTOCOL = MOD for Modbus™ RTU protocol.

Refer to *Appendix D: Distributed Port Switch Protocol* for details on the LMD protocol.

Refer to *Appendix E: Modbus™ RTU Communications Protocol*.

**Protocol = SEL**

If PROTOCOL is set to SEL, the following are the applicable fields that need to be entered by the user.

**Communications Settings**

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)

SPEED = \_\_\_\_\_

Data Bits (7, 8)

DATA\_BITS = \_\_\_\_\_

Parity (None [N], Even [E], Odd [O])

PARITY = \_\_\_\_\_

Stop Bits (1, 2)

STOP = \_\_\_\_\_

**Other Port Settings (see below)**

Time-Out (0-30 minutes)

TIMEOUT = \_\_\_\_\_

Automatic Message Output (Y, N)

AUTO = \_\_\_\_\_

Enable RTS/CTS Hardware Handshaking (Y, N)

RTS\_CTS = \_\_\_\_\_

Fast Operate Enable (Y, N)

FAST\_OP = \_\_\_\_\_

**Other Port Settings.** Set TIMEOUT to the number of minutes of serial port inactivity for an automatic log out. Set TIMEOUT = 0 for no port time-out.

Set AUTO = Y to allow automatic messages at the serial port.

Set RTS\_CTS = Y to enable hardware handshaking. With RTS\_CTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTS\_CTS is not applicable for EIA-485 serial port option or when PROTOCOL = LMD.

Set FAST\_OP = Y to enable binary *Fast Operate* messages at the serial port. Set FAST\_OP = N to block binary *Fast Operate* messages.

SETTINGS SHEET  
FOR THE SEL-501-2 RELAY

Page 5 of 5  
Date \_\_\_\_\_

Document Control# TSM09-2215-09

RELAY SETTINGS (SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol = LMD

If PROTOCOL is set to LMD, the following are the applicable fields that need to be entered by the user.

**Communications Settings**

LMD Prefix (@, #, \$, %, &)	PREFIX = _____
LMD Address (1-99)	ADDRESS = _____
LMD Settling Time (0-30 seconds)	SETTLE_TIME = _____
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

**Other Port Settings (see below)**

Time-Out (0-30 minutes)	TIMEOUT = _____
Automatic Message Output (Y, N)	AUTO = _____
Fast Operate Enable (Y, N)	FAST_OP = _____

**Other Port Settings.** Set TIMEOUT to the number of minutes of serial port inactivity for an automatic log out. Set TIMEOUT = 0 for no port time-out.

Set AUTO = Y to allow automatic messages at the serial port.

Set FAST\_OP = Y to enable binary *Fast Operate* messages at the serial port. Set FAST\_OP = N to block binary *Fast Operate* messages.

Protocol = MOD

If PROTOCOL is set to MOD, the following are the applicable fields that need to be entered by the user.

**Communications Settings**

Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	SPEED = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____
Modbus Slave ID (1-247)	SLAVEID = _____

SETTINGS SHEET  
FOR THE SEL-501-2 RELAY

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

General Data

Relay Identifier (13 characters) ID = 50/51 55  
Current Transformer Ratio (CTR:1); (1-6000) CTR = 40  
Demand Ammeter Time Constant (Off, 5-60 minutes) DATC = OFF  
Programmable Input Function (EN, BLK, ET)  
{EN = Enable, BLK = Block, ET = External Trigger} IN = EN

Phase Definite-Time/Instantaneous Overcurrent Elements

Phase Definite-Time Overcurrent Pickup  
(Off, 0.5-30 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50PP = off  
Phase Definite-Time Overcurrent Delay (0-16,000 cycles) 50PD = 0  
Assign 50PT to trip output contacts (N, 1, 2, B)  
{N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50PTT = N  
50PT controlled by input IN or remote bit (N, Y, IN, RB)  
(N = none, Y = input, IN = input, RB = remote bit) 50PTC = N  
Phase Instantaneous Overcurrent Pickup  
(Off, 0.5-30 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50H = 15.0  
Assign 50H to trip output contacts (N, 1, 2, B)  
{N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50HT = B  
50H controlled by input IN or remote bit (N, Y, IN, RB)  
(N = none, Y = input, IN = input, RB = remote bit) 50HC = IN

Negative-Sequence Definite-Time Overcurrent Element

Negative-Sequence Definite-Time Overcurrent Pickup  
(Off, 0.5-30 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50QP = off  
Negative-Sequence Definite-Time Overcurrent Delay (1.5-16,000 cycles) 50QD = 1.5  
Assign 50QT to trip output contacts (N, 1, 2, B)  
{N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50QTT = N  
50QT controlled by input IN or remote bit (N, Y, IN, RB)  
(N = none, Y = input, IN = input, RB = remote bit) 50QTC = N

Ground Definite-Time/Instantaneous Overcurrent Elements

Ground Definite-Time Overcurrent Pickup  
(Off, 0.5-30 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50NP = OFF  
Ground Definite-Time Overcurrent Delay (0-16,000 cycles) 50ND = 0  
Assign 50NT to trip output contacts (N, 1, 2, B)  
{N = none, 1 = TRIP 1, 2 = TRIP2, B = both} 50NTT = N

SETTINGS SHEET  
FOR THE SEL-501-2 RELAY

RELAY SETTINGS (SERIAL PORT COMMAND SET AND FRONT PANEL)

50NT controlled by input IN or remote bit (N, Y, IN, RB)  
(N = none, Y = input, IN = input, RB = remote bit) 50NTC =  N   
Ground Instantaneous Overcurrent Pickup  
(Off, 0.5-30 A sec {5 A Model}, 0.1-16 A sec {1 A Model}) 50NH =  Off   
Assign 50NH to trip output contacts (N, 1, 2, B)  
(N = none, 1 = TRIP 1, 2 = TRIP2, B = both) 50NHT =  N   
50NH controlled by input IN or remote bit (N, Y, IN, RB)  
(N = none, Y = input, IN = input, RB = remote bit) 50NHC =  N

Phase Time-Overcurrent Element

Phase Time-Overcurrent Pickup  
(Off, 0.5-16 A sec {5 A Model}, 0.1-3.2 A sec {1 A Model}) 51PP =  3.0   
Phase Time-Overcurrent Operating Curve  
(U1-U4 {US Curves}, C1-C4 {IEC Curves}) 51PC =  U4   
Phase Time-Overcurrent Time-Dial  
(0.5-15 {US Curves}, 0.05-1.0 {IEC Curves}) 51PTD =  15   
Phase Time-Overcurrent EM Reset (Y, N) 51PRS =  N   
Assign 51PT to trip output contacts (N, 1, 2, B)  
(N = none, 1 = TRIP 1, 2 = TRIP2, B = both) 51PTT =  B   
51PT controlled by input IN or remote bit (N, Y, IN, RB)  
(N = none, Y = input, IN = input, RB = remote bit) 51PTC =  IN

Negative-Sequence Time-Overcurrent Element

Negative-Sequence Time-Overcurrent Pickup  
(Off, 0.5-16 A sec {5 A Model}, 0.1-3.2 A sec {1 A Model}) 51QP =  Off   
Negative-Sequence Time-Overcurrent Operating Curve  
(U1-U4 {US Curves}, C1-C4 {IEC Curves}) 51QC =  -   
Negative-Sequence Time-Overcurrent Time-Dial  
(0.50-15 {US Curves}, 0.05-1.0 {IEC Curves}) 51QTD =  -   
Negative-Sequence Time-Overcurrent Electromechanical Reset (Y, N) 51QRS =  -   
Assign 51QT to trip output contacts (N, 1, 2, B)  
(N = none, 1 = TRIP 1, 2 = TRIP2, B = both) 51QTT =  N   
51QT controlled by input IN or remote bit (N, Y, IN, RB)  
(N = none, Y = input, IN = input, RB = remote bit) 51QTC =  N

**Ground Time-Overcurrent Element**

Ground Time-Overcurrent Pickup (Off, 0.5-16 A sec {5 A Model}, 0.1-3.2 A sec {1 A Model})	51NP = <u>  10  </u>
Ground Time-Overcurrent Operating Curve (U1-U4 {US Curves}, C1-C4 {IEC Curves})	51NC = <u>  44  </u>
Ground Time-Overcurrent Time-Dial (0.50-15 {US Curves}, 0.05-1.0 {IEC Curves})	51NTD = <u>  3.0  </u>
Ground Time-Overcurrent Electromechanical Reset (Y, N)	51NRS = <u>  N  </u>
Assign 51NT to trip output contacts (N, 1, 2, B) (N = none, 1 = TRIP 1, 2 = TRIP2, B = both)	51NTT = <u>  B  </u>
51NT controlled by input IN or remote bit (N, Y, IN, RB) (N = none, Y = input, IN = input, RB = remote bit)	51NTC = <u>  IN  </u>

**TRIP Output Contact Timers/Latch**

TRIP1 time-delay pickup (0-16,000 cycles)	TRPU1 = <u>  0  </u>
Minimum TRIP1 duration (0-16,000 cycles)	TDUR1 = <u>  30  </u>
TRIP2 time-delay pickup (0-16,000 cycles)	TRPU2 = <u>  0  </u>
Minimum TRIP2 duration (0-16,000 cycles)	TDUR2 = <u>  15  </u>
Enable phase current latch condition for trip output contacts (Y, N)	ELTCH = <u>  N  </u>

SETTINGS SHEET  
FOR THE SEL-501-2 RELAY

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Document Control# TSM09-2215-09

Date \_\_\_\_\_

RELAY SETTINGS (SERIAL PORT COMMAND SET P AND FRONT PANEL)

Protocol Setting (see below)

Protocol (SEL, LMD, MOD)

PROTOCOL = \_\_\_\_\_

**Protocol Settings.**

Set PROTOCOL = SEL for standard SEL ASCII protocol.

Set PROTOCOL = LMD for SEL Distributed Port Switch Protocol (LMD).

Set PROTOCOL = MOD for Modbus™ RTU protocol.

Refer to *Appendix D: Distributed Port Switch Protocol* for details on the LMD protocol.

Refer to *Appendix E: Modbus™ RTU Communications Protocol*.

Protocol = SEL

If PROTOCOL is set to SEL, the following are the applicable fields that need to be entered by the user.

**Communications Settings**

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)

SPEED = \_\_\_\_\_

Data Bits (7, 8)

DATA\_BITS = \_\_\_\_\_

Parity (None [N], Even [E], Odd [O])

PARITY = \_\_\_\_\_

Stop Bits (1, 2)

STOP = \_\_\_\_\_

**Other Port Settings (see below)**

Time-Out (0-30 minutes)

TIMEOUT = \_\_\_\_\_

Automatic Message Output (Y, N)

AUTO = \_\_\_\_\_

Enable RTS/CTS Hardware Handshaking (Y, N)

RTS\_CTS = \_\_\_\_\_

Fast Operate Enable (Y, N)

FAST\_OP = \_\_\_\_\_

**Other Port Settings.** Set TIMEOUT to the number of minutes of serial port inactivity for an automatic log out. Set TIMEOUT = 0 for no port time-out.

Set AUTO = Y to allow automatic messages at the serial port.

Set RTS\_CTS = Y to enable hardware handshaking. With RTS\_CTS = Y, the relay will not send characters until the CTS input is asserted. Also, if the relay is unable to receive characters, it deasserts the RTS line. Setting RTS\_CTS is not applicable for EIA-485 serial port option or when PROTOCOL = LMD.

Set FAST\_OP = Y to enable binary *Fast Operate* messages at the serial port. Set FAST\_OP = N to block binary *Fast Operate* messages.

**Protocol = LMD**

If PROTOCOL is set to LMD, the following are the applicable fields that need to be entered by the user.

**Communications Settings**

LMD Prefix (@, #, \$, %, &)	PREFIX = _____
LMD Address (1-99)	ADDRESS = _____
LMD Settling Time (0-30 seconds)	SETTLE_TIME = _____
Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400)	SPEED = _____
Data Bits (7, 8)	DATA_BITS = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____

**Other Port Settings (see below)**

Time-Out (0-30 minutes)	TIMEOUT = _____
Automatic Message Output (Y, N)	AUTO = _____
Fast Operate Enable (Y, N)	FAST_OP = _____

**Other Port Settings.** Set TIMEOUT to the number of minutes of serial port inactivity for an automatic log out. Set TIMEOUT = 0 for no port time-out.

Set AUTO = Y to allow automatic messages at the serial port.

Set FAST\_OP = Y to enable binary *Fast Operate* messages at the serial port. Set FAST\_OP = N to block binary *Fast Operate* messages.

**Protocol = MOD**

If PROTOCOL is set to MOD, the following are the applicable fields that need to be entered by the user.

**Communications Settings**

Baud Rate (300, 1200, 2400, 4800, 9600, 19200)	SPEED = _____
Parity (None [N], Even [E], Odd [O])	PARITY = _____
Stop Bits (1, 2)	STOP = _____
Modbus Slave ID (1-247)	SLAVEID = _____



MIDSUN COGEN PROJECT  
LM2500 TG UNIT NO. 1, FELLOWS, CA  
PROTECTIVE RELAY SETTING SELECTION

NOVEMBER 7, 2001

***Schweitzer SEL-587***

This relay is utilized for Step-Up Transformer protection. The transformer has the following rating:

18.5/24.6/30.8, 20.7/27.5/34.8 MVA, Class OA/FA/FA, 55°C/65°C Rise,  
120 Grd Y/69.28 KV-13.8 KV, 7.8% Impedance, Configured Gnd Wye-Delta.

See attached Schweitzer setting sheets for recommended setting.

SETTINGS SHEET  
FOR THE SEL-587-0, -1 RELAY

Settings Increment Chart	
Amps	in .1 steps
Cycles	in 25 steps
KV	in .01 steps

SET Command

General Data			
Description	Range		
Relay Identifier	12 Characters	RID =	MIDSUN SUT
Terminal Identifier	12 Characters	TID =	MIDSUN STA
Description	Range		
Maximum Power Transformer Capacity	OFF, 0.2-5000 MVA in .1 steps	MVA =	34.6
Winding 1 Line-to-Line Voltage	1-1000 kV	VWDG1 =	120KV
Winding 2 Line-to-Line Voltage	1-1000 kV	VWDG2 =	13.8KV
Transformer Connection	YY, YDAC, YDAB, DACDAC, DABDAB, DABY, DACY, OTHER	TRCON =	YDAC
CT Connection	DACDAC, DABDAB, DACY, DABY, YY, YDAB, YDAC	CTCON =	YY
Remove IO from Wye Connection Compensation (SEL-587-1 Relay only)	Y, N	RZS =	Y
Winding 1 CT Ratio	1-50000	CTR1 =	120
Winding 2 CT Ratio	1-50000	CTR2 =	300
Demand Ammeter Time Constant	OFF, 5-255 min	DATC =	off
Phase Demand Ammeter Threshold	0.5-16 A	5 Amp	PDEM =
	0.1-3.2 A	1 Amp	
Negative-Sequence Demand Ammeter Threshold	0.5-16 A	5 Amp	QDEM =
	0.1-3.2 A	1 Amp	
Residual Demand Ammeter Threshold	0.5-16 A	5 Amp	NDEM =
	0.1-3.2 A	1 Amp	

CURRENT TAPS			
Description			
Winding 1 Current TAP		TAP1 =	—
Winding 2 Current TAP		TAP2 =	—

Input Assignment			
Description	Range		
Input 1	NA, 52A1, 152A1, TCEN, TCBL	IN1 =	NA
Input 2	NA, 52A2, 152A2, TCEN, TCBL	IN2 =	NA

<sup>1</sup> IN1 or IN2 set to TCEN or TCBL enables torque-control settings.

SETTINGS SHEET  
FOR THE SEL-587-0, -1 RELAY

Differential Elements			
Description	Range		
Restrained Element Operating Current Pickup	0.1-1.0 in per unit of tap	O87P =	0.6
Restraint Slope 1 Percentage	5-100%	SLP1 =	30%
Restraint Slope 2 Percentage	OFF, 25-200%	SLP2 =	off
Restraint Current Slope 1 Limit	1-16 in per unit of tap	IRS1 =	-
Unrestrained Operating Current Pickup	1-16 in per unit of tap	U87P =	8
Second-Harmonic Blocking Percentage	OFF, 5-100%	PCT2 =	15
Fourth-Harmonic Blocking Percentage (SEL-587-1 Relay only)	OFF, 5-100%	PCT4 =	15
Fifth-Harmonic Blocking Percentage	OFF, 5-100%	PCT5 =	35
Fifth-Harmonic Alarm Threshold	0.1-3.2 in per unit of tap	TH5 =	1.8
Fifth-Harmonic Alarm Time-Delay Pickup	0.00-8000.00 cycles	THSD =	700
DC Ratio Blocking (SEL-587-1 Relay only)	Y, N	DCRB =	Y
Harmonic Restraint (SEL-587-1 Relay only)	Y, N	HRSTR =	Y
Independent Harmonic Blocking	Y, N	IHBL =	Y

Winding 1 Phase Overcurrent Elements			
Description	Range		
Phase Definite-Time Overcurrent Pickup	OFF, 0.5-80 A	5 Amp	
	OFF, 0.1-16 A	1 Amp	50P1P = off
Phase Definite-Time Overcurrent Delay	0-16000.00 cycles		50P1D = off
Phase Definite-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		50P1TC = off
Phase Instantaneous Overcurrent Pickup	OFF, 0.5-80 A	5 Amp	
	OFF, 0.1-16 A	1 Amp	50P1H = 9.5
Phase Instantaneous Overcurrent External Torque-Control <sup>2</sup>	Y, N		50P1HC = N
Phase Inverse-Time Overcurrent Pickup	OFF, 0.5-16 A	5 Amp	
	OFF, 0.1-3.2 A	1 Amp	51P1P = 1.5
Phase Inverse-Time Overcurrent Curve	U1-U4, C1-C4		51P1C = U4
Phase Inverse-Time Overcurrent Time-Dial	US 0.5-15 in .01 increments IEC 0.05-1 in .01 increments		51P1TD = 8
Phase Inverse-Time Overcurrent Electromechanical Reset	Y, N		51P1RS = N
Phase Inverse-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		51P1TC = N

<sup>2</sup> Torque-control enable settings are only shown if either IN1 or IN2 is set to TCEN or TCBL.

SETTINGS SHEET  
FOR THE SEL-587-0, -1 RELAY

Winding 1 Negative-Sequence Overcurrent Elements				
Description	Range			
Negative-Sequence Definite-Time Overcurrent Pickup	OFF, 0.5-80 A	5 Amp		
	OFF, 0.1-16 A	1 Amp	50Q1P =	<u>off</u>
Negative-Sequence Definite-Time Overcurrent Delay	0.5-16000.00 cycles		50Q1D =	<u>-</u>
Negative-Sequence Definite-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		50Q1TC =	<u>N</u>
Negative-Sequence Inverse-Time Overcurrent Pickup	OFF, 0.5-16 A	5 Amp		
	OFF, 0.1-3.2 A	1 Amp	51Q1P =	<u>off</u>
Negative-Sequence Inverse-Time Overcurrent Curve	U1-U4, C1-C4		51Q1C =	<u>-</u>
Negative-Sequence Inverse-Time Overcurrent Time-Dial	US 0.5-15 in .01 increments IEC 0.05-1 in .01 increments		51Q1TD =	<u>-</u>
Negative-Sequence Inverse-Time Overcurrent Electromechanical Reset	Y, N		51Q1RS =	<u>N</u>
Negative-Sequence Inverse-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		51Q1TC =	<u>N</u>

Winding 1 Residual Overcurrent Elements				
Description	Range			
Residual Definite-Time Overcurrent Pickup	OFF, 0.5-80 A	5 Amp		
	OFF, 0.1-16 A	1 Amp	50N1P =	<u>off</u>
Residual Definite-Time Overcurrent Delay	0-16000.00 cycles		50N1D =	<u>-</u>
Residual Definite-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		50N1TC =	<u>N</u>
Residual Instantaneous Overcurrent Pickup	OFF, 0.5-80 A	5 Amp		
	OFF, 0.1-16 A	1 Amp	50N1H =	<u>off</u>
Residual Instantaneous Overcurrent External Torque-Control <sup>2</sup>	Y, N		50N1HC =	<u>N</u>
Residual Inverse-Time Overcurrent Pickup	OFF, 0.5-16 A	5 Amp		
	OFF, 0.1-3.2 A	1 Amp	51N1P =	<u>0.83</u>
Residual Inverse-Time Overcurrent Curve	U1-U4, C1-C4		51N1C =	<u>44</u>
Residual Inverse-Time Overcurrent Time-Dial	US 0.5-15 in .01 increments IEC 0.05-1 in .01 increments		51N1TD =	<u>15</u>
Residual Inverse-Time Overcurrent Electromechanical Reset	Y, N		51N1RS =	<u>N</u>
Residual Inverse-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		51N1TC =	<u>N</u>

<sup>2</sup> Torque-control enable settings are only shown if either IN1 or IN2 is set to TCEN or TCBL.

**SETTINGS SHEET  
FOR THE SEL-587-0, -1 RELAY**

<b>Winding 2 Phase Overcurrent Elements</b>			
<b>Description</b>	<b>Range</b>		
Phase Definite-Time Overcurrent Pickup	OFF, 0.5-80 A	5 Amp	50P2P = <u>off</u>
	OFF, 0.1-16 A	1 Amp	50P2D = <u>-</u>
Phase Definite-Time Overcurrent Delay	0-16000.00 cycles		
Phase Definite-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		50P2TC = <u>N</u>
Phase Instantaneous Overcurrent Pickup	OFF, 0.5-80 A	5 Amp	50P2H = <u>14</u>
	OFF, 0.1-16 A	1 Amp	
Phase Instantaneous Overcurrent External Torque-Control <sup>2</sup>	Y, N		50P2HC = <u>N</u>
Phase Inverse-Time Overcurrent Pickup	OFF, 0.5-16 A	5 Amp	51P2P = <u>5.0</u>
	OFF, 0.1-3.2 A	1 Amp	51P2C = <u>4</u>
Phase Inverse-Time Overcurrent Curve	U1-U4, C1-C4		
Phase Inverse-Time Overcurrent Time-Dial	US 0.5-15 in .01 increments		51P2TD = <u>3</u>
	IEC 0.05-1 in .01 increments		
Phase Inverse-Time Overcurrent Electromechanical Reset	Y, N		51P2RS = <u>N</u>
Phase Inverse-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		51P2TC = <u>N</u>

<b>Winding 2 Negative-Sequence Overcurrent Elements</b>			
<b>Description</b>	<b>Range</b>		
Negative-Sequence Definite-Time Overcurrent Pickup	OFF, 0.5-80 A	5 Amp	50Q2P = <u>off</u>
	OFF, 0.1-16 A	1 Amp	50Q2D = <u>-</u>
Negative-Sequence Definite-Time Overcurrent Delay	0.5-16000.00 cycles		
Negative-Sequence Definite-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		50Q2TC = <u>N</u>
Negative-Sequence Inverse-Time Overcurrent Pickup	OFF, 0.5-16 A	5 Amp	51Q2P = <u>off</u>
	OFF, 0.1-3.2 A	1 Amp	
Negative-Sequence Inverse-Time Overcurrent Curve	U1-U4, C1-C4		51Q2C = <u>-</u>
Negative-Sequence Inverse-Time Overcurrent Time-Dial	US 0.5-15 in .01 increments		51Q2TD = <u>-</u>
	IEC 0.05-1 in .01 increments		
Negative-Sequence Inverse-Time Overcurrent Electromechanical Reset	Y, N		51Q2RS = <u>N</u>
Negative-Sequence Inverse-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		51Q2TC = <u>N</u>

<sup>2</sup> Torque-control enable settings are only shown if either IN1 or IN2 is set to TCEN or TCBL.

Winding 2 Residual Overcurrent Elements			
Description	Range		
Residual Definite-Time Overcurrent Pickup	OFF, 0.5-80 A	5 Amp	
	OFF, 0.1-16 A	1 Amp	50N2P = <u>off</u>
Residual Definite-Time Overcurrent Delay	0-16000.00 cycles		50N2D = <u>-</u>
Residual Definite-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		50N2TC = <u>N</u>
Residual Instantaneous Overcurrent Pickup	OFF, 0.5-80 A	5 Amp	
	OFF, 0.1-16 A	1 Amp	50N2H = <u>off</u>
Residual Instantaneous Overcurrent External Torque-Control <sup>2</sup>	Y, N		50N2HC = <u>N</u>
Residual Inverse-Time Overcurrent Pickup	OFF, 0.5-16 A	5 Amp	
	OFF, 0.1-3.2 A	1 Amp	51N2P = <u>off</u>
Residual Inverse-Time Overcurrent Curve	U1-U4, C1-C4		51N2C = <u>-</u>
Residual Inverse-Time Overcurrent Time-Dial	US 0.5-15 in .01 increments IEC 0.05-1 in .01 increments		51N2TD = <u>-</u>
Residual Inverse-Time Overcurrent Electromechanical Reset	Y, N		51N2RS = <u>N</u>
Residual Inverse-Time Overcurrent External Torque-Control <sup>2</sup>	Y, N		51N2TC = <u>N</u>

Miscellaneous Timers			
Description	Range		
Latch Trips	Y, N, 1, 2, 3 (SEL-587-0)		
	Y, N, NL, 1, 2, 3 (SEL-587-1)		LTRP = <u>NL</u>
Minimum Trip Duration Time	0-2000.00 cycles		TDURD = <u>30</u>
Timer X Pickup Delay	0-8000.00 cycles		TXPU = <u>0</u>
Timer X Dropout Delay	0-8000.00 cycles		TXDO = <u>0</u>
Timer Y Pickup Delay	0-8000.00 cycles		TYPU = <u>0</u>
Timer Y Dropout Delay	0-8000.00 cycles		TYDO = <u>0</u>

Power System Data			
Description	Range		
Nominal Frequency	50, 60 Hz		NFREQ = <u>60</u>
Phase Rotation	ABC, ACB		PHROT = <u>ABC</u>

<sup>2</sup> Torque-control enable settings are only shown if either IN1 or IN2 is set to TCEN or TCBL.

SETTINGS SHEET  
FOR THE SEL-587-0, -1 RELAY

SET L Command (Logic)

Logic Variables	
X =	N/A
Y =	N/A

Tripping Logic	
MTU1 =	87R + 87U + 50PIT + 50PAT + 51PIT + 51NIT + 51PAT + 51NAT
MTU2 =	N/A
MTU3 =	N/A

Event Report Trigger Condition Logic	
MER =	87R + 87U + 50PIT + 50PAT + 51PIT + 51NIT + 51PAT + 51NAT

Output Contact Logic	
OUT1 =	TRP1
OUT2 =	TRP2
OUT3 =	TRP1
OUT4 =	N/A

SETTINGS SHEET  
FOR THE SEL-587-0, -1 RELAY

**SET P Command (Port Settings)**

Protocol and Communications Settings			
Description	Range		
Serial Port Protocol	SEL, LMD, MOD	<b>PROTO</b>	= <u>SEL</u>
<b>If PROTO = SEL</b>			
Serial Port Baud Rate	300, 1200, 2400, 4800, 9600, 19200, 38400	<b>SPEED</b>	= <u>9600</u>
Serial Port Data Bits	7, 8	<b>D_BITS</b>	= <u>8</u>
Serial Port Parity	N, E, O	<b>PARITY</b>	= <u>N</u>
Serial Port Stop Bits	1, 2	<b>STOP</b>	= <u>1</u>
Serial Port Time Out	0-30 minutes	<b>TIMEOUT</b>	= <u>0</u>
Send Auto Message to Port	Y, N	<b>AUTO</b>	= <u>N</u>
Enable RTS/CTS Handshaking	Y, N	<b>RTS_CTS</b>	= <u>N</u>
Fast Operate Enable	Y, N	<b>FAST_OP</b>	= <u>N</u>
<b>If PROTO = LMD</b>			
LMD Prefix	#, \$, %, &, @	<b>PREFIX</b>	= _____
LMD Address	1-99	<b>ADDRESS</b>	= _____
LMD Settling Time	0-30 seconds	<b>SETTLE_TIME</b>	= _____
Serial Port Baud Rate	300, 1200, 2400, 4800, 9600, 19200, 38400	<b>SPEED</b>	= _____
Serial Port Data Bits	7, 8	<b>D_BITS</b>	= _____
Serial Port Parity	N, E, O	<b>PARITY</b>	= _____
Serial Port Stop Bits	1, 2	<b>STOP</b>	= _____
Serial Port Time Out	0-30 minutes	<b>TIMEOUT</b>	= _____
Send Auto Message to Port	Y, N	<b>AUTO</b>	= _____
Fast Operate Enable	Y, N	<b>FAST_OP</b>	= _____
<b>If PROTO = MOD (SEL-587-1 Relay)</b>			
Serial Port Baud Rate	300, 1200, 2400, 4800, 9600, 19200	<b>SPEED</b>	= _____
Serial Port Parity	N, E, O	<b>PARITY</b>	= _____
Serial Port Stop Bits	1, 2	<b>STOP</b>	= _____
Slave ID	1-99	<b>SLAVED</b>	= _____
Send Auto Message to Port	Y, N	<b>AUTO</b>	= _____
Fast Operate Enable	Y, N	<b>FAST_OP</b>	= _____



Test Results of SEL-587(SUT)

<u>Function (#)</u>	<u>As Set</u>	<u>As Tested</u>
<u>Differential Protection (87)</u>	P.U. = 38.3A Restraint Slope = 30% tested by first calculating: IAW1=11.03A IAW2=12.3A Harmonic Blocking: 2nd harmonic = 15% 4th harmonic = 15% 5th harmonic = 35%	38.3A  11.03A 12.1A  15.86% 17.74% 35.90%
<u>(Winding 1)</u> <u>Phase Instantaneous OC (50)</u>	P.U. = 18.33A	18.3A
<u>Phase Time OC (51V)</u>	P.U. = 2.97A Curve = Extremely Inv. Time Dial = 8 Test Points (multiples of tap): 2 trips in ~15 sec 3 trips in ~6 sec 4 trips in ~3.25 sec	   15.56 sec 6.02 sec 3.34 sec
<u>Ground Time OC (51N)</u>	P.U. = 0.8A Curve = Extremely Inv. Time Dial = 15 Test Points (multiples of tap): 2 trips in ~30 sec 3 trips in ~10 sec 4 trips in ~6 sec	   28.51 sec 11.09 sec 6.13 sec
<u>(Winding 2)</u> <u>Phase Instantaneous OC (50)</u>	P.U. = 3.67A	3.7A
<u>Phase Time OC (51V)</u>	P.U. = 0.59A Curve = Extremely Inv. Time Dial = 3 Test Points (multiples of tap): 2 trips in ~5.5 sec 3 trips in ~2 sec 4 trips in ~1.25 sec	   5.96 sec 2.31 sec 1.28 sec
<u>Ground Time OC (51N)</u>	Not used (Delta side)	



Test Results of Basler 25S and 25AS relays

<u>Function</u>	<u>As Set</u>	<u>As Tested</u>
<u>(25AS)</u> <u>Undervoltage Inhibit</u>	P.U. = 105V	104.2V
<u>Slip Frequency</u>	Slip=0.1Hz	0.1Hz
<u>Breaker Compensation Time</u>	Set to 0.1 sec	Not tested
<u>(25S)</u> <u>Phase Angle Window</u>	Window= +/- 10 deg	+/- 10 deg



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

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CUSTOMER  
**001044**

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CUSTOMER PURCHASE ORDER NUMBER  
**120kV Step Up Transformer**

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CT LOCATION  
**H.K. Porter Co. Inc.**

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CT MANUFACTURER

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PREVIOUS INSPECTION DATE

**9/27/01**

---

DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

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CUSTOMER SITE  
**A Phase for SEL-587 and SEL-501-2X**

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CIRCUIT IDENTIFICATION

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INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT #	R-062-179528-M	Serial #	
Ratio	Multi Ratio	BIL	
Type	Bushing CT	NSV	
Accuracy Class	C 200	Sec. Res.	0.0030 Ohms/Turn @ 85 ° C
Hertz	60	R.F.	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	CT internal	Case Cleaned	
Primary wires		Connections Tight	Yes
Secondary wires	Good		
Overheating			

Tests Performed with Biddle Three Phase TTR Model #550100-39			
RATIO	RESULT	mA During Test	
250:5 = Tap X3-X4	50.018:1	330 mA	
300:5 = Tap X2-X4	60.012:1	272 mA	
400:5 = Tap X1-X4	79.988:1	169 mA	

Comments    CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



CURRENT TRANSFORMER INSPECTION & TEST REPORT

<b>Turbine Technologies Construction</b>	<b>9/27/01</b>
CUSTOMER <b>001044</b>	DATE <b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER <b>120kV Step Up Transformer</b>	E SQUARED CONTRACT NUMBER <b>Fellows, CA</b>
CT LOCATION <b>H.K. Porter Co. Inc.</b>	CUSTOMER SITE <b>B Phase for SEL-587 and SEL-501-2X</b>
CT MANUFACTURER	CIRCUIT IDENTIFICATION
PREVIOUS INSPECTION DATE	INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT #	R-062-179528-M	Serial #	
Ratio	Multi Ratio	BIL	
Type	Bushing CT	NSV	
Accuracy Class	C 200	Sec. Res.	0.0030 Ohms/Turn @ 85 ° C
Hertz	60	R.F.	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	CT internal	Case Cleaned	
Primary wires		Connections Tight	Yes
Secondary wires	Good		
Overheating			

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
250:5 = Tap X3-X4	50.023:1	331 mA
300:5 = Tap X2-X4	60.012:1	265 mA
400:5 = Tap X1-X4	80.007:1	167 mA

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



CURRENT TRANSFORMER INSPECTION & TEST REPORT

Turbine Technologies Construction

9/27/01

CUSTOMER

DATE

001044

2138T1835

CUSTOMER PURCHASE ORDER NUMBER

E SQUARED CONTRACT NUMBER

120kV Step Up Transformer

Fellows, CA

CT LOCATION

CUSTOMER SITE

H.K. Porter Co. Inc.

C Phase for SEL-587 and SEL-501-2X

CT MANUFACTURER

CIRCUIT IDENTIFICATION

PREVIOUS INSPECTION DATE

INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA

CT #	R-062-179528-M	Serial #	
Ratio	Multi Ratio	BIL	
Type	Bushing CT	NSV	
Accuracy Class	C 200	Sec. Res.	0.0030 Ohms/Turn @ 85 ° C
Hertz	60	R.F.	

VISUAL & MECHANICAL INSPECTION

OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	CT internal	Case Cleaned	
Primary wires		Connections Tight	Yes
Secondary wires	Good		
Overheating			

Tests Performed with Biddle Three-Phase TTR Model #550100-39

RATIO	RESULT	mA During Test
250:5 = Tap X3-X4	50.006:1	335 mA
300:5 = Tap X2-X4	60.012:1	272 mA
400:5 = Tap X1-X4	79.988:1	168 mA

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY:



**CURRENT TRANSFORMER INSPECTION & TEST REPORT**

**Turbine Technologies Construction**

**9/28/01**

CUSTOMER

DATE

**001044**

**2138T1835**

CUSTOMER PURCHASE ORDER NUMBER

E SQUARED CONTRACT NUMBER

**52M 13.8 kV Circuit Breaker**

**Fellows, CA**

CT LOCATION

CUSTOMER SITE

**Westinghouse Electric Corp.**

**A Phase for PML-6200 and PML-7350**

CT MANUFACTURER

CIRCUIT IDENTIFICATION

PREVIOUS INSPECTION DATE

INSTRUCTION BOOK

**CURRENT TRANSFORMER NAMEPLATE DATA**

CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

**VISUAL & MECHANICAL INSPECTION**

OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

**Tests Performed with Bidle Three Phase TTR Model #550100-39**

RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.11:1	63mA

Comments CT testing was performed with the Bidle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

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CUSTOMER  
**001044**

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CUSTOMER PURCHASE ORDER NUMBER  
**52M 13.8 kV Circuit Breaker**

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CT LOCATION  
**Westinghouse Electric Corp.**

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CT MANUFACTURER

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PREVIOUS INSPECTION DATE

**9/28/01**

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DATE  
**2138T1835**

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E SQUARED CONTRACT NUMBER  
**Fellows, CA**

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CUSTOMER SITE  
**B Phase for PML-6200 and PML-7350**

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CIRCUIT IDENTIFICATION

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INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.31:1	23mA

Comments    CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

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CUSTOMER  
**001044**

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CUSTOMER PURCHASE ORDER NUMBER  
**52M 13.8 kV Circuit Breaker**

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CT LOCATION  
**Westinghouse Electric Corp.**

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CT MANUFACTURER

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PREVIOUS INSPECTION DATE

**9/28/01**

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DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

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CUSTOMER SITE  
**C Phase for PML-6200 and PML-7350**

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CIRCUIT IDENTIFICATION

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INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.03:1	56mA

Comments    CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

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CUSTOMER  
**001044**

---

CUSTOMER PURCHASE ORDER NUMBER  
**52M 13.8 kV Circuit Breaker**

---

CT LOCATION  
**Westinghouse Electric Corp.**

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CT MANUFACTURER

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PREVIOUS INSPECTION DATE

**9/28/01**

---

DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

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CUSTOMER SITE  
**A Phase for SEL-587**

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CIRCUIT IDENTIFICATION

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INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.15:1	77mA

Comments    CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

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CUSTOMER  
**001044**

---

CUSTOMER PURCHASE ORDER NUMBER  
**52M 13.8 kV Circuit Breaker**

---

CT LOCATION  
**Westinghouse Electric Corp.**

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CT MANUFACTURER

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PREVIOUS INSPECTION DATE

**9/28/01**

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DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

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CUSTOMER SITE  
**B Phase for SEL-587**

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CIRCUIT IDENTIFICATION

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INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.00:1	30mA

Comments      CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

**9/28/01**

CUSTOMER

DATE

**001044**

**2138T1835**

CUSTOMER PURCHASE ORDER NUMBER

E SQUARED CONTRACT NUMBER

**52M 13.8 kV Circuit Breaker**

**Fellows, CA**

CT LOCATION

CUSTOMER SITE

**Westinghouse Electric Corp.**

**C Phase for SEL-587**

CT MANUFACTURER

CIRCUIT IDENTIFICATION

PREVIOUS INSPECTION DATE

INSTRUCTION BOOK

#### CURRENT TRANSFORMER NAMEPLATE DATA

CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

#### VISUAL & MECHANICAL INSPECTION

OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

#### Tests Performed with Biddle Three-Phase TTR Model #550100-39

RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	299.96:1	34mA

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

---

CUSTOMER  
**001044**

---

CUSTOMER PURCHASE ORDER NUMBER  
**52G 13.8 kV Circuit Breaker**

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CT LOCATION  
**Westinghouse Electric Corp.**

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CT MANUFACTURER

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PREVIOUS INSPECTION DATE

**9/28/01**

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DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

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CUSTOMER SITE  
**A Phase for M3420-GG and M3420-BG**

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CIRCUIT IDENTIFICATION

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INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.03:1	69mA

Comments     CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

---

CUSTOMER  
**001044**

---

CUSTOMER PURCHASE ORDER NUMBER  
**52G 13.8 kV Circuit Breaker**

---

CT LOCATION  
**Westinghouse Electric Corp.**

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CT MANUFACTURER

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PREVIOUS INSPECTION DATE

**9/28/01**

---

DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

---

CUSTOMER SITE  
**B Phase for M3420-GG and M3420-BG**

---

CIRCUIT IDENTIFICATION

---

INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.03:1	67mA

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

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CUSTOMER  
**001044**

---

CUSTOMER PURCHASE ORDER NUMBER  
**52G 13.8 kV Circuit Breaker**

---

CT LOCATION  
**Westinghouse Electric Corp.**

---

CT MANUFACTURER

---

PREVIOUS INSPECTION DATE

**9/28/01**

---

DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

---

CUSTOMER SITE  
**C Phase for M3420-GG and M3420-BG**

---

CIRCUIT IDENTIFICATION

---

INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #	6353C88H12	Serial #	None
Ratio	1500:5	BIL	10 kV
Type	SCV	NSV	
Accuracy Class	C200	Class	600 volt
Hertz	50-400	Product Bulletin	42-860

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Installed over Porcelain Tubes	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.07:1	27mA

Comments    CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**  
 CUSTOMER  
**001044**  
 CUSTOMER PURCHASE ORDER NUMBER  
**Generator Neutral Compartment**  
 CT LOCATION  
**Brownell Electro Inc.**  
 CT MANUFACTURER  
 PREVIOUS INSPECTION DATE

**9/29/01**  
 DATE  
**2138T1835**  
 E SQUARED CONTRACT NUMBER  
**Fellows, CA**  
 CUSTOMER SITE  
**Neutral Ground CT for M3420-GG & M3420- BG**  
 CIRCUIT IDENTIFICATION  
 INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
Cat. #	115-101	Serial #	
Ratio	100:5	BIL	10 kV
Type		RF	
Accuracy Class		Class	600 volt
Hertz	50-400	Instruction Book	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires		Connections Tight	
Secondary wires			
Overheating	None		

Tests Performed by Current Injection		
RATIO	Primary Current Injected	Secondary Current Output
100:5/Secondary Tap = X1-X2	20 Amps	.982 Amps
	40 Amps	1.973 Amps
	60 Amps	2.969 Amps
	80 Amps	3.99 Amps
	100 Amps	4.99 Amps

Comments This CT was tested by Current Injection due to its small ratio. Polarity was checked visually .  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**  
 CUSTOMER  
**001044**  
 CUSTOMER PURCHASE ORDER NUMBER  
**Generator Neutral Compartment**  
 CT LOCATION  
**Instrument Transformers Inc.**  
 CT MANUFACTURER  
 PREVIOUS INSPECTION DATE

**9/28/01**  
 DATE  
**2138T1835**  
 E SQUARED CONTRACT NUMBER  
**Fellows, CA**  
 CUSTOMER SITE  
**A Phase for M3420-GG & M3420- BG**  
 CIRCUIT IDENTIFICATION  
 INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
Cat. #	100-152	Serial #	
Ratio	1500:5	BIL	10 kV
Type		RF	1.33
Accuracy Class	0.3B1.8/C20	Class	600 volt
Hertz	50-400	Instruction Book	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Insulated Conductor	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.05:1	58mA

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**  
 CUSTOMER  
**001044**  
 CUSTOMER PURCHASE ORDER NUMBER  
**Generator Neutral Compartment**  
 CT LOCATION  
**Instrument Transformers Inc.**  
 CT MANUFACTURER  
 PREVIOUS INSPECTION DATE

**9/28/01**  
 DATE  
**2138T1835**  
 E SQUARED CONTRACT NUMBER  
**Fellows, CA**  
 CUSTOMER SITE  
**B Phase for M3420-GG & M3420- BG**  
 CIRCUIT IDENTIFICATION  
 INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
Cat. #	100-152	Serial #	
Ratio	1500:5	BIL	10 kV
Type		RF	1.33
Accuracy Class	0.3B1.8/C20	Class	600 volt
Hertz	50-400	Instruction Book	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Insulated Conductor	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.09:1	62 mA

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

---

CUSTOMER  
**001044**

---

CUSTOMER PURCHASE ORDER NUMBER  
**Generator Neutral Compartment**

---

CT LOCATION  
**Instrument Transformers Inc.**

---

CT MANUFACTURER

---

PREVIOUS INSPECTION DATE

**9/28/01**

---

DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

---

CUSTOMER SITE  
**C Phase for M3420-GG & M3420- BG**

---

CIRCUIT IDENTIFICATION

---

INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
Cat. #	100-152	Serial #	
Ratio	1500:5	BIL	10 kV
Type		RF	1.33
Accuracy Class	0.3B1.8/C20	Class	600 volt
Hertz	50-400	Instruction Book	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Insulated Conductor	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	300.05:1	59 mA

Comments    CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**

---

CUSTOMER  
**001044**

---

CUSTOMER PURCHASE ORDER NUMBER  
**Generator LA/Surge Compartment**

---

CT LOCATION  
**Hawker Siddely Brush Switchgear Ltd.**

---

CT MANUFACTURER

---

PREVIOUS INSPECTION DATE

**9/28/01**

---

DATE  
**2138T1835**

---

E SQUARED CONTRACT NUMBER  
**Fellows, CA**

---

CUSTOMER SITE  
**A Phase for PML 7350-A & PSS-100**

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CIRCUIT IDENTIFICATION

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INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #		Serial #	8302642
Ratio	1500:5	IL	.66/2.5
Type		NSV	
Accuracy Class		Class	0.3
Hertz	50-60	Instruction Book	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Insulated Conductor	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	299.99:1	24mA

**Comments** CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

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TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**  
 CUSTOMER  
**001044**  
 CUSTOMER PURCHASE ORDER NUMBER  
**Generator LA/Surge Compartment**  
 CT LOCATION  
**Hawker Siddely Brush Switchgear Ltd.**  
 CT MANUFACTURER  
 PREVIOUS INSPECTION DATE

**9/28/01**  
 DATE  
**2138T1835**  
 E SQUARED CONTRACT NUMBER  
**Fellows, CA**  
 CUSTOMER SITE  
**B Phase for PML 7350-A & PSS-100**  
 CIRCUIT IDENTIFICATION  
 INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #		Serial #	8302640
Ratio	1500:5	IL	.66/2.5
Type		NSV	
Accuracy Class		Class	0.3
Hertz	50-60	Instruction Book	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Insulated Conductor	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	299.99:1	14mA

Comments CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



### CURRENT TRANSFORMER INSPECTION & TEST REPORT

**Turbine Technologies Construction**  
 CUSTOMER  
**001044**  
 CUSTOMER PURCHASE ORDER NUMBER  
**Generator LA/Surge Compartment**  
 CT LOCATION  
**Hawker Siddely Brush Switchgear Ltd.**  
 CT MANUFACTURER  
 PREVIOUS INSPECTION DATE

**9/28/01**  
 DATE  
**2138T1835**  
 E SQUARED CONTRACT NUMBER  
**Fellows, CA**  
 CUSTOMER SITE  
**C Phase for PML 7350-A & PSS-100**  
 CIRCUIT IDENTIFICATION  
 INSTRUCTION BOOK

CURRENT TRANSFORMER NAMEPLATE DATA			
CT Style #		Serial #	8302641
Ratio	1500:5	IL	.66/2.5
Type		NSV	
Accuracy Class		Class	0.3
Hertz	50-60	Instruction Book	

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary wires	Insulated Conductor	Connections Tight	Yes
Secondary wires	Good		
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
1500:5/Secondary Tap = X1-X2	299.96:1	15mA

**Comments** CT testing was performed with the Biddle Three Phase TTR model # 550100-39  
 Proper polarity was verified both visually in the field and also by the test set  
 No problems were found

TESTED BY: Scott Mills

WITNESSED BY: \_\_\_\_\_



MIDSUN COGEN PROJECT  
LM2500 TG UNIT NO. 1, FELLOWS, CA  
CT CIRCUIT BURDEN CHECKS AND SINGLE GROUND TESTS  
TESTING PROCEDURES AND RESULTS

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November 25, 2001

## I. Testing Procedures

In order to measure the burden of each CT circuit a Doble test set was used in conjunction with a Fluke DMM. Using the Doble test set, 5 amps were injected into each current circuit. The voltage at the injection point was then measured using the Fluke DMM.

To ensure that only one ground exists on each current circuit, the one (known) ground was lifted and a Megger was used. To be thorough, 1000VDC was applied between each phase (and neutral) and ground. The Megger then measured the resistance between its two output leads.

The following page details the results from the tests outlined above.



CT Circuit Burden Checks and Single Ground Tests

<u>CT</u>	<u>Phase</u>	<u>Burden</u>	<u>Megger Test with Ground Lifted</u>
Generator Ground CT (lands on SCTB2)	(neutral)	9.25VA	> 500 MegaOhms
Gen Neutral Side CT's (lands on SCTB1)	A	10.565VA	> 500 MegaOhms
	B	10.385VA	> 500 MegaOhms
	C	10.88VA	> 500 MegaOhms
DECS-300 CT (lands on SCTB4)	B	20.95VA	> 500 MegaOhms
PML-7350-A CT's (lands on SCTB)	A	10.97VA	> 500 MegaOhms
	B	10.465VA	> 500 MegaOhms
	C	11.055VA	> 500 MegaOhms
M-3420 CT's (lands on SCTB5)	A	9.455VA	> 500 MegaOhms
	B	9.46VA	> 500 MegaOhms
	C	9.435VA	> 500 MegaOhms
SEL587 CT's (lands on SCTB8)	A	9.845VA	0.75 MegaOhms
	B	9.795VA	0.75 MegaOhms
	C	9.775VA	0.75 MegaOhms
PML-6200 CT's (lands on SCTB9)	A	9.465VA	> 500 MegaOhms
	B	9.41VA	> 500 MegaOhms
	C	9.39VA	> 500 MegaOhms
Main SUT CT's (lands on SCTB7)	A	17VA	> 500 MegaOhms
	B	16.505VA	> 500 MegaOhms
	C	16.55VA	> 500 MegaOhms
Station Service CT's (lands on SCTB10)	A	10.1VA	> 500 MegaOhms
	B	10.82VA	> 500 MegaOhms
	C	9.99VA	> 500 MegaOhms



MIDSUN COGEN PROJECT  
LM2500 TG UNIT NO. 1, FELLOWS, CA  
SWITCHGEAR CURRENT TRANSFORMERS

NOVEMBER 7, 2001

Following are the saturation curves and other information pertaining to the current transformers in the 15KV switchgear.

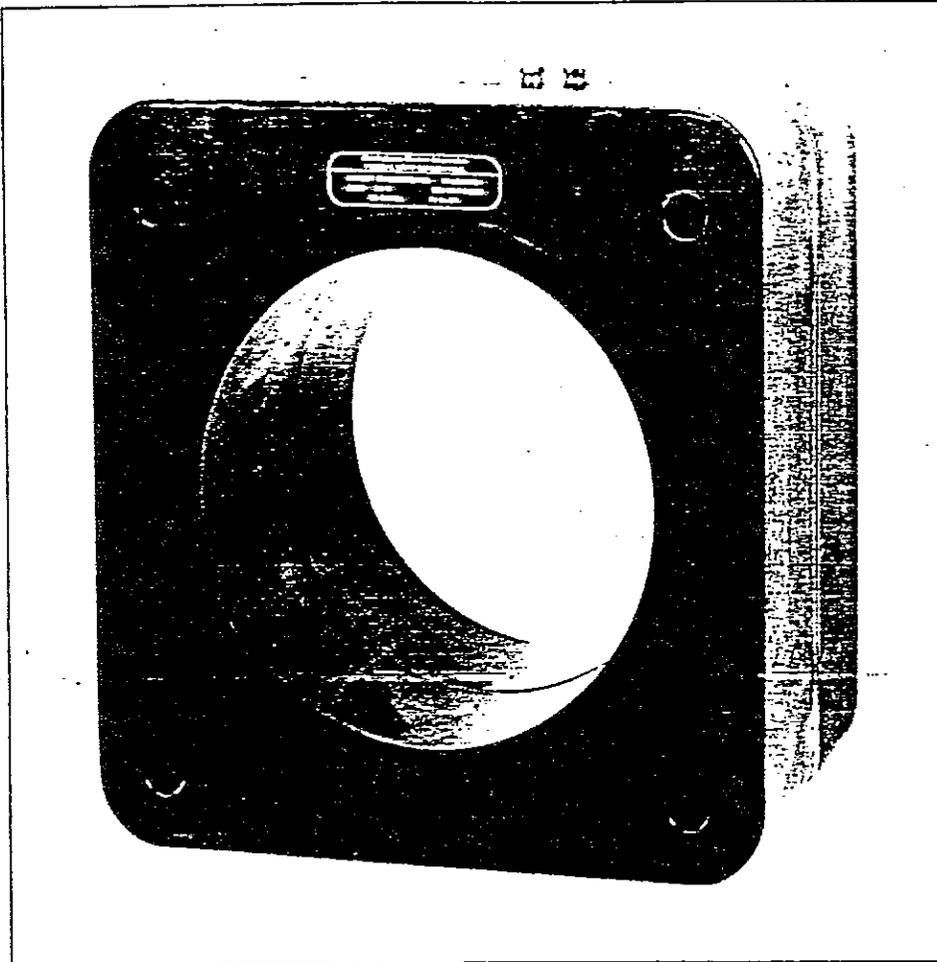


7-1

May, 1983  
 New Information  
 Mailed to: E. D. C 2047 DB

600 Volt, Indoor, 10kV BIL  
 Primary Amperes 50 and 100  
 25 through 400Hz

# Type BYZ-S Current Transformers



### Application

The BYZ-S zero-sequence current transformer is used for ground fault detection. It is designed for zero-sequence overcurrent relaying schemes and for mounting in the cable compartment of VAC-CLAD Metal-Clad Switchgear. A phase imbalance in the outgoing cables, which run through the transformer window, produces a secondary current in the BYZ-S.

### Ratings

Mechanical: 180 × rated current.  
 Thermal: 100 × rated current for one second.

### Construction

The ring core is insulated with thermoplastic core cups and toroidally wound with a fully distributed secondary winding. A protective case molded of glass and mica reinforced polyester has four .56 inch corner bolt holes to facilitate mounting.

"White on black" nameplate information is thermally bonded to the face of the transformer.

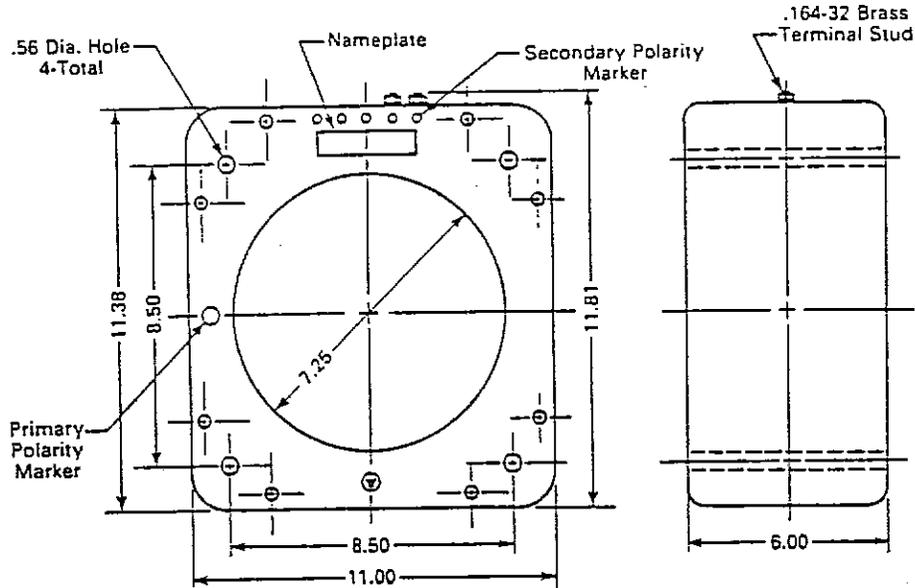
Secondary terminals are .164-32 brass studs.

### Selector Guide

Primary Current Rating	Ratio	Style Number	Relay Accuracy Class
50	10:1	6353C97H01	C10
100	20:1	6353C97H02	C20

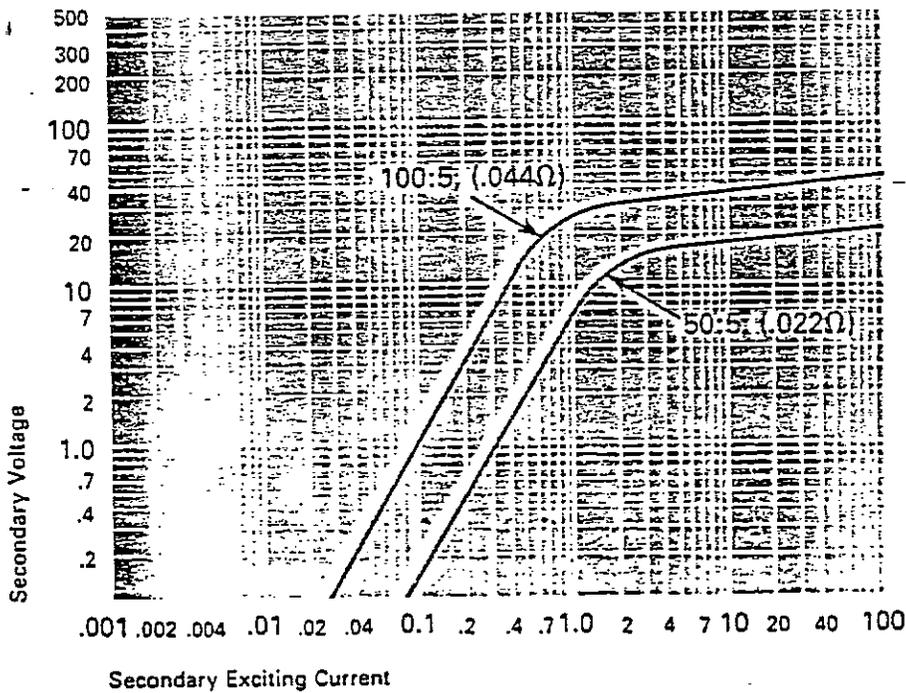


Dimensions (in inches)



Wt. = 52 lbs.

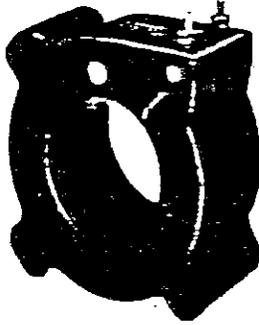
Performance Curves  
Secondary Excitation Curve



Further Information  
Prices: Price List 42-800

00V CURRENT TRANSFORMERS

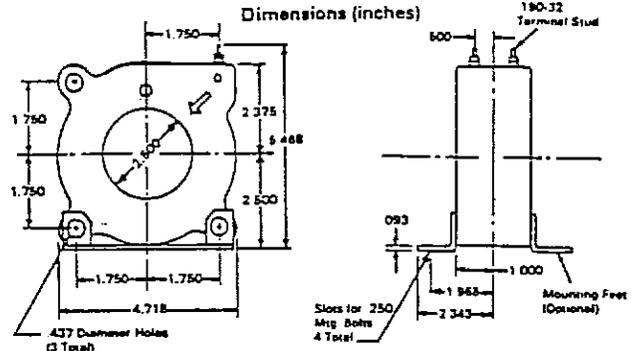
TYPE IMC



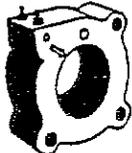
600 Volts, Indoor  
10 Kv BIL, 25 thru 400 Hz  
Mechanical Rating:  
180 x Normal

Optional Mounting Feet  
Style 1889C44G02

PB 42-810



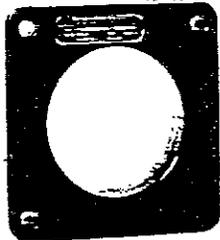
Primary Current Rating	Style Number	ANSI Meter	
		B0.1	B0.2
50	7524A98G11	2.4	
100	7524A98G01	1.2	
150	7524A98G02	1.2	1.2
200	7524A98G03	0.6	1.2
250	7524A98G04	0.6	1.2
300	7524A98G05	0.6	0.6
400	7524A98G06	0.6	0.6
500	7524A98G07	0.3	0.3
600	7524A98G08	0.3	0.3
800	7524A98G09	0.3	0.3
1000	7524A98G10	0.3	0.3



Wt. = 3.5 lbs.

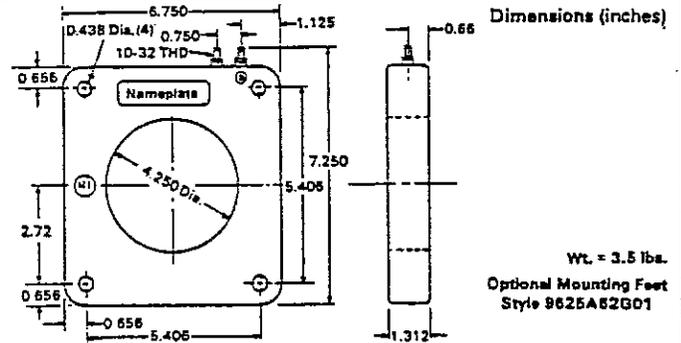
Accuracy			Rating Factor (30°C Amb.)	Thermal Rating (x Normal, 1 sec.)
B0.5	B0.9	B1.8		
			2.0	100
			2.0	100
			2.0	100
2.4			2.0	100
2.4			2.0	100
0.6			2.0	100
0.6	0.6	2.4	2.0	100
0.6	1.2	2.4	2.0	100
0.6	0.6	1.2	1.5	80
0.3	0.3	0.6	1.33	60
0.3	0.3	0.6	1.0	50

TYPE SCE



600 Volts, Indoor  
10 Kv BIL, 25 thru 400 Hz  
Mechanical Rating:  
180 x Normal

PB 42-863



Primary Current Rating	Style Number	ANSI Meter	
		B0.1	B0.2
200	7525A44G01	1.2	1.2
300	7525A44G03	0.6	0.6
400	7525A44G04	0.3	0.6
500	7525A44G05	0.3	0.3
600	7525A44G06	0.3	0.3
800	7525A44G08	0.3	0.3
1000	7525A44G09	0.3	0.3
1200	7525A44G10	0.3	0.3
1500	7525A44G11	0.3	0.3
1600	7525A44G12	0.3	0.3
2000	7525A44G13	0.3	0.3
2500	7525A44G14	0.3	0.3
3000	7525A44G15	0.3	0.3
4000	7525A44G17	0.3	0.3

Accuracy			Rating Factor (30°C Amb.)	Thermal Rating (x Normal, 1 sec.)
B0.5	B0.9	B1.8		
			2.0	100
1.2	2.4		2.0	100
1.2	1.2	2.4	2.0	100
0.6	1.2	2.4	2.0	100
0.6	0.6	1.2	2.0	100
0.3	0.6	0.6	1.5	80
0.3	0.3	0.6	1.5	80
0.3	0.3	0.6	1.33	80
0.3	0.3	0.6	1.33	60
0.3	0.3	0.6	1.33	60
0.3	0.3	0.3	1.33	60
0.3	0.3	0.3	1.33	60
0.3	0.3	0.3	1.0	50

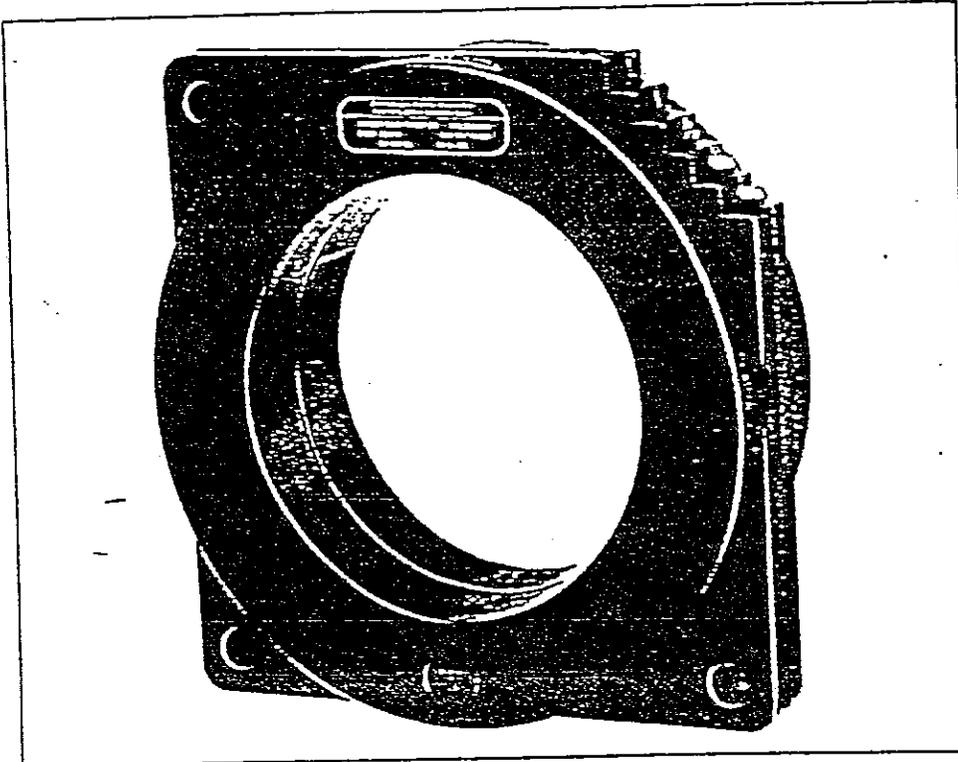


6-1

March, 1986  
 Supersedes Product Bulletin 42-860,  
 pages 1-2, dated August, 1983  
 Mailed to: E, D, C.42-800A

600 Volt Indoor, 10 kV BIL  
 Primary Amperes 100-4000  
 50 through 400 Hz

# Type SCV Current Transformers



**Application**  
 The type SCV current transformer is used in VAC-CLAD Metal-Clad Switchgear as the source of current for relaying and metering. Up to four transformers per phase can be mounted over the primary insulating tubes located in the circuit breaker compartment.

**Ratings**  
 Mechanical Rating: 180 × rated current  
 Thermal Rating: 80 × rated current for one second  
 Continuous Current Rating Factor:  
 2.0 at 30°C Ambient  
 1.5 at 55°C Ambient

**Construction**  
 The ring core is insulated with thermoplastic core cups and toroidally wound with a fully distributed secondary winding. A protective case molded of glass and mica reinforced polyester is ultrasonically sealed to withstand full switchgear impulse test level when installed over the switchgear primary insulating tubes.

\*'White on black' nameplate information is thermally bonded to the face of the transformer.

Secondary terminals are 8-32, brass, screw type with phosphor bronze lock washers. Space is available for a maximum of 5 terminals to accommodate multi-ratio design.

### Selector Guide Single Ratio

Primary Current Ratings <sup>Ⓞ</sup>	ANSI Metering Accuracy					Relay Accuracy	Style Number
	B.1	B.2	B.5	B.9	B1.8		
50	Refer to PB 42-860A						
75						C10	6353C88H07
100	1.2	2.4				C20	6353C88H02
150	0.6	1.2	2.4			C20	6353C88H03
200	0.6	0.6	1.2			C20	6353C88H04
250	0.6	0.6	1.2	2.4		C20	6353C88H05
300	0.3	0.6	1.2	1.2	2.4	C50	6353C88H06
400	0.3	0.3	0.6	1.2	1.2	C50	6353C88H07
500	0.3	0.3	0.3	0.6	1.2	C100	6353C88H08
600	0.3	0.3	0.3	0.6	0.6	C100	6353C88H09
800	0.3	0.3	0.3	0.3	0.6	C100	6353C88H10
1000	0.3	0.3	0.3	0.3	0.3	C200	6353C88H11
1200	0.3	0.3	0.3	0.3	0.3	C200	6353C88H12
1500	0.3	0.3	0.3	0.3	0.3	C200	6353C88H13
2000	0.3	0.3	0.3	0.3	0.3	C700	6353C88H14
2500	0.3	0.3	0.3	0.3	0.3	C700	6353C88H15
3000	0.3	0.3	0.3	0.3	0.3	C700	6353C88H16
4000	0.3	0.3	0.3	0.3	0.3	C700	6353C88H18

### Multi-Ratio, ANSI/IEEE, 5 Terminals

600 MR	0.3	0.3	0.3	0.6	0.6	C100	6350C23H01
1200 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C24H01
2000 MR	0.3	0.3	0.3	0.3	0.3	C700	6350C25H01
3000 MR	0.3	0.3	0.3	0.3	0.3	C700	6350C26H01
4000 MR	0.3	0.3	0.3	0.3	0.3	C700	6350C27H01

Ⓞ Secondary current is 5 amperes at primary current.

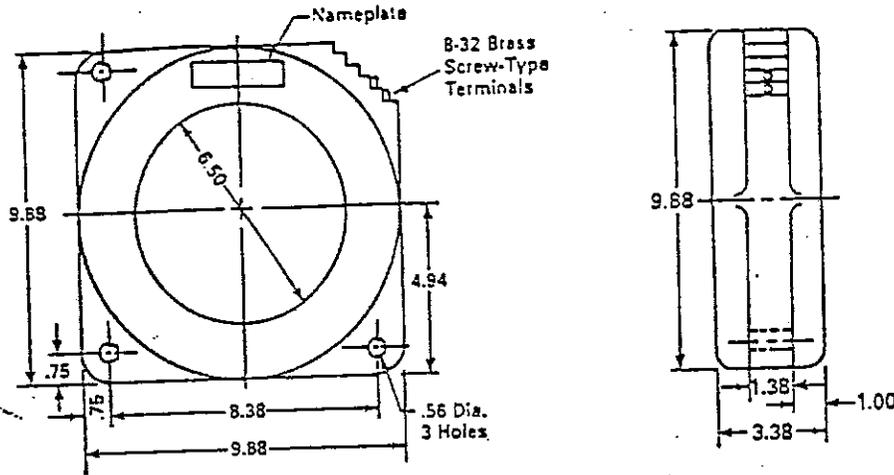


Dimensions (in Inches)

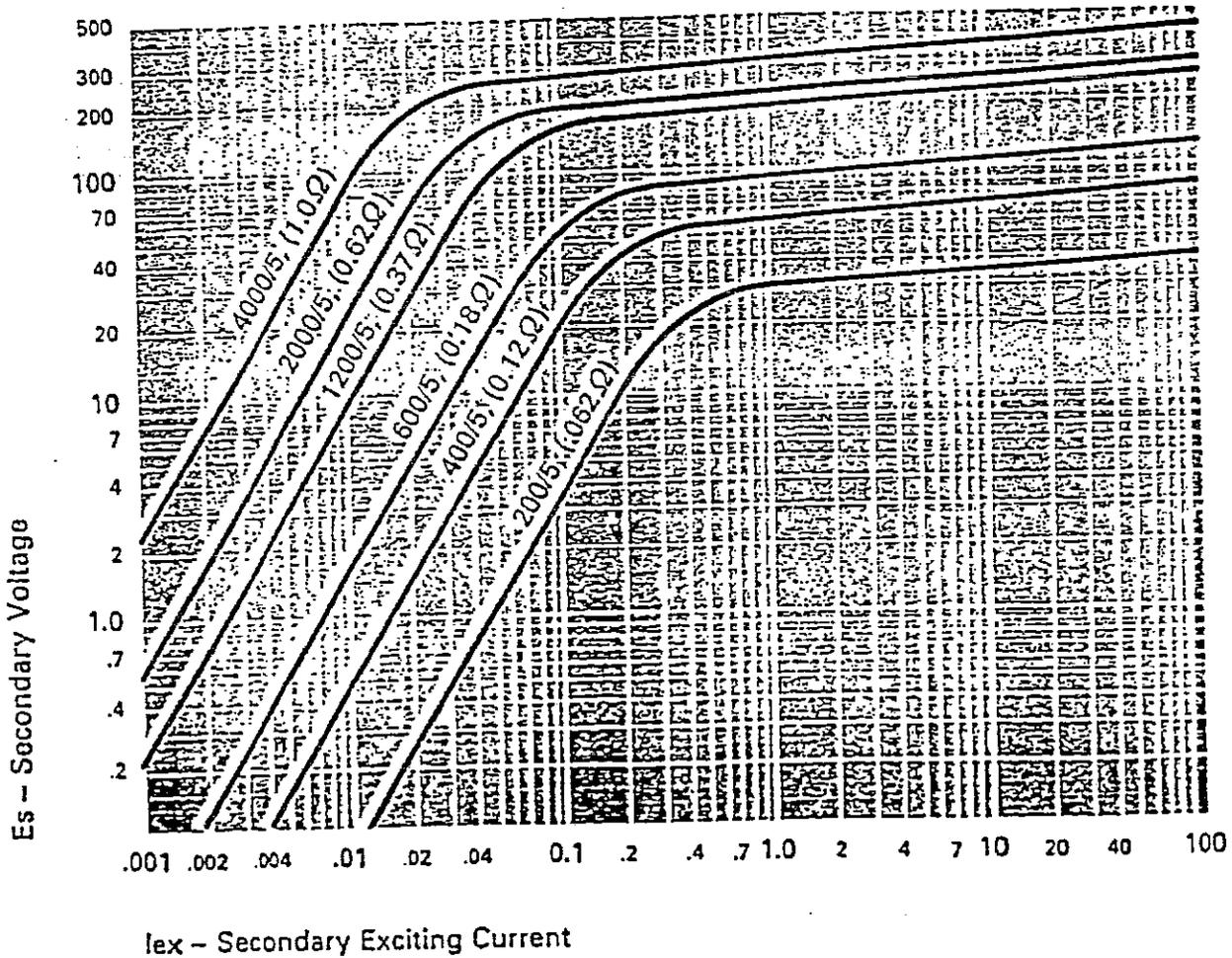
Primary Current Ratings 100-4000 Amperes

Approximate weight: 20.29 lbs.

Further Information  
Prices: Price List 42-800



Performance Curve  
Secondary Excitation Curve



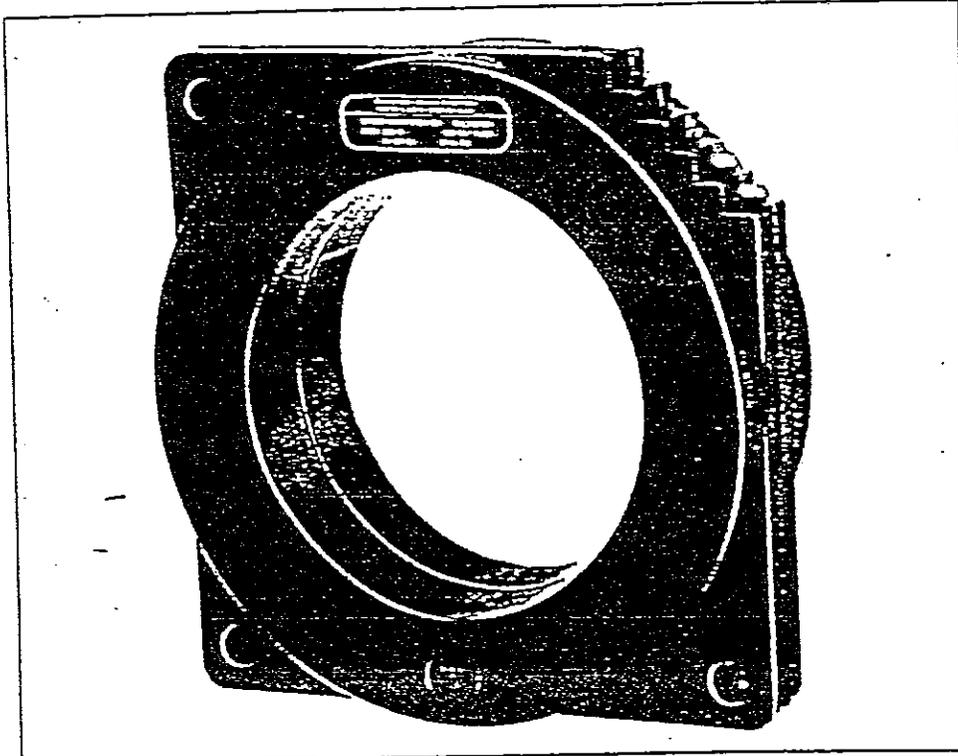


6-1

March, 1986  
 Supersedes Product Bulletin 42-860,  
 pages 1-2, dated August, 1983  
 Mailed to: E, D, C 42-800A

600 Volt Indoor, 10 kV BIL  
 Primary Amperes 100-4000  
 50 through 400 Hz

# Type SCV Current Transformers



**Application**  
 The type SCV current transformer is used in VAC-CLAD Metal-Clad Switchgear as the source of current for relaying and metering. Up to four transformers per phase can be mounted over the primary insulating tubes located in the circuit breaker compartment.

**Ratings**  
 Mechanical Rating: 180 x rated current  
 Thermal Rating: 80 x rated current for on second  
 Continuous Current Rating Factor:  
 2.0 at 30°C Ambient  
 1.5 at 55°C Ambient

**Construction**  
 The ring core is insulated with thermoplastic core cups and toroidally wound with a fully distributed secondary winding. A protective case molded of glass and mica reinforced polyester is ultrasonically sealed to withstand full switchgear impulse test level when installed over the switchgear primary insulating tubes.

'White on black' nameplate information is thermally bonded to the face of the transformer.

Secondary terminals are 8-32, brass, screw type with phosphor bronze lock washers. Space is available for a maximum of 5 terminals to accommodate multi-ratio design.

### Selecter Guide Single Ratio

Primary Current Ratings <sup>Ⓞ</sup>	ANSI Metering Accuracy					Relay Accuracy	Style Number
	B.1	B.2	B.5	B.9	B1.8		
50	Refer to PB 42-860A						
75							
100	1.2	2.4				C10	6353C88H07
150	0.6	1.2	2.4			C20	6353C88H02
200	0.6	0.6	1.2			C20	6353C88H03
250	0.6	0.6	1.2	2.4		C20	6353C88H04
300	0.3	0.6	1.2	1.2	2.4	C20	6353C88H05
400	0.3	0.3	0.6	1.2	1.2	C50	6353C88H08
500	0.3	0.3	0.3	0.6	1.2	C50	6353C88H07
600	0.3	0.3	0.3	0.6	0.6	C100	6353C88H08
800	0.3	0.3	0.3	0.3	0.6	C100	6353C88H09
1000	0.3	0.3	0.3	0.3	0.3	C100	6353C88H10
1200	0.3	0.3	0.3	0.3	0.3	C200	6353C88H11
1500	0.3	0.3	0.3	0.3	0.3	C200	6353C88H12
2000	0.3	0.3	0.3	0.3	0.3	C200	6353C88H13
2500	0.3	0.3	0.3	0.3	0.3	C200	6353C88H14
3000	0.3	0.3	0.3	0.3	0.3	C200	6353C88H15
4000	0.3	0.3	0.3	0.3	0.3	C200	6353C88H16

### Multi-Ratio, ANSI IEEE, 5 Terminals

600 MR	0.3	0.3	0.3	0.6	0.6	C100	6350C27H01
1200 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C27H01
2000 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C27H01
3000 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C27H01
4000 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C27H01

<sup>Ⓞ</sup> Secondary current is 5 amperes at primary current.

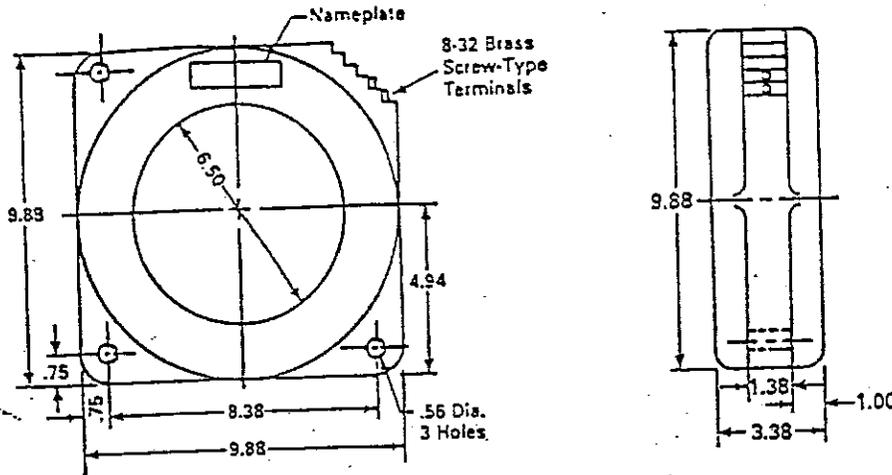


Dimensions (in Inches)

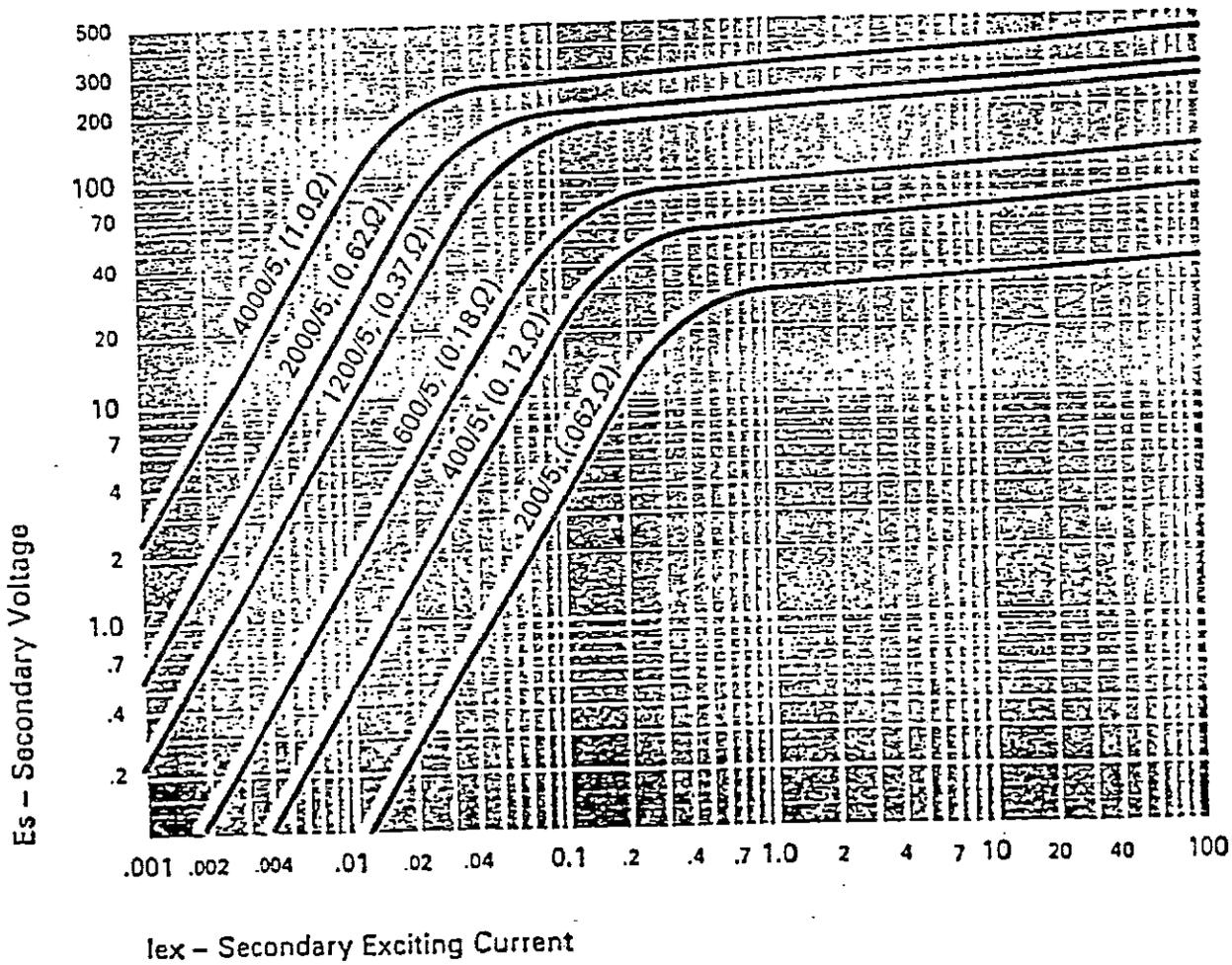
Primary Current Ratings 100-4000 Amperes

Approximate weight: 20-29 lbs.

Further Information  
Prices: Price List 42-800



Performance Curve  
Secondary Excitation Curve



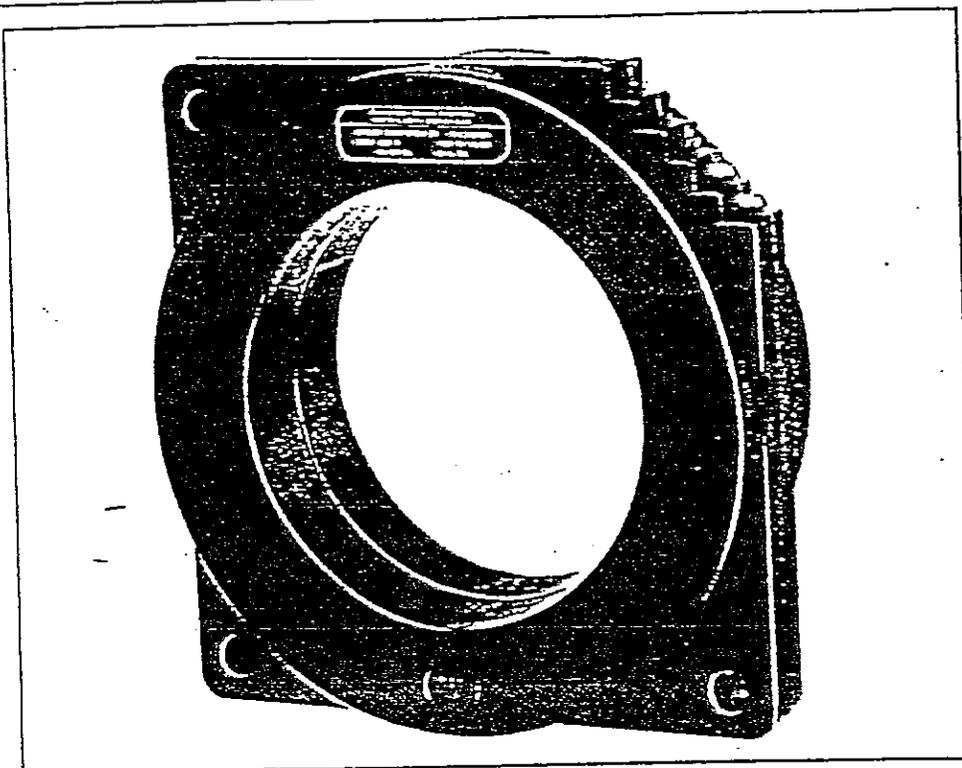


6-1

March, 1986  
 Supersedes Product Bulletin 42-860,  
 pages 1-2, dated August, 1983  
 Mailed to: E, D, C 42-800A

600 Volt Indoor, 10 kV BIL  
 Primary Amperes 100-4000  
 50 through 400 Hz

# Type SCV Current Transformers



**Application**  
 The type SCV current transformer is used in VAC-CLAD Metal-Clad Switchgear as the source of current for relaying and metering. Up to four transformers per phase can be mounted over the primary insulating tube located in the circuit breaker compartment.

**Ratings**  
 Mechanical Rating: 180 x rated current  
 Thermal Rating: 80 x rated current for one second  
 Continuous Current Rating Factor:  
 2.0 at 30°C Ambient  
 1.5 at 55°C Ambient

**Construction**  
 The ring core is insulated with thermoplastic core cups and toroidally wound with fully distributed secondary winding. A protective case molded of glass and mica reinforced polyester is ultrasonically sealed to withstand full switchgear impulse test level when installed over the switchgear primary insulating tubes.

'White on black' nameplate information thermally bonded to the face of the transformer.

Secondary terminals are 8-32, brass, screw type with phosphor bronze lock washer. Space is available for a maximum of 5 terminals to accommodate multi-ratio design.

## Selector Guide Single Ratio

Primary Current Ratings <sup>Ⓢ</sup>	ANSI Metering Accuracy					Relay Accuracy	Style Number
	B.1	B.2	B.5	B.9	B1.8		
50	Refer to PB 42-860A						
75							
100	1.2	2.4				C10	6353C88H07
150	0.6	1.2	2.4			C20	6353C88H02
200	0.6	0.6	1.2			C20	6353C88H03
250	0.6	0.6	1.2	2.4		C20	6353C88H04
300	0.3	0.6	1.2	1.2	2.4	C20	6353C88H05
400	0.3	0.3	0.6	1.2	1.2	C50	6353C88H06
500	0.3	0.3	0.3	0.6	1.2	C50	6353C88H07
600	0.3	0.3	0.3	0.6	0.6	C100	6353C88H08
800	0.3	0.3	0.3	0.3	0.6	C100	6353C88H09
1000	0.3	0.3	0.3	0.3	0.3	C100	6353C88H10
1200	0.3	0.3	0.3	0.3	0.3	C200	6353C88H11
1500	0.3	0.3	0.3	0.3	0.3	C200	6353C88H12
2000	0.3	0.3	0.3	0.3	0.3	C200	6353C88H13
2500	0.3	0.3	0.3	0.3	0.3	C200	6353C88H14
3000	0.3	0.3	0.3	0.3	0.3	C200	6353C88H15
4000	0.3	0.3	0.3	0.3	0.3	C200	6353C88H16

## Multi-Ratio, ANSI/IEEE, 5 Terminals

600 MR	0.3	0.3	0.3	0.6	0.6	C100	6350C27H01
1200 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C27H01
2000 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C27H01
3000 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C27H01
4000 MR	0.3	0.3	0.3	0.3	0.3	C200	6350C27H01

<sup>Ⓢ</sup> Secondary current is 5 amperes at primary current.

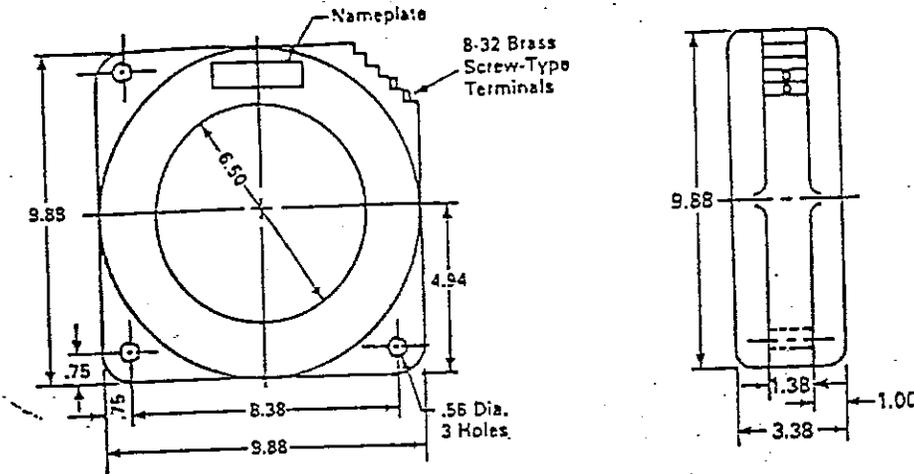


Dimensions (in Inches)

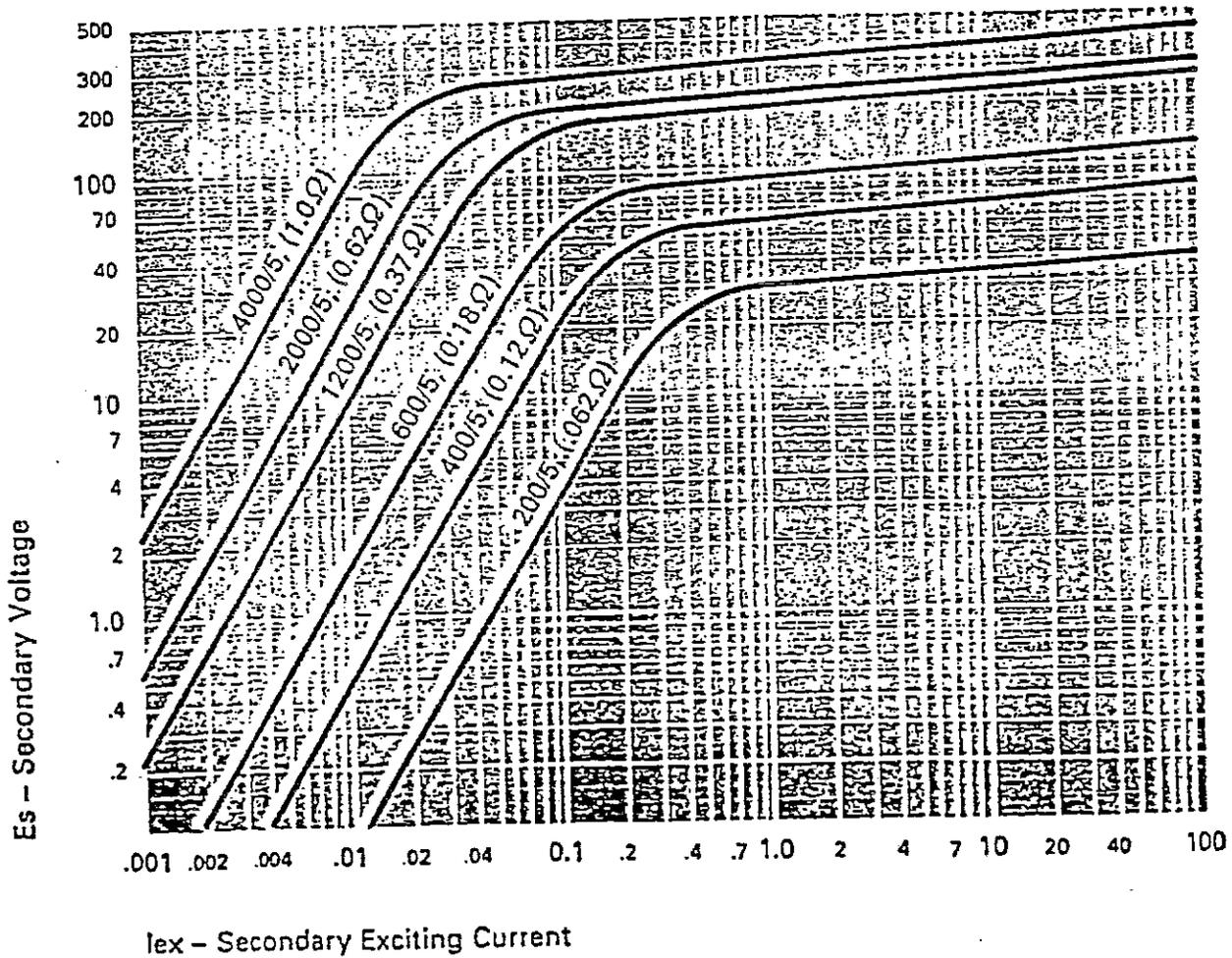
Primary Current Ratings 100-4000 Amperes

Approximate weight: 20-29 lbs.

Further Information  
Prices: Price List 42-800



Performance Curve  
Secondary Excitation Curve



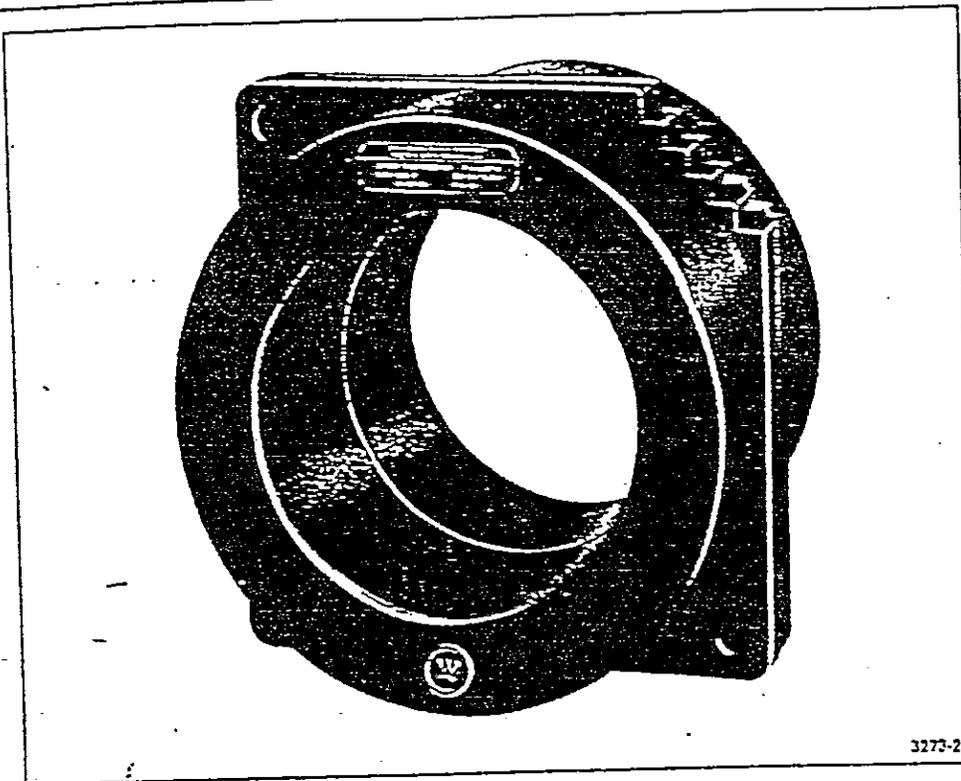


6-2

August, 1983  
 New Information  
 Mailed to: E, D, C-2047/DB

600 Volt Indoor, 12 kV EIL  
 Primary Amperes 50-4000  
 50 through 400 Hz

# Type SCV-D Current Transformers



**Application**  
 The Type SCV-D, deep case, current transformer is used in VAC-CLAD Metal-Clad Switchgear when heavy relaying and metering is required. Two current transformers per phase can be mounted over the primary insulating tubes located in the circuit breaker compartment.

**Ratings**  
 Mechanical Rating: 180 x rated current  
 Thermal Rating: 80 x rated current for one second  
 Continuous Current Rating Factor:  
 2.0 at 30°C Ambient  
 1.5 at 55°C Ambient

**Construction**  
 The ring core is insulated with thermoplastic core cups and toroidally wound with fully distributed secondary winding. A protective case molded of glass and mica reinforced polyester is ultrasonically sealed to withstand full switchgear impulse test level when installed over the switchgear primary insulating tubes.

'White on black' nameplate information thermally bonded to the face of the transformer.

Secondary terminals are 8-32, brass, screw type with phosphor bronze lock washers. Space is available for a maximum of 5 terminals to accommodate multi-ratio design.

### Selector Guide Single Ratio

Primary Current Ratings <sup>⊙</sup>	ANSI Metering Accuracy					Relay Accuracy	Style Number
	B.1	B.2	B.5	B.9	B.1.8		
50	1.2	2.4				C10	6253C89H01
75	1.2	1.2	2.4			C20	6353C89H02
100	0.6	1.2	2.4			C20	6353C89H03
150	0.6	0.6	1.2	1.2	2.4	C50	6353C89H04
200	0.3	0.3	0.6	1.2	2.4	C50	6353C89H05
250	0.3	0.3	0.6	0.6	2.4	C50	6353C89H06
300	0.3	0.3	0.3	0.6	1.2	C100	6353C89H07
400	0.3	0.3	0.3	0.3	0.6	C100	6353C89H08
500	0.3	0.3	0.3	0.3	0.3	C100	6353C89H09
600	0.3	0.3	0.3	0.3	0.3	C200	6353C89H10
800	0.3	0.3	0.3	0.3	0.3	C200	6353C89H11
1000	0.3	0.3	0.3	0.3	0.3	C200	6353C89H12
1200	0.3	0.3	0.3	0.3	0.3	C400	6353C89H13
1500	0.3	0.3	0.3	0.3	0.3	C400	6353C89H14
2000	0.3	0.3	0.3	0.3	0.3	C400	6353C89H15
2500	0.3	0.3	0.3	0.3	0.3	C400	6353C89H16
3000	0.3	0.3	0.3	0.3	0.3	C800	6353C89H17
4000	0.3	0.3	0.3	0.3	0.3	C800	6353C89H18

### Multi-Ratio, ANSIMEEE, 5 Terminals

600 MR	0.3	0.3	0.3	0.3	0.6	C200	6436C45H01
1200 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C47H01
2000 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C48H01
3000 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C49H01
4000 MR	0.3	0.3	0.3	0.3	0.3	C800	6436C50H01

⊙ Secondary current is 5 amperes at primary current.

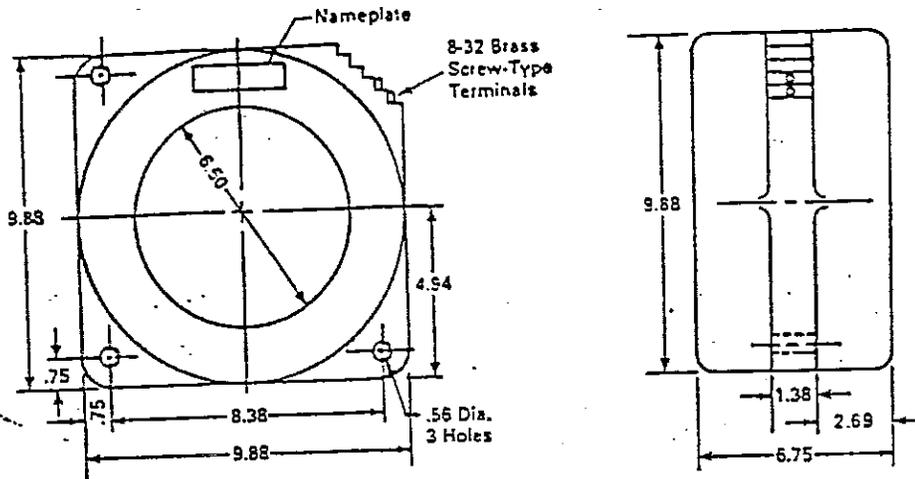


Dimensions (in Inches)

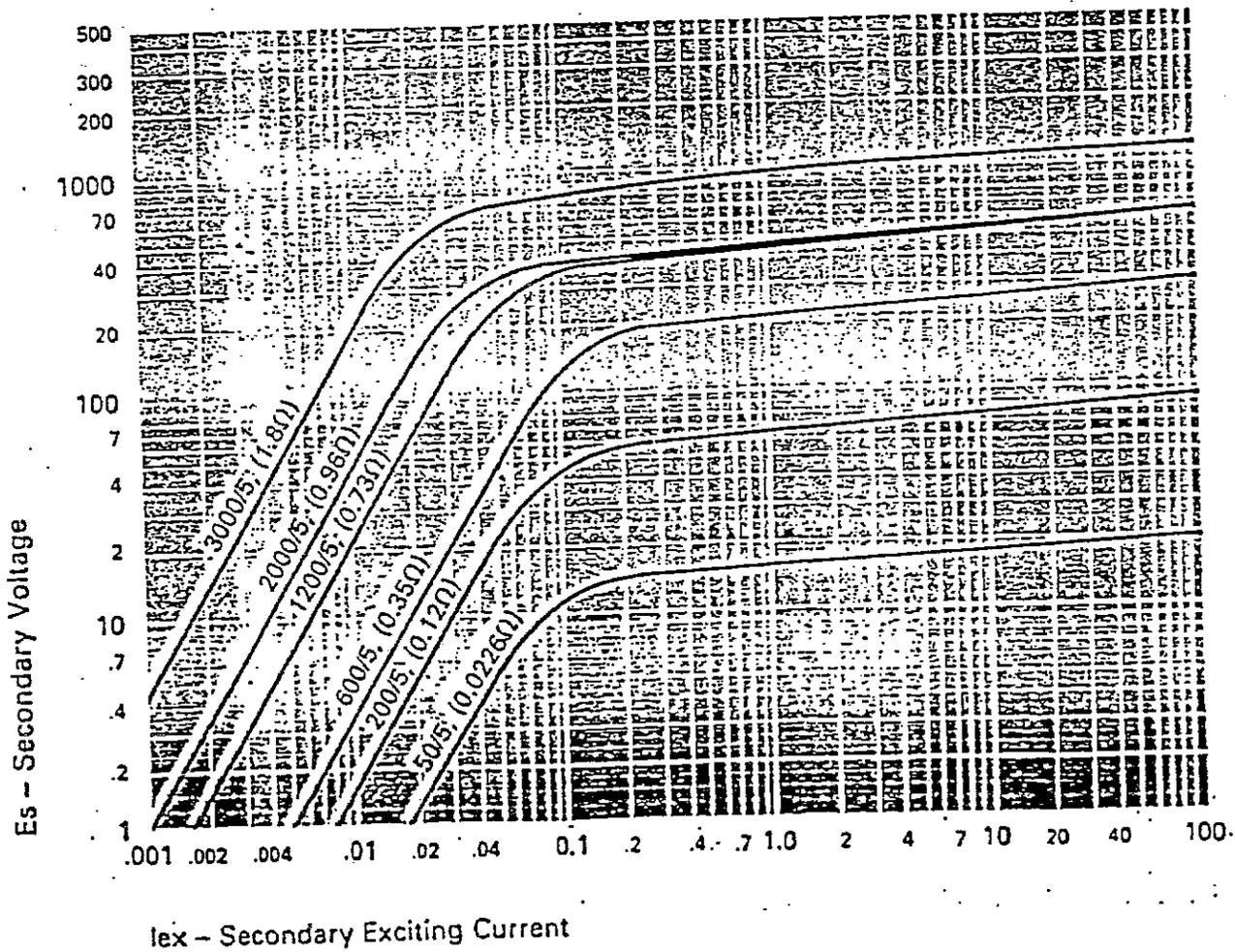
Primary Current Ratings 50-4000 Amperes

Approximate weight = 48 lbs.

Further Information  
Prices: Price List 42-800



Performance Curve  
Secondary Excitation Curve



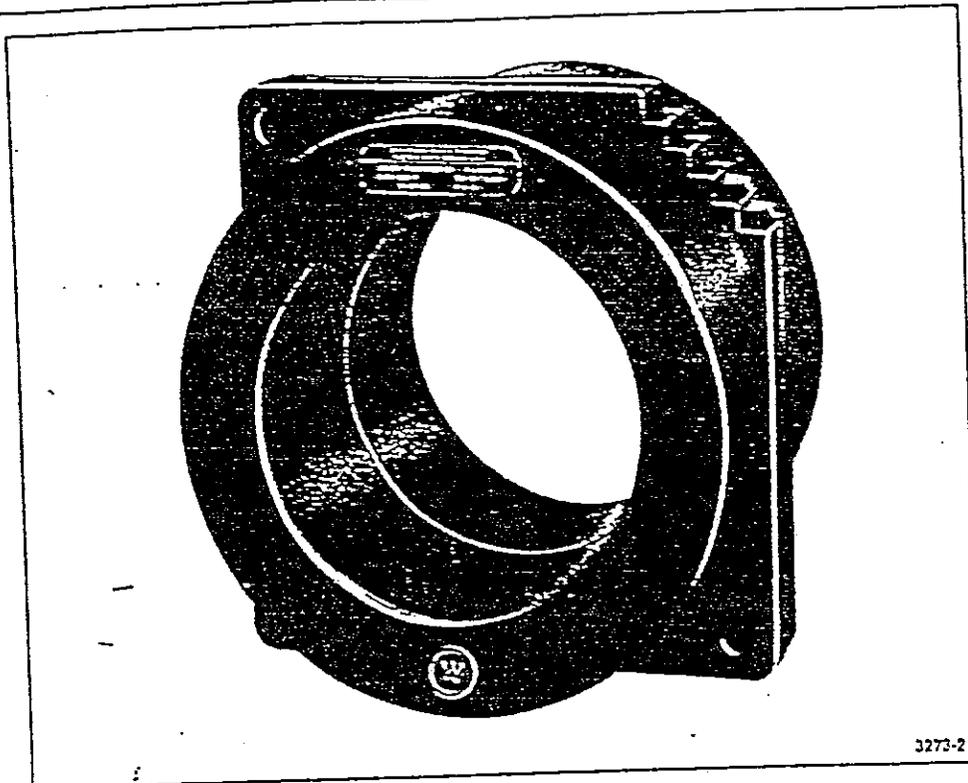


6-2

August, 1983  
 New Information  
 Mailed to: E, D, C2047/DB

600 Volt Indoor, 10 kV BIL  
 Primary Amperes 50-4000  
 50 through 400 Hz

# Type SCV-D Current Transformers



**Application**  
 The Type SCV-D, deep case, current transformer is used in VAC-CLAD Metal-Clad Switchgear when heavy relaying and metering is required. Two current transformers per phase can be mounted over the primary insulating tubes located in the circuit breaker compartment.

**Ratings**  
 Mechanical Rating: 180 x rated current  
 Thermal Rating: 80 x rated current for one second  
 Continuous Current Rating Factor:  
 2.0 at 30°C Ambient  
 1.5 at 55°C Ambient

**Construction**  
 The ring core is insulated with thermoplastic core cups and toroidally wound with a fully distributed secondary winding. A protective case molded of glass and mica reinforced polyester is ultrasonically sealed to withstand full switchgear impulse test level when installed over the switchgear primary insulating tubes.

'White on black' nameplate information is thermally bonded to the face of the transformer.

Secondary terminals are 8-32, brass, screw type with phosphor bronze lock washers. Space is available for a maximum of 5 terminals to accommodate multi-ratio design.

### Selector Guide Single Ratio

Primary Current Ratings <sup>Ⓞ</sup>	ANSI Metering Accuracy					Relay Accuracy	Style Number
	B.1	B.2	B.5	B.9	B1.8		
50	1.2	2.4				C10	6353C89H01
75	1.2	1.2	2.4			C20	6353C89H02
100	0.6	1.2	2.4			C20	6353C89H03
150	0.6	0.6	1.2	1.2	2.4	C50	6353C89H04
200	0.3	0.3	0.6	1.2	2.4	C50	6353C89H05
250	0.3	0.3	0.6	0.6	2.4	C50	6353C89H06
300	0.3	0.3	0.3	0.6	1.2	C100	6353C89H07
400	0.3	0.3	0.3	0.3	0.6	C100	6353C89H08
500	0.3	0.3	0.3	0.3	0.3	C100	6353C89H09
600	0.3	0.3	0.3	0.3	0.3	C200	6353C89H10
800	0.3	0.3	0.3	0.3	0.3	C200	6353C89H11
1000	0.3	0.3	0.3	0.3	0.3	C200	6353C89H12
1200	0.3	0.3	0.3	0.3	0.3	C400	6353C89H13
1500	0.3	0.3	0.3	0.3	0.3	C400	6353C89H14
2000	0.3	0.3	0.3	0.3	0.3	C400	6353C89H15
2500	0.3	0.3	0.3	0.3	0.3	C400	6353C89H16
3000	0.3	0.3	0.3	0.3	0.3	C800	6353C89H17
4000	0.3	0.3	0.3	0.3	0.3	C800	6353C89H18

### Multi-Ratio, ANSIMEEE, 5 Terminals

600 MR	0.3	0.3	0.3	0.3	0.6	C200	6436C46H01
1200 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C47H01
2000 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C48H01
3000 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C49H01
4000 MR	0.3	0.3	0.3	0.3	0.3	C800	6436C50H01

Ⓞ Secondary current is 5 amperes at primary current.

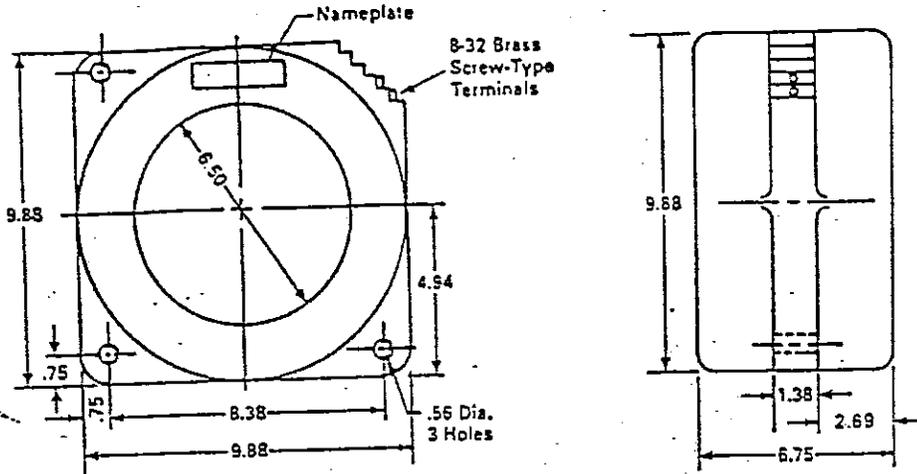


Dimensions (in Inches)

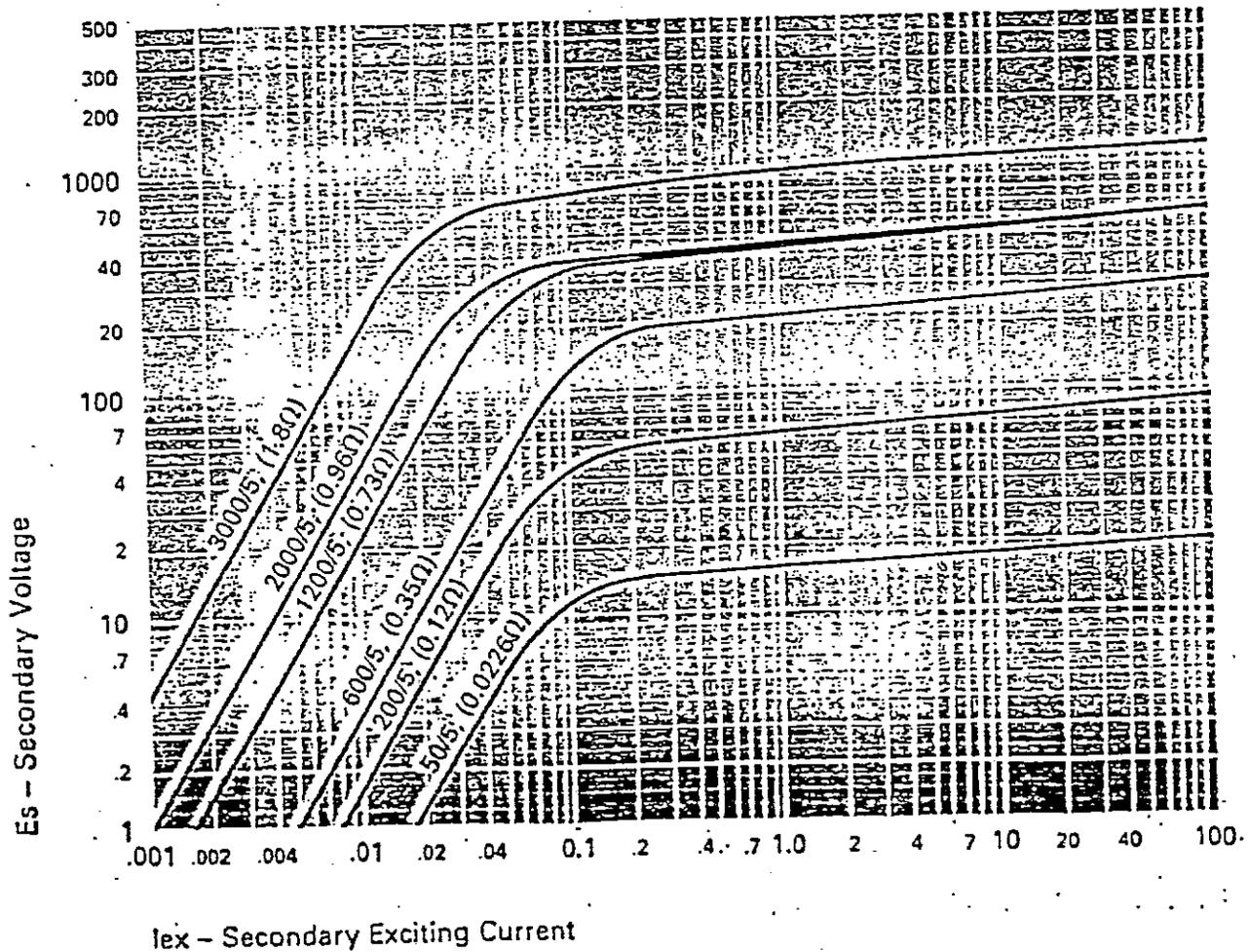
Primary Current Ratings 50-4000 Amperes

Approximate weight = 48 lbs.

Further Information  
Prices: Price List 42-800



Performance Curve  
Secondary Excitation Curve



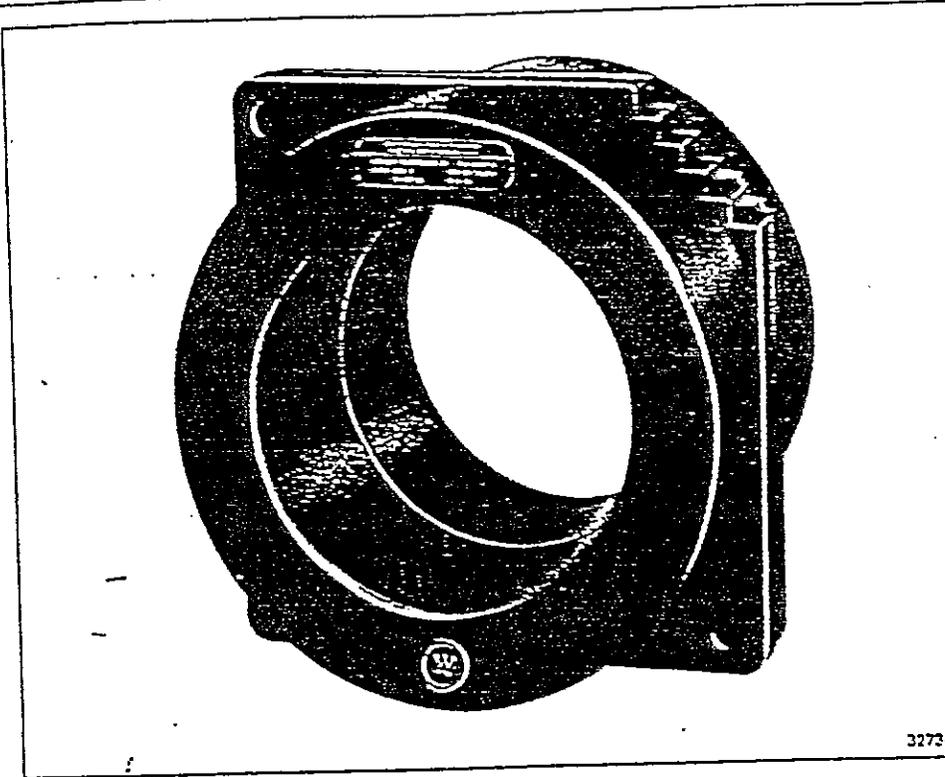


6-2

August, 1983  
 New Information  
 Mailed to: E, D, C/2047/DB

600 Volt Indoor, 13 kV SIL  
 Primary Amperes 50-4000  
 50 through 400 Hz

# Type SCV-D Current Transformers



**Application**  
 The Type SCV-D, deep case, current transformer is used in VAC-CLAD Metal-Clad Switchgear when heavy relaying and metering is required. Two current transformers per phase can be mounted over the primary insulating tubes located in the circuit breaker compartment.

**Ratings**  
 Mechanical Rating: 180 x rated current  
 Thermal Rating: 80 x rated current for second  
 Continuous Current Rating Factor:  
 2.0 at 30°C Ambient  
 1.5 at 55°C Ambient

**Construction**  
 The ring core is insulated with thermoplastic core cups and toroidally wound with fully distributed secondary winding. A protective case molded of glass and mica forced polyester is ultrasonically sealed to withstand full switchgear impulse test when installed over the switchgear primary insulating tubes.

'White on black' nameplate information thermally bonded to the face of the transformer.

Secondary terminals are 8-32, brass, split type with phosphor bronze lock washers. Space is available for a maximum of 5 terminals to accommodate multi-ratio design.

### Selector Guide Single Ratio

Primary Current Ratings <sup>Ⓞ</sup>	ANSI Metering Accuracy					Relay Accuracy	Style Number
	B.1	B.2	B.5	B.9	B1.8		
50	1.2	2.4				C10	6353C89H01
75	1.2	1.2	2.4			C20	6353C89H02
100	0.6	1.2	2.4			C30	6353C89H03
150	0.6	0.6	1.2	1.2	2.4	C50	6353C89H04
200	0.3	0.3	0.6	1.2	2.4	C50	6353C89H05
250	0.3	0.3	0.6	0.6	2.4	C50	6353C89H06
300	0.3	0.3	0.3	0.6	1.2	C100	6353C89H07
400	0.3	0.3	0.3	0.3	0.6	C100	6353C89H08
500	0.3	0.3	0.3	0.3	0.3	C100	6353C89H09
600	0.3	0.3	0.3	0.3	0.3	C200	6353C89H10
800	0.3	0.3	0.3	0.3	0.3	C200	6353C89H11
1000	0.3	0.3	0.3	0.3	0.3	C200	6353C89H12
1200	0.3	0.3	0.3	0.3	0.3	C400	6353C89H13
1500	0.3	0.3	0.3	0.3	0.3	C400	6353C89H14
2000	0.3	0.3	0.3	0.3	0.3	C400	6353C89H15
2500	0.3	0.3	0.3	0.3	0.3	C400	6353C89H16
3000	0.3	0.3	0.3	0.3	0.3	C800	6353C89H17
4000	0.3	0.3	0.3	0.3	0.3	C800	6353C89H18

### Multi-Ratio, ANSMEEE, 5 Terminals

600 MR	0.3	0.3	0.3	0.3	0.6	C200	6436C45H01
1200 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C47H01
2000 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C48H01
3000 MR	0.3	0.3	0.3	0.3	0.3	C400	6436C49H01
4000 MR	0.3	0.3	0.3	0.3	0.3	C600	6436C50H01

Ⓞ Secondary current is 5 amperes at primary current.



MODEL RCI-2 CURRENT TRANSFORMER MULTI-RATIO

139 MR EQUIV

9628A37

Standard Ratings

0.6 kV Class System  
 10 kV Full Wave Impulse  
 50-500 Hz Operation  
 Indoor Application  
 Rating Factor Shown @30°C Amb.

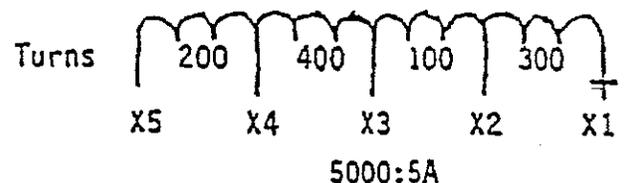
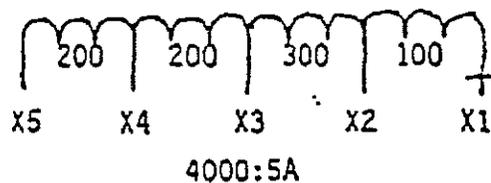
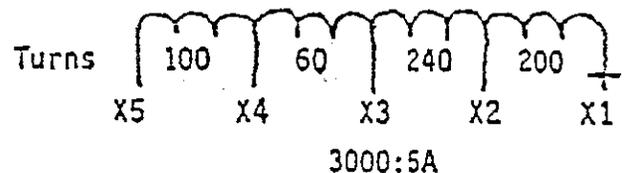
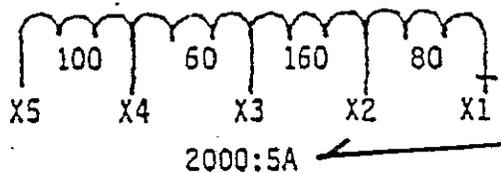
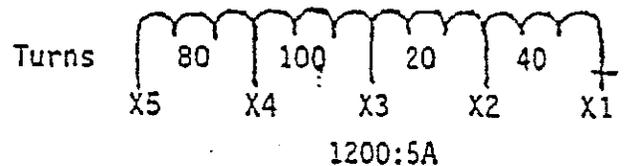
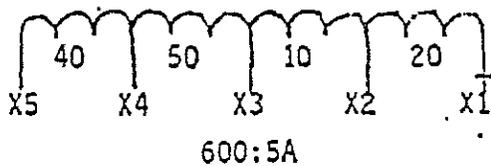
6-3

Mechanical

Encapsulant - Polyurethane  
 Terminals - 10-32 Stud Type  
 Outline - 9627A15  
 Weight - 50#

PRINTED IN U.S.A.

PINETOPS STYLE	RATIO	L-SPEC	R.F.	EXCITATION CURVE	RELAY CLASS
9628A37G01	600:5	L-674A05	1.33	775880	C100
9628A37G02	1200:5	L-674A06	1.33	775881	C200
9628A37G03	2000:5	L-674A07	1.33	775882	C200
9628A37G04	3000:5	L-674A08	1.33	775883	C400
9628A37G05	4000:5	L-674A09	1.33	775884	C400
9628A37G05	5000:5	L-674A10	1.33	775885	C400



Mark Nameplate: Type \_\_\_\_\_ Ratio \_\_\_\_\_  
 S # \_\_\_\_\_

1 ORIGINAL  
 F. Ludlap  
 5/26/87

9628A37

137 EAVIV.

Standard Ratings

**G-4**

Mechanical

0.6 kV Class System  
 10 kV Full Wave Impulse  
 50-400 Hz Operation  
 Indoor Application  
 Rating Factor Shown @ 30°C Amb.

Encapsulant - Polyurethane  
 Terminals - 10-32 Stud Type  
 Outline - 9627A09  
 Weight - 50#

PRINTED IN U.S.A.

PINETOPS STYLE	RATIO	L-SPEC	R.F.	EXCITATION CURVE	RELAY CLASS	ANSI METERING @ 60 Hz				
						B0.1	B0.2	B0.5	B0.9	B1.8
9628A32G01	50/5	673A65	2.0	775844	C10	4.8				
G02	75/5	673A66	2.0	775845	C10	2.4	4.8			
G03	100/5	673A67	2.0	775846	C20	1.2	2.4			
G04	200/5	673A68	2.0	775847	C50	0.6	0.6	1.2	2.4	2.4
G05	300/5	673A69	2.0	775848	C50	0.3	0.3	0.6	1.2	1.2
G06	400/5	673A70	2.0	775849	C100	0.3	0.3	0.3	0.6	1.2
G07	600/5	673A71	2.0	775850	C100	0.3	0.3	0.3	0.3	0.6
G08	800/5	673A72	2.0	775851	C200	0.3	0.3	0.3	0.3	0.3
G09	1000/5	673A73	2.0	775852	C200	0.3	0.3	0.3	0.3	0.3
G10	1200/5	673A74	2.0	775853	C200	0.3	0.3	0.3	0.3	0.3
G11	1500/5	673A75	1.5	775854	C400	0.3	0.3	0.3	0.3	0.3
G12	2000/5	673A76	1.33	775855	C400	0.3	0.3	0.3	0.3	0.3
G13	2500/5	673A77	1.33	775856	C400	0.3	0.3	0.3	0.3	0.3
G14	3000/5	673A78	1.33	775857	C400	0.3	0.3	0.3	0.3	0.3
G15	4000/5	673A79	1.33	775858	C400	0.3	0.3	0.3	0.3	0.3
G16	5000/5	673A80	1.33	775859	C400	0.3	0.3	0.3	0.3	0.3

Mark Nameplate

Type \_\_\_\_\_ Ratio \_\_\_\_\_

S # \_\_\_\_\_

1 Original  
 F. hydram  
 4/27/87

SK

MODEL RCI-1 CURRENT TRANSFORMER

137 EQUIV.

9628A31

Standard Ratings

0.6 kV Class System  
 10 kV Full Wave Impulse  
 50 - 500 Hz Operation  
 Indoor Application  
 Rating Factor Shown @ 30°C Amb.

6-5

Mechanical

Encapsulant - Polyurethane  
 Terminals - 10-32 Stud Type  
 Outline - 9627A08  
 Weight - 60#

PRINTED IN U.S.A.

PINETOPS STYLE	RATIO	L-SPEC	R.F.	EXCITATION CURVE	RELAY CLASS	ANSI METERING @ 60 Hz				
						BO.1	BO.2	BO.5	BO.9	B1.8
9628A31G01	50/5	673A49	2.0	775828	C10	2.4				
G02	75/5	673A50	2.0	775829	C20	1.2	2.4			
G03	100/5	673A51	2.0	775830	C20	1.2	1.2	2.4		
G04	200/5	673A52	2.0	775831	C50	0.3	0.6	1.2	1.2	2.4
G05	300/5	673A53	2.0	775832	C100	0.3	0.3	0.3	0.6	1.2
G06	400/5	673A54	2.0	775833	C100	0.3	0.3	0.3	0.3	0.6
G07	600/5	673A55	2.0	775834	C200	0.3	0.3	0.3	0.3	0.3
G08	800/5	673A56	2.0	775835	C200	0.3	0.3	0.3	0.3	0.3
G09	1000/5	673A57	2.0	775836	C200	0.3	0.3	0.3	0.3	0.3
G10	1200/5	673A58	2.0	775837	C400	0.3	0.3	0.3	0.3	0.3
G11	1500/5	673A59	1.5	775838	C400	0.3	0.3	0.3	0.3	0.3
G12	2000/5	673A60	1.33	775839	C400	0.3	0.3	0.3	0.3	0.3
G13	2500/5	673A61	1.33	775840	C400	0.3	0.3	0.3	0.3	0.3
G14	3000/5	673A62	1.33	775841	C400	0.3	0.3	0.3	0.3	0.3
G15	4000/5	673A63	1.33	775842	C400	0.3	0.3	0.3	0.3	0.3
G16	5000/5	673A64	1.33	775843	C400	0.3	0.3	0.3	0.3	0.3

Mark Nameplate:

Type \_\_\_\_\_ Ratio \_\_\_\_\_

S # \_\_\_\_\_

Original  
 F. Ludlam  
 4/27/87



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

<b>Turbine Technologies Construction</b>	10/01/01
CUSTOMER <b>001044</b>	DATE <b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER <b>13.8 kV Switchgear above 52P</b>	E SQUARED CONTRACT NUMBER <b>Fellows, CA</b>
PT LOCATION <b>Instrument Transformer Inc.</b>	CUSTOMER SITE <b>A-B Phase Sync Bus PT</b>
PT MANUFACTURER	CIRCUIT IDENTIFICATION
PREVIOUS INSPECTION DATE	INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA			
Type:	PTG5-2-110-1442FF	Serial #	1023294
Ratio	14400:120	BIL	110 kV
Class	0.3Z	Weight	
Primary	14400	Style	
Hertz	60	VA	1500

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
14400:120 or 120:1	119.79:1	2 mA

Megger Tests performed with Amprobe Model #AMB-5kV		
Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
A Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
B Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
A Primary to A Secondary	> 500 Giga $\Omega$	1000 Volts
A Secondary to Ground	> 500 Giga $\Omega$	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found.

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

<b>Turbine Technologies Construction</b>	10/01/01
CUSTOMER <b>001044</b>	DATE <b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER <b>13.8 kV Switchgear above 52P</b>	E SQUARED CONTRACT NUMBER <b>Fellows, CA</b>
PT LOCATION <b>Instrument Transformer Inc.</b>	CUSTOMER SITE <b>B-C Phase Sync Bus PT</b>
PT MANUFACTURER	CIRCUIT IDENTIFICATION
PREVIOUS INSPECTION DATE	INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA			
Type:	PTG5-2-110-1442FF	Serial #	1023295
Ratio	14400:120	BIL	110 kV
Class	0.3Z	Weight	
Primary	14400	Style	
Hertz	60	VA	1500

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
14400:120 or 120:1	119.81:1	2 mA
Megger Tests performed with Amprobe Model # AMB-5kV		
Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
B Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
C Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
C Primary to C Secondary	> 500 Giga $\Omega$	1000 Volts
C Secondary to Ground	> 500 Giga $\Omega$	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found.

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

<b>Turbine Technologies Construction</b>	<b>10/01/01</b>
CUSTOMER <b>001044</b>	DATE <b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER <b>13.8 kV Switchgear above 52M</b>	E SQUARED CONTRACT NUMBER <b>Fellows, CA</b>
PT LOCATION <b>Instrument Transformer Inc.</b>	CUSTOMER SITE <b>A-B Phase Main Sync Bus PT</b>
PT MANUFACTURER	CIRCUIT IDENTIFICATION
PREVIOUS INSPECTION DATE	INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA			
Type:	PTG5-2-110-1442FF	Serial #	1023290
Ratio	14400:120	BIL	110 kV
Class	0.3Z	Weight	
Primary	14400	Style	
Hertz	60	VA	1500

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
14400:120 or 120:1	119.78:1	2 mA
Megger Tests performed with Amprobe Model # AMB-5kV		
Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
A Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
B Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
A Primary to A Secondary	> 500 Giga $\Omega$	1000 Volts
A Secondary to Ground	> 500 Giga $\Omega$	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found.

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

<b>Turbine Technologies Construction</b>	<b>10/01/01</b>
CUSTOMER <b>001044</b>	DATE <b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER <b>13.8 kV Switchgear above 52M</b>	E SQUARED CONTRACT NUMBER <b>Fellows, CA</b>
PT LOCATION <b>Instrument Transformer Inc.</b>	CUSTOMER SITE <b>B-C Phase Main Sync Bus PT</b>
PT MANUFACTURER	CIRCUIT IDENTIFICATION
PREVIOUS INSPECTION DATE	INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA			
Type:	PTG5-2-110-1442FF	Serial #	1023291
Ratio	14400:120	BIL	110 kV
Class	0.3Z	Weight	
Primary	14400	Style	
Hertz	60	VA	1500

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
14400:120 or 120:1	119.79:1	2 mA
Megger Tests performed with Amprobe Model #AMB-5kV		
Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
B Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
C Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
C Primary to C Secondary	> 500 Giga $\Omega$	1000 Volts
C Secondary to Ground	> 500 Giga $\Omega$	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found.

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

Turbine Technologies Construction

10/01/01

CUSTOMER

DATE

001044

2138T1835

CUSTOMER PURCHASE ORDER NUMBER

E SQUARED CONTRACT NUMBER

13.8 kV Switchgear above 52G

Fellows, CA

PT LOCATION

CUSTOMER SITE

Instrument Transformer Inc.

B-C Phase Generator PT

PT MANUFACTURER

CIRCUIT IDENTIFICATION

PREVIOUS INSPECTION DATE

INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA

Type:	PTG5-2-110-1442FF	Serial #	1023289
Ratio	14400:120	BIL	110 kV
Class	0.3Z	Weight	
Primary	14400	Style	
Hertz	60	VA	1500

VISUAL & MECHANICAL INSPECTION

OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39

RATIO	RESULT	mA During Test
14400:120 or 120:1	119.79:1	2 mA

Megger Tests performed with Amprobe Model #AMB-5kV

Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
B Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
C Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
C Primary to C Secondary	> 500 Giga $\Omega$	1000 Volts
C Secondary to Ground	> 500 Giga $\Omega$	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found.

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

<b>Turbine Technologies Construction</b>	<b>10/01/01</b>
CUSTOMER	DATE
<b>001044</b>	<b>2138T1835</b>
CUSTOMER PURCHASE ORDER NUMBER	E SQUARED CONTRACT NUMBER
<b>13.8 kV Switchgear above 52G</b>	<b>Fellows, CA</b>
PT LOCATION	CUSTOMER SITE
<b>Instrument Transformer Inc.</b>	<b>A-B Phase Generator PT</b>
PT MANUFACTURER	CIRCUIT IDENTIFICATION
PREVIOUS INSPECTION DATE	INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA			
Type:	PTG5-2-110-1442FF	Serial #	1023288
Ratio	14400:120	BIL	110 kV
Class	0.3Z	Weight	
Primary	14400	Style	
Hertz	60	VA	1500

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	
14400:120 or 120:1	119.89:1	mA During Test 2 mA

Megger Tests performed with Amprobe Model #AMB-5kV		
Test Connection	Resistance in Ω for 1 Minute	Test Voltage Level
A Phase Primary to Ground	> 500 Giga Ω	5000 Volts
B Phase Primary to Ground	> 500 Giga Ω	5000 Volts
A Primary to A Secondary	> 500 Giga Ω	1000 Volts
A Secondary to Ground	> 500 Giga Ω	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found.

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

Turbine Technologies Construction

10/01/01

CUSTOMER

DATE

001044

2138T1835

CUSTOMER PURCHASE ORDER NUMBER

E SQUARED CONTRACT NUMBER

13.8 kV Switchgear above Cubicle #4

Fellows, CA

PT LOCATION

CUSTOMER SITE

Instrument Transformer Inc.

A-B Phase AVR PT

PT MANUFACTURER

CIRCUIT IDENTIFICATION

PREVIOUS INSPECTION DATE

INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA

Type:	PTG5-2-110-1442FF	Serial #	1023292
Ratio	14400:120	BIL	110 kV
Class	0.3Z	Weight	
Primary	14400	Style	
Hertz	60	VA	1500

VISUAL & MECHANICAL INSPECTION

OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39

RATIO	RESULT	mA During Test
14400:120 or 120:1	119.89:1	2 mA

Megger Tests performed with Amprobe Model # AMB-5kV

Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
A Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
B Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
A Primary to A Secondary	> 500 Giga $\Omega$	1000 Volts
A Secondary to Ground	> 500 Giga $\Omega$	1000 Volts

Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found.

TESTED BY: S. Mills

WITNESSED BY: \_\_\_\_\_



POTENTIAL TRANSFORMER INSPECTION & TEST REPORT

<b>Turbine Technologies Construction</b>	10/01/01
CUSTOMER	DATE
001044	2138T1835
CUSTOMER PURCHASE ORDER NUMBER	E SQUARED CONTRACT NUMBER
13.8 kV Switchgear above Cubicle #4	Fellows, CA
PT LOCATION	CUSTOMER SITE
Instrument Transformer Inc.	B-C Phase AVR PT
PT MANUFACTURER	CIRCUIT IDENTIFICATION
PREVIOUS INSPECTION DATE	INSTRUCTION BOOK

POTENTIAL TRANSFORMER NAMEPLATE DATA			
Type:	PTG5-2-110-1442FF	Serial #	1023293
Ratio	14400:120	BIL	110 kV
Class	0.3Z	Weight	
Primary	14400	Style	
Hertz	60	VA	1500

VISUAL & MECHANICAL INSPECTION			
OBSERVATIONS		ROUTINE MAINTENANCE	
Case Condition	Good	Case Cleaned	
Primary, Secondary wires	OK	Connections Tight	Yes
Overheating	None		

Tests Performed with Biddle Three Phase TTR Model #550100-39		
RATIO	RESULT	mA During Test
14400:120 or 120:1	119.82:1	2 mA

Megger Tests performed with Amprobe Model #AMB-5kV		
Test Connection	Resistance in $\Omega$ for 1 Minute	Test Voltage Level
B Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
C Phase Primary to Ground	> 500 Giga $\Omega$	5000 Volts
C Primary to C Secondary	> 500 Giga $\Omega$	1000 Volts
C Secondary to Ground	> 500 Giga $\Omega$	1000 Volts

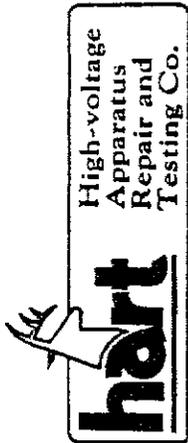
Comments PT testing was performed using the Biddle Three Phase TTR Model # 550100-39  
 Proper polarity was verified visually in the field and also by the test set.  
 Megger Testing was performed using the Amprobe model # AMB-5kV  
 No problems were found.

TESTED BY: S. Mills WITNESSED BY: \_\_\_\_\_



DC High Potential Test Report															
Customer TTS Construction						Job No. 2663									
Location Fellows, CA						Date #####									
						Tested By JW									
SWGR PNL Identification					Test Equipment Hipotronics 860 PL, AEMC 5100,										
Feeder Identification Generator					Used V.O.M. Psychrometer										
CABLE INFORMATION				ELECTRICAL TEST DATA											
CABLE MFG. Pirelli Cable				STEP VOLTAGE TEST				LEAKAGE @ TEST VOLTAGE				VOLTAGE DECAY			
INSULATION TYPE XLP MV-90		MILS 220		KILOVOLT	MICRO AMPS			TIME	MICRO AMPS			TIME	KILOVOLTS		
VOLTAGE 15Kv 133%	GND	UNGND	X		A	B	C		A	B	C		A	B	C
CONDUCTOR SIZE 750 MCM		COPPER ALUM X		5	0.10	0.10	0.20	1 min.	1.20	1.35	1.25	10 sec.	6.0	6.0	6.0
LENGTH 40'		SHLD X UNSHLD		10	0.30	0.30	0.30	2 min.	1.15	1.35	1.25	20 sec.	1.0	1.0	1.0
DATE INSTALLED 08/01		NO. TERM 18		15	0.50	0.50	0.50	3 min.	1.15	1.35	1.25	30 sec.	0.5	0.5	0.5
TEST INFORMATION				20	0.70	0.80	0.70	4 min.	1.15	1.35	1.25	40 sec.	0.5	0.5	0.5
TEST VOLTAGE 30Kv		NO. STEPS 6		25	0.90	1.00	1.00	5 min.	1.15	1.35	1.25	50 sec.	-	-	-
TEMP. 95°F		HUMIDITY 32%		30	1.20	1.35	1.25	6 min.	1.10	1.35	1.25	60 sec.	-	-	-
MEGGER TEST @500 VOLTS								7 min.	1.10	1.35	1.20				
A-GND		B-GND						8 min.	1.10	1.35	1.20				
3KGΩ		3KGΩ						9 min.	1.10	1.35	1.20				
SHLD CONTINUITY		SHLD CONTINUITY						10 min.	1.10	1.35	1.20				
A 4.0Ω		B 4.0Ω C 4.0Ω													
Remarks Ek = A, Rd = B, Bl = C Note: Test performed with 3 each phase conductors bonded together for test.															





## DC High Potential Test Report

Customer	TTS Construction		Job No.	2663
Location	Fellows, CA		Date	#####
			Tested By	JW
SWGR PNL Identification	Hipotronics 860 PL, AEMC 5100,			
Feeder Identification	Excitation XFMR Used V.O.M. Psychrometer			

CABLE INFORMATION				
CABLE MFG.	INSULATION TYPE	MILS	PIRELLI CABLE	
EPR MV-105	UNGND	220	X	
15Kv 133%	COPPER ALUM		X	
2 AWG	SHLD		UNSHLD	
30'	NO. TERM	6		
DATE INSTALLED	08/01			

STEP VOLTAGE TEST				
KILOVOLT	MICRO AMPS			TIME
	A	B	C	
5	0.10	0.10	0.10	1 min.
10	0.25	0.20	0.20	2 min.
15	0.40	0.35	0.35	3 min.
20	0.50	0.50	0.50	4 min.
25	0.65	0.65	0.60	5 min.
30	0.85	0.80	0.80	6 min.
				7 min.
				8 min.
				9 min.
				10 min.

ELECTRICAL TEST DATA				
LEAKAGE @ TEST VOLTAGE				
TIME	MICRO AMPS			TIME
	A	B	C	
1 min.	0.85	0.80	0.80	10 sec.
2 min.	0.85	0.80	0.80	20 sec.
3 min.	0.85	0.80	0.75	30 sec.
4 min.	0.85	0.80	0.75	40 sec.
5 min.	0.85	0.80	0.75	50 sec.
6 min.	0.85	0.80	0.75	60 sec.
7 min.	0.85	0.80	0.70	
8 min.	0.85	0.80	0.70	
9 min.	0.85	0.80	0.70	
10 min.	0.85	0.80	0.70	

VOLTAGE DECAY				
TIME	KILOVOLTS			
	A	B	C	
10 sec.	1.0KV	1.0KV	1.0KV	
20 sec.	0.5KV	0.5KV	0.5KV	
30 sec.	-	-	-	
40 sec.	-	-	-	
50 sec.	-	-	-	
60 sec.	-	-	-	

TEST INFORMATION		
TEST VOLTAGE	30Kv	
NO. STEPS	6	
TEMP.	95°F	
HUMIDITY	32%	
MEGGER TEST @5000 VOLTS		
A-GND	B-GND	C-GND
3KΩ	3KΩ	3KΩ
SHLD CONTINUITY	A 0.3Ω B 0.3Ω C 0.3Ω	

Remarks Bk = A, Rd = B, BI = C



### DC High Potential Test Report

Customer	TTS Construction		Job No.	2663
Location	Fellows, CA		Date	####
			Tested By	JW
SWGR PNL Identification	Hipotronics 860 PL, AEMC 5100,			
Feeder Identification	Station Service XFMR Used V.O.M. Psychrometer			

CABLE INFORMATION				
CABLE MFG.	MILS			
Pirelli Cable				
INSULATION TYPE	GND	UNGND		
15Kv	X	X		
CONDUCTOR SIZE	COPPER	ALUM		
2 AWG	X	X		
LENGTH	SHLD	UNSHLD		
80'	X	X		
DATE INSTALLED	NO. TERM			
08/01	6			

STEP VOLTAGE TEST				
KILOVOLT	MICRO AMPS			
	A	B	C	
5	0.10	0.10	0.10	0.10
10	0.25	0.25	0.25	0.25
15	0.35	0.35	0.40	0.40
20	0.50	0.55	0.60	0.60
25	0.75	0.70	0.80	0.80
30	0.90	1.50	1.00	1.00

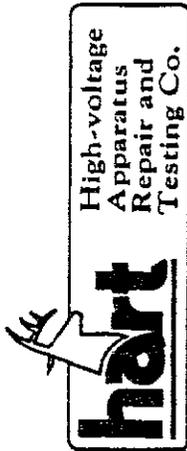
ELECTRICAL TEST DATA				
LEAKAGE @ TEST VOLTAGE				
TIME	MICRO AMPS			KILOVOLTS
	A	B	C	
1 min.	0.90	1.50	1.00	1.0KV
2 min.	0.90	1.50	1.00	0.5KV
3 min.	0.90	1.50	1.00	-
4 min.	0.90	1.40	1.00	-
5 min.	0.90	1.40	1.00	-
6 min.	0.90	1.40	1.00	-
7 min.	0.90	1.40	1.00	-
8 min.	0.90	1.40	1.00	-
9 min.	0.85	1.35	0.95	-
10 min.	0.85	1.35	0.95	-

TEST INFORMATION				
TEST VOLTAGE	NO. STEPS			
30Kv	6			
TEMP.	HUMIDITY			
95°F	32%			
MEGGER TEST @5000 VOLTS				
A-GND	B-GND	C-GND		
3KGΩ	3KGΩ	3KGΩ		
SHLD CONTINUITY				
A 0.5Ω	B 0.5Ω	C 0.5Ω		

Remarks	Bk = A, Rd = B, Bl = C
---------	------------------------



### Transformer Test Report

Customer: TTS Construction	Location: Fellows, CA	Job No: 2663	Date: 8/31/2001
Transformer Identification: Station Service	Test Equipment Used: 5KV Megger	Tested By: RM	

Nameplate Information				Electrical Test Data			
Manufacturer: Sunbelt XFMR, Inc.				Megger Test: @ 5000 Volts L-H&G 500V			
Oil: X	Dry: OA	H-L	H&G	H-L	H&G	H-L	H&G
KVA: 1500	Class: OA	95GΩ	40GΩ	150GΩ	40GΩ	150GΩ	40GΩ
Voltage: 14400 - 480/277		Duration: 5 min.	Temp: 80°	Humidity: 40%	Winding Resistance:		
S/N: 4.286E+09		IMP: 5.8%		Temp Rise: 85°			
Phase: 3		Temp Rise: 85°		Primary Voltage			
1	2	3	4	5	6	7	
Oil Sample Taken: <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No				(See Attached Data Sheet)			

Visual Inspection		Remarks/Comments	
Bushings	OK		
Insulators	OK		
Connections	Disconnected		
Grounding	①	① Ungrounded (Grounding Available)	
Anchoring	②	② Anchoring points available.	
Fans/Controls	OK		
Temp. Gauge - Oil	30°C		
Liquid Level Gauge	25°C		
Pressure Gauge	1 lb.		
Sudden Pressure Dev.	No		
Pressure Relief Dev.	Yes		
Temp Gauge - Windin	No		

**Diagram:**

Turns Ratio Test	Turns Ratio Determination
Tap Position	H1 - H0
Calculated Ratio	X1 - X2
	H2 - H0
	X2 - X3
	H3 - H0
	X3 - X1

**Summary of the  
Startup and Testing of the  
Generator Excitation System**

**Midsun Cogen,  
Fellows, CA**

January 22, 2002

Michael Dube' & Matthew Farrar

SECTION  
**1**

---

## **Midsun Cogen GEC Gas Turbine Unit**

### Startup and Testing of DECS-300 Excitation System

#### **Summary and Recommendations**

#### **SUMMARY**

In January 2002, testing and startup of the generator excitation system was performed on the GEC Gas Turbine Unit at Midsun Cogen.

All control input and output were previously tested between the turbine PLC and the generator control panel in late 2001. The potential transformer and current transformer inputs to the generator control panel were simulated. In addition, the 52 sync breaker trip/block/close and protective trips were tested.

On January 22, the generator was started and brought up to full speed-no load by Rich Strayer (TTSC). The excitation system was then tested and tuned off-line. Synchronization checks were performed. The unit was then put on-line and brought up to 10MW. On-line excitation system tuning was performed. Graph A and Graph B illustrate the startup curve (generator terminal voltage) for the DECS-300 on this unit. The unit was operated to full load and rated power factor. All systems worked well.

#### **RECOMMENDATIONS**

1. No periodic maintenance of the excitation system is needed. However, the excitation system should be tested any time there is a fault on the generator that involves the excitation system (i.e. Loss of excitation, Extended Overexcitation).
2. The Beckwith M-3420 and Schweitzer 587 protective relays do not need regular calibration, but should be trip checked every year to ensure proper protection tripping.

## SECTION

**2****Midsun Cogen GEC Gas Turbine Unit**

## Startup and Testing of DECS-300 Excitation System

**TESTING DETAILS****Automatic Voltage Regulator (AVR)**

The Automatic Voltage Regulator was tuned and tested to ensure that it is responsive, yet stable. 5% and 10% step tests were performed to evaluate and tune the DECS-300. This involved jumping the generator voltage up and down %5 and 10% and watching the regulator response for overshoot and time to stability. Graph C illustrates the AVR step response test.

It is desirable to have the over/undershoot below 25% and the total time less than 3 seconds. The results we obtained after tuning were commensurate with a very responsive regulator.

**Field Current Regulator (FCR)**

The Field Current Regulator was tuned and tested to ensure that it is responsive, yet stable. 5% and 10% step tests were performed to evaluate and tune the DECS-300. This involved jumping the generator voltage up and down %5 and 10% and watching the regulator response for overshoot and time to stability. Graph D illustrates the FCR step response test.

It is desirable to have the over/undershoot below 10% and the total time less than 2 seconds. These results we obtained after tuning were commensurate with a very responsive regulator.

## **OverExcitation Limiting (OEL)**

The OverExcitation Limiter was tested to ensure it was responsive, yet did not cause an instability. This test was performed in AVR mode. The OEL limit was stepped down below the current operating level and observed. The OEL quickly reduced the field current, but did not cause the AVR to oscillate. When the OEL was stepped back above the current operating level, the field current immediately returned to its original level.

## **UnderExcitation Limiting (UEL)**

The UnderExcitation Limiter was tested to it was responsive, yet did not cause an instability. This test was performed in AVR mode. The UEL limit above the current VAR operating level and observed. The UEL quickly increased the field current to raise the VAR output, but did not cause the AVR to oscillate. When the UEL was stepped back below the current VAR operating level, the field current immediately returned to its original level.

150.00

1= # .00  
ACV

MIDSum 1/22/02

MIDSum 1/22/02

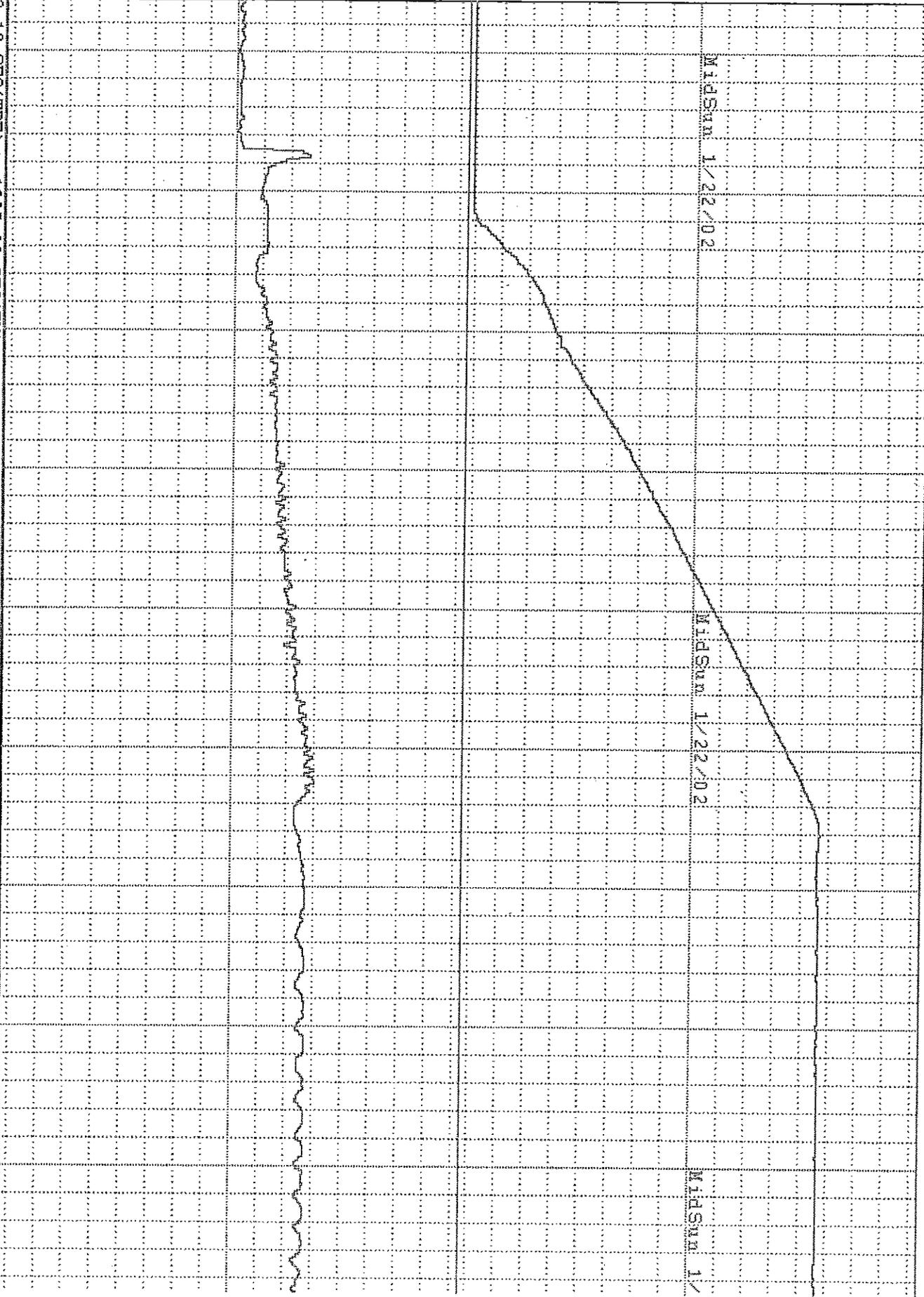
MIDSum 1/

-2.00  
75.00

2=2 2.07  
DCV

-75.00

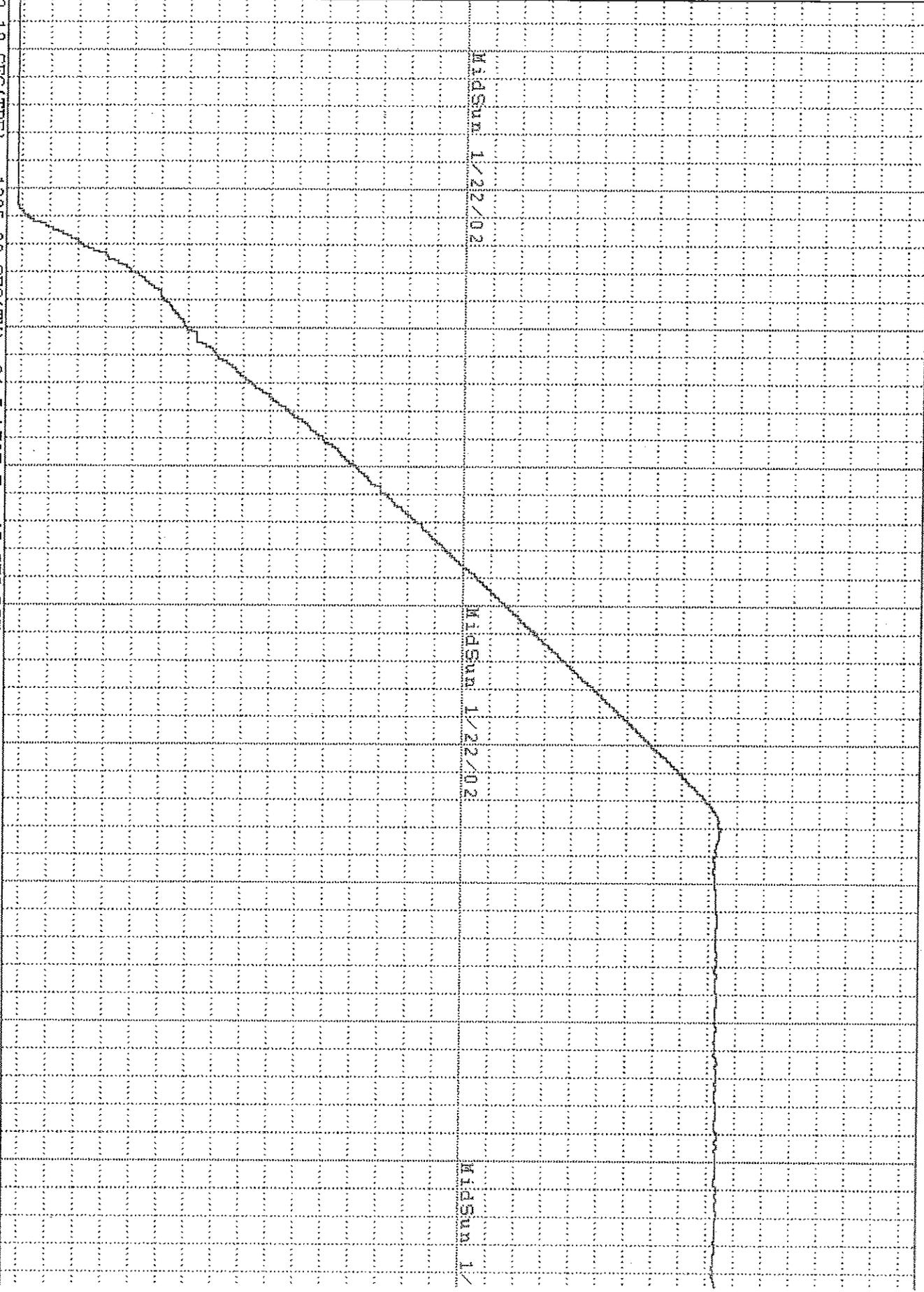
DATA 452.10 SEC(TBF) -1395.30 SEC(TM) 24.5 %EOF T: .67 SEC/DIV



GRAPH A

1=1  
ACTV

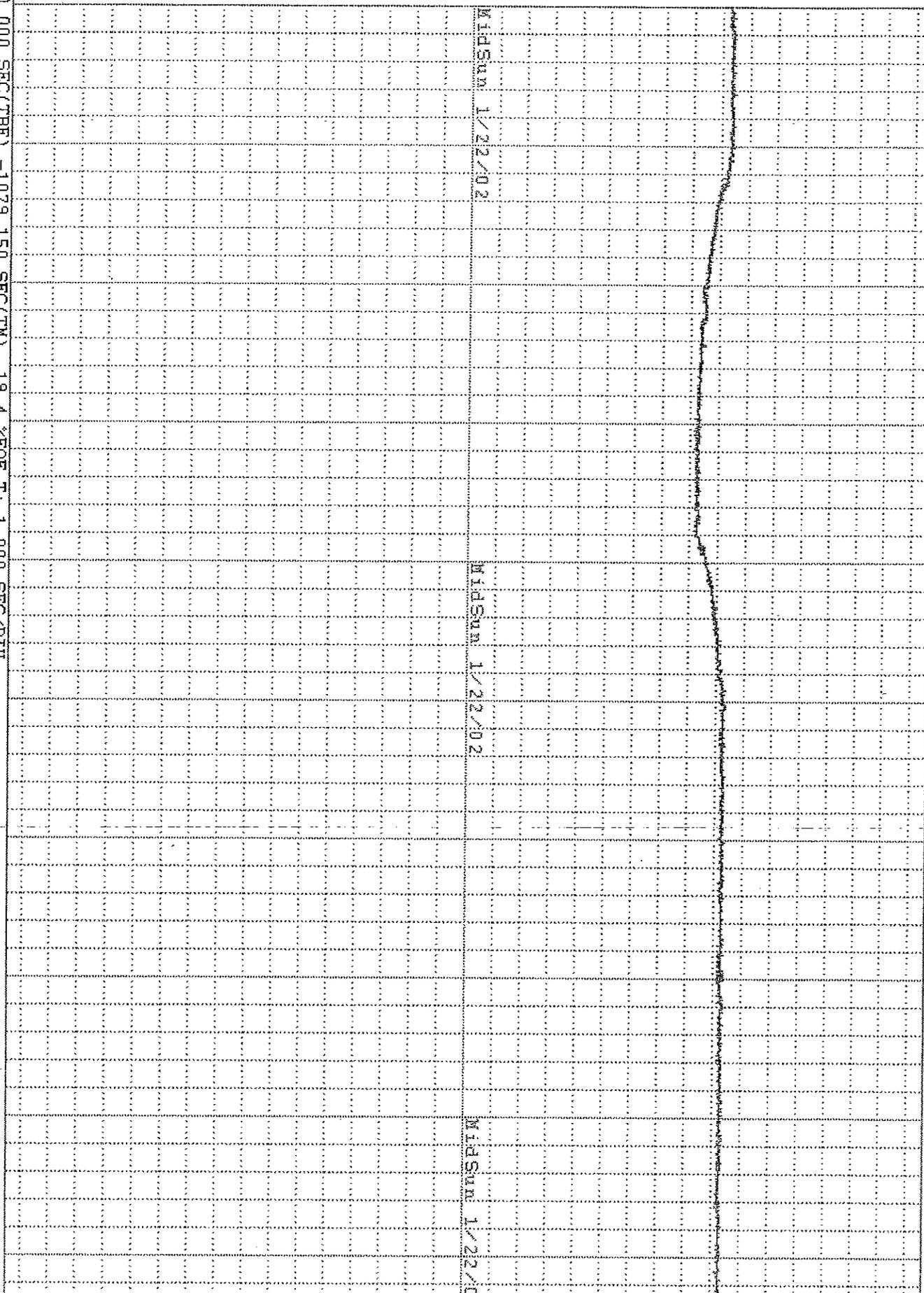
DATA -2.00  
452.10 SEC(TBF) -1395.30 SEC(TM) 24.5 %EOF T: .67 SEC/DIV



GRAPH B

116.71  
1#1  
ACV

MID -2.00  
260.000 SEC(TBF) -1079.150 SEC(TM) 19.4 XEOF T: 1.000 SEC/DIV



GRAPHIC

123.43  
1-1 ACT

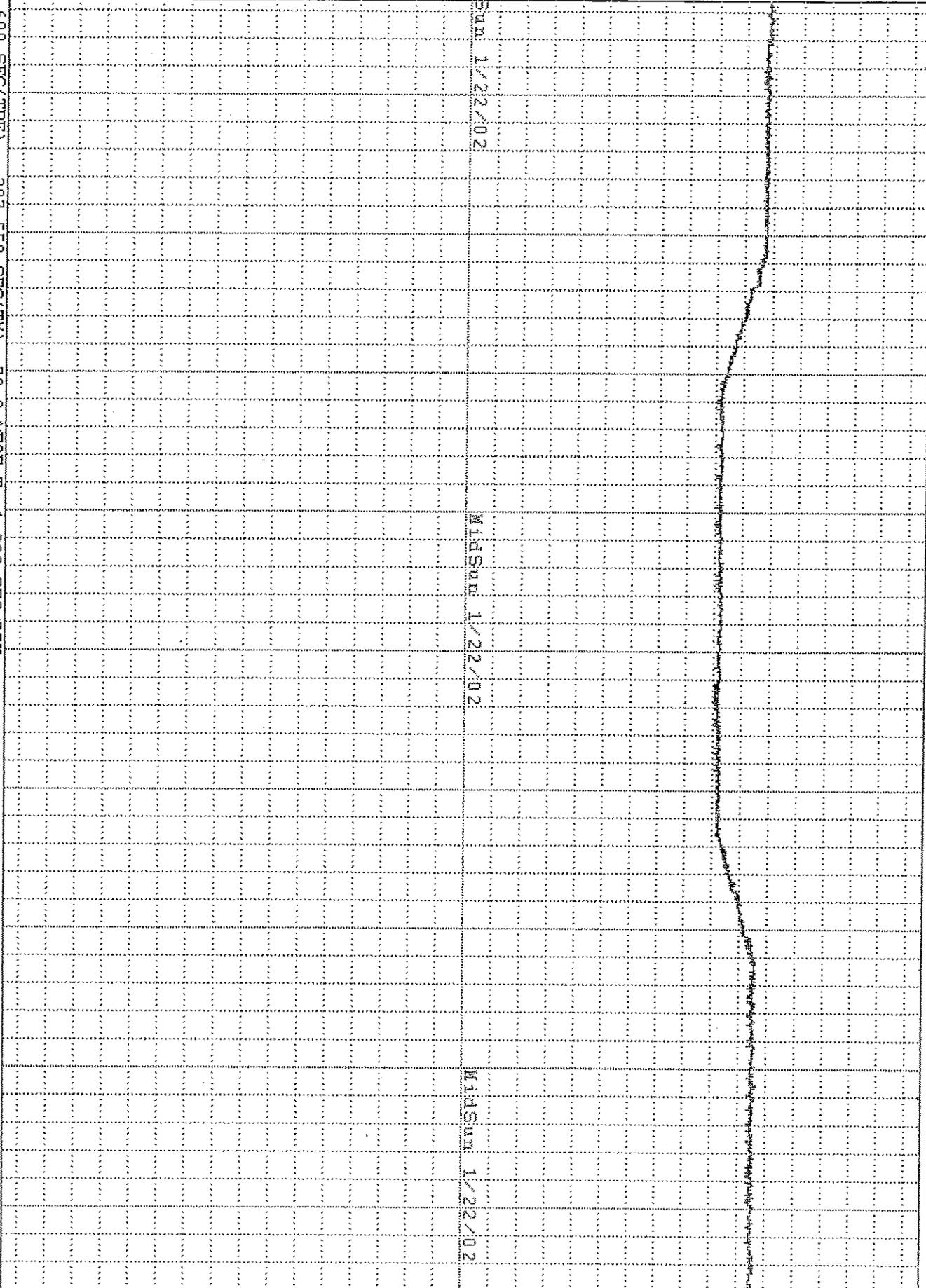
SUN 1/22/02

MID SUN 1/22/02

MID SUN 1/22/02

941.600 SEC(TBF) -397.550 SEC(TM) 70.3 %EOF T. 1.000 SEC/DIV

GRAPH D



\*\*\*\*\* BESTCOMS-DECS300-32 Windows Software Version 2.06.03 \*\*\*\*\*

Date: Tuesday, May 07, 2002

Time: 2:01:10 PM

=====User Specified Information=====

GEC Gas Turbine Unit

Midsun Cogen Plant

As Left settings 1-22-02

\*\*\*\*\* System Configuration \*\*\*\*\*

System Operating Mode:	Stop
System Control Mode:	FCR
System Operating Status:	Droop
Voltage Matching Switch:	Off
Limiter Mode:	Both OEL and UEL
Sensing Voltage Type:	Three Phase
Field Type:	Exciter Field
Bridge Control Signal:	-10 to 10 V
Internal Tracking:	Off
Temperature Mode:	Celsius
Generator Frequency:	60 Hz
Underfrequency Mode:	UF
Pre-position Enabled:	Off

---

Generator Primary Voltage:	14400 V
Generator Secondary Voltage:	120 V
Generator Primary Current:	1500 A
Generator Secondary Current:	5 A
Bus Primary Voltage:	14400 V
Bus Secondary Voltage:	120 V
Field Current Sensing Shunt Rating:	10 A
Field Voltage Isolation Box Input:	125 V
Internal Tracking Time Delay:	2 sec
Internal Tracking Traverse Rate:	5 sec
External Tracking Time Delay:	2 sec
External Tracking Traverse Rate:	10 sec

---

Generator Rated Apparent Power:	28228.60 kVA
Generator Rated Power Factor:	0.8
Generator Rated Real Power:	22582.90 kW
Generator Rated Voltage:	13800 V
Generator Rated Current:	1181 A
Field Ambient Temperature:	25 Degrees

Brush Voltage Drop:	1.50 V
Rated Field Voltage:	85 V
Rated Field Current:	5.6 A
Exciter Field Rated Resistance:	4.500 ohm

---

Accessory Voltage Input Mode:	Voltage
Accessory Voltage Summing Mode:	Inner Loop
Accessory Voltage Gain:	1
Accessory Current Gain:	1
Accessory Reactive Power Gain:	1
Accessory Power Factor Gain:	1
Reactive Droop Setting:	5%
Cross Current Compensation Gain:	0%

\*\*\*\*\* Setting Adjustments \*\*\*\*\*

AVR Setpoint:	11730 V
AVR Minimum Setpoint:	85%
AVR Maximum Setpoint:	110%
AVR Pre-position Setpoint:	11730 V
AVR Traverse Rate:	20 sec
AVR Pre-position Mode:	Release
FCR Setpoint:	1 A
FCR Minimum Setpoint:	0%
FCR Maximum Setpoint:	120%
FCR Pre-position Setpoint:	1 A
FCR Traverse Rate:	20 sec
FCR Pre-position Mode:	Release

---

VAR Setpoint:	221 kvar
VAR/PF Fine Voltage Band Adjustment:	10%
VAR Minimum Setpoint:	-5%
VAR Maximum Setpoint:	25%
VAR Pre-position Setpoint:	500 kvar
VAR Traverse Rate:	20 sec
VAR Pre-position Mode:	Release
PF Setpoint:	0.85
Leading PF Setpoint:	-0.8
Lagging PF Setpoint:	0.8
PF Pre-position Setpoint:	1
PF Traverse Rate:	20 sec
PF Pre-position Mode:	Release

---

Generator Voltage Soft Start Level:	5%
-------------------------------------	----

Generator Voltage Soft Start Time:	20 sec
Field Flash Dropout Level:	20%
Maximum Field Flash Dropout Time:	20 sec
Underfrequency Setting - Corner Frequency:	57 Hz
Underfrequency Setting - Slope:	1 V/Hz
Voltage Matching - Band:	20%
Voltage Matching - Level (Generator to Bus):	100%
Fail To Build Up Relay - Contact Type:	Latched
Fail To Build Up Relay - Momentary Time:	0.1 sec

Off-Line OEL Setting - High Current Level:	2 A
Off-Line OEL Setting - High Current Time:	2 sec
Off-Line OEL Setting - Low Current Level:	1.5 A
On-Line OEL Setting - High Current Level:	3 A
On-Line OEL Setting - High Current Time:	1 sec
On-Line OEL Setting - Medium Current Level:	2 A
On-Line OEL Setting - Medium Current Time:	1 sec
On-Line OEL Setting - Low Current Level:	1.5 A

UEL Curve - 1st Point kW Generate:	
UEL Curve - 1st Point kvar Absorbed:	1000 kvar
UEL Curve - 2nd Point kW Generate:	
UEL Curve - 2nd Point kvar Absorbed:	
UEL Curve - 3rd Point kW Generate:	
UEL Curve - 3rd Point kvar Absorbed:	
UEL Curve - 4th Point kW Generate:	
UEL Curve - 4th Point kvar Absorbed:	
UEL Curve - 5th Point kW Generate:	
UEL Curve - 5th Point kvar Absorbed:	

\*\*\*\*\* Control Gains \*\*\*\*\*

System Model:	Exciter Field
Stability Range:	21
AVR/FCR - Proportional Gain KP:	30
AVR/FCR - Integral Gain KI:	150
AVR/FCR - Derivative Gain KD:	2
AVR/FCR - Derivative Time Delay TD:	0.08
AVR - Loop Gain Kg:	2
FCR - Loop Gain Kg:	750
PF - Integral Gain KI:	120
VAR - Integral Gain KI:	120
VAR - Loop Gain Kg:	1
PF - Loop Gain Kg:	1

) Voltage Matching - Loop Gain Kg: 2  
 OEL - Integral Gain KI: 10  
 OEL - Loop Gain Kg: 2  
 UEL - Integral Gain KI: 10  
 UEL - Loop Gain Kg: 2

\*\*\*\*\* Protection Settings \*\*\*\*\*

Generator Overvoltage Option: Enabled  
 Generator Undervoltage Option: Enabled  
 Field Overvoltage Option: Enabled  
 Field Overcurrent Option: Enabled  
 Field Overtemperature Option: Disabled  
 Loss Of Sensing Voltage (LOS): Enabled  
 Loss of Sensing Time Delay: 2 sec  
 LOS Transfer To FCR Mode: Enabled

-----  
 Generator Overvoltage Level: 15000 V  
 Generator Undervoltage Level: 12800 V  
 Field Overvoltage Level: 100 V  
 Field Overcurrent Level: 2 A  
 Field Overtemperature Level: 150 Degrees  
 Generator Overvoltage Time Delay: 5 sec  
 Generator Undervoltage Time Delay: 5 sec  
 Field Overvoltage Time Delay: 5 sec  
 Field Overcurrent Time Dial Setting: 1  
 Field Overtemperature Time Delay: 5.0 sec

\*\*\*\*\* Output Relay #1 Settings \*\*\*\*\*

Generator Overvoltage Protection: Disabled  
 Generator Undervoltage Protection: Disabled  
 Field Overvoltage Protection: Disabled  
 Field Overcurrent Protection: Disabled  
 Loss of Sensing Voltage Protection: Disabled  
 Field Overtemperature: Disabled  
 System Below 10 Hz Protection: Disabled  
 Setpoint Upper Limit: Enabled  
 Setpoint Lower Limit: Enabled  
 FCR Mode: Disabled  
 Overexcitation Limit: Disabled  
 Underexcitation Limit: Disabled  
 UF or V/Hz Limit: Disabled

-----  
 Contact Status: Normally Open

Contact Type: Maintained  
Momentary Time Delay: 0.1 sec

\*\*\*\*\* Output Relay #2 Settings \*\*\*\*\*

Generator Overvoltage Protection: Enabled  
Generator Undervoltage Protection: Enabled  
Field Overvoltage Protection: Enabled  
Field Overcurrent Protection: Enabled  
Loss of Sensing Voltage Protection: Disabled  
Field Overtemperature: Disabled  
System Below 10 Hz Protection: Disabled  
Setpoint Upper Limit: Disabled  
Setpoint Lower Limit: Disabled  
FCR Mode: Disabled  
Overexcitation Limit: Enabled  
Underexcitation Limit: Enabled  
UF or V/Hz Limit: Disabled

-----  
Contact Status: Normally Open  
Contact Type: Maintained  
Momentary Time Delay: 0.1 sec

\*\*\*\*\* Output Relay #3 Settings \*\*\*\*\*

Generator Overvoltage Protection: Disabled  
Generator Undervoltage Protection: Disabled  
Field Overvoltage Protection: Disabled  
Field Overcurrent Protection: Disabled  
Loss of Sensing Voltage Protection: Disabled  
Field Overtemperature: Disabled  
System Below 10 Hz Protection: Disabled  
Setpoint Upper Limit: Disabled  
Setpoint Lower Limit: Disabled  
FCR Mode: Enabled  
Overexcitation Limit: Disabled  
Underexcitation Limit: Disabled  
UF or V/Hz Limit: Disabled

-----  
Contact Status: Normally Open  
Contact Type: Maintained  
Momentary Time Delay: 0.1 sec

\*\*\*\*\* Output Relay #4 Settings \*\*\*\*\*

Generator Overvoltage Protection: Disabled

Generator Undervoltage Protection: Disabled  
Field Overvoltage Protection: Disabled  
Field Overcurrent Protection: Disabled  
Loss of Sensing Voltage Protection: Enabled  
Field Overtemperature: Disabled  
System Below 10 Hz Protection: Disabled  
Setpoint Upper Limit: Disabled  
Setpoint Lower Limit: Disabled  
FCR Mode: Disabled  
Overexcitation Limit: Disabled  
Underexcitation Limit: Disabled  
UF or V/Hz Limit: Disabled

-----  
Contact Status: Normally Open  
Contact Type: Maintained  
Momentary Time Delay: 0.1 sec

\*\*\*\*\* Hardware Contact Status \*\*\*\*\*  
52 JK Switch for VAR/PF Option: Disabled (SW Closed or Black LED)  
52 LM Switch for Droop Option: Disabled (SW Closed or Black LED)  
Secondary DECS-300 Contact Status: Disabled (SW Open or Black LED)  
External Tracking Switch Status: Disabled (SW Open or Black LED)

===== All settings were saved =====

**EUMAC INC.** • [REDACTED] •  
Electronics for Utility Measurement and Control

Phoenix, Arizona 85029  
Phone/FAX (602) 942-9168

April 18, 2002

Mssrs. Matt Farrar & John Estes  
E<sup>2</sup> Power Systems, Inc.  
7961 Shaffer Parkway, Unit 2  
Littleton, CO 80127

Subject: Midsun PSS Settings

Dear Matt & John:

This transmittal documents the results of the PSS setting work at Midsun. All data taken on the HP digital signal analyzer is logged into an EXCEL spreadsheet also provided as part of this transmittal. First, the frequency response of the generator, exciter and power system (**GEP(s)**) was taken over a 5.0 Hz bandwidth for 32 averages. Generator terminal voltage deviation during testing never deviated more than 0.4% from the nominal 13.8kV machine rating. **Figure 1** from **Chart 1** in the EXCEL spreadsheet documents the results of that measurement. Based upon **GEP(s)**, the first two PSS phase lead time constants were set to 0.46 seconds to provide phase lead compensation in the 0.35 Hz region where phase lag of GEP(s) reaches approximately -90 degrees. The phase lag time constants were chosen to be 0.05sec. This yielded a lead/lag ratio of 9.2 to 1, which is near the upper range of typical ratios. A third phase lead time constant was set at 0.21sec to provide additional phase lead in the 0.75 Hz regime where GEP(s) phase lag is in the -130 degree range. The associated phase lag time constant was set at .02 seconds to yield a 10.5:1 ratio.

Next, frequency response data for the Basler PSS-100 with the proposed time constants is taken on the HP DSA and entered into the EXCEL spreadsheet. Noise problems were encountered with the measurement and the performance of the Midsun PSS was compared to a spare PSS-100 unit I had with me. Both performed the same and focus of the investigation then shifted to the battery charger adjacent to the test equipment setup. It could not be conclusively proven that the charger was causing interference, but a work around was required to take PSS data. The method that worked best was to measure the frequency response of the PSS-100, PSS(s), as two separate functions. First, the two phase leads stages at 0.35Hz were measured. **Figure 2** documents the PSS data from Chart 2 in the EXCEL spreadsheet. The PSS gain was set to .01 volts per volt and the output scaling factor to 1.0. The low gain setting was tried to mitigate the high ambient noise factor present. It only affects the Figure 2 magnitude values but not the phase and magnitude plot's characteristic shape. The data quality is good enough to confirm proper operation of the PSS (i.e. approximately 70 degrees phase lead at 0.35 Hz). **Figure 3** is the frequency response plot from EXCEL **Chart 3** for the single PSS-100 phase lead time constant at 0.21sec (0.75Hz). In this case, the PSS gain was set to 0.1volts per

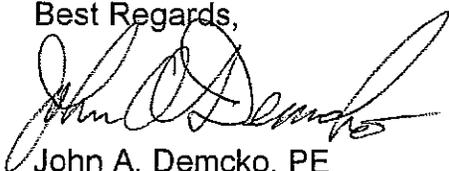
volt and the output scaling factor was 1.0 . Again, the data quality is good enough to confirm that the PSS is functioning correctly, yet noise is present in the measurement process so that the plot does not appear as smooth as it should for a nearly noiseless measurement. It is important to note that the PSS-100 digital to analog converter output exhibits a significant transport delay. At the 0.75Hz break frequency, one would expect a theoretical phase lead of 45 degrees. Instead a phase lead of 26 degrees is obtained. The EXCEL spreadsheet contains the data from an additional PSS-100 frequency response measurement with the lead and lag time constants set equal to each other. The transport delay (i.e. frequency dependant phase lag) at 0.76Hz is 17 degrees. When this value is added to the 26 degree phase lead actually measured, a phase lead of +43 degrees is obtained. This agrees very well with the theoretical value of +45 degrees phase lead.

Next, the PSS compensated frequency response of the generator, exciter and power system is calculated from the EXCEL spreadsheet data as  $PSS(s)*GEP(s)$ . **Figure 4** is the compensated frequency response from EXCEL **Chart 4**. It shows that reasonably flat phase compensation (i.e. 46 degrees phase lag at 2 Hz). Experience has shown that the both the inter-area and local modes will be damped with the PSS compensation selected.

Last, the PSS gain must be optimized. This was accomplished by observing PSS output voltage,  $V_{pss}$ , and generator terminal voltage deviation,  $\Delta V_t$ , on a strip chart recorder while increasing PSS gain. At some point, normal system perturbations will begin to produce oscillatory response in  $V_{pss}$  and  $\Delta V_t$ . When the gain is raised high enough, the PSS will break into a sustained limit-cycled oscillation at the crossover frequency for the control system. **Figure 5** is the strip chart record that documents the gain at which the system broke into oscillation at a frequency of approximately 3.2 Hz. It is divided into 4 sections denoted **Figure 5-1** through **5-4**. The control system clearly breaks into oscillation at approximately 3.13 Hz as documented by  $V_{pss}$ . This is somewhat lower than the predicted frequency of oscillation of approximately 4.3 Hz (the frequency at which the compensated  $GEP(s)*PSS(s)$  phase characteristic reaches 180 degrees phase lag). This is still within reason and is, in fact, why PSS is set by field testing rather than from the results of computer simulations of the power system. Complete documentation of the as left PSS settings is contained in the file "**Midsun Final.PSS**". The EXCEL spreadsheet containing all the frequency response data for  $GEP(s)$  and  $PSS(s)$  is also supplied in the file "**Midsun.XLS**". Testing was completed at 18:00hrs PDST on Friday, April 5, 2002.

Please don't hesitate to contact me if you have any questions on this transmittal.

Best Regards,



John A. Demcko, PE  
Principal Engineer

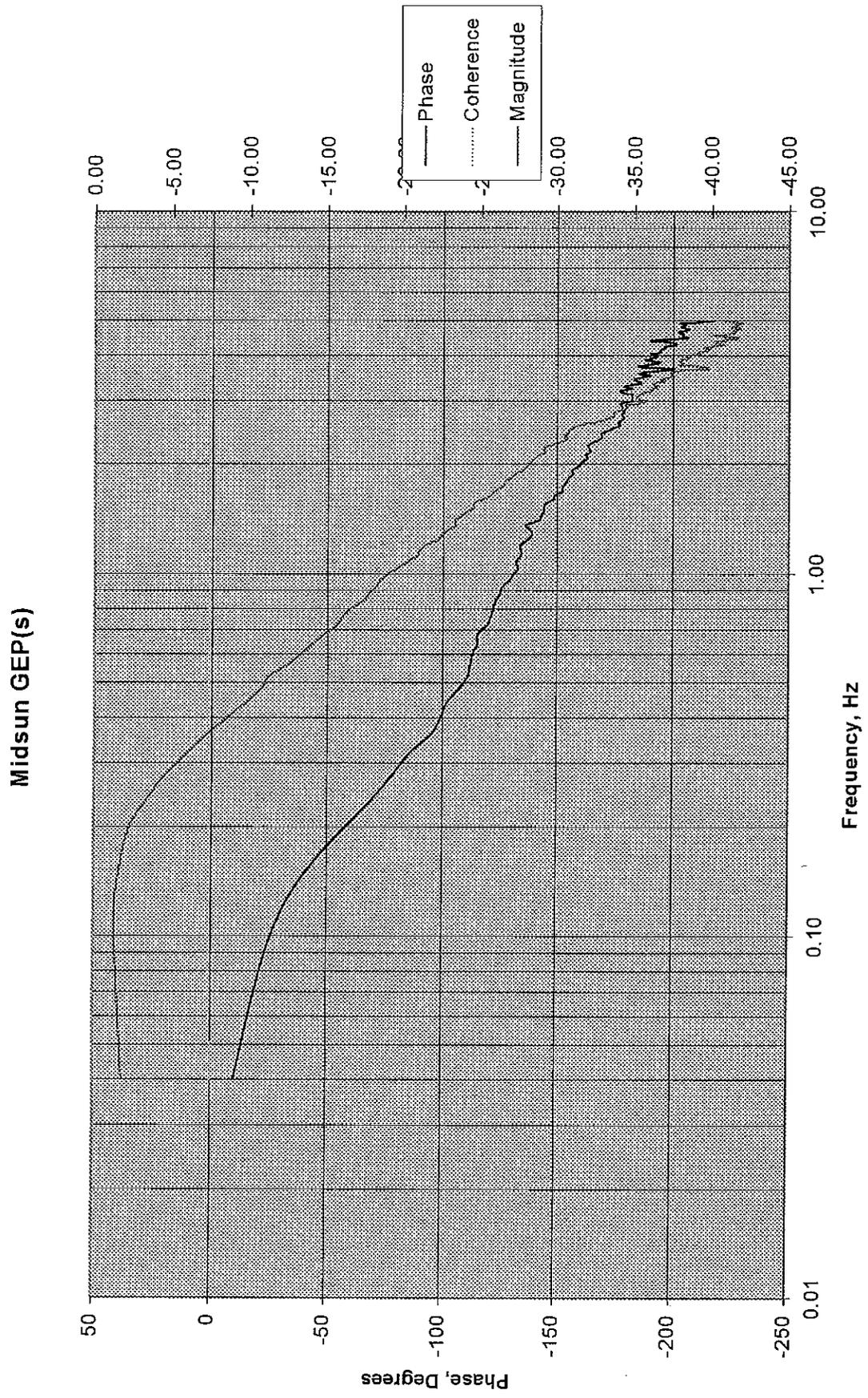


Figure 1

PSS(s) - 2 Stage Lead/Lag

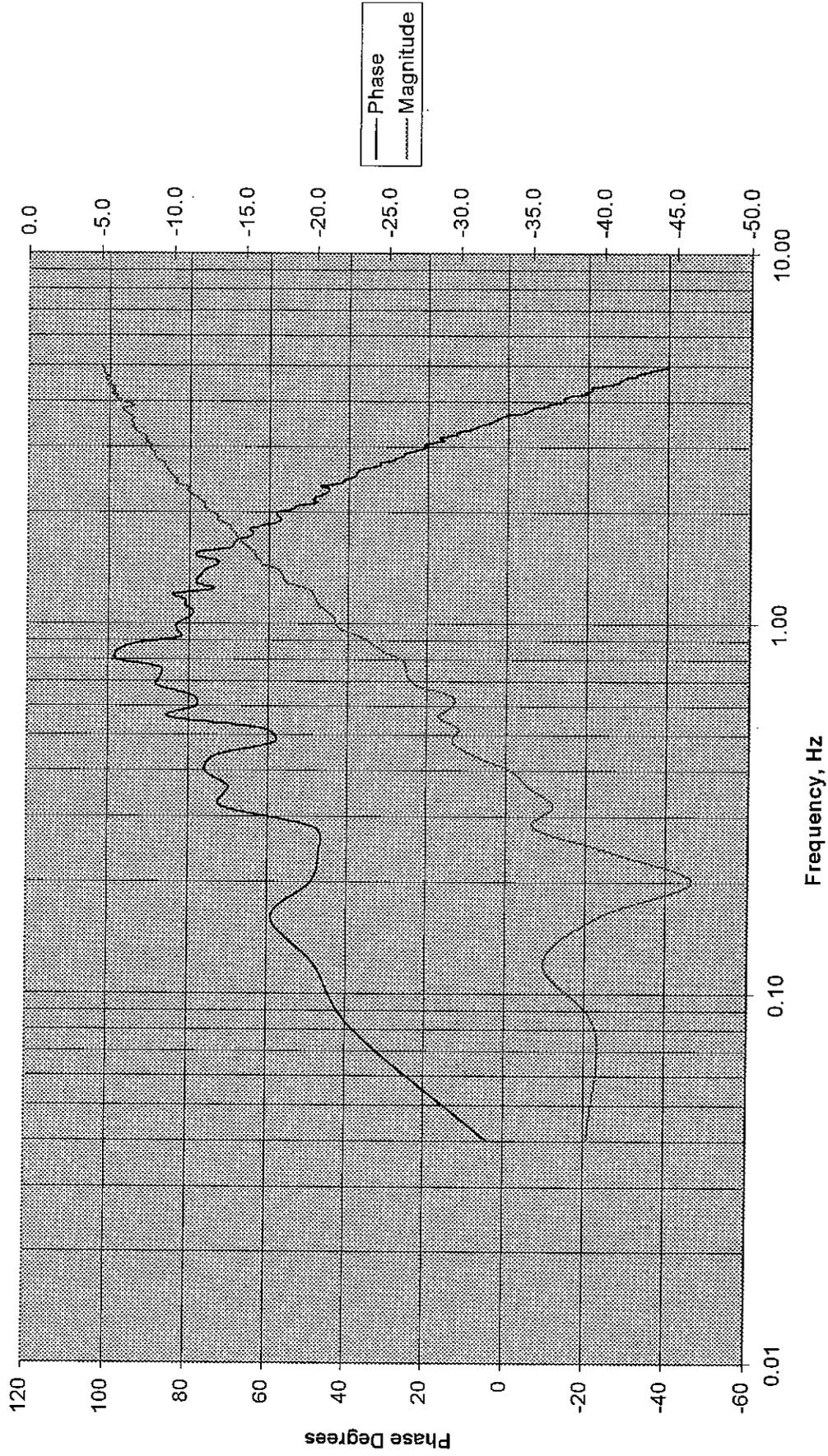


Figure 2

PSS - Stage 3

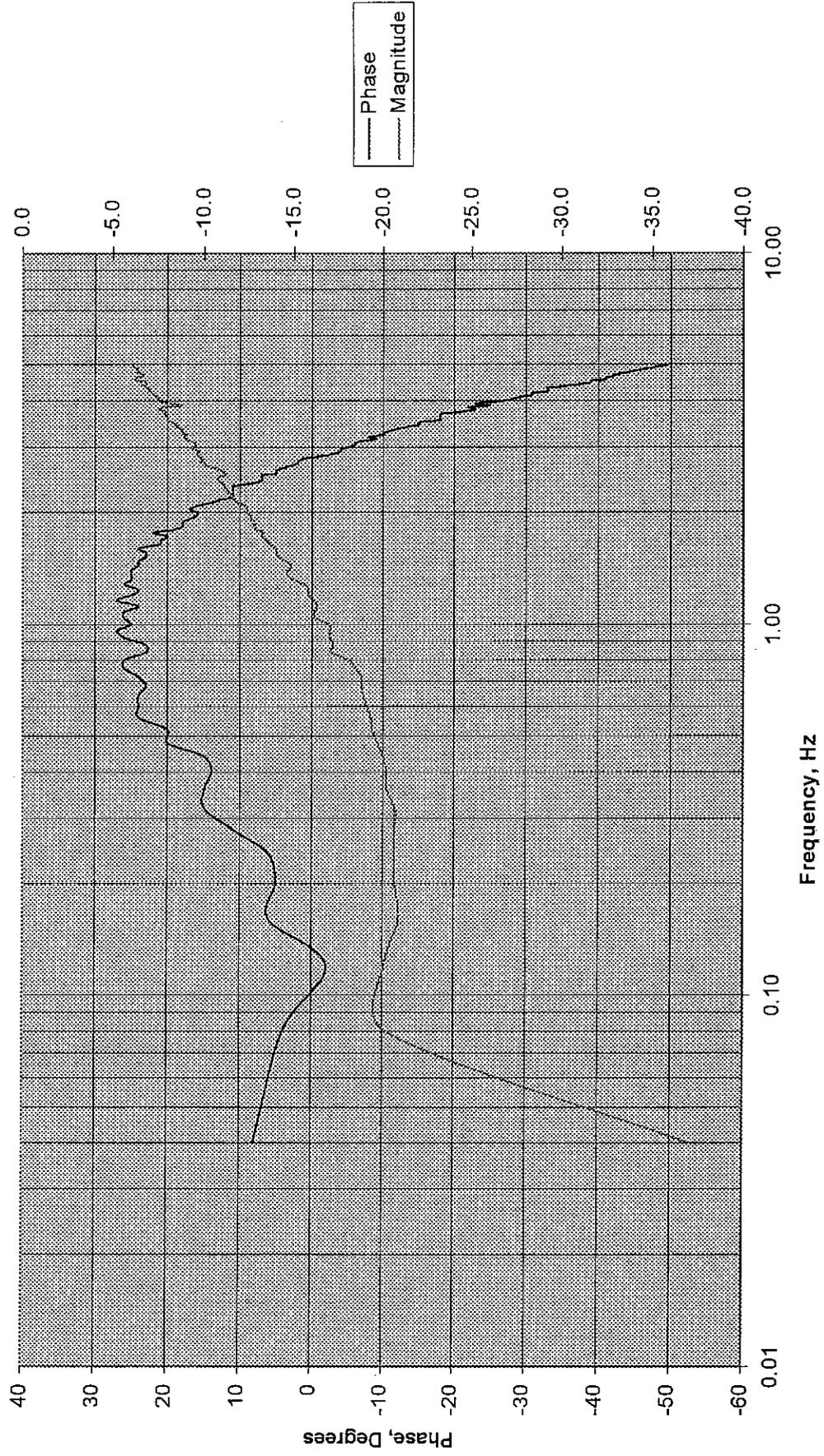


Figure 3

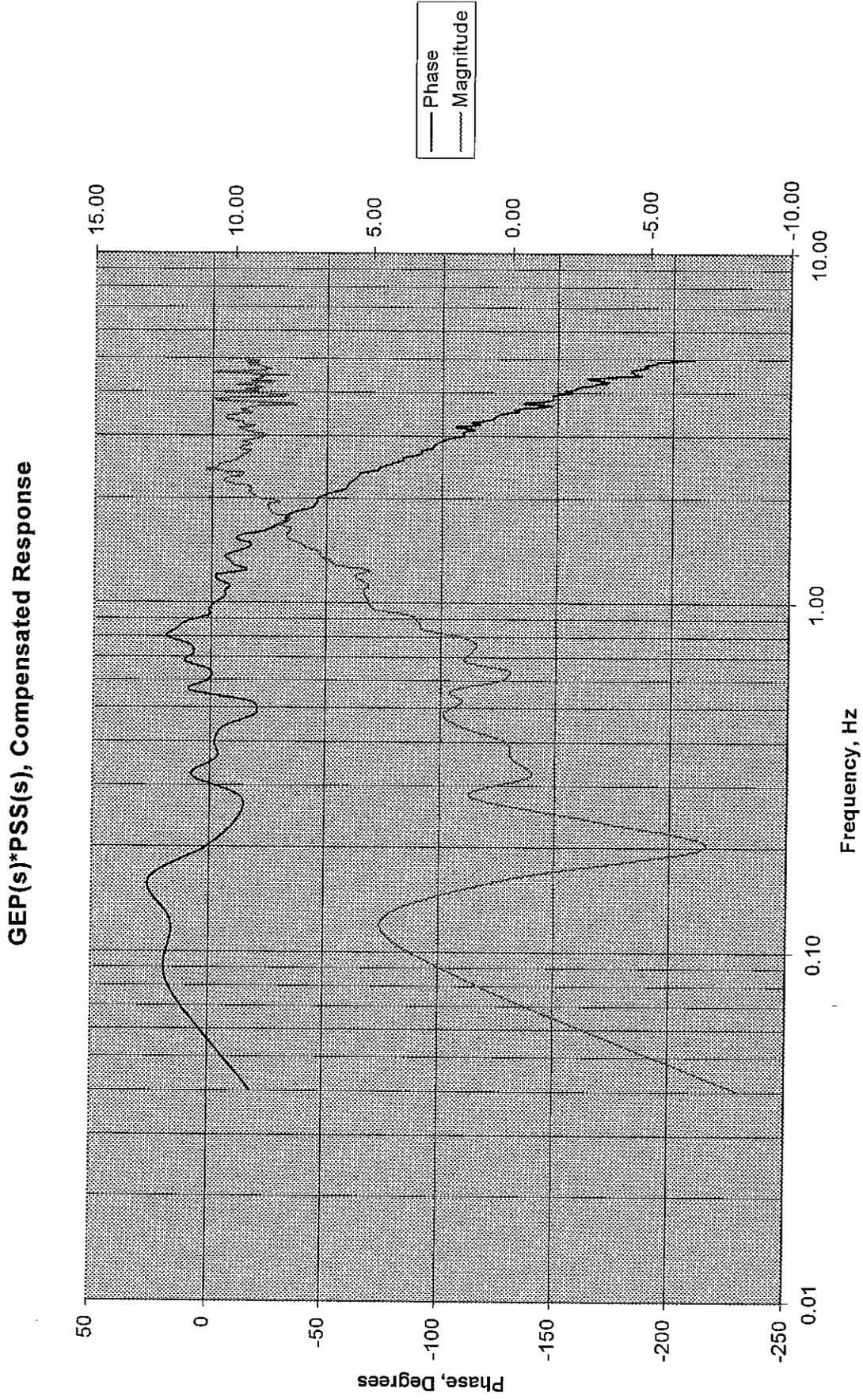


Figure 4

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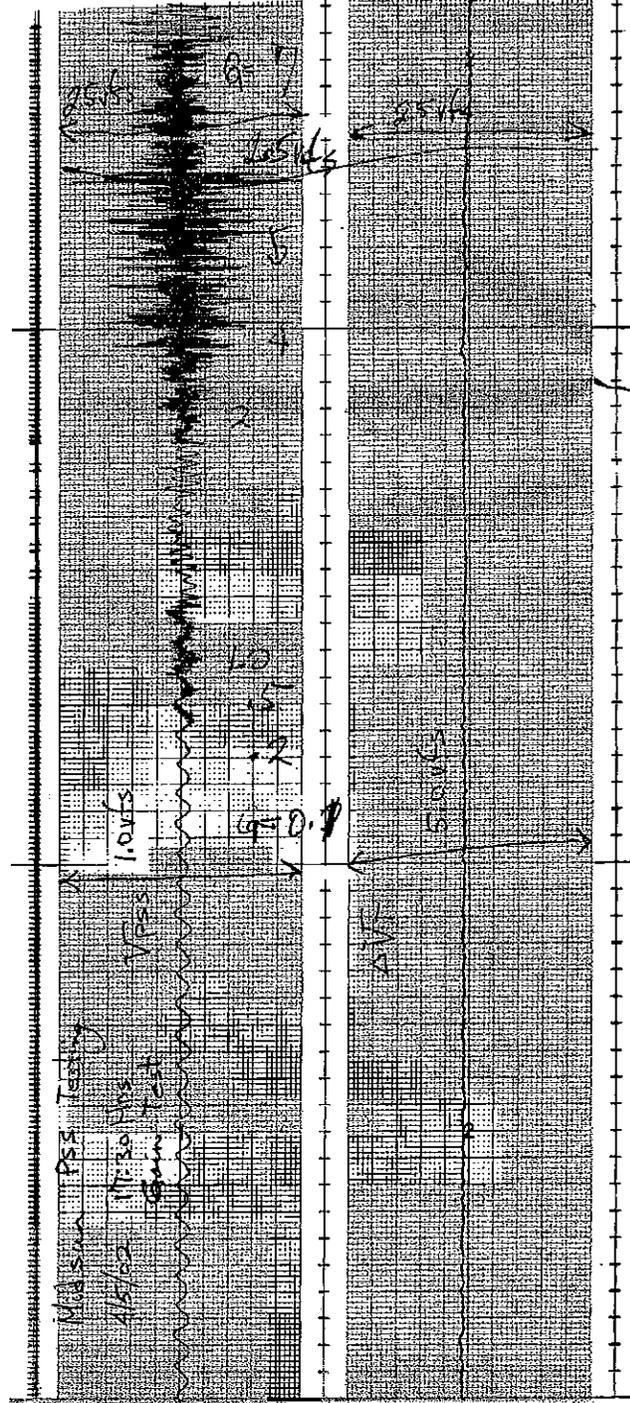


Figure 5 - 1

2/A

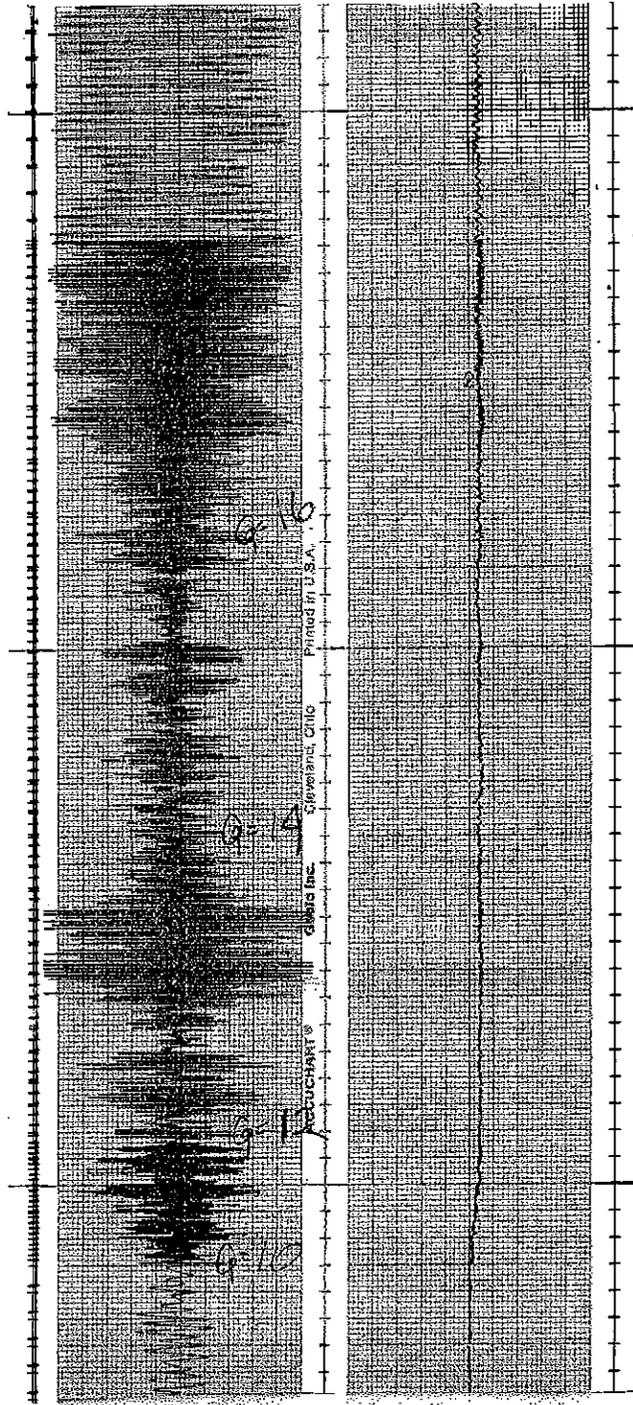


Figure 5 - 2

3/A

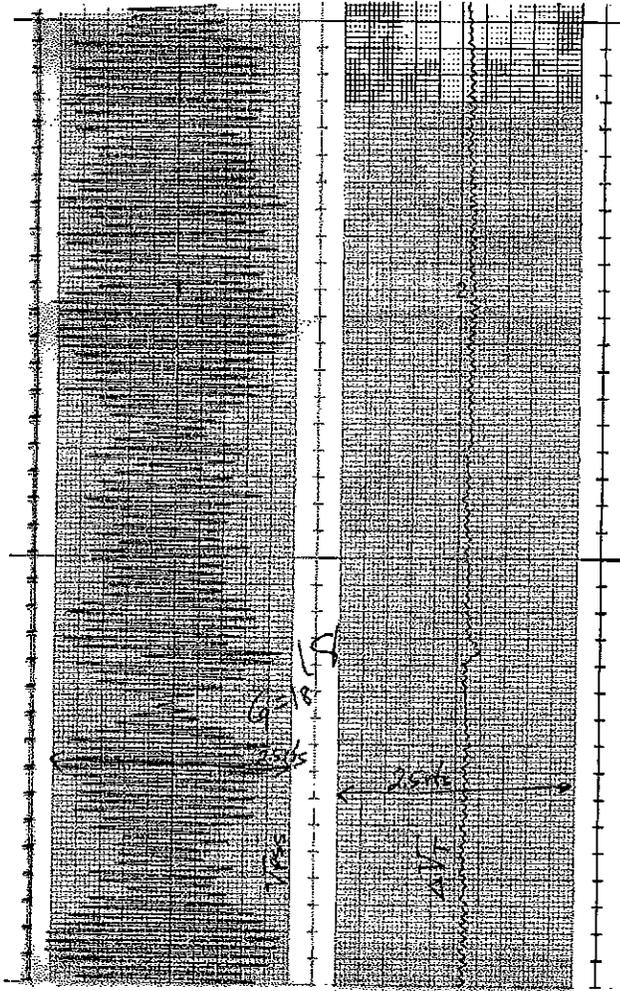


Figure 5 - 3

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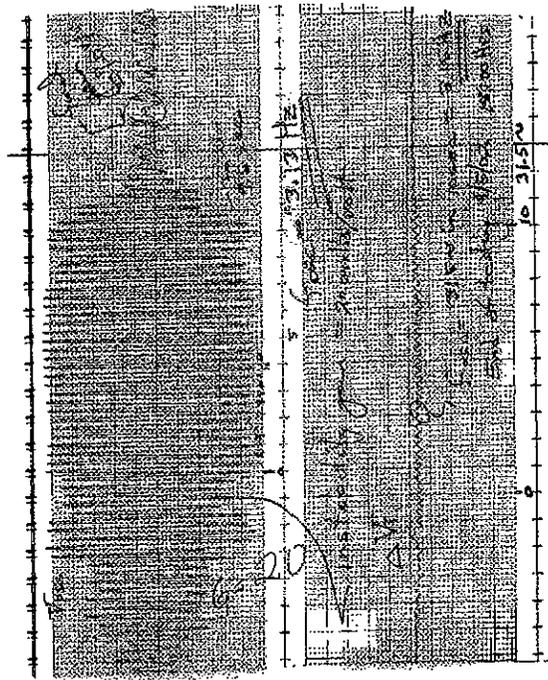


Figure 5 - 4

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GENERATING SYSTEM  
 ELEMENTARY  
 DRAWINGS  
 FOR  
 LM2500 T-G UNIT #1  
  
 AT THE  
 ENERGY TRANSFER GROUP'S  
 MIDSUN CO-GEN PROJECT  
 FELLOWS, CA  
  
 BY  
  
 E SQUARED POWER SYSTEMS, INC.  
 LITTLETON, CO

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP008.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	 <small>E<sup>2</sup> Power Systems, Inc.</small>
				<small>CONT. ON SH.</small> EA02A <small>SH. NO.</small> EA01



SHEET NO.	DESCRIPTION
E022	LINE SYNCH MODULE CT/PT CONNECTIONS
E023	52-120KV CIRCUIT SWITCHER CONTROL
E024	52-120KV MOTOR CONTROL
E025	52M UTILITY INTERCONNECT BREAKER "CLOSE"
E026	52M UTILITY INTERCONNECT BREAKER "TRIP"
E027	86T TRANSFORMER LOCKOUT
E028	52P STATION SERVICE BREAKER "CLOSE"
E029	52P STATION SERVICE BREAKER "TRIP"
E030	TRANSFER TRIP INTERFACE
E031	120VAC CONTROL POWER INPUT
C001	CONNECTIONS-GENERATOR CONTROL CABINET (MIDDLE DOOR)
C002	CONNECTIONS-GENERATOR CONTROL CABINET (RIGHT DOOR))
C003A,B,C	CONNECTIONS-GENERATOR CONTROL CABINET(BACK PANEL)
C004	CONNECTIONS-GENERATOR CONTROL CABINET (SIDE PANEL)
C005,A	CONNECTIONS-TRANSFORMER PANEL
C006	CONNECTIONS-UTILITY INTERCONNECT SWITCHGEAR 52M
C007	CONNECTIONS--GENERATOR SWITCHGEAR 52G
CP01	GENERATOR CONTROL CABINET (CUTOUT DIMENSIONS)
CP02	GENERATOR CONTROL CABINET
IC001	INTERCONNECTIONS - GENERATOR CONTROL CABINET
IC002	INTERCONNECTIONS - GENERATOR CONTROL CABINET
IC003	INTERCONNECTIONS - GENERATOR CONTROL CABINET
IC004	INTERCONNECTIONS - TRANSFORMER PANEL
IC005	INTERCONNECTIONS - STATION SERVICE SWITCHGEAR 52P
IC006	INTERCONNECTIONS - UTILITY INTERCONNECT SWITCHGEAR 52M
IC007	INTERCONNECTIONS - GENERATOR SWITCHGEAR 52G
IC008	INTERCONNECTIONS - GENERATOR COMPARTMENT - JB #4
IC009	INTERCONNECTIONS - GENERATOR LINE SUPPRESSION CUBICLE
IC010	INTERCONNECTIONS - SUT JUNCTION BOX
IC011	INTERCONNECTIONS - STEP-UP TRANSFORMER
IC012	INTERCONNECTIONS - 52-120KV SWITCHER

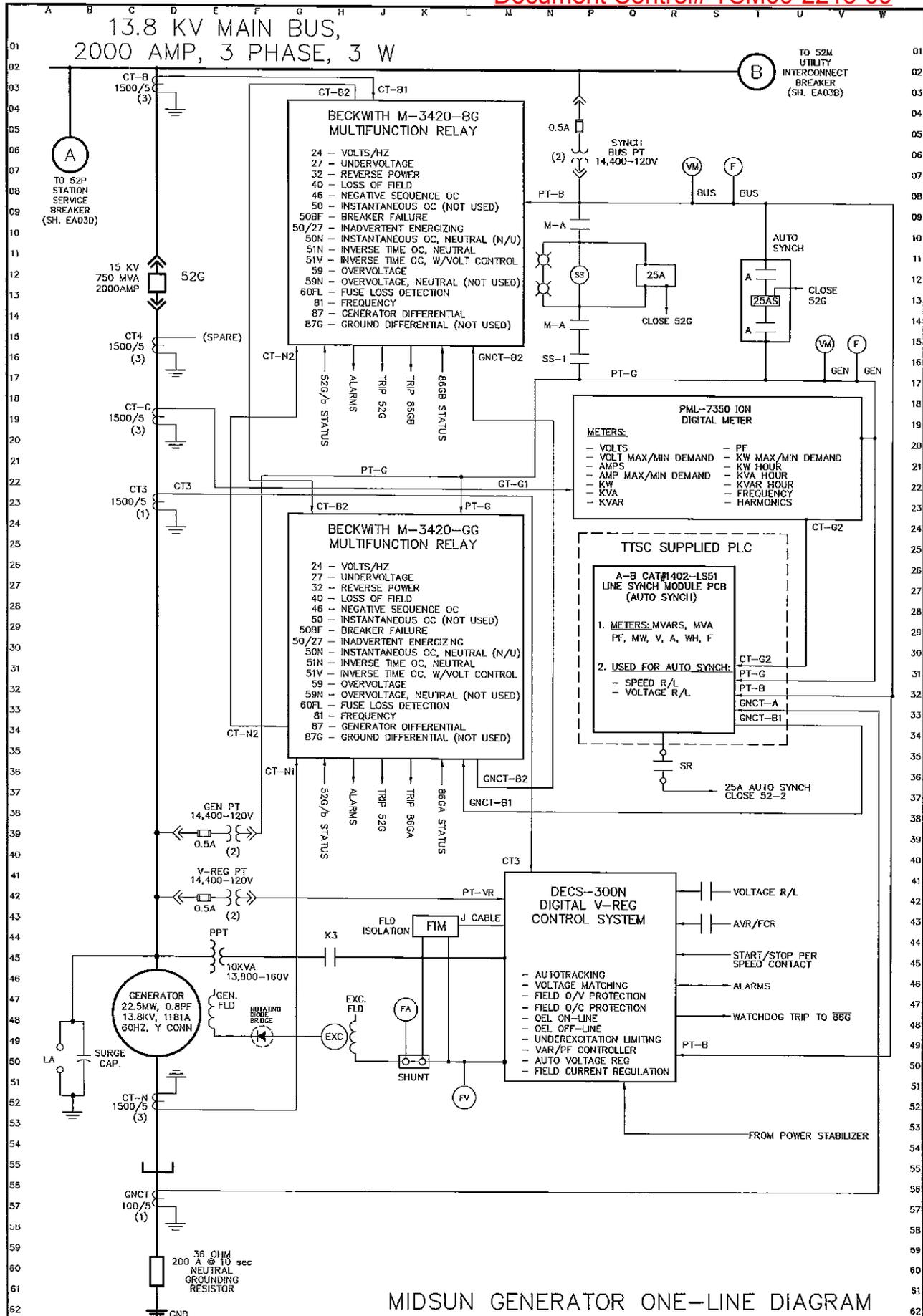
INDEX

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP002C.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY M. FARRAR		FELLOWS, CA	CONT. ON SH. EA03A SIL. NO. EA02B



E<sup>2</sup> Power Systems, Inc.



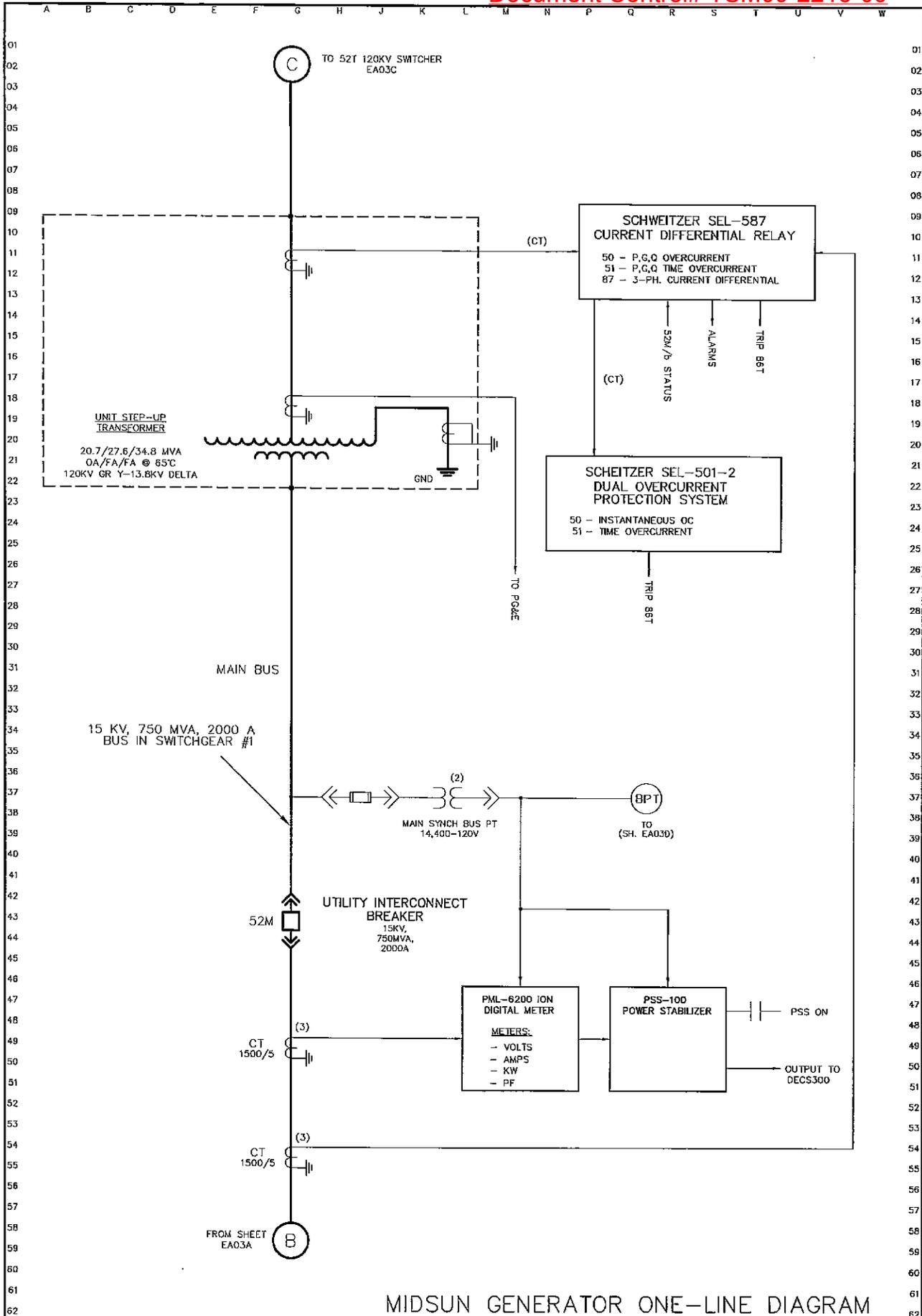
MIDSUN GENERATOR ONE-LINE DIAGRAM

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REV. 3	REV. 2	REV. 1	9-05-01	APPROVALS	2127T1794
REV. 4	01MCP001.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY:	M. FARRAR	FOR	FELLOWS, CA	CONT. ON SH. EA03B SH. NO. EA03A



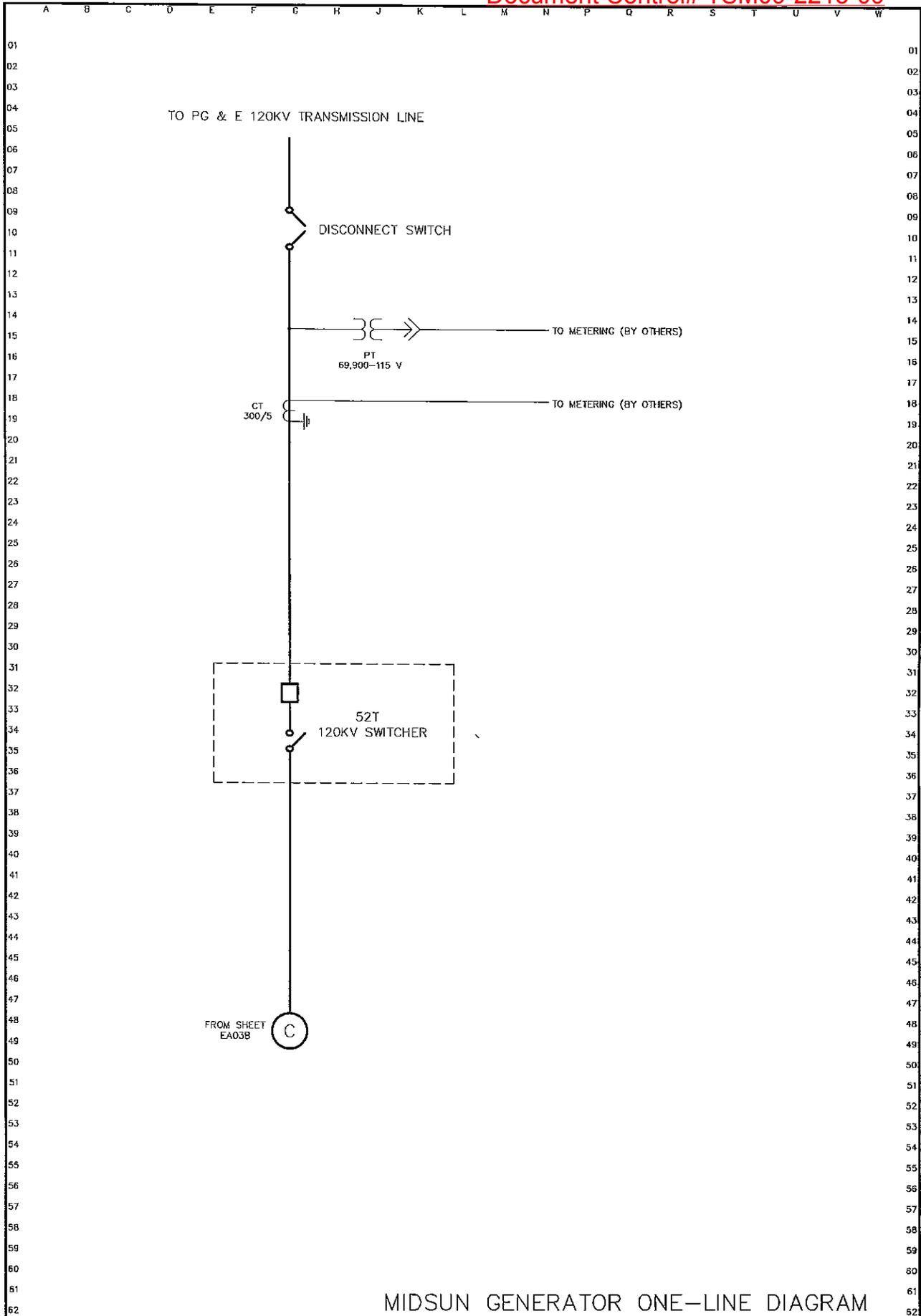
E<sup>2</sup> Power Systems, Inc.



MIDSUN GENERATOR ONE-LINE DIAGRAM

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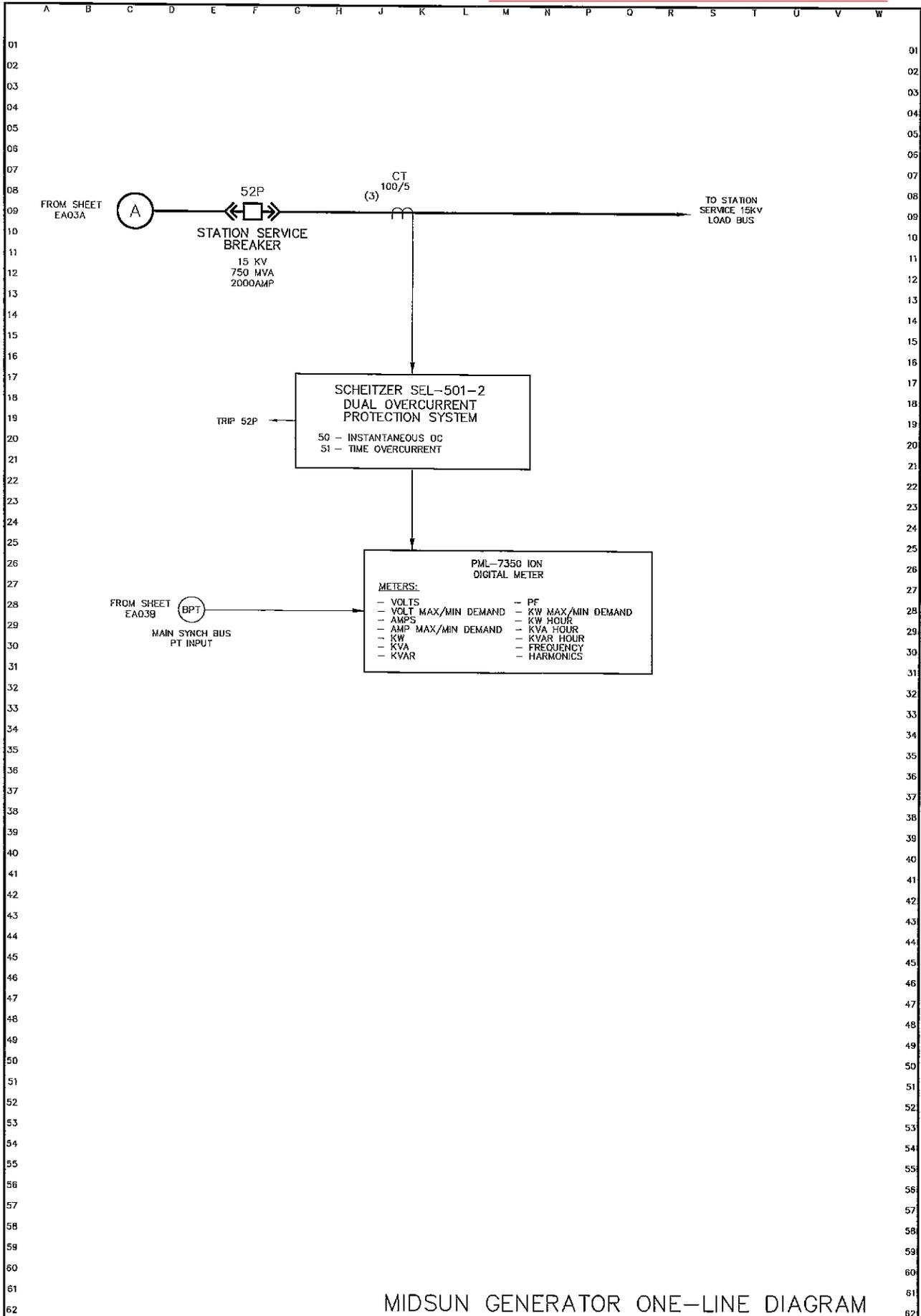
REV. 3	REV. 2	REV. 1 9-05-01	APPROVALS	 E² Power Systems, Inc.	ELEMENTARY DIAGRAM
REV. 4	01MCP001A.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT		2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA		CONT. ON SH. EA03C



MIDSUN GENERATOR ONE-LINE DIAGRAM

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REV. 3	REV. 2	REV. 1	APPROVAL	ELMENTARY DIAGRAM
REV. 4	01MCP001C.DWG	9-05-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup>PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. EA03D SH. NO. EA03C



MIDSUN GENERATOR ONE-LINE DIAGRAM

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REV. 3	REV. 2	REV. 1	9-05-01	APPROVED	 <b>E<sup>2</sup> PSI</b> E <sup>2</sup> Power Systems, Inc.	ELEMENTARY DIAGRAM	
REV. 4	01MCP001B.DWG	3-10-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT		2127T1794	
REV. 5	MADE BY:	M. FARRAR	FELLOWS, CA			CONT. ON SH. EA04	SH. NO. EA03D

# EXCITATION SYSTEM CONTROL & PROTECTION DEVICE SETTINGS

DEVICE	MANUFACTURER	MODEL/CAT NO.	FUNCTION
DECS	BASLER ELECTRIC	DECS-300N	DIGITAL V-REG CONTROL & PROTECTION MODULE

## SETTINGS

**SETTING ADJUSTMENTS (CONT.)**

GENERATOR VOLTAGE SOFT START BIAS: 28%  
 GENERATOR VOLTAGE SOFT START TIME: 15 SEC  
 FIELD FLASH DROPOUT LEVEL: 30%  
 WASH DROPOUT TIME: 2 SEC  
 UNDERFREQUENCY SETTING - SLOPE: 57.1%/HZ  
 UNDERFREQUENCY SETTING - BAND: 20%  
 VOLTAGE MATCHING - LEVEL (GENERATOR TO BUS): 100.2%  
 FAIL TO BUILD UP RELAY - CONTACT TYPE: MOMENTARY  
 FAIL TO BUILD UP RELAY - MOMENTARY TIME: 0.1 SEC

**SETTING ADJUSTMENTS (CONT.)**

GENERATOR VOLTAGE SOFT START BIAS: 28%  
 GENERATOR VOLTAGE SOFT START TIME: 15 SEC  
 FIELD FLASH DROPOUT LEVEL: 30%  
 WASH DROPOUT TIME: 2 SEC  
 UNDERFREQUENCY SETTING - SLOPE: 57.1%/HZ  
 UNDERFREQUENCY SETTING - BAND: 20%  
 VOLTAGE MATCHING - LEVEL (GENERATOR TO BUS): 100.2%  
 FAIL TO BUILD UP RELAY - CONTACT TYPE: MOMENTARY  
 FAIL TO BUILD UP RELAY - MOMENTARY TIME: 0.1 SEC

**SETTING ADJUSTMENTS (CONT.)**

GENERATOR VOLTAGE SOFT START BIAS: 28%  
 GENERATOR VOLTAGE SOFT START TIME: 15 SEC  
 FIELD FLASH DROPOUT LEVEL: 30%  
 WASH DROPOUT TIME: 2 SEC  
 UNDERFREQUENCY SETTING - SLOPE: 57.1%/HZ  
 UNDERFREQUENCY SETTING - BAND: 20%  
 VOLTAGE MATCHING - LEVEL (GENERATOR TO BUS): 100.2%  
 FAIL TO BUILD UP RELAY - CONTACT TYPE: MOMENTARY  
 FAIL TO BUILD UP RELAY - MOMENTARY TIME: 0.1 SEC

## CONTROL GAINS

STABILITY RANGE: 21  
 AVR/FCR - INTEGRAL GAIN KI: 100.0  
 AVR/FCR - DERIVATIVE GAIN KD: 21.0  
 AVR - LOOP GAIN KG: 2.5  
 FCR - LOOP GAIN KG: 750  
 PF - INTEGRAL GAIN KI: 120  
 VAR - LOOP GAIN KG: 1  
 PF - LOOP GAIN KG: 1

VOLTAGE MATCHING - LOOP GAIN KG: 6.0  
 OEL - INTEGRAL GAIN KI: 10  
 UEL - INTEGRAL GAIN KI: 7  
 UEL - LOOP GAIN KG: 2

## PROTECTION SETTINGS

GENERATOR OVERVOLTAGE OPTION: ENABLED  
 FIELD OVERCURRENT PROTECTION: ENABLED  
 LOSS OF SENSING VOLTAGE (LOS): 2.0 SEC  
 LOSS OF SENSING TIME DELAY: ENABLED  
 LOS TRANSFER TO FOR MODE: DISABLED  
 FIELD OVERTEMPERATURE: 15000 V  
 GENERATOR OVERVOLTAGE LEVEL: 12800 V  
 FIELD OVERCURRENT LEVEL: 100  
 FIELD OVERVOLTAGE LEVEL: 6.5 A  
 GENERATOR OVERVOLTAGE TIME DELAY: 5 SEC  
 FIELD OVERCURRENT TIME DELAY: 5 SEC  
 FIELD OVERTEMPERATURE TIME DELAY: 5 SEC  
 FIELD OVERTEMPERATURE SETTING: 150 C  
 FIELD OVERTEMPERATURE TIME: 5.0 SEC

## SYSTEM CONFIGURATION

VOLTAGE MATCHING SWITCH: ON BOTH OEL AND UEL  
 LIMITER MODE: THREE PHASE  
 EXCITER TYPE: OF 0 TO 10 V  
 INTERNAL TRACKING: 14400/120 V  
 GENERATOR PT: 1500/S A  
 GENERATOR CT: 14400/120 V  
 FIELD CURRENT SENSING SHUNT RATING: 125 V  
 FIELD VOLTAGE ISOLATION BOX INPUT: 2 SEC  
 INTERNAL TRACKING TIME DELAY: 5 SEC  
 EXTERNAL TRACKING TRAVERSE RATE: 2.5 SEC  
 EXTERNAL TRACKING TRAVERSE RATE: 10 SEC  
 GENERATOR RATED APPARENT POWER: 28928 KVA  
 GENERATOR RATED REAL POWER: 0.8  
 EXCITER FIELD RATED RESISTANCE: 22582 KW  
 GENERATOR RATED VOLTAGE: 13800 V  
 RATED FIELD CURRENT: 1181 A  
 RATED FIELD VOLTAGE: 5.6 V  
 BRUSH VOLTAGE DROP: 1.5 V

## SETTING ADJUSTMENTS

AVR PRE-POSITION MODE: 85%  
 AVR MAXIMUM SETPOINT: 13800 V  
 AVR PRE-POSITION SETPOINT: 20 SEC  
 AVR TRAVERSE RATE: 120%  
 AVF PRE-POSITION MODE: 120%  
 AVF MAXIMUM SETPOINT: 120 SEC  
 AVF PRE-POSITION SETPOINT: 20 SEC  
 AVF TRAVERSE RATE: 10%  
 VAR/PF FINE VOLTAGE BAND ADJUSTMENTS: 25%  
 VAR MAXIMUM SETPOINT: 500 KVAR  
 VAR PRE-POSITION SETPOINT: 20 SEC  
 VAR TRAVERSE RATE: 0.8  
 PF SETPOINT MODE: 0.8  
 LEADING PF SETPOINT: 1.0  
 LAGGING PF SETPOINT: 1.0  
 PF PRE-POSITION SETPOINT: 20 SEC  
 PF TRAVERSE RATE: 10%  
 PF PRE-POSITION MODE: RELEASE

REV. 3	REV. 2	4-8-02	REV. 1	10-29-01	APPROVALS	ELEMENTARY DIAGRAM	2127T1794
REV. 4	01MCP030.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	<b>E<sup>2</sup> PSI</b>	CONT. ON SH. EA05A	SH. NO. EA04
REV. 5	MADE BY: M. FARRAR			PBLOWS, CA	<b>E<sup>2</sup> Power Systems, Inc.</b>		

## MIDSUN CO-GEN T-G UNIT #1

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MIDSUN CO-GEN PROJECT  
 GENERATOR #1 (52G)

PROTECTION DEVICE SPECIFICATION

DEVICE	MANUFACTURER	MODEL/CAT NO.	FUNCTION	SENSOR LOCATION	RATING	SETTING	NUMBER OF CONTACTS	DEVICE LOCATION	NOTES
25A	BASLER	BE1-25 MOD. #M1E-ABP-N4R0F	GENERATOR SYNCH CHECK RELAY	GEN. PT & BUS PT	120 VAC	PHASE ANGLE = 10 TIME = 0.5sec  CONDITION SWITCHES: 52b MODE SW 1 UP (NORMAL) MODE SW 2 UP (NORMAL)  CONDITION SW 1 UP CONDITION SW 2 UP CONDITION SW 3 UP CONDITION SW 4 UP CONDITION SW 5 UP  LB LIVERUS VOLTS=100 LL LIVELINE VOLTS=100 DELTA V=32 VOLTS DB/OV=30 DL/OV=30	OUTPUT CONTACT TO CLOSE 52G	GENERATOR CONTROL PANEL	GENERATOR BUS = "LINE" ON 25A RELAY 13.8 KV BUS = "BUS" ON 25A RELAY
25AS	BASLER	BE1-25A MOD. #A2-F5-V0-D0	GENERATOR AUTOMATIC SYNCH MODULE	GEN. PT & BUS PT	120 VAC	BRKR CLOSE TIME: 0.1 SEC SPEED PULSE WIDTH: 0.5 SPEED PULSE INTERVAL: 2.5 MAX SLIP RATE: 0.10Hz LOCKOUT ON/OFF: ON BUS UPPER LIMIT: 121 BUS LOWER LIMIT: 104 ΔV: 1V VOLT PULSE DIRECTION: WIDTH 0.5sec VOLT PULSE INTERVAL: 10sec	OUTPUT CONTACT TO CLOSE 52G	GENERATOR CONTROL PANEL	

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP003.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. NO. EA05B SH. NO. EA05A



MIDSUN CO-GEN PROJECT

GENERATOR #1 (52G)

PROTECTION DEVICE SPECIFICATION

M3420 - GG (FED BY GEN PT) GENERATOR PROTECTION MODULE BECKWITH MODEL M-3420					
BASIC RELAY SETUP					
NOMINAL FREQUENCY: 60 Hz PHASE ROTATION: ABC NOMINAL VOLTAGE: 115 NOMINAL CURRENT: 3.93 INPUT ACTIVE STATUS: 1 ON MEANS 52G BREAKER IS OPEN		V.T. CONFIGURATION: LINE to LINE V.T. NEUTRAL RATIO: N/A V.T. PHASE RATIO: 120:1 C.T. PHASE RATIO: 300:1 C.T. SECONDARY RATING: 5A GROUND RESISTORS = 36 OHMS		OUT1 GEN (52G) LOCKOUT TRIP OUT2 GEN (52G) BREAKER TRIP OUT3 BREAKER (52M) TRIP OUT4 TROUBLE ALARM OUT5 NOT USED OUT6 SPARE	
RELAY FUNCTION		PARAMETER	SETTING	OUTPUT	COMMENTS
24 VOLTS per HERTZ	OT #1	PICKUP: TIME DELAY:	118% 150 CYCLES	OUT 2	(52G TRIP)
	OT #2	PICKUP: TIME DELAY:	110% 300 CYCLES	OUT 4	(ALARM)
	INV	PICKUP: CURVE #: TIME DIAL: RESET TIME:	110% 1 10 240 s	OUT 2	(52G TRIP)
27 RMS UNDERVOLTAGE (3 PHASE)	#1	PICKUP: TIME DELAY:	92 V 30 CYCLES	OUT 2	(52G TRIP)
	#2	PICKUP: TIME DELAY:	DISABLED		DISABLED
32 DIRECTIONAL POWER	#1	PICKUP: TIME DELAY:	-0.05 p.u. 600 CYCLES	OUT 2	(52G TRIP)
	#2	PICKUP: TIME DELAY:	1.10 p.u. 600 CYCLES	OUT 4	ALARM OVERPOWER ALARM
40 LOSS OF FIELD	#1	CIRCLE DIAMETER: OFFSET: TIME DELAY:	16.9 -1.9 15 CYCLES	OUT 1	(86G TRIP)
	#2	CIRCLE DIAMETER: OFFSET: TIME DELAY:	36 -1.9 45 CYCLES	OUT 1	(86G TRIP)
46 NEGATIVE SEQUENCE OVERCURRENT	DT	PICKUP: TIME DELAY:	7% 3600 CYCLES	OUT 4	(ALARM)
	INV	PICKUP: K=: MAXIMUM TIME:	12% 30 36000 CYCLES	OUT 1 OUT 2	(TRIP 86G) (TRIP 52G)
50/27 INADVERTENT ENERGIZATION		50 OVERCURRENT PICKUP: 27 UNDERVOLTAGE PICKUP: PICKUP TD: DROPOUT TD:	1 AMP 80 V 3 CYCLES 60 CYCLES	OUT 2	(52G TRIP)
50BF BREAKER FAILURE		PHASE CURRENT PICKUP: NEUTRAL CURRENT PICKUP: TIME DELAY: INPUT INITIATE:	0.5 A 0.5 A 30 CYCLES INPUT 1	OUT 3	(52M TRIP)  ENABLED BY INPUT 1 52G/b
51V VOLT RESTRAINED OVERCURRENT	#1	TAP SETTING: TIME DIAL: VOLTAGE CONTROL: CURVE:	6 A 1.0 VOLT RESTR. INVERSE	OUT 1 OUT 2	(86G TRIP) (52G TRIP)
	#1	TAP SETTING: TIME DIAL: CURVE:	0.5 A 4.0 INVERSE	OUT 2	(52G TRIP)
59 RMS OVERVOLTAGE (3 PHASE)	#1	PICKUP: TIME DELAY:	132 V 6 CYCLES	OUT 2	(52G TRIP)
	#2	PICKUP: TIME DELAY:	120 V 300 CYCLES	OUT 4	(ALARM)
59N RMS OVERVOLTAGE (NEUTRAL)	#1	PICKUP: TIME DELAY:	DISABLED		DISABLED
	#2	PICKUP: TIME DELAY:	DISABLED		DISABLED
60FL VT FUSE-LOSS DETECTION		INPUT INITIATE: TIME DELAY:	(NONE) 25 CYCLES	OUT 4	(ALARM)
81 FREQUENCY	#1	PICKUP: TIME DELAY:	63.00 HERTZ 30 CYCLES	OUT 2	(52G TRIP)
	#2	PICKUP: TIME DELAY:	58.00 HERTZ 10800 CYCLES	OUT 2	(52G TRIP)
	#3	PICKUP: TIME DELAY:	57.00 HERTZ 3600 CYCLES	OUT 2	(52G TRIP)
	#4	PICKUP: TIME DELAY:	55.00 HERTZ 30 CYCLES	OUT 2	(52G TRIP)
87 PHASE DIFFERENTIAL CURRENT		MINIMUM PICKUP: PERCENT SLOPE: TIME DELAY:	0.20 A 10% 1 CYCLE	OUT 1 OUT 2	(86G TRIP) (52G TRIP)

Notes to Table: Input #1 ( ) is a 52 "b" contact from the Generator Breaker, 52G.  
"FL" input is the M-3420 60FL FUSE LOSS function.

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP003A.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	E <sup>2</sup> PSI 2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. EA05C SH. NO. EA05B

MIDSUN CO-GEN PROJECT

GENERATOR #1 (52G)

PROTECTION DEVICE SPECIFICATION

M3420 - BG (FED BY BUS PT)  
 GENERATOR PROTECTION MODULE  
 BECKWITH MODEL M-3420

BASIC RELAY SETUP NOMINAL FREQUENCY: 60 Hz PHASE ROTATION: ABC NOMINAL VOLTAGE: 115 NOMINAL CURRENT: 3.93 INPUT ACTIVE STATUS: 1 ON MEANS 52G BREAKER IS OPEN		V.T. CONFIGURATION: LINE TO LINE V.T. NEUTRAL RATIO: N/A V.T. PHASE RATIO: 120:1 C.T. PHASE RATIO: 300:1 C.T. SECONDARY RATING: 5A GROUND RESISTORS = 36 OHMS		OUT1 GEN (52G) LOCKOUT TRIP OUT2 GEN (52G) BREAKER TRIP OUT3 BREAKER (52M) TRIP OUT4 TROUBLE ALARM OUT5 NOT USED OUT6 SPARE	
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RELAY FUNCTION		RELAY SETPOINTS		OUTPUT	COMMENTS
	PARAMETER	SETTING			
24 VOLTS per HERTZ	DT #1	PICKUP: 118% TIME DELAY: 150 CYCLES		OUT 2	(52G TRIP)
	DT #2	PICKUP: 110% TIME DELAY: 300 CYCLES		OUT 4	(ALARM)
	INV	PICKUP: 110% CURVE #: 1 TIME DIAL: 10 RESET TIME: 240 s		OUT 2	(52G TRIP)
27 RMS UNDERVOLTAGE (3 PHASE)	#1	PICKUP: 92 V TIME DELAY: 30 CYCLES		OUT 2	(52G TRIP)
	#2	PICKUP: DISABLED TIME DELAY: DISABLED			DISABLED
32 DIRECTIONAL POWER	#1	PICKUP: -0.05 p.u. TIME DELAY: 600 CYCLES		OUT 2	(52G TRIP)
	#2	PICKUP: 1.10 p.u. TIME DELAY: 600 CYCLES		OUT 4	ALARM OVERPOWER ALARM
40 LOSS OF FIELD	#1	CIRCLE DIAMETER: 18.9 OFFSET: -1.9 TIME DELAY: 15 CYCLES		OUT 1	(86G TRIP)
	#2	CIRCLE DIAMETER: 38 OFFSET: -1.9 TIME DELAY: 45 CYCLES		OUT 1	(86G TRIP)
46 NEGATIVE SEQUENCE OVERCURRENT	DT	PICKUP: 7% TIME DELAY: 3600 CYCLES		OUT 4	(ALARM)
	INV	PICKUP: 12% K= 30 MAXIMUM TIME: 36000 CYCLES		OUT 1 OUT 2	(TRIP 86G) (TRIP 52G)
50/27 INADVERTENT ENERGIZATION		50 OVERCURRENT PICKUP: 1 AMP 27 UNDERVOLTAGE PICKUP: 80 V PICKUP TD: 3 CYCLES DROPOUT TD: 60 CYCLES		OUT 2	(52G TRIP)
50BF BREAKER FAILURE		PHASE CURRENT PICKUP: 0.5 A NEUTRAL CURRENT PICKUP: 0.5 A TIME DELAY: 30 CYCLES INPUT INITIATE: INPUT 1		OUT 3	(52M TRIP)  ENABLED BY INPUT 1 52G/b
51V VOLT RESTRAINED OVERCURRENT	#1	TAP SETTING: 6 A TIME DIAL: 1.0 VOLTAGE CONTROL: VOLT RESTR. CURVE: INVERSE		OUT 1 OUT 2	(86G TRIP) (52G TRIP)
	#1	TAP SETTING: 0.5 A TIME DIAL: 4.0 CURVE: INVERSE		OUT 2	(52G TRIP)
59 RMS OVERVOLTAGE (3 PHASE)	#1	PICKUP: 132 V TIME DELAY: 6 CYCLES		OUT 2	(52G TRIP)
	#2	PICKUP: 129 V TIME DELAY: 300 CYCLES		OUT 4	(ALARM)
59N RMS OVERVOLTAGE (NEUTRAL)	#1	PICKUP: DISABLED TIME DELAY: DISABLED			DISABLED
	#2	PICKUP: DISABLED TIME DELAY: DISABLED			DISABLED
60FL VT FUSE-LOSS DETECTION		INPUT INITIATE: (NONE) TIME DELAY: 25 CYCLES		OUT 4	(ALARM)
81 FREQUENCY	#1	PICKUP: 63.00 HERTZ TIME DELAY: 30 CYCLES		OUT 2	(52G TRIP)
	#2	PICKUP: 58.00 HERTZ TIME DELAY: 10800 CYCLES		OUT 2	(52G TRIP)
	#3	PICKUP: 57.00 HERTZ TIME DELAY: 3600 CYCLES		OUT 2	(52G TRIP)
	#4	PICKUP: 55.00 HERTZ TIME DELAY: 30 CYCLES		OUT 2	(52G TRIP)
87 PHASE DIFFERENTIAL CURRENT		MINIMUM PICKUP: 0.20 A PERCENT SLOPE: 10% TIME DELAY: 1 CYCLE		OUT 1 OUT 2	(86G TRIP) (52G TRIP)

Notes to Table: input #1 ( ) is a 52 "b" contact from the Generator Breaker, 52G.  
 "FL" input is the M-3420 60FL FUSE LOSS function.

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP003B.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONTR. ON SH. EA05D SH. NO. EA05C



E<sup>2</sup> Power Systems, Inc.

MIDSUN CO-GEN PROJECT

STATION SERVICE BUS (52P)

PROTECTION DEVICE SPECIFICATION

STATION SERVICE PROTECTION MODULE SEL 501-2				
NOMINAL FREQUENCY: 60 Hz PHASE ROTATION: ABC NOMINAL VOLTAGE: 115 NOMINAL CURRENT: 3.93 INPUT ACTIVE STATUS:	BASIC RELAY SETUP C.T. PHASE RATIO: 200:5		OUT1 52P BREAKER TRIP	
RELAY SETPOINTS				
RELAY FUNCTION	PARAMETER	SETTING	OUTPUT	COMMENTS
50P PHASE INSTANTANEOUS OVERCURRENT	PICKUP:	15 AMPS	Y OUT 1	52P TRIP
51N NEUTRAL INVERSE TIME OVERCURRENT	PICKUP: CURVE: TIME DIAL:	1.0 AMPS U4 3	Y OUT 1	52P TRIP
51P PHASE INVERSE TIME OVERCURRENT	PICKUP: CURVE: TIME DIAL:	3.0 AMPS U4 15	Y OUT 1	52P TRIP

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REV. 3	REV. 2	REV. 1	APPROVAL <i>[Signature]</i>	ELEMENTARY DIAGRAM
REV. 4	01MCP003C.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA		E <sup>2</sup> Power Systems, Inc.

CONY. ON SH. EA05E SH. NO. EA05D

MIDSUN CO-GEN PROJECT

UTILITY INTERCONNECTION BUS (52M)

PROTECTION DEVICE SPECIFICATION

SEL 587  
TRANSFORMER PROTECTION MODULE

BASIC RELAY SETUP

NOMINAL FREQUENCY: 60 Hz  
PHASE ROTATION: ABC  
NOMINAL VOLTAGE: 115  
NOMINAL CURRENT: 3.93

HIGH SIDE C.T. PHASE RATIO: 300:5  
LOW SIDE C.T. PHASE RATIO: 1500:5

OUT1 86T LOCKOUT TRIP

RELAY SETPOINTS				
RELAY FUNCTION	PARAMETER	SETTING	OUTPUT	COMMENTS
87T	PICKUP: PERCENT SLOPE: UNRESTRAINED CURRENT PU: 2nd HARMONIC BLOCKING %: 4th HARMONIC BLOCKING %: 5th HARMONIC BLOCKING %: 5th HARMONIC ALARM 5th HARMONIC ALARM DELAY	0.3 p.u. 30% 8 p.u. 15 15 35 1.8 700 CYCLES	OUT 1	87T TRIP
50P WINDING 1 PHASE INSTANTANEOUS OVERCURRENT	PICKUP:	18.33 A	OUT 1	87T TRIP
51P WINDING 1 PHASE INVERSE TIME OVERCURRENT	PICKUP: CURVE: TIME DIAL:	2.97 A U4=EXTREMELY INVERSE 8 PU OF TAP	OUT 1	87T TRIP
51N WINDING 1 RESIDUAL INVERSE TIME OVERCURRENT	PICKUP: CURVE: TIME DIAL:	0.83 A U4=EXTREMELY INVERSE 15 PU OF TAP	OUT 1	87T TRIP
50P WINDING 2 PHASE INSTANTANEOUS OVERCURRENT	PICKUP:	3.67 A	OUT 1	87T TRIP
51P WINDING 2 PHASE INVERSE TIME OVERCURRENT	PICKUP: CURVE: TIME DIAL:	0.59 A U4=EXTREMELY INVERSE 3 PU OF TAP	OUT 1	87T TRIP
51N WINDING 2 RESIDUAL INVERSE TIME OVERCURRENT	PICKUP: CURVE: TIME DIAL:	DISABLED		DISABLED

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REV. 3	REV. 2	REV. 1	APPROVALS	 E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.	ELEMENTARY DIAGRAM
REV. 4	01MCP003D.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT		2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA		CONT. ON SH. EA05F SH. NO. EA05E

MIDSUN CO-GEN PROJECT

UTILITY INTERCONNECTION BUS (52M)

PROTECTION DEVICE SPECIFICATION

BACKUP TRANSFORMER PROTECTION MODULE SEL 501-2				
BASIC RELAY SETUP NOMINAL FREQUENCY: 60 Hz PHASE ROTATION: ABC C.T. PHASE RATIO: 300:5 OUT1 86T LOCKOUT TRIP				
RELAY SETPOINTS				
RELAY FUNCTION	PARAMETER	SETTING	OUTPUT	COMMENTS
50P PHASE INSTANTANEOUS OVERCURRENT	PICKUP:	19 AMPS	X OUT 1	86T TRIP
51N NEUTRAL INVERSE TIME OVERCURRENT	PICKUP: CURVE: TIME DIAL:	3.0 AMPS U4 8	X OUT 1	86T TRIP
51P PHASE INVERSE TIME OVERCURRENT	PICKUP: CURVE: TIME DIAL:	0.5 AMPS U4 15	X OUT 1	86T TRIP

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP003E.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup>PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. EA06 SH. NO. EA05F

SYMBOL LEGEND

SYMBOL

DEVICE LOCATION

01			01
02			02
03			03
04			04
05			05
06			06
07			07
08			08
09			09
10			10
11			11
12			12
13	▣	EXCITATION CUBICLE	13
14	▲	GENERATOR AUX. COMPARTMENT	14
15	▣	13.8KV SWITCHGEAR DEVICE	15
16	⊗	GENERATOR CONTROL PANEL DEVICE	16
17	⊙	TURBINE DEVICE	17
18	⊕	MOTOR CONTROL CENTER DEVICE	18
19	⊖	TURBINE CONTROL PANEL DEVICE	19
20	⊗	GENERATOR COMPARTMENT DEVICE	20
21	⊗	TRANSFORMER CUBICLE	21
22	⊗	STEP UP TRANSFORMER	22
23	⊗	52-120KV CIRCUIT SWITCHGEAR	23
24	⊗	FIELD SPLICE JB	24
25	⊗	GENERATOR LINE SUPPRESSION CUBICLE	25
26	⊗	52G SWITCHGEAR CUBICLE	26
27	⊗	52P SWITCHGEAR CUBICLE	27
28	⊗	52M SWITCHGEAR CUBICLE	28
29	⊗	AUX SWITCHGEAR CUBICLE	29
30			30
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DEVICE NOMENCLATURE

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP031.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. EA07A SH. NO. EA06



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**43S-CS SYNCHRONIZING CONTROL SWITCH**

CONTACT	POSITION		
	MANUAL	OFF	AUTO
11-13	X		
12-18			X
15-17	X		
18-14			X
21-23	X		
22-28			X
25-27	X		
26-24			X
31-33	X		
32-38			X
35-37	X		
36-34			X
41-43	X		
42-48			X
45-47	X		
46-44			X

(SH. E015)  
ELECTROSWITCH MODEL 24204B

X - DENOTES CONTACT CLOSED

**43-V SETPOINT RAISE/LOWER CONTROL SWITCH**

CONTACT	POSITION		
	LOWER	OFF	RAISE
11-18	X		
12-13			X
15-14	X		
16-17			X

(SH. E011)  
ELECTROSWITCH MODEL 74201D

**52G-CS GENERATOR BREAKER CONTROL SWITCH**

CONTACT	POSITION		
	TRIP	NORMAL	CLOSE
11-18	X		
16-17			X

(SH. E015 & E016)  
ELECTROSWITCH MODEL 2438D

**52P-CS STATION SERV. BREAKER CONTROL SWITCH**

CONTACT	POSITION		
	TRIP	NORMAL	CLOSE
11-18	X		
16-17			X

(SH. E028 & E029)  
ELECTROSWITCH MODEL 24PB38D

**52M-CS UTILITY BREAKER CONTROL SWITCH**

CONTACT	POSITION		
	TRIP	NORMAL	CLOSE
11-18	X		
16-17			X

(SH. E025 & E026)  
ELECTROSWITCH MODEL 24PB38D

DEVICE CONNECTIONS & ARRANGEMENTS

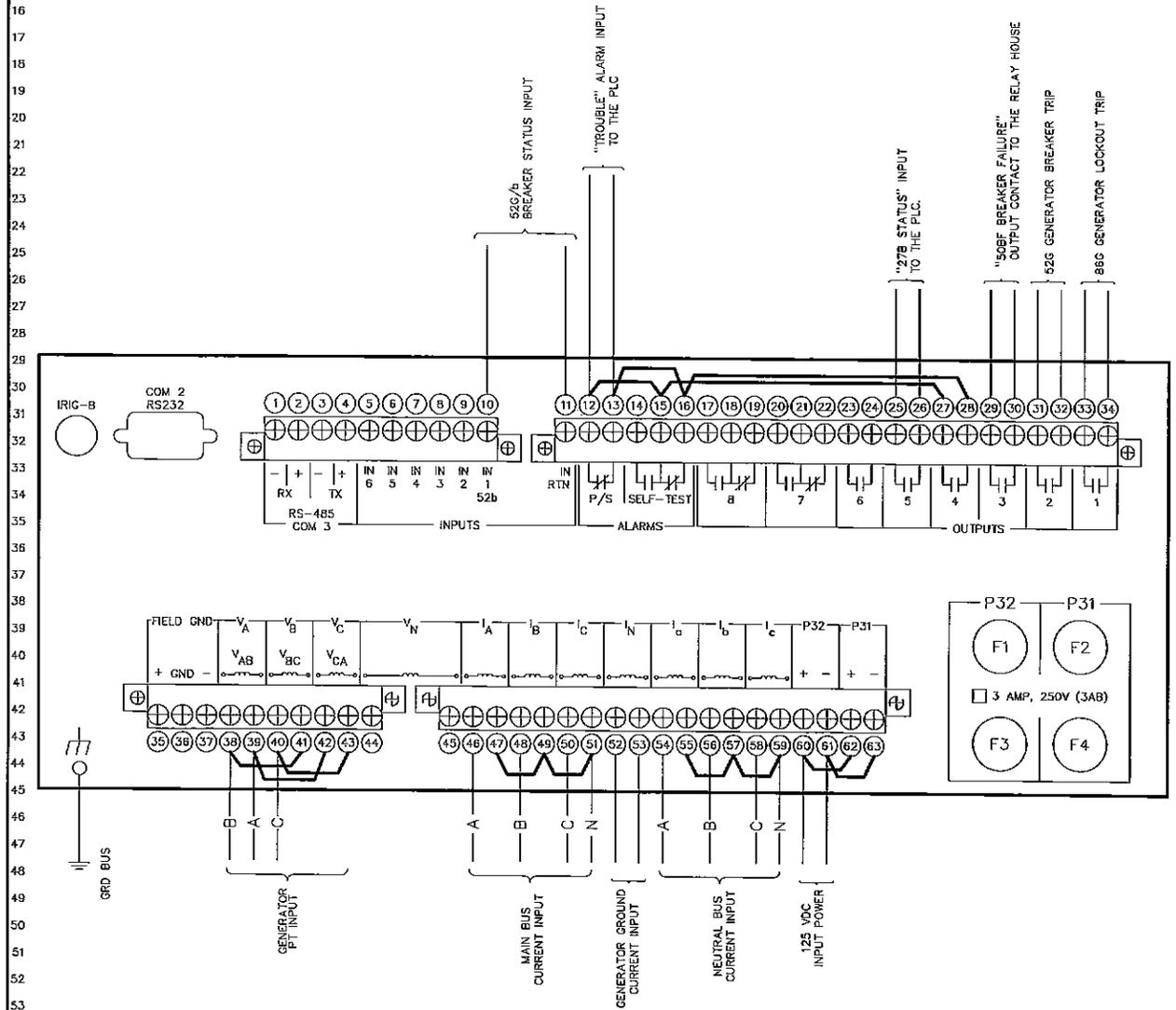
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REV. 3	REV. 2	REV. 1	6-18-01	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP032.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA	CONT. ON SH. EA07C SH. NO. EA07A



E<sup>2</sup> Power Systems, Inc.

BECKWITH MODEL #3420  
GENERATOR PROTECTION MODULE "GG"



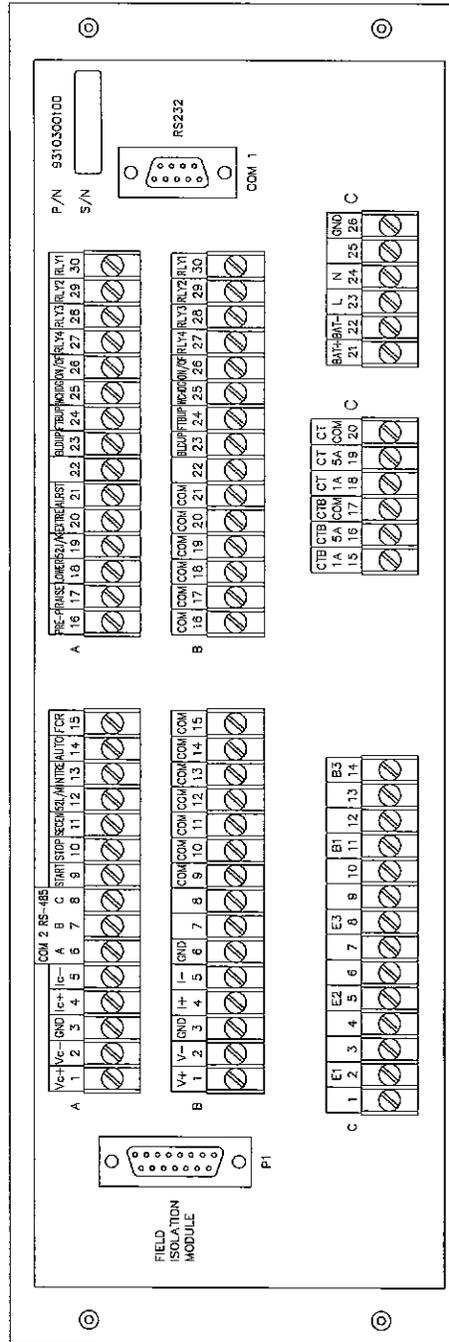
DEVICE CONNECTIONS & ARRANGEMENTS

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REV. 3	REV. 2	REV. 1	APPROVED	ELEMENTARY DIAGRAM
REV. 4	01MCP002.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup> PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. EA07D SH. NO. EA07C



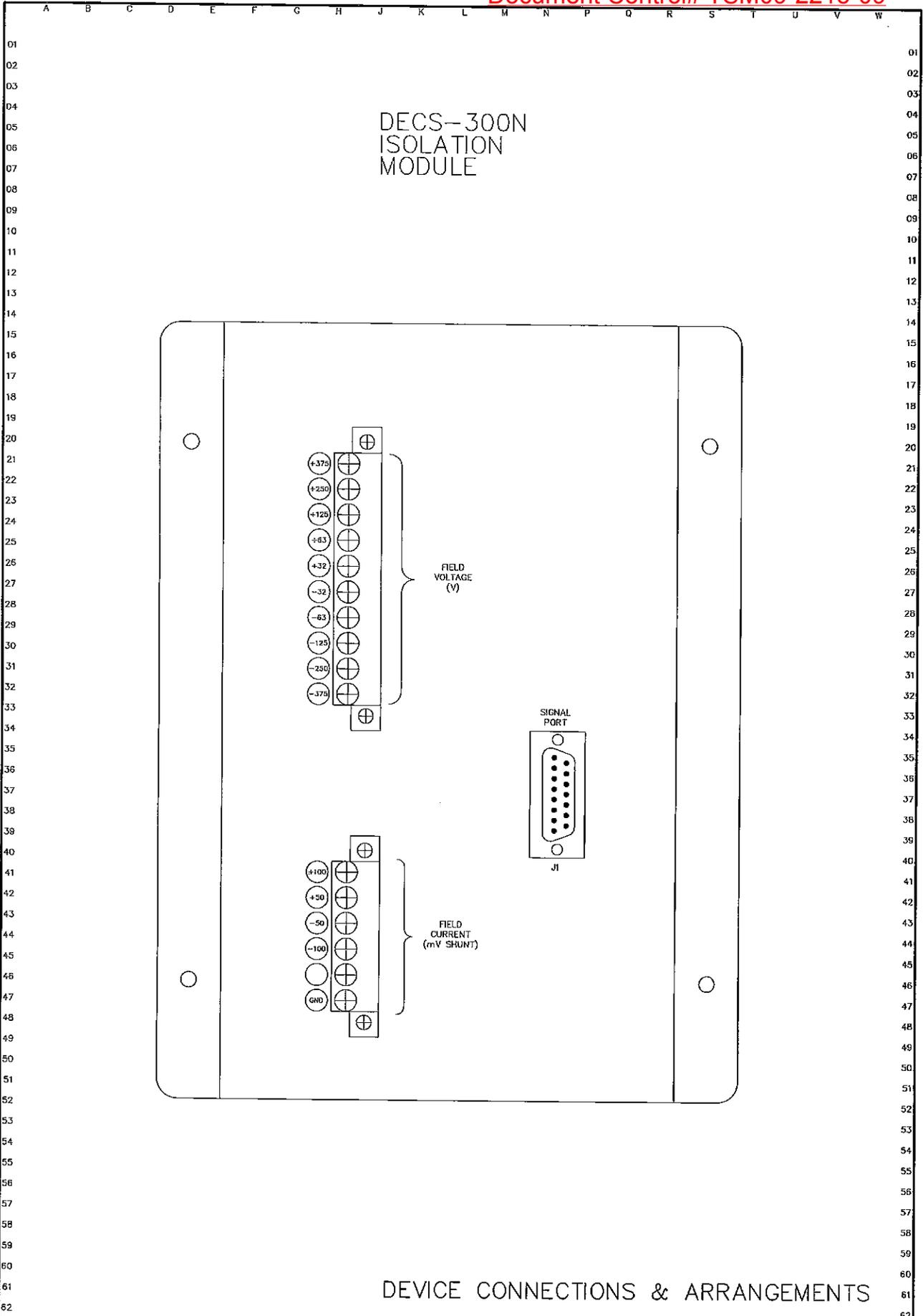
# BASLER DECS-300N VOLTAGE REGULATOR MODULE



## DEVICE CONNECTIONS & ARRANGEMENTS

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REV. 3	REV. 2	REV. 1	APPROVAL	ELEMENTARY DIAGRAM	2127T1794
REV. 4	01MCP010.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	<b>E<sup>2</sup>PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. EA07F
REV. 5	MADE BY: M. FARRAR		STOCKTON, CA		SH. NO. EA07E



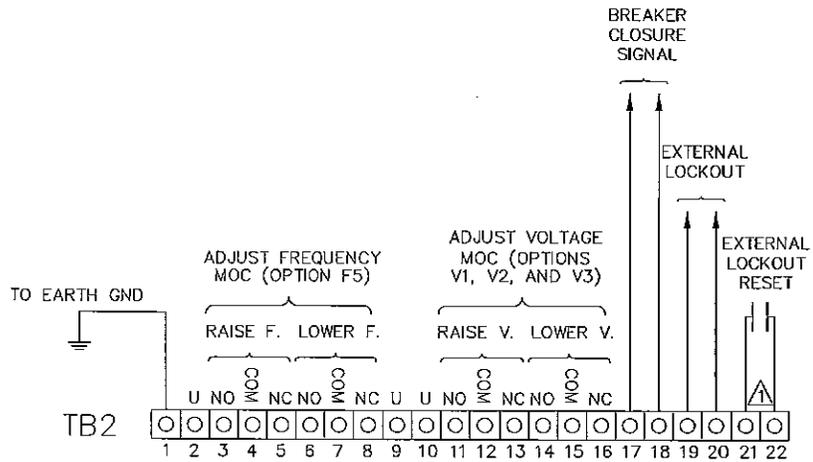
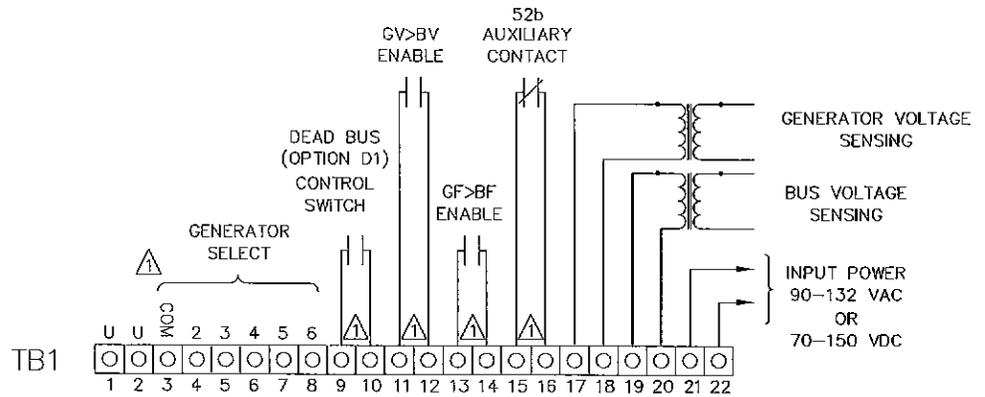
DEVICE CONNECTIONS & ARRANGEMENTS

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REV. 3	REV. 2	REV. 1	APPROVALS	E <sup>2</sup> PSI		ELEMENTARY DIAGRAM
REV. 4	01MCP011.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794		
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA		E <sup>2</sup> Power Systems, Inc.		CONT. ON SH. EA07G SH. NO. EA07F



BASLER BE1-25A  
AUTO SYNCH MODULE

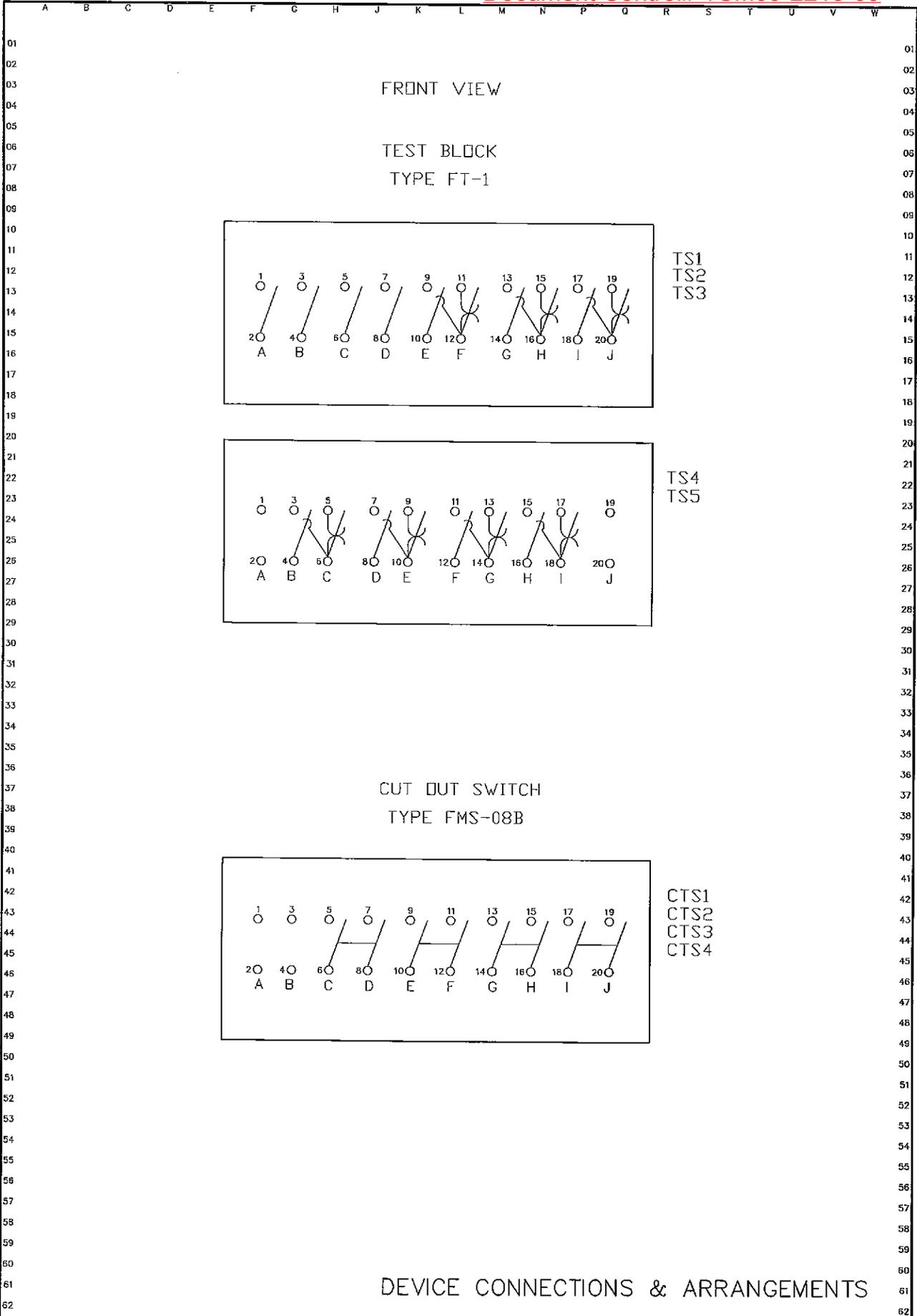


- NOTES: MOC - MOTOR OPERATED CONTROLS  
 NO - NORMALLY OPEN CONTACT  
 NC - NORMALLY CLOSED CONTACT  
 U - UNUSED TERMINAL  
 Δ - CONTACT SENSING INPUTS

DEVICE CONNECTIONS & ARRANGEMENTS

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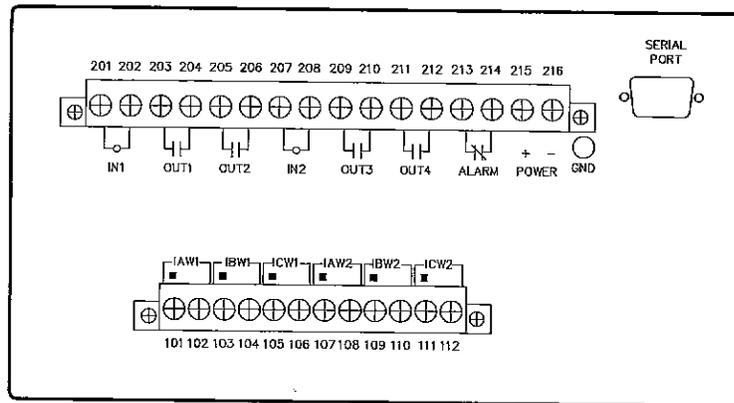
REV. 3	REV. 2	REV. 1	APPROVALS	 E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.	ELEMENTARY DIAGRAM 2127T1794 CONT. ON SH. EA07J SH. NO. EA07H
REV. 4	01MCPD12B.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT		
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA			



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REV. 3	REV. 2	REV. 1	APPROVALS								
REV. 4	01MCP012A.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT				<b>E<sup>2</sup> PSI</b>		ELEMENTARY DIAGRAM 2127T1794	
REV. 5	MADE BY:	M. FARRAR	FELLOWS, CA		<b>E<sup>2</sup> Power Systems, Inc.</b>		DWG. ON SH. EA07K	SH. NO. EA07J			



SCHWEITZER MODEL SEL-587  
CURRENT DIFFERENTIAL RELAY

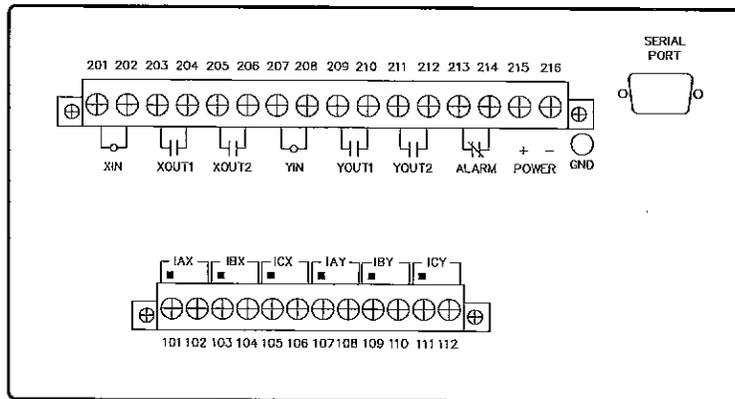


DEVICE CONNECTIONS & ARRANGEMENTS

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REV. 3	REV. 2	REV. 1	APPROVAL	ELEMENTARY DIAGRAM
	01MCP0120.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup> PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. EA07M SH. NO. EA07L

SCHWEITZER MODEL SEL-501-2  
 DUAL OVERCURRENT RELAY  
 STEP UP TRANSFORMER & STATION SERVICE PROTECTION

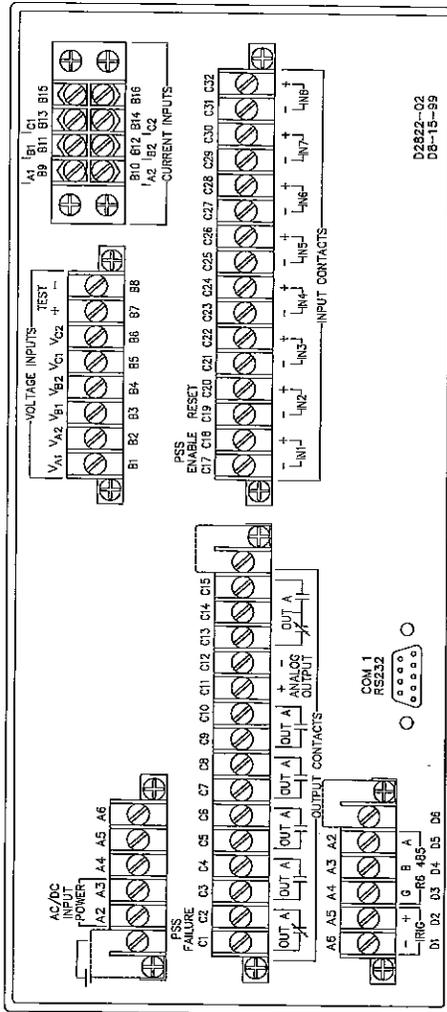


DEVICE CONNECTIONS & ARRANGEMENTS

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
01MCP012E.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
MADE BY:	M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup>PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. QN SH. EA07N SH. NO. EA07M

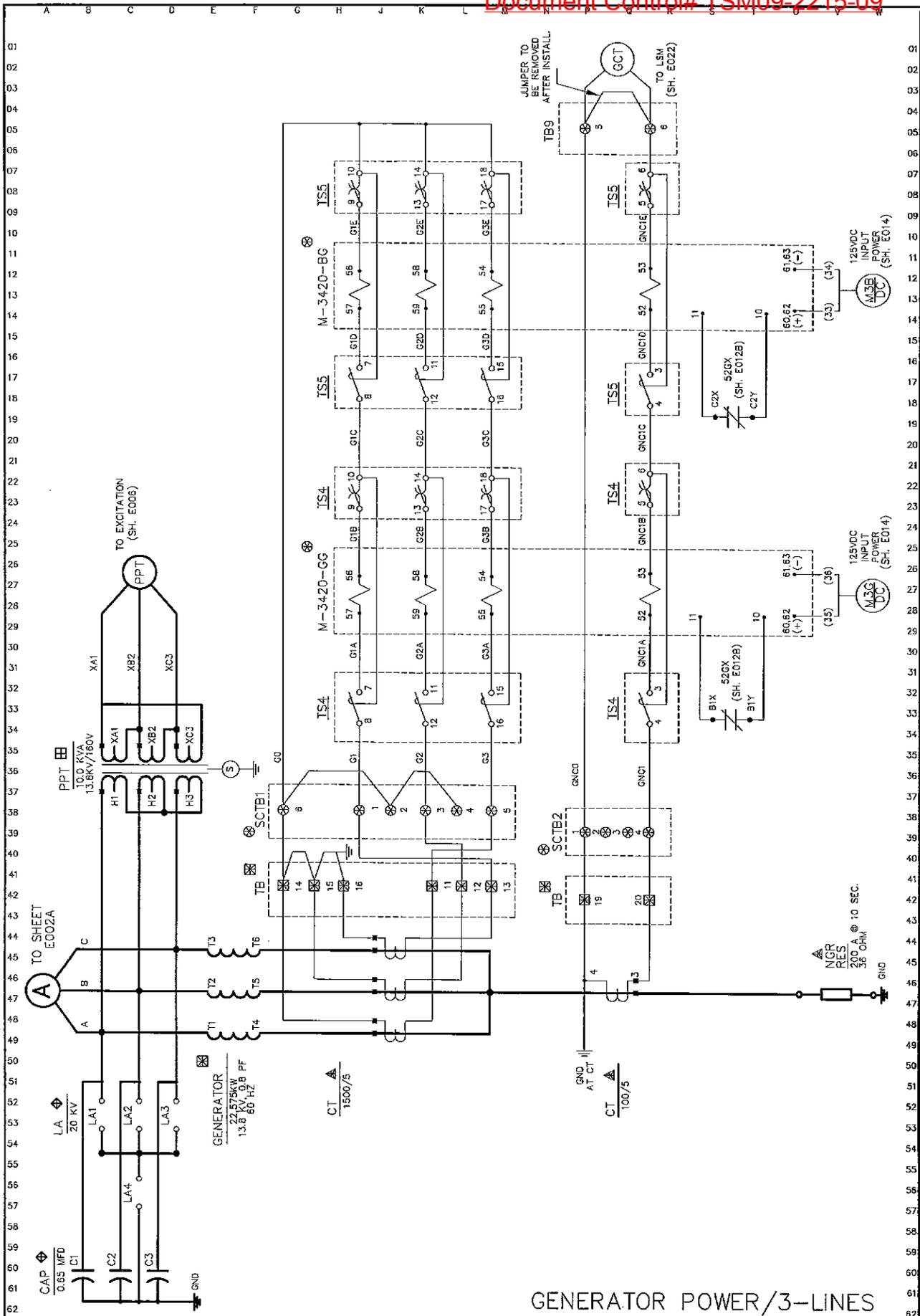
# BASLER PSS-100 POWER SYSTEM STABILIZER



## DEVICE CONNECTIONS & ARRANGEMENTS

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REV. 3	REV. 2	REV. 1	APPROVALS							
REV. 4	01MCP056.DWG	10-29-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	 E <sup>2</sup> Power Systems, Inc.					ELEMENTARY DIAGRAM
REV. 5	MADE BY:	R. GLENN	FELLOWS, CA							2127T1794
					CONT. ON SH. E001	SH. NO. EA07N				

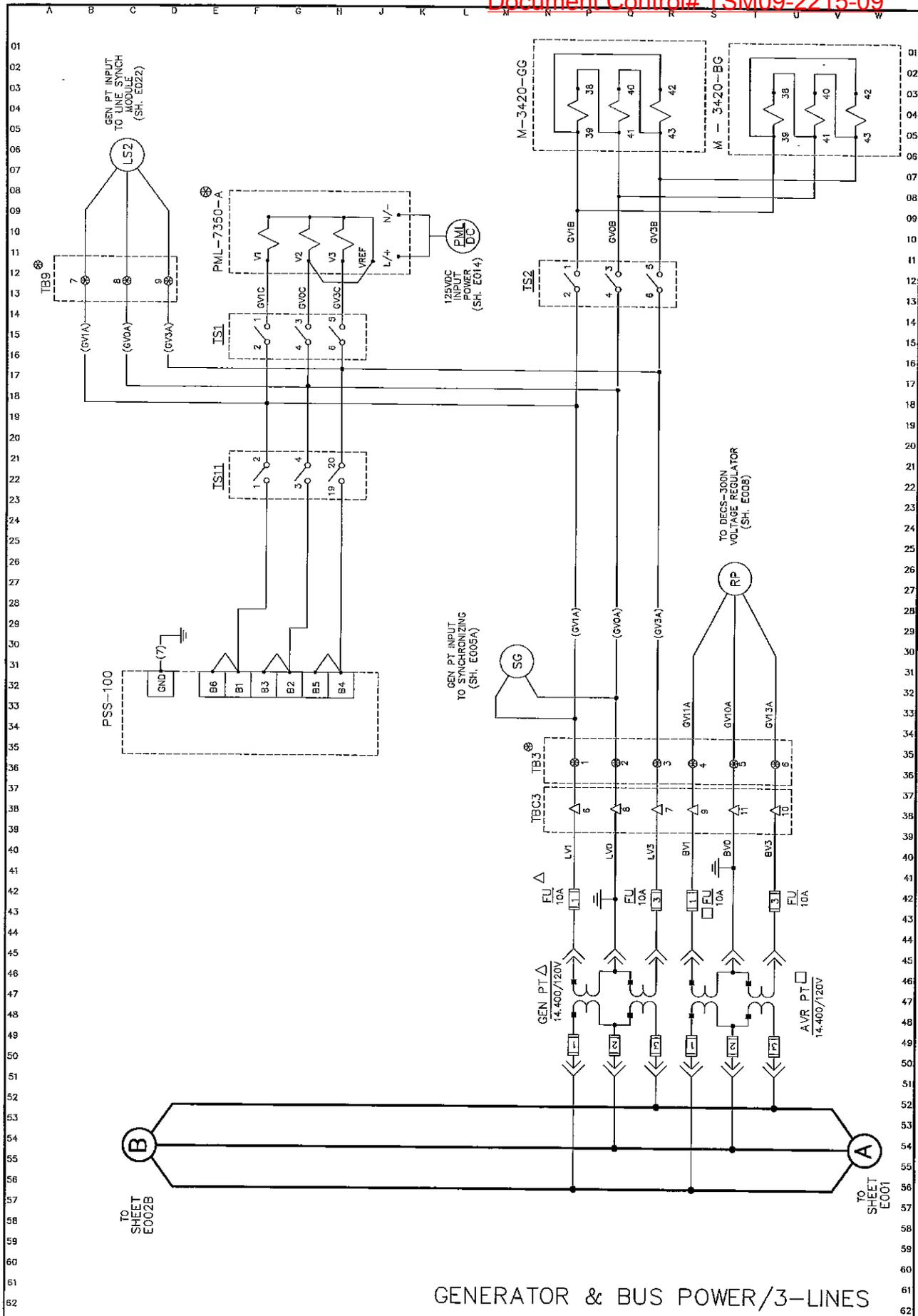


GENERATOR POWER/3-LINES

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP004.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. E002A SH. NO. E001

**E<sup>2</sup>PSI**  
E<sup>2</sup> Power Systems, Inc.



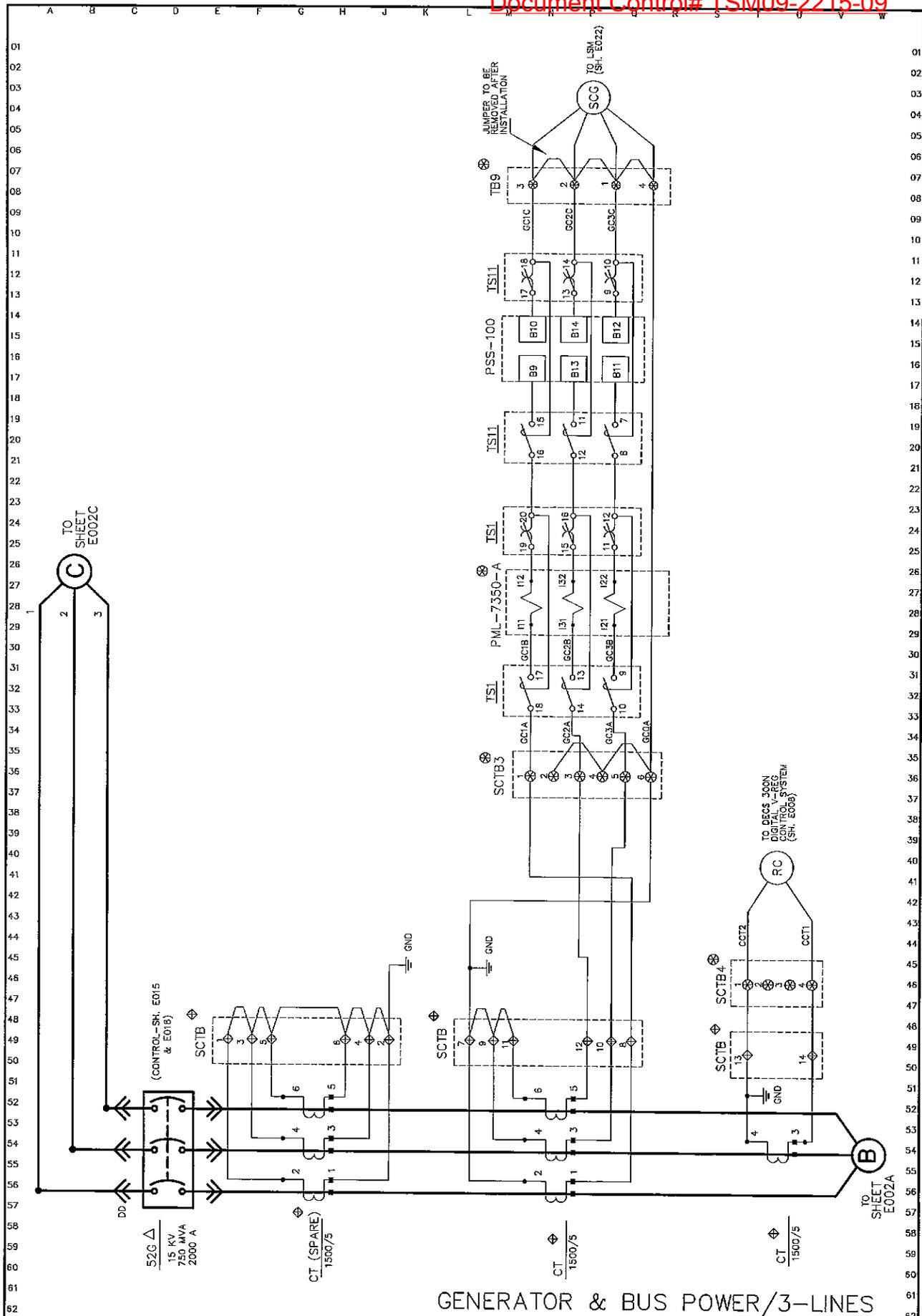
GENERATOR & BUS POWER/3-LINES

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REV. 3	REV. 2	REV. 1	9-05-01	APPROVALS	<i>[Signature]</i>	ELEMENTARY DIAGRAM
REV. 4	01MCP005.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT		2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA		CONT. ON SH. E002B SH. NO. E002A



E<sup>2</sup> Power Systems, Inc.

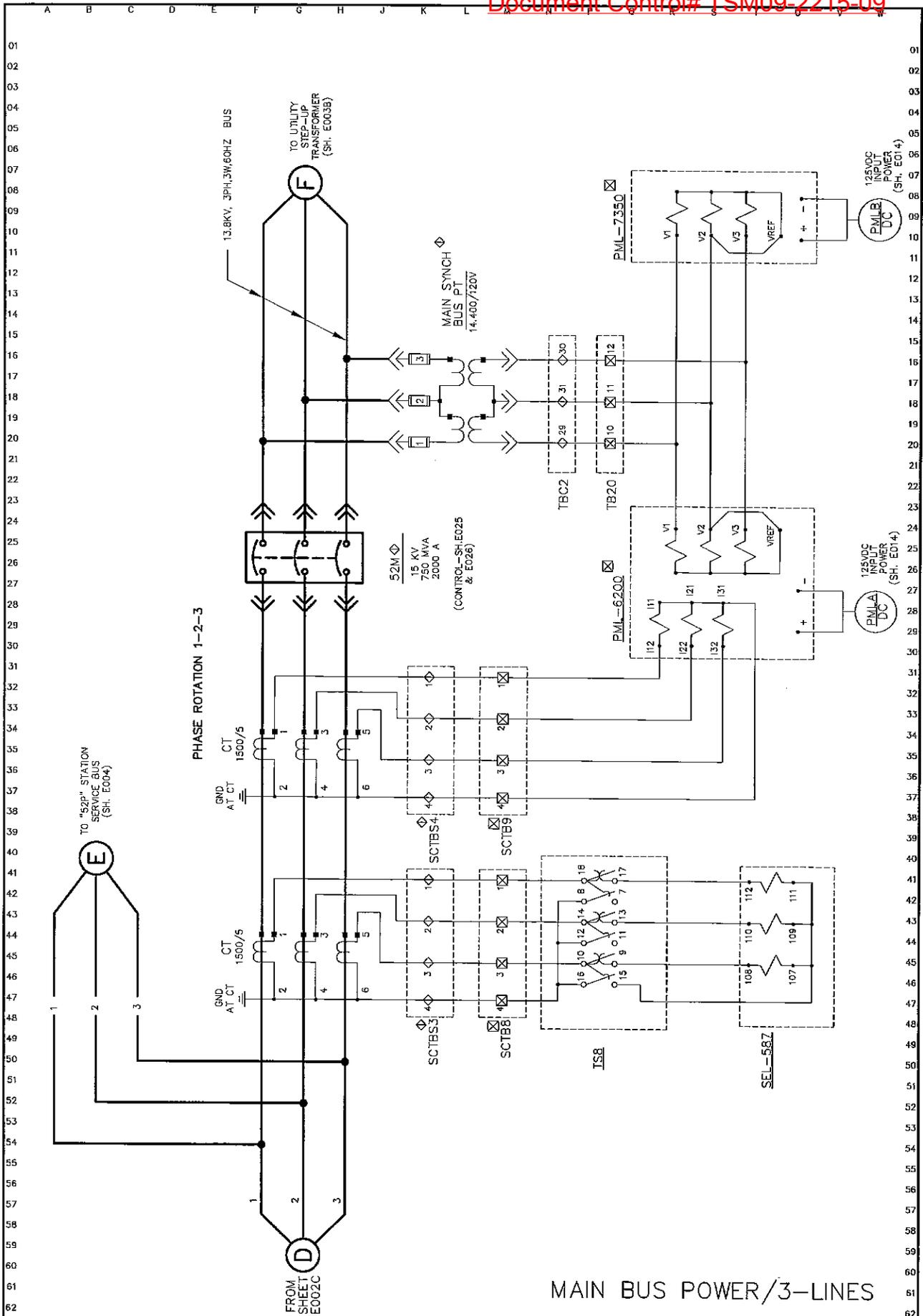


GENERATOR & BUS POWER/3-LINES

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REV. 3	REV. 2	REV. 1	9-05-01	APPROVALS	<i>M. J. J.</i>	ELEMENTARY DIAGRAM
REV. 4	01MCP005B.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	<b>E<sup>2</sup>PSI</b>	2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA	<b>E<sup>2</sup> Power Systems, Inc.</b>	CONT. ON SH. E002C SH. NO. E002B

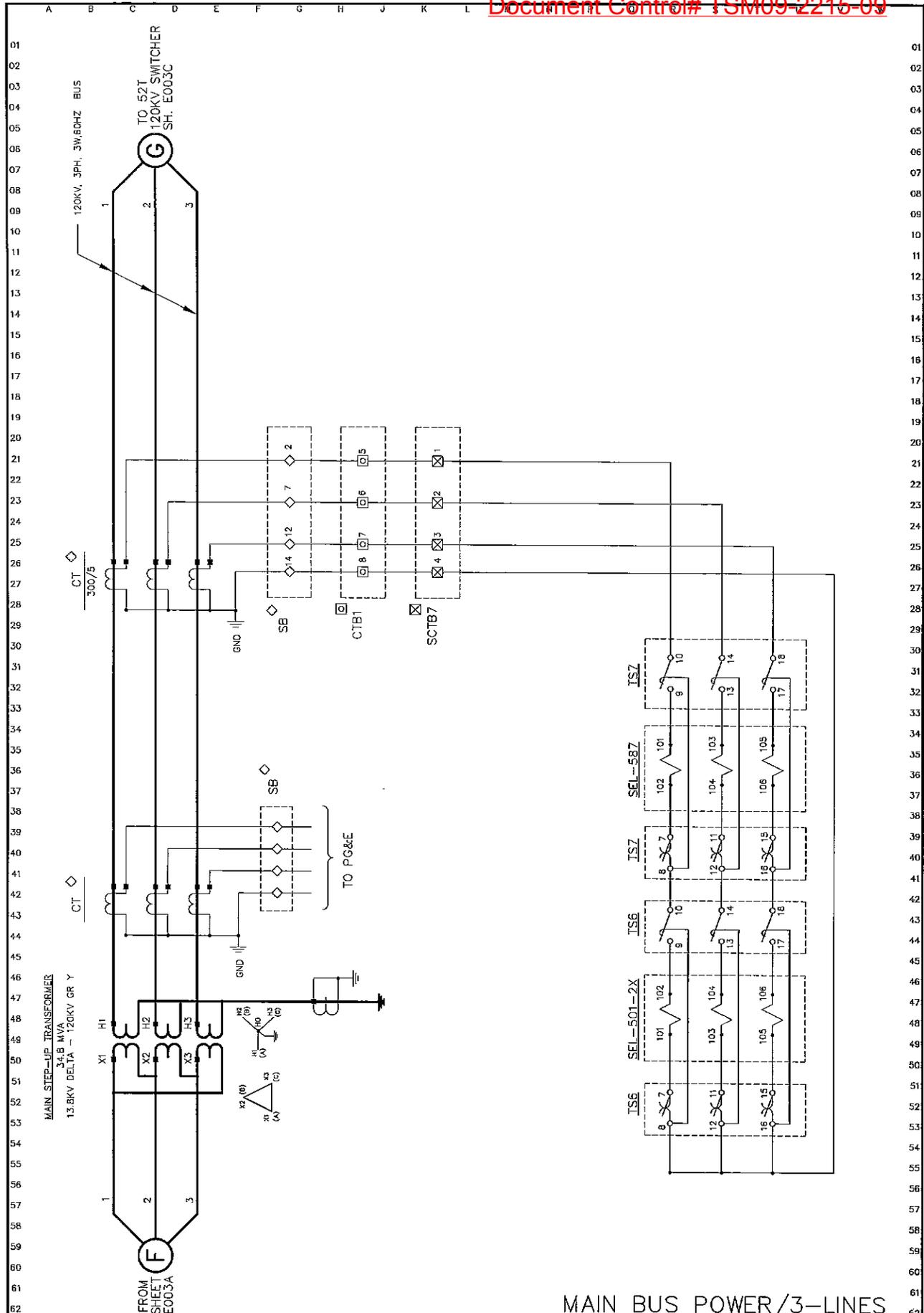




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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP013.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY M. FARRAR		FELLOWS, CA	CONT. ON SH. E003B SH. NO. E003A

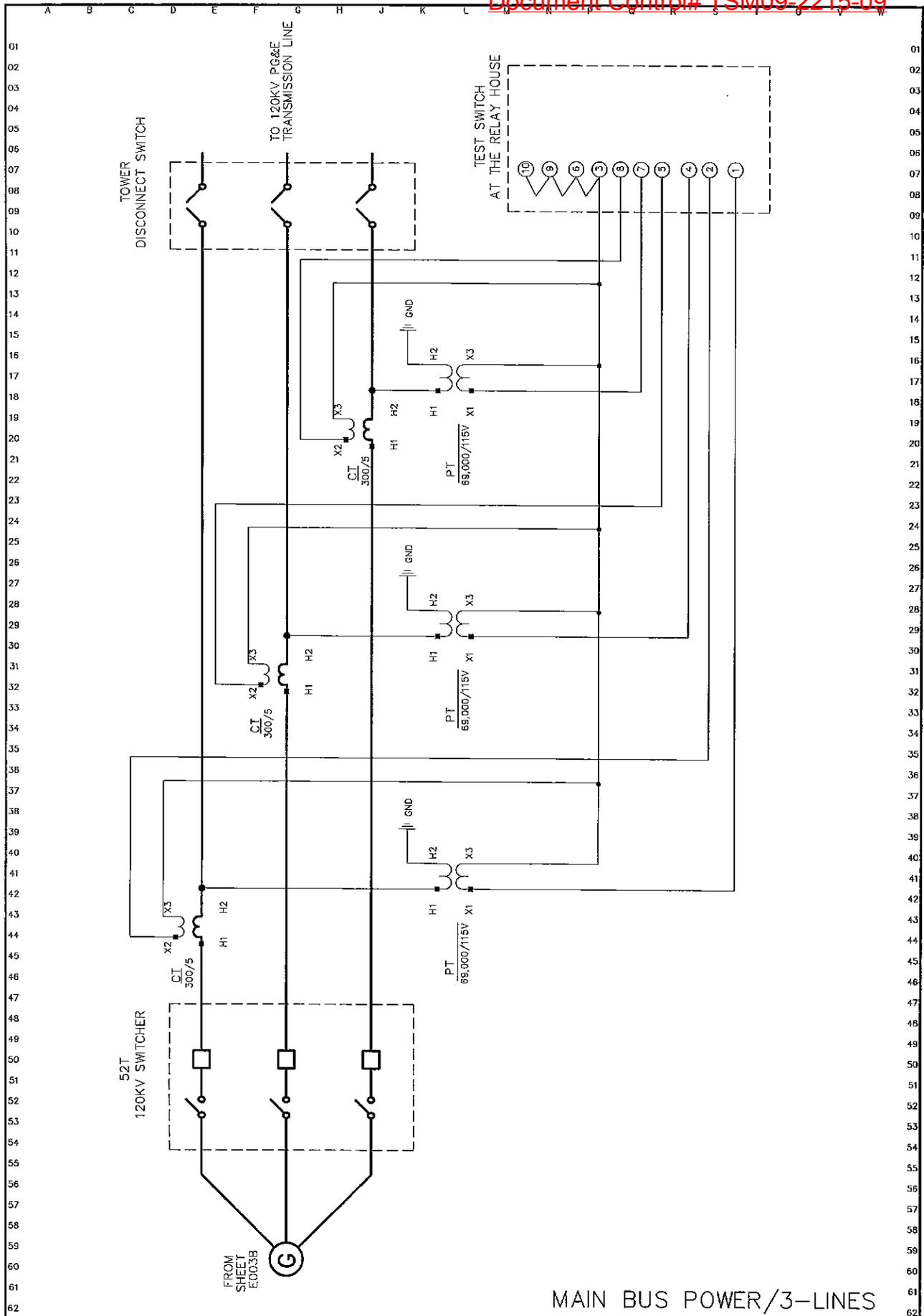
**E<sup>2</sup>PSI**  
E<sup>2</sup> Power Systems, Inc.



MAIN BUS POWER/3-LINES

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REV. 3	REV. 2	10-05-01	REV. 1	9-05-01	APPROVALS	<b>E<sup>2</sup>PSI</b> E <sup>2</sup> Power Systems, Inc.	ELEMENTARY DIAGRAM 2127T1794 CONT. GN SH. E003C SH. NO. E003B
REV. 4	01MCP013B.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT			
REV. 5	MADE BY:	M. FARRAR		FELLOWS, CA			



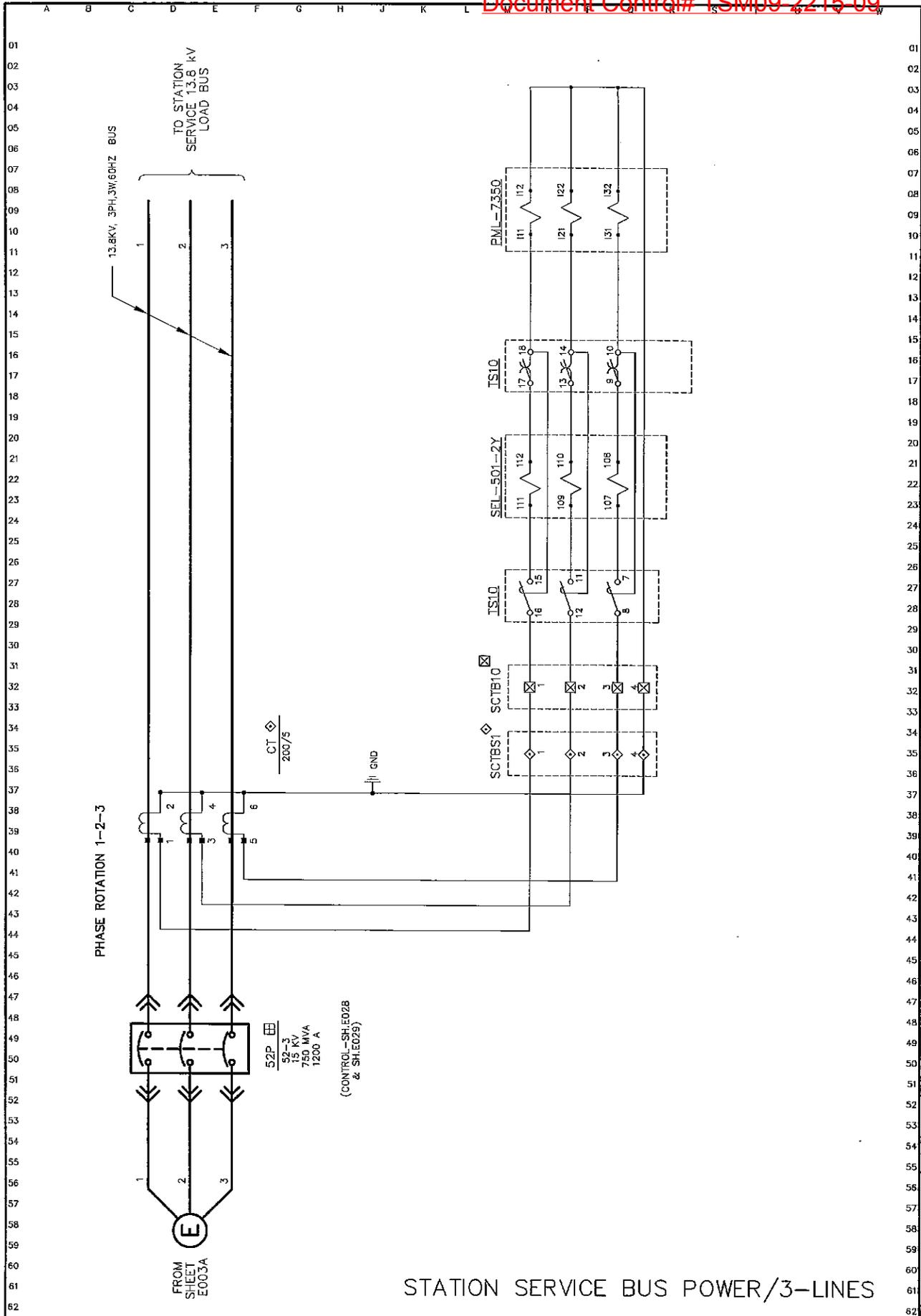
MAIN BUS POWER/3-LINES

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REV. 3	REV. 2	REV. 1	APPROVALS	ELMENTARY DIAGRAM
REV. 4	01MCP005C.DWG	9-05-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	COUNT. ON SH. E004 SH. NO. E003C



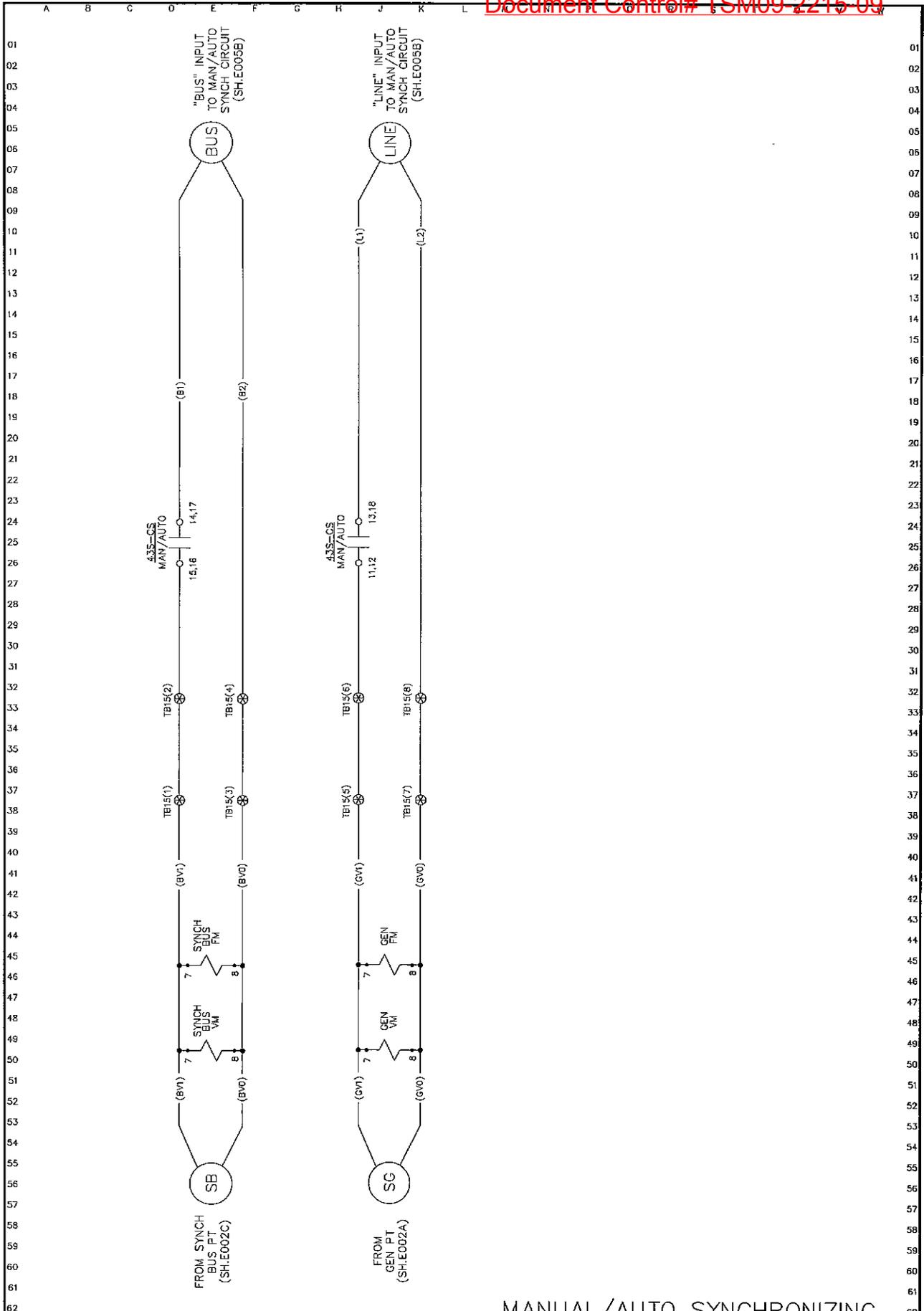
E<sup>2</sup> Power Systems, Inc.



STATION SERVICE BUS POWER/3-LINES

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP013A.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. E005A SH. NO. E004

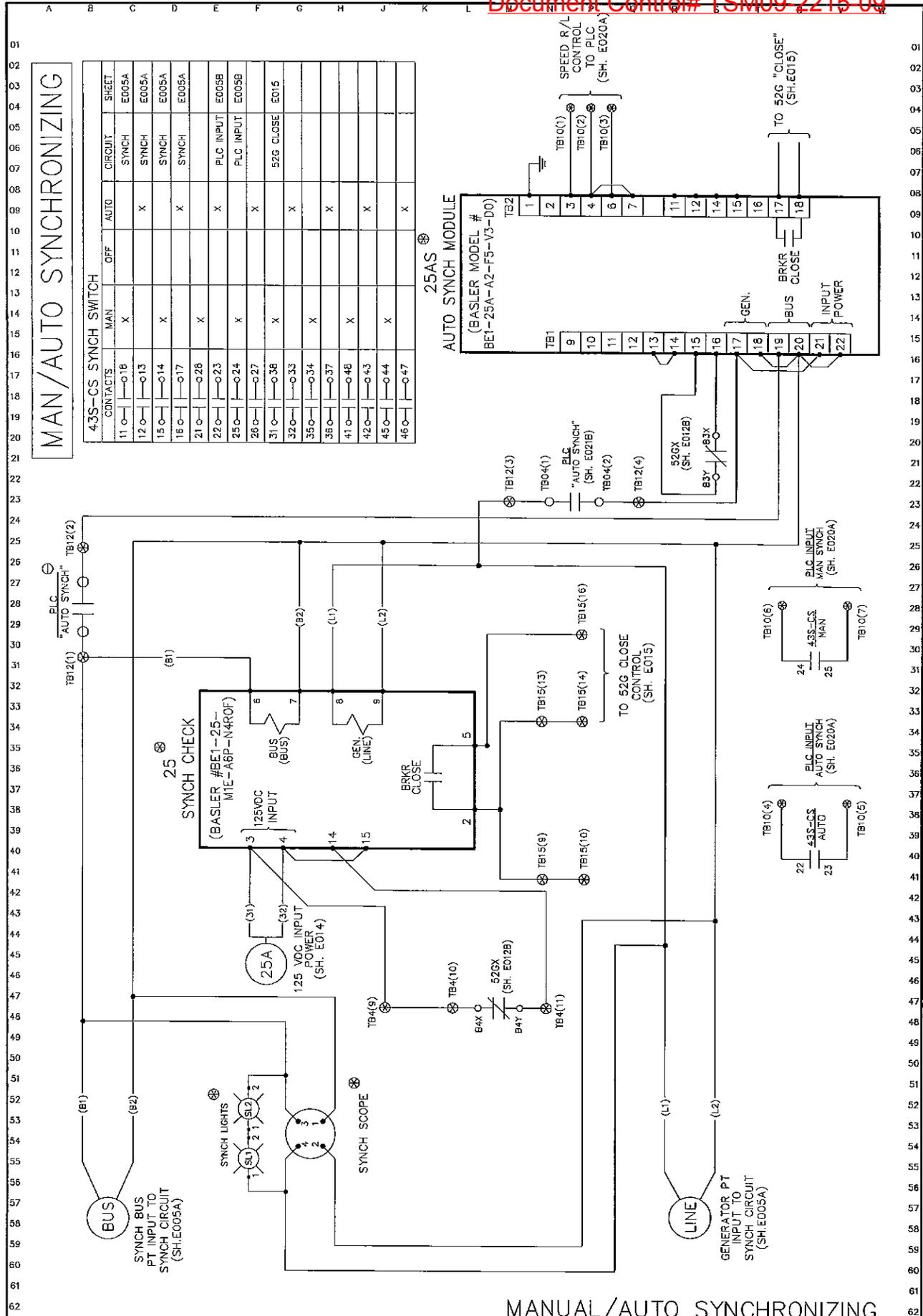
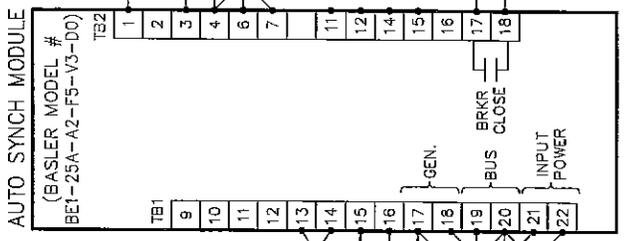


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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM							
REV. 4	01MCP023A.DWG	8-7-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT				E <sup>2</sup> PSI		2127T1794	
REV. 5	MADE BY:	M. FARRAR	FELLOWS, CA		E <sup>2</sup> Power Systems, Inc.			CONT. ON SH. E005B	SH. NO. E005A		

# MAN/AUTO SYNCHRONIZING

43S-CS SYNCH SWITCH			
CONTACTS	MAN	OFF	AUTO
11 0-18	X		
12 0-13		X	
15 0-14	X		
16 0-17		X	
21 0-28	X		
22 0-23		X	
25 0-24	X		
26 0-27		X	
31 0-38	X		
32 0-33		X	
35 0-34	X		
36 0-37		X	
41 0-48	X		
42 0-43		X	
45 0-44	X		
46 0-47		X	

## 25AS

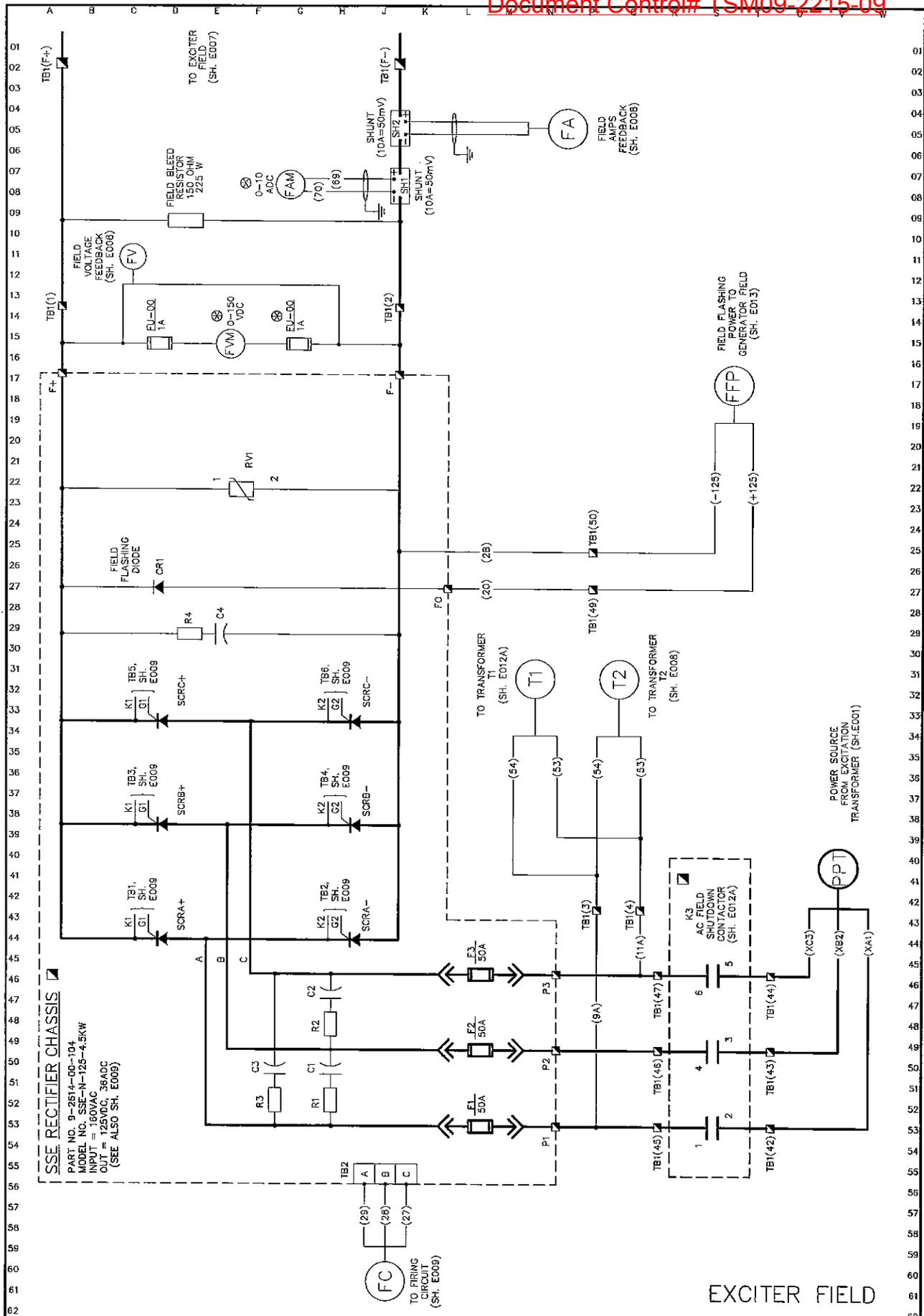


# MANUAL/AUTO SYNCHRONIZING

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

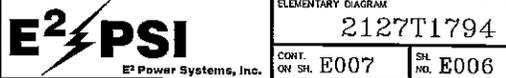
REV. 3	REV. 2	REV. 1	APPROVAL	ELEMENTARY DIAGRAM
REV. 4	01MCP023.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CON. NO. E006 SH. NO. E005B

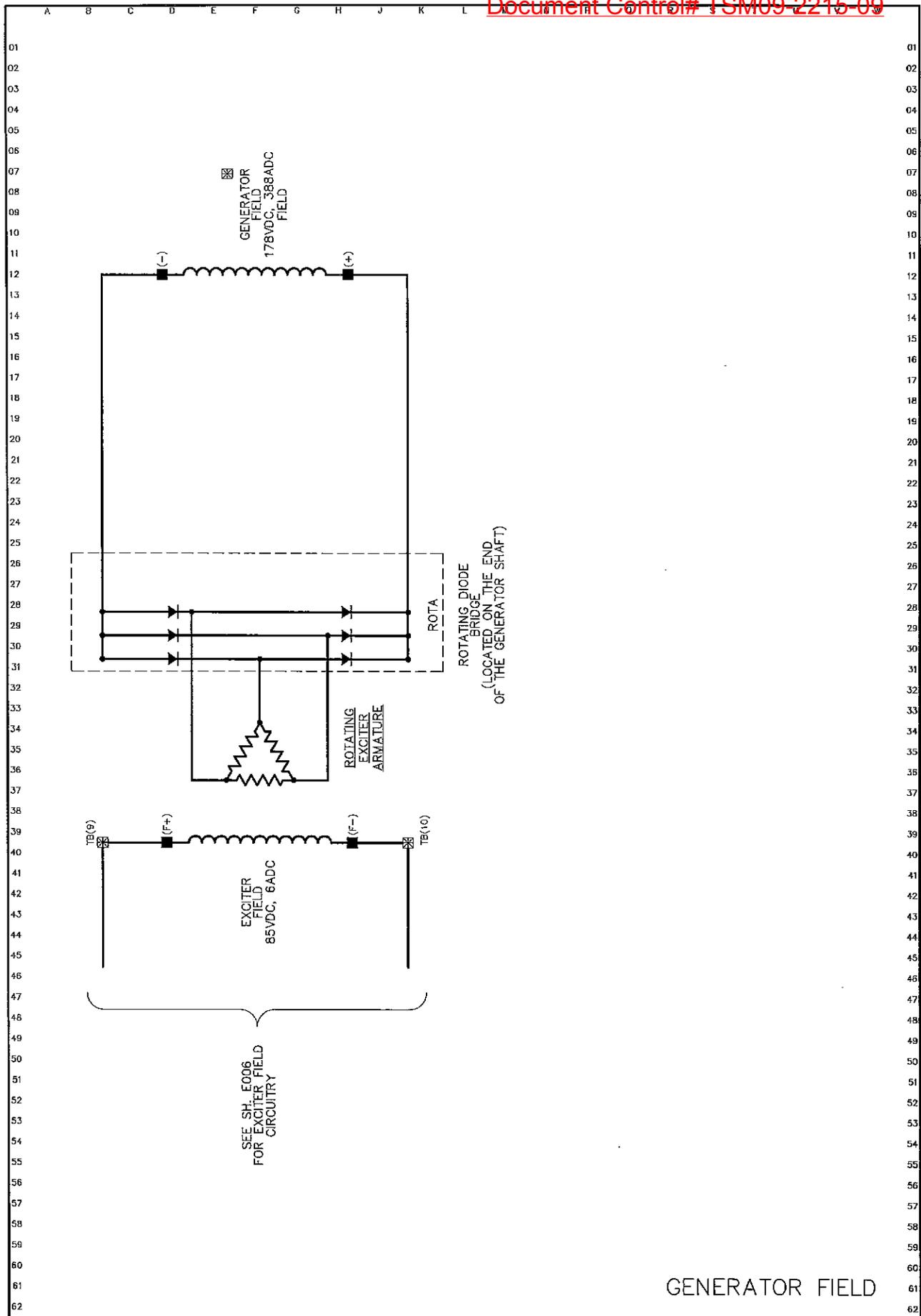




IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP009.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. E007 SH. NO. E006





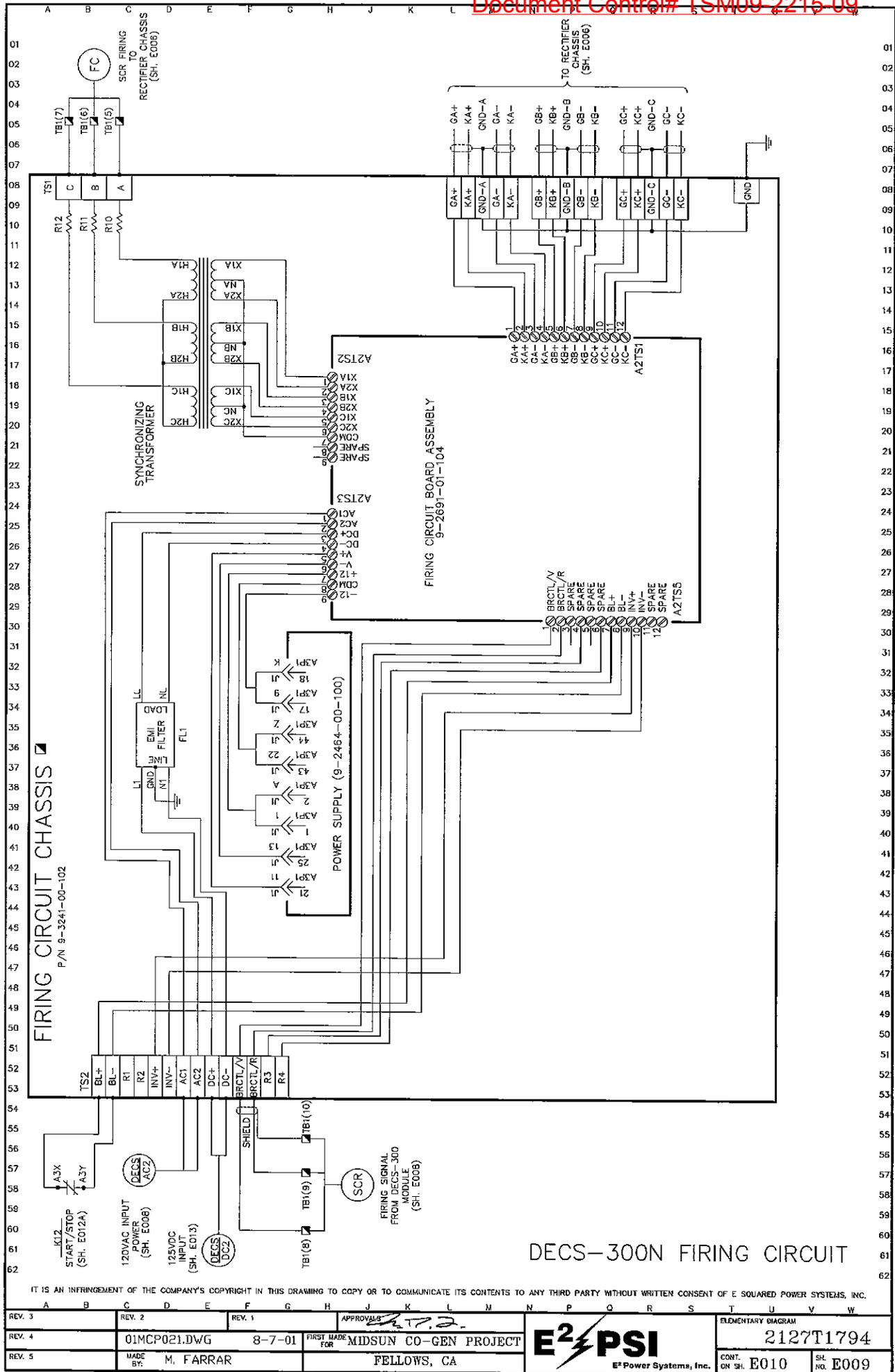
SEE SH. E006  
FOR EXCITER FIELD  
CIRCUITRY

GENERATOR FIELD

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP029.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup>PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. E008 SH. NO. E007

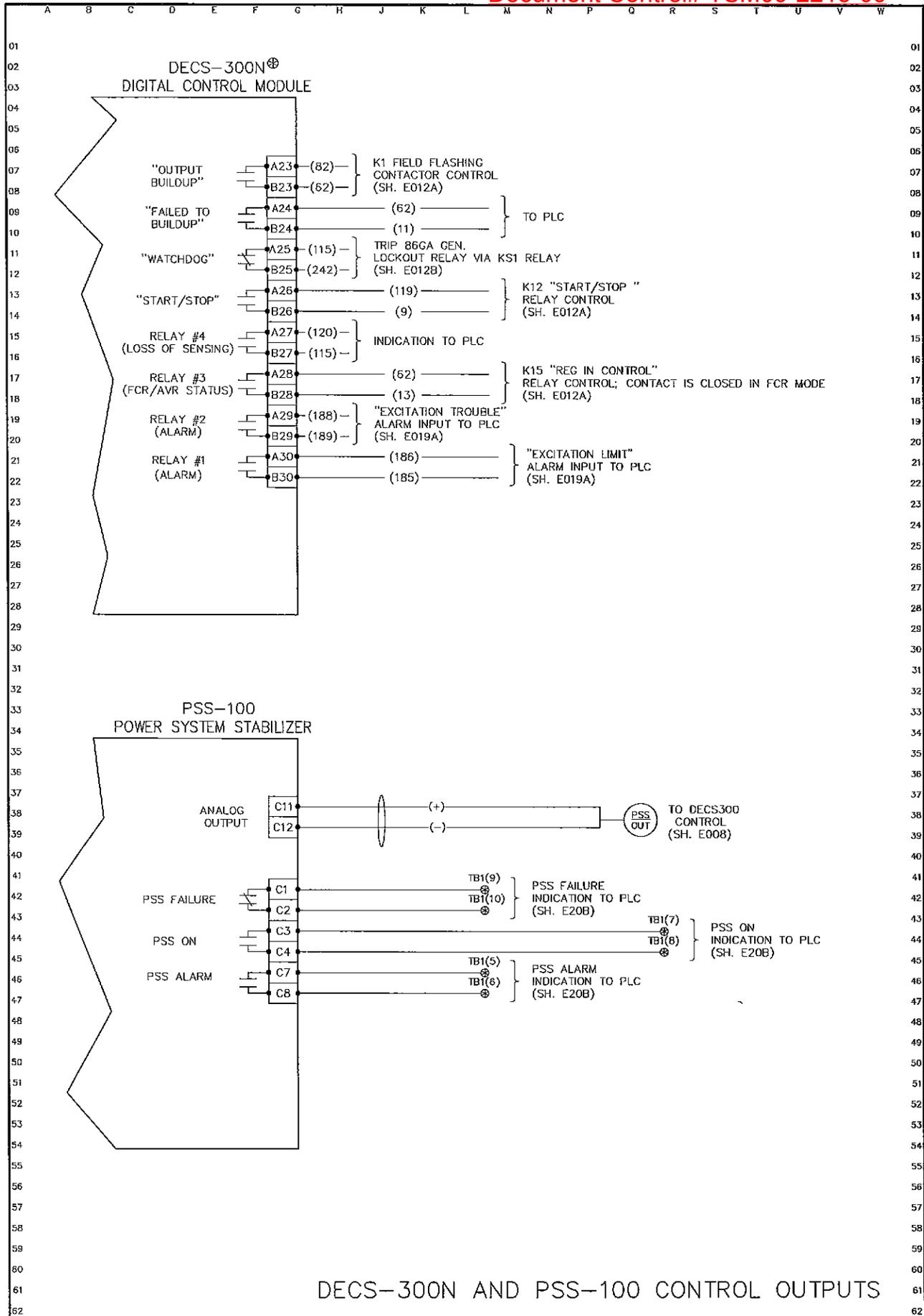




DECS-300N FIRING CIRCUIT

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP021.DWG	8-7-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup>PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. E010 SH. NO. E009

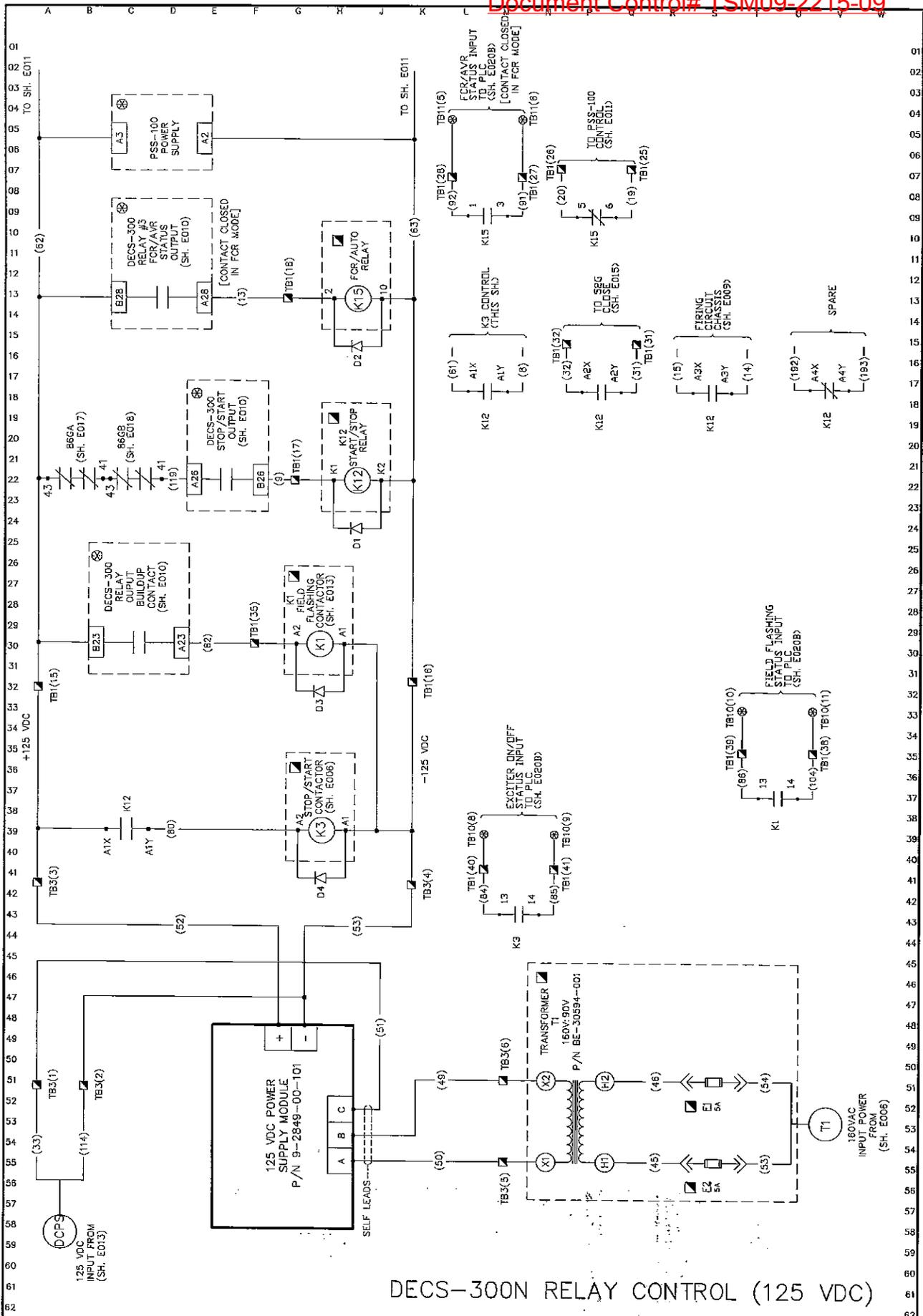


DECS-300N AND PSS-100 CONTROL OUTPUTS

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	9-05-01	APPROVAL	 <b>E<sup>2</sup> PSI</b> E <sup>2</sup> Power Systems, Inc.	ELEMENTARY DIAGRAM	2127T1794
REV. 4	01MCP034.DWG	8-8-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT		CONT. ON SH. E011	SH. NO. E010
REV. 5	MADE BY:	M. FARRAR		FELLOWS, CA			





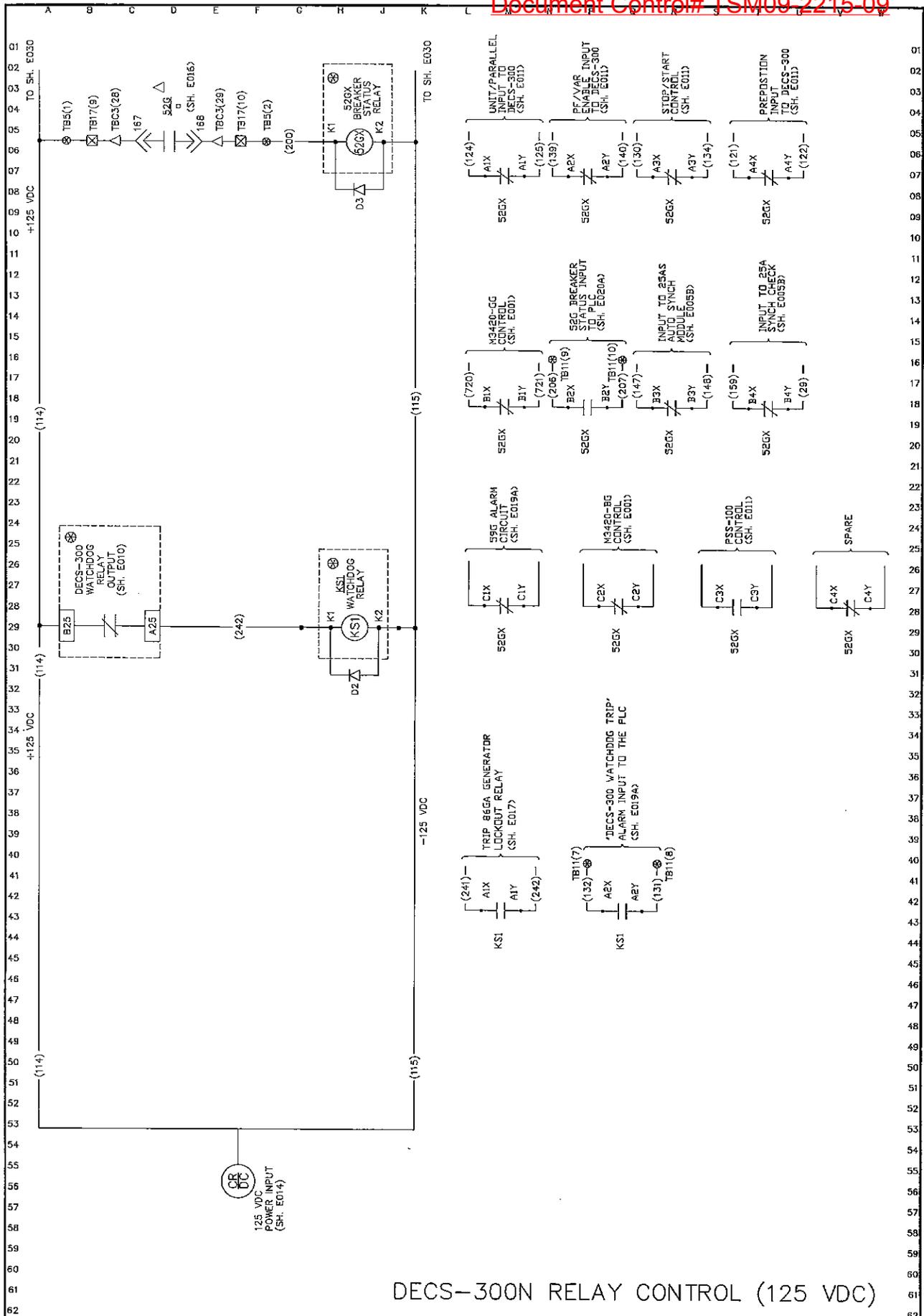
### DECS-300N RELAY CONTROL (125 VDC)

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	9-05-01	APPROVAL	ELEMENTARY DIAGRAM
REV. 4	01MCP035.DWG	B-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. E012B SR. NO. E012A



E<sup>2</sup> Power Systems, Inc.



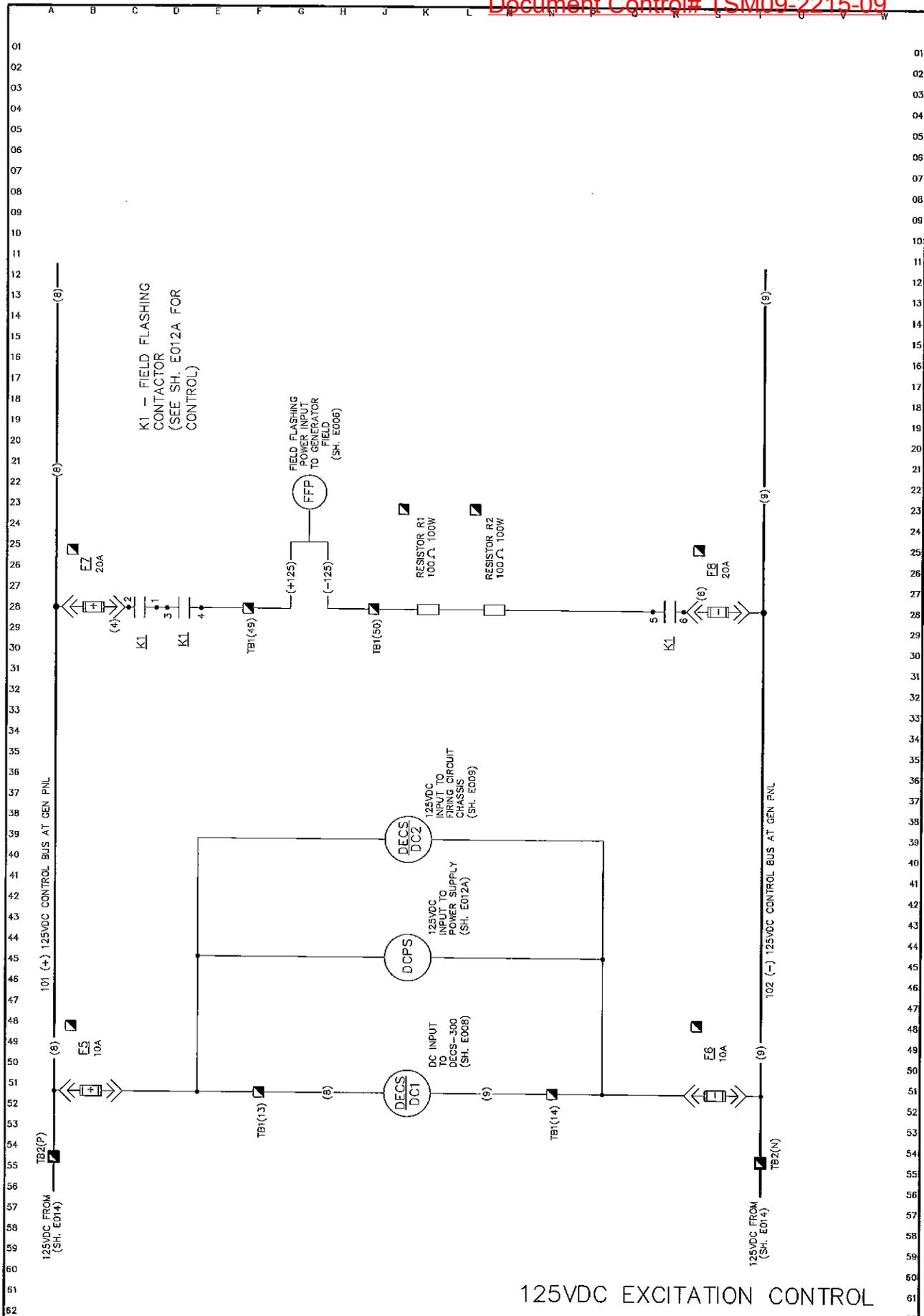
DECS-300N RELAY CONTROL (125 VDC)

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	9-05-01	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP037.DWG	8-8-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA	CONT. ON SH. E013 SH. NO. E012B



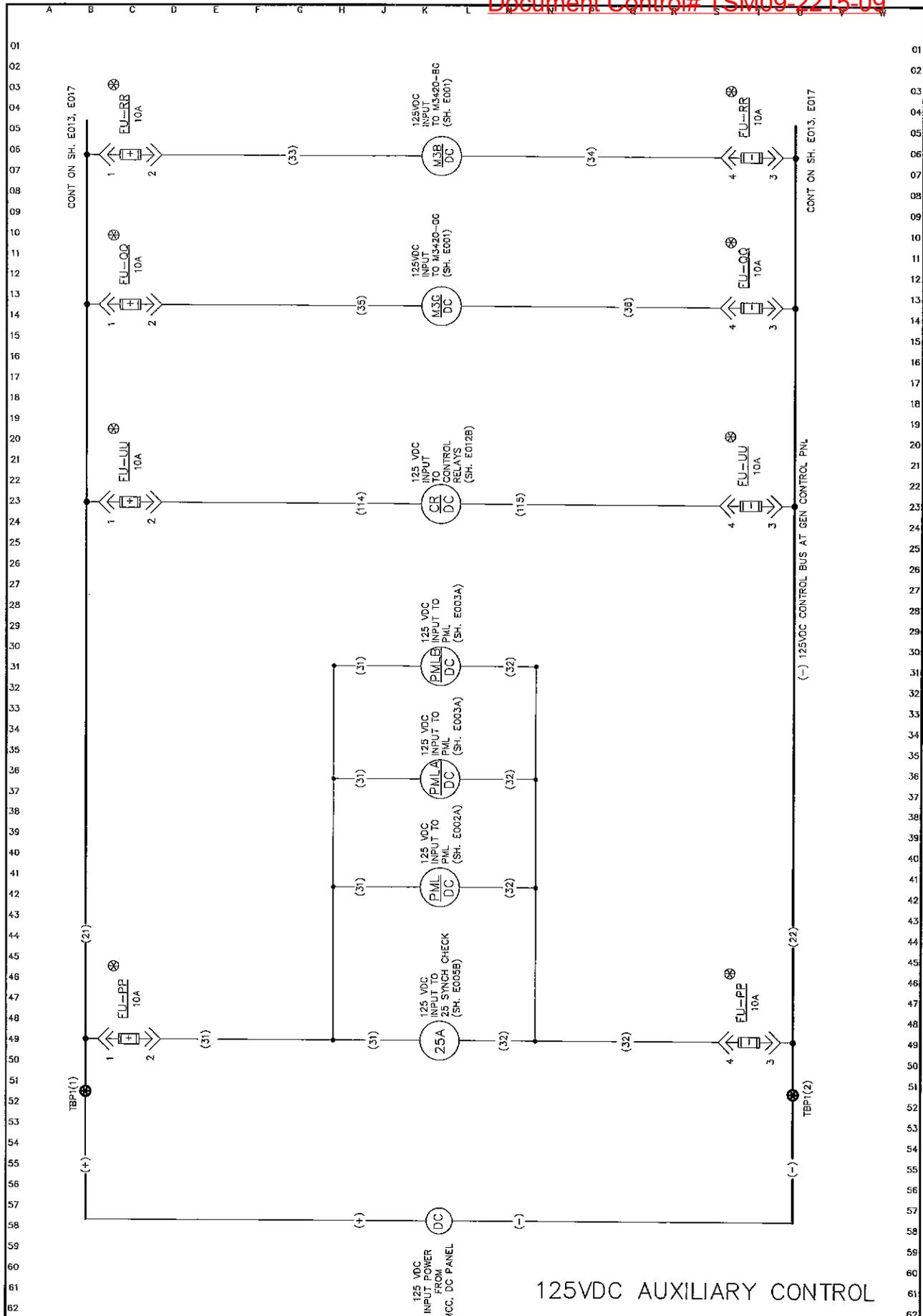
E<sup>2</sup> Power Systems, Inc.



125VDC EXCITATION CONTROL

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVED	E <sup>2</sup> PSI		ELEMENTARY DIAGRAM
REV. 4	01MCP018.DWG	8-8-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794	
REV. 5	MADE BY	M. FARRAR	FELLOWS, CA		CONL ON SH. E014	SH NO. E013



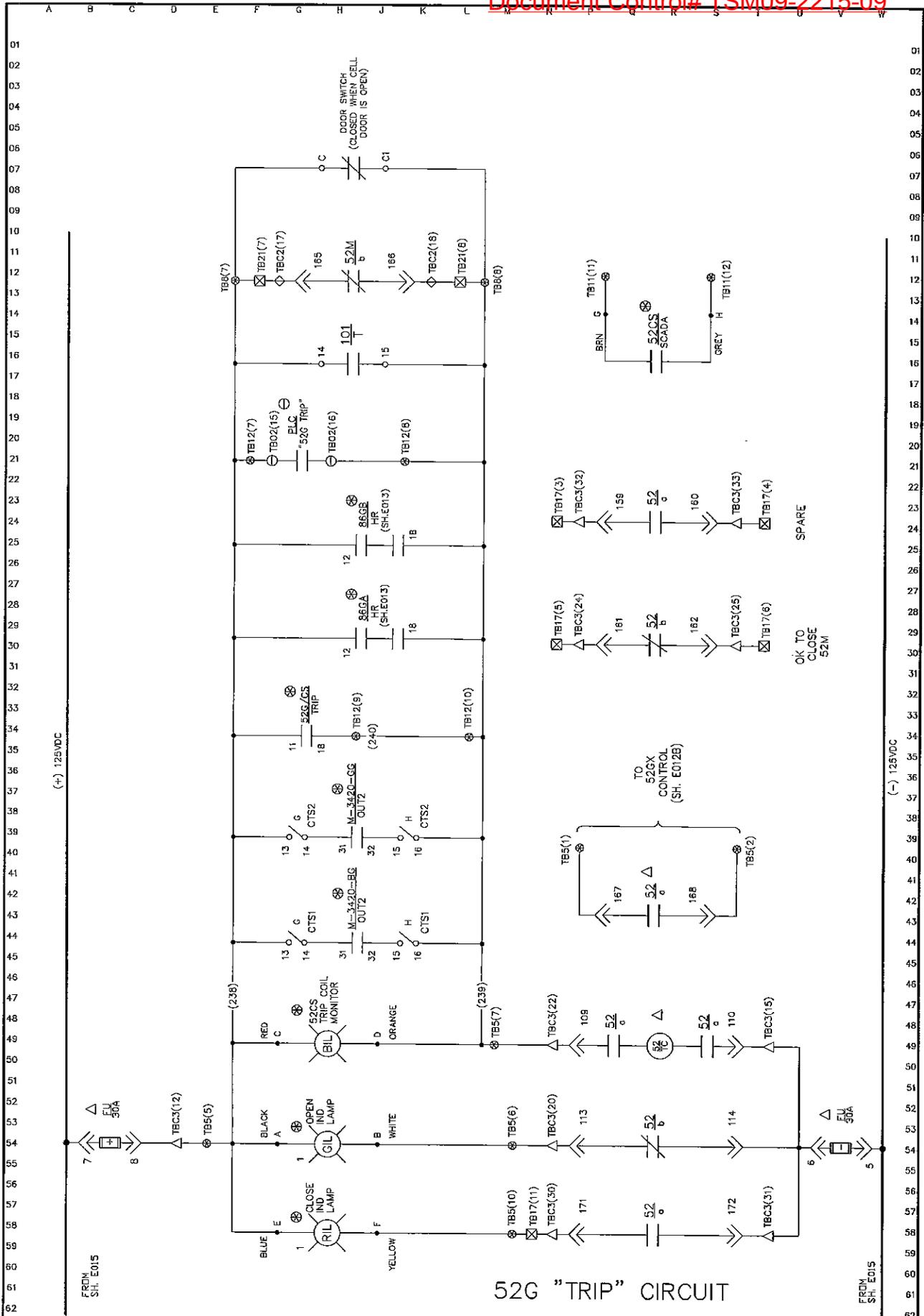
### 125VDC AUXILIARY CONTROL

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP019.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. E015 SH. NO. E014





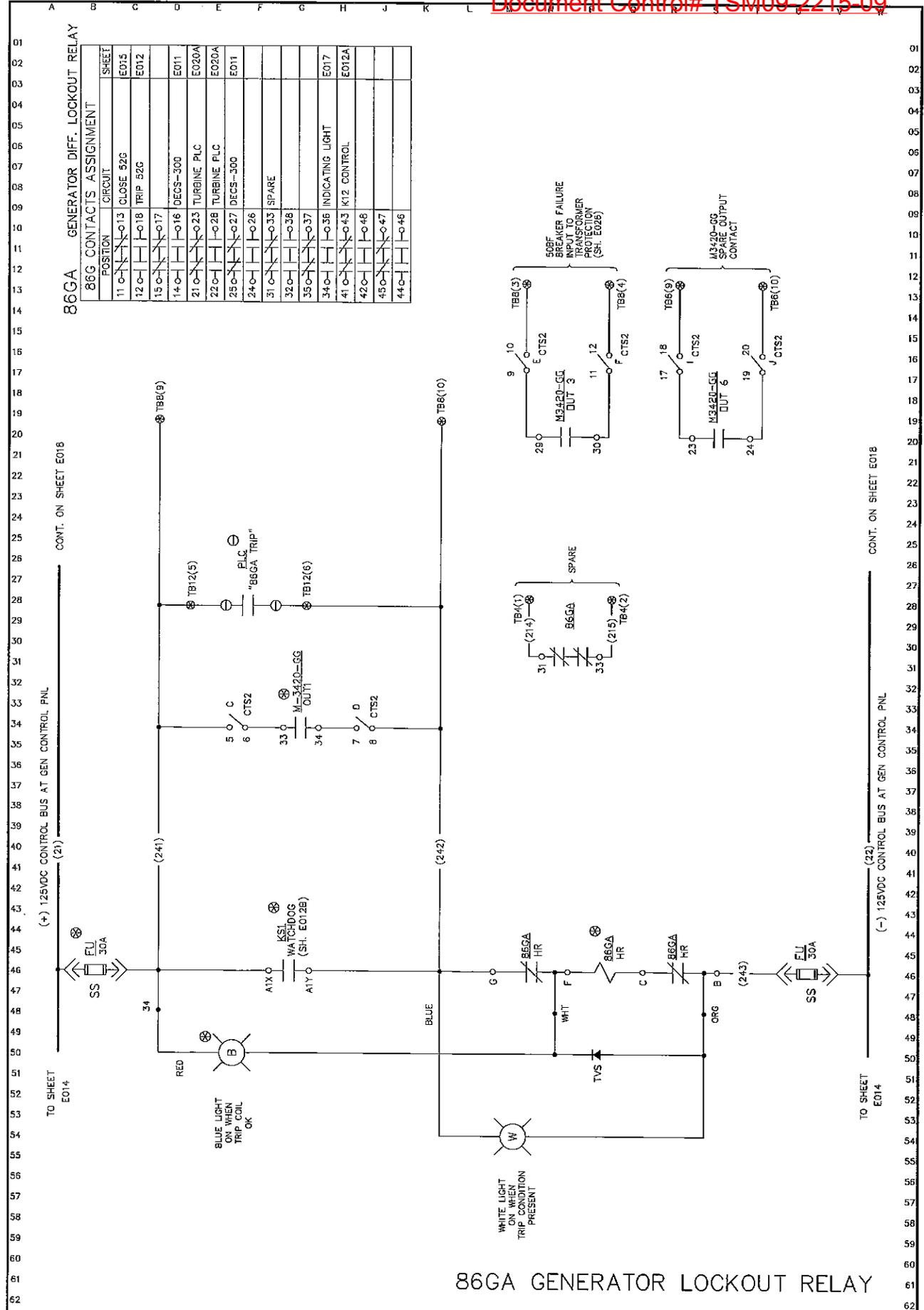


52G "TRIP" CIRCUIT

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
		10-5-01	<i>[Signature]</i>	2127T1794
REV. 4	01MCP026.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	CONT. ON SH. E017
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	SH. NO. E016





86GA GENERATOR DIFF. LOCKOUT RELAY

POSITION	CIRCUIT	SHEET
11	13 CLOSE 523	E015
12	18 TRIP 52C	E012
15	17	
14	16 DECS-300	E011
21	23 TURBINE PLC	E020A
22	28 TURBINE PLC	E020A
25	27 DECS-300	E011
24	26	
31	33 SPARE	
32	38	
35	37	
34	36 INDICATING LIGHT	E017
41	43 K12 CONTROL	E012A
42	46	
45	47	
44	46	

86GA GENERATOR LOCKOUT RELAY

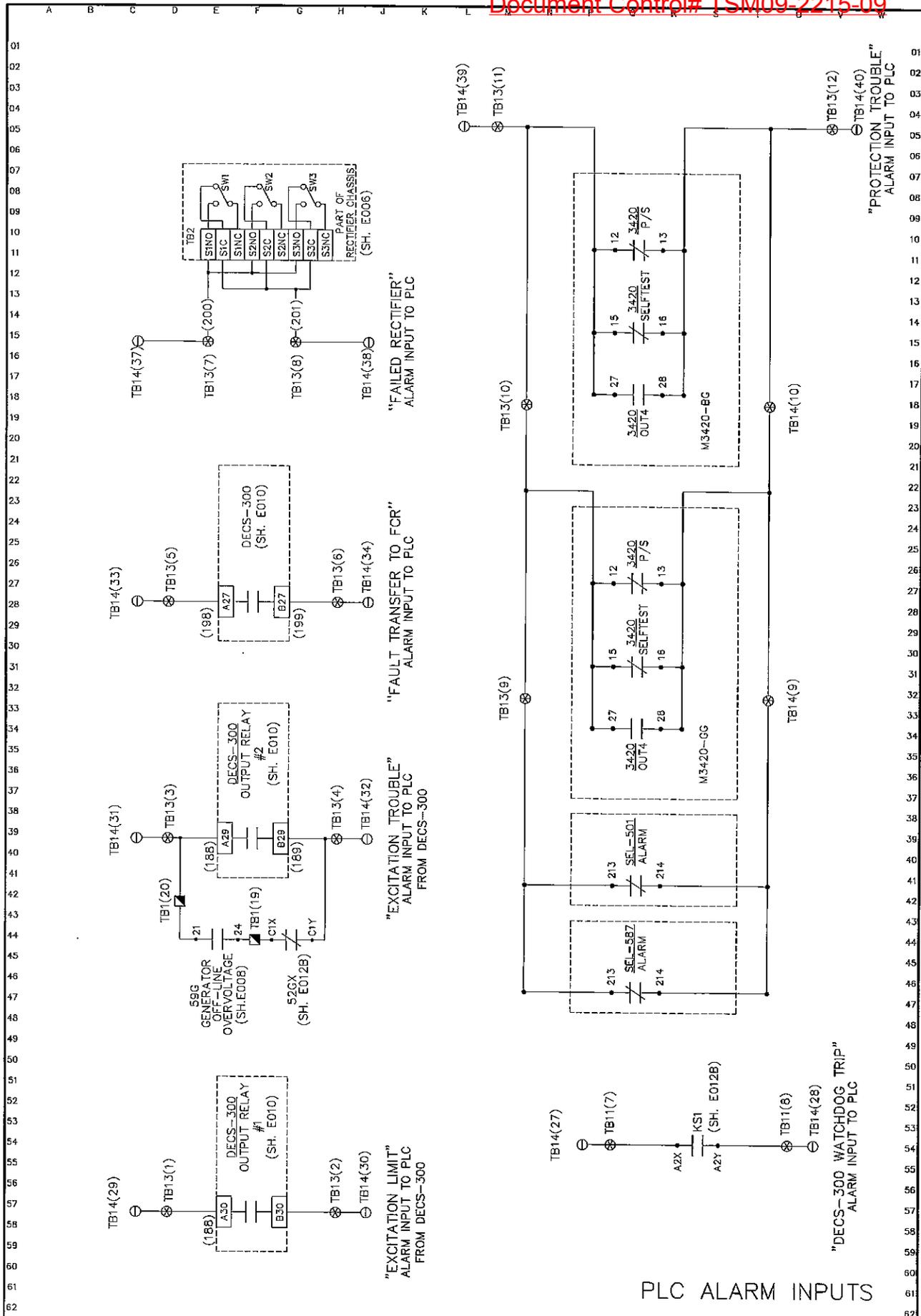
IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP024.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. E018 SH. NO. E017



E<sup>2</sup> Power Systems, Inc.





PLC ALARM INPUTS

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

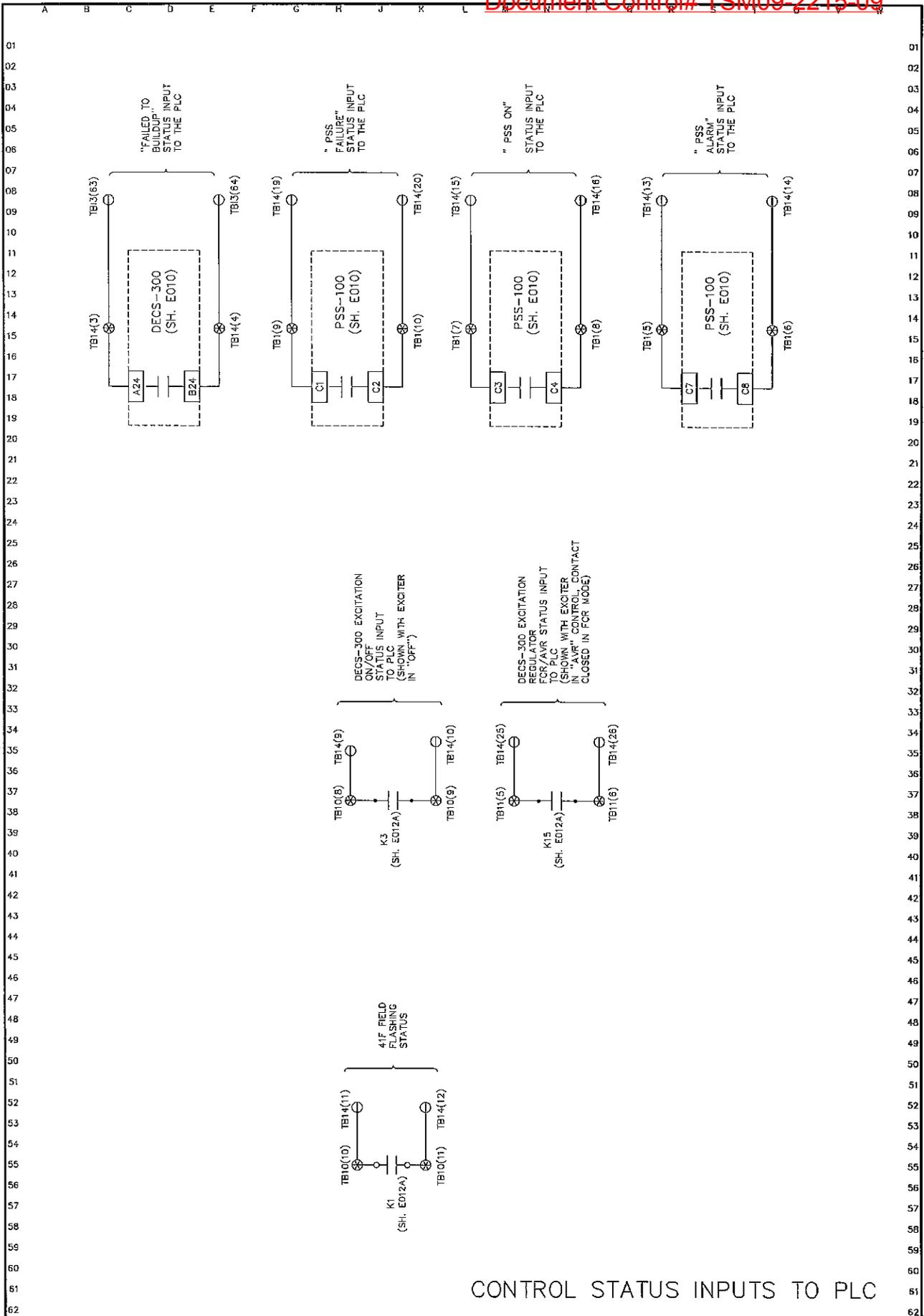
REV. 3	REV. 2	REV. 1	APPROVALS	ELEMNTARY DIAGRAM	
REV. 4	01MCP028.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794	
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA		CONT. ON SH. E019B	SH. NO. E019A



E<sup>2</sup> Power Systems, Inc.



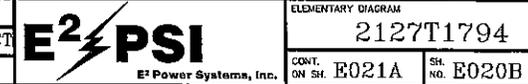


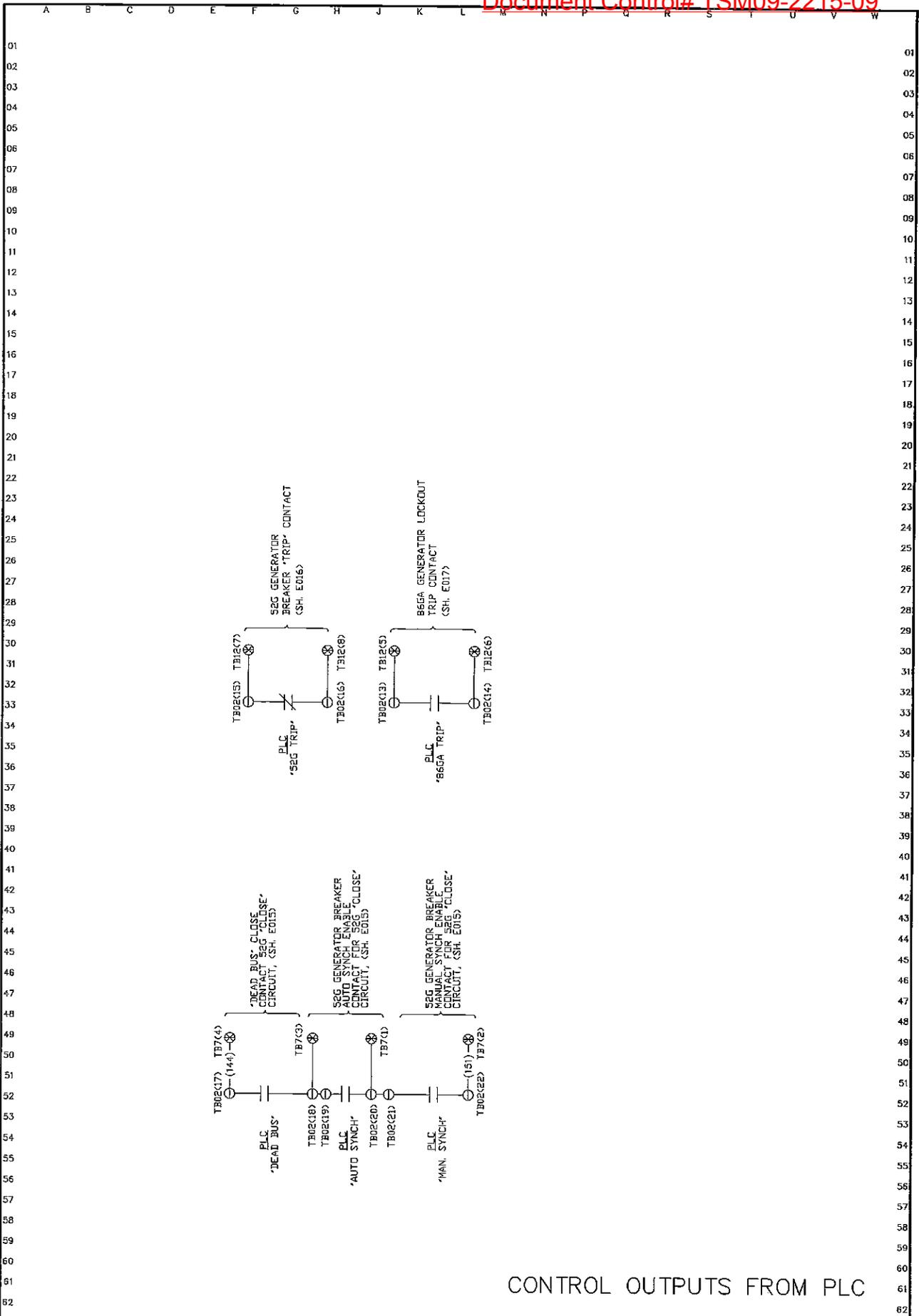


CONTROL STATUS INPUTS TO PLC

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	9-05-01	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP039.DWG	8-8-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA	CONT. ON SH. E021A SH. NO. E020B

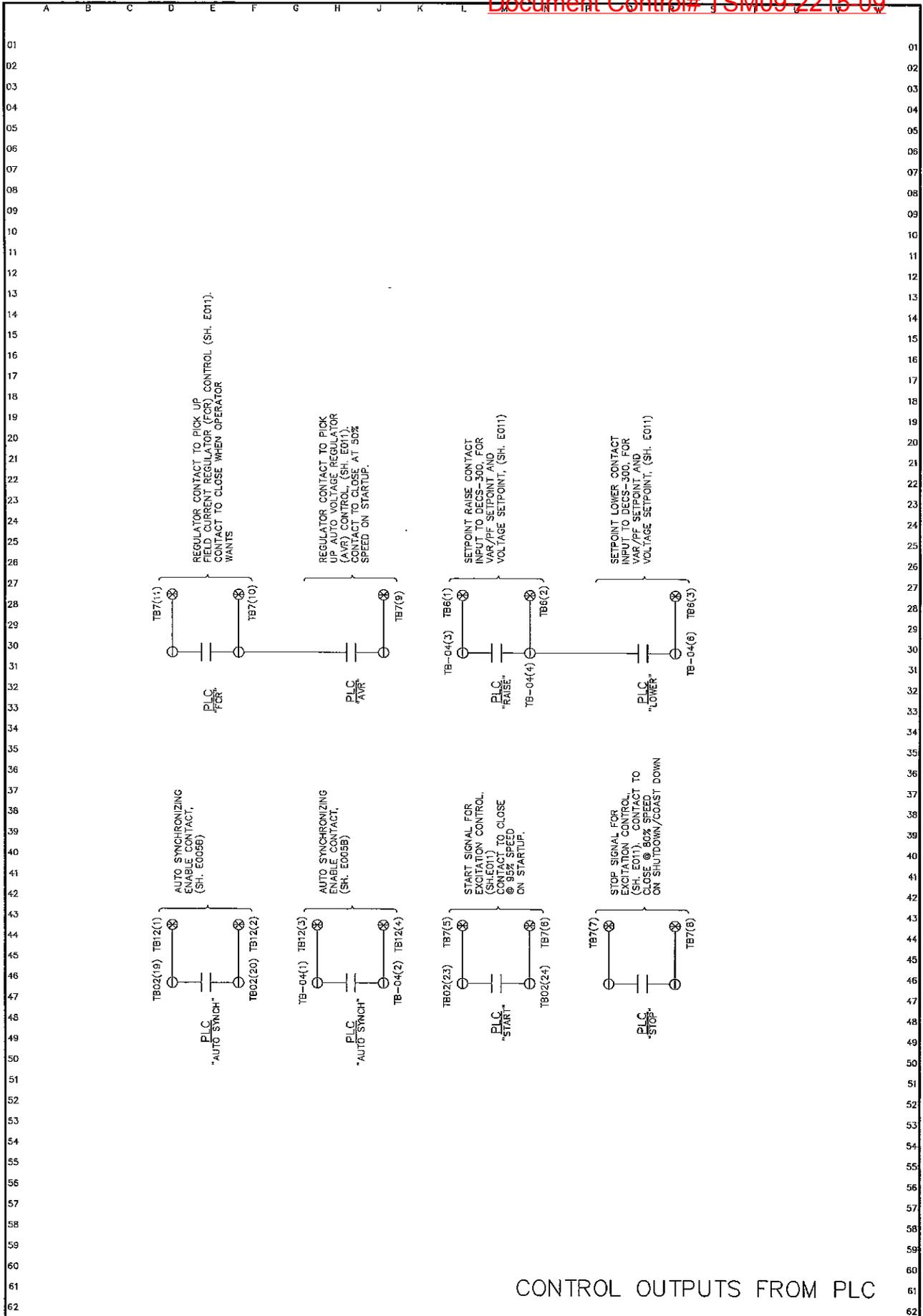




CONTROL OUTPUTS FROM PLC

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP040.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup>PSI</b> E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. E021B SH. NO. E021A



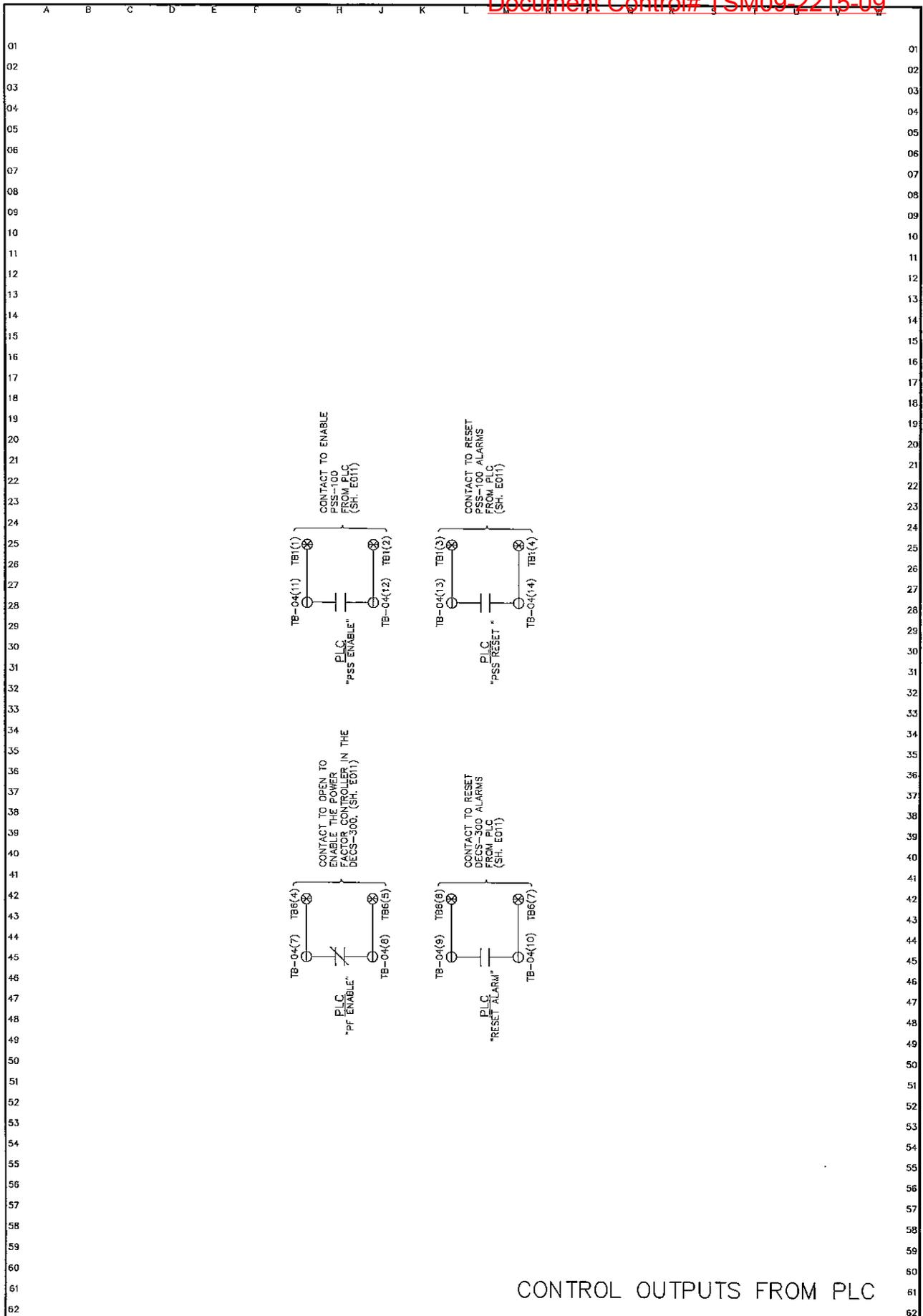
CONTROL OUTPUTS FROM PLC

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	2127T1794
REV. 4	01MCP041.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY M. FARRAR		FELLOWS, CA	CONT. ON SH. E021C SH. NO. E021B



E<sup>2</sup> Power Systems, Inc.



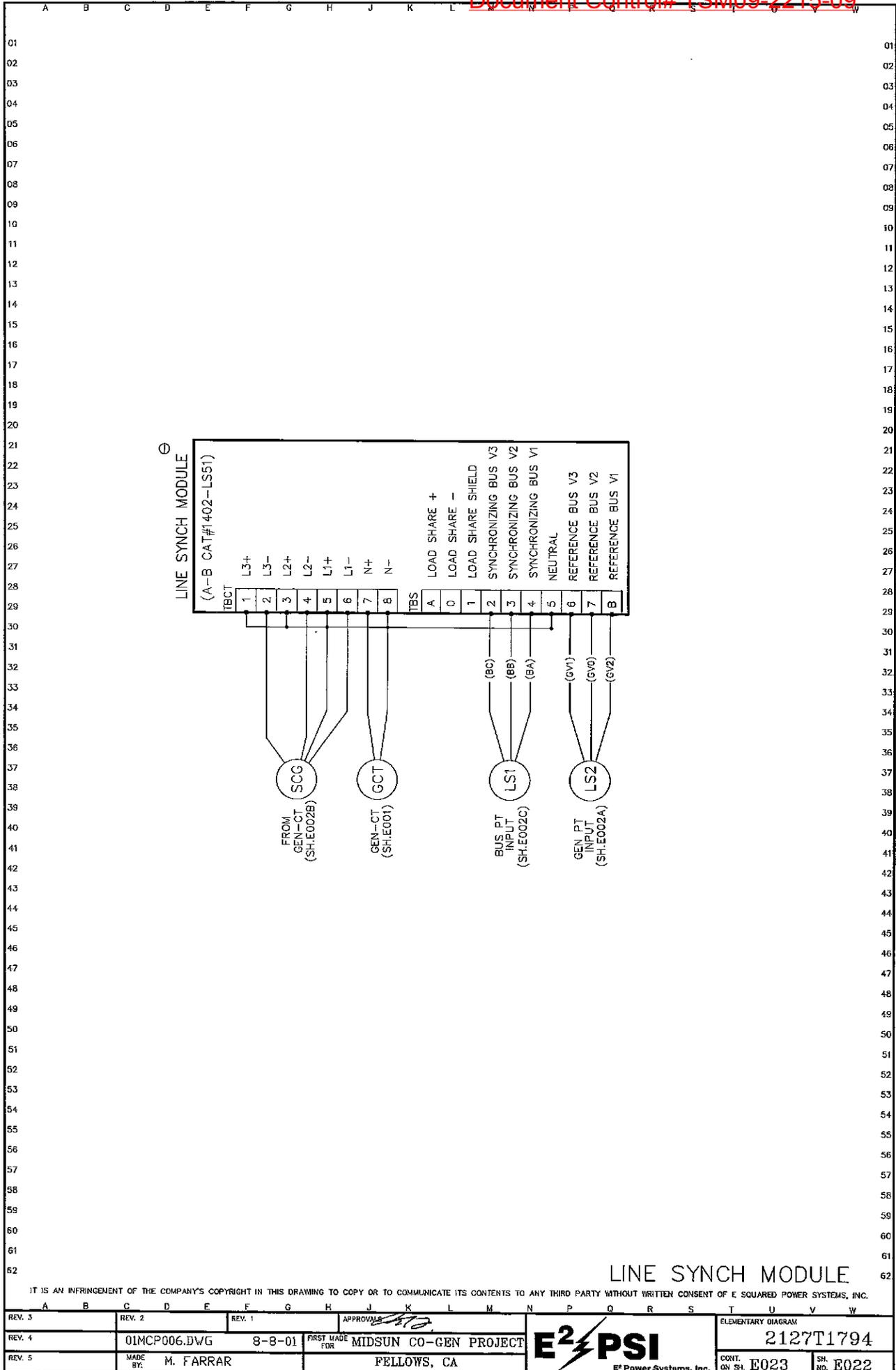
CONTROL OUTPUTS FROM PLC

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	9-05-01	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP042.DWG	8-8-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 3	MADE BY: M. FARRAR			FELLOWS, CA	CONT. ON SH. E022 SH. NO. E021C



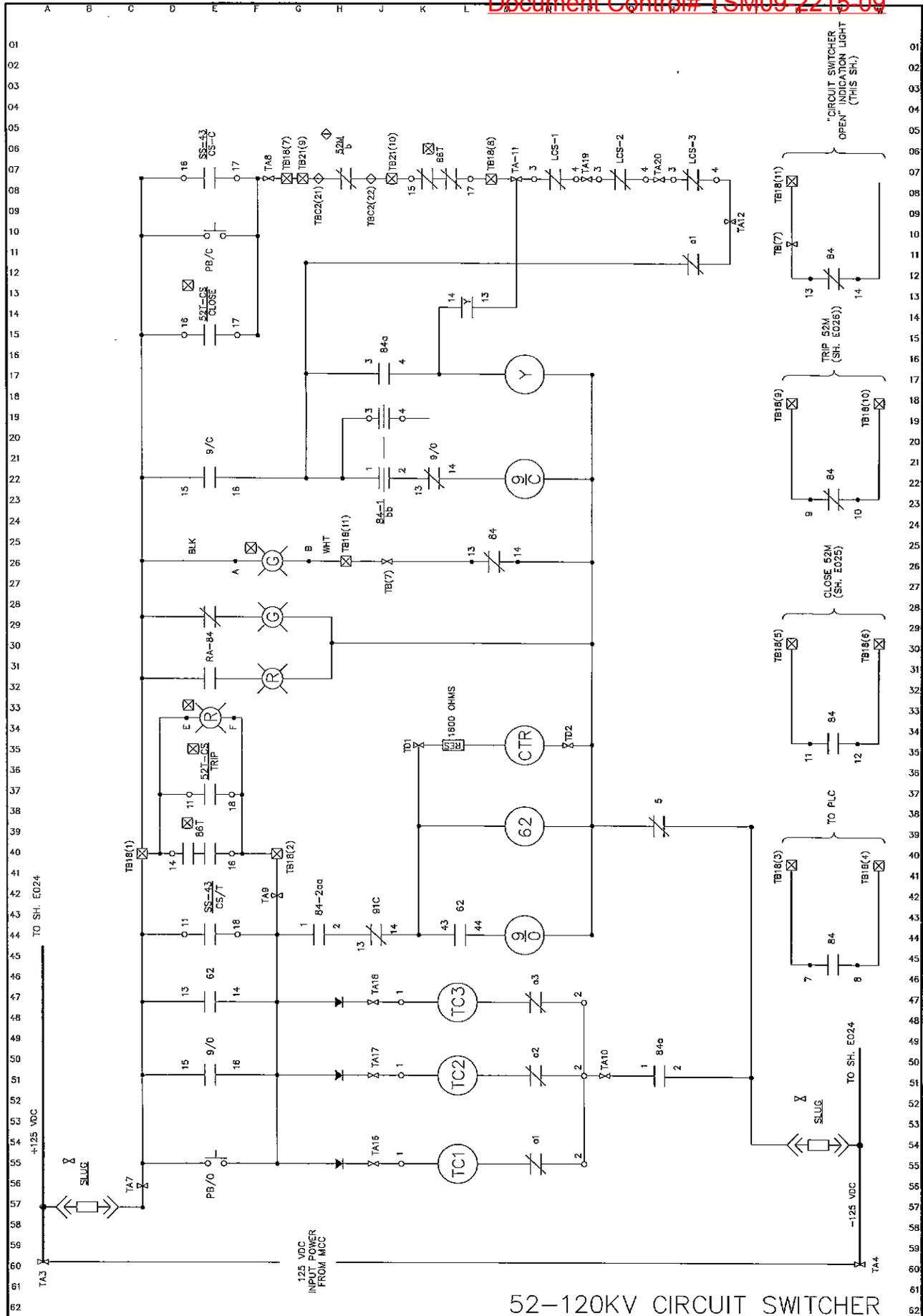
E<sup>2</sup> Power Systems, Inc.



IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVAL	ELMENTARY DIAGRAM
REV. 4	01MCP006.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. E023 SH. NO. E022

**E<sup>2</sup> PSI**  
E<sup>2</sup> Power Systems, Inc.

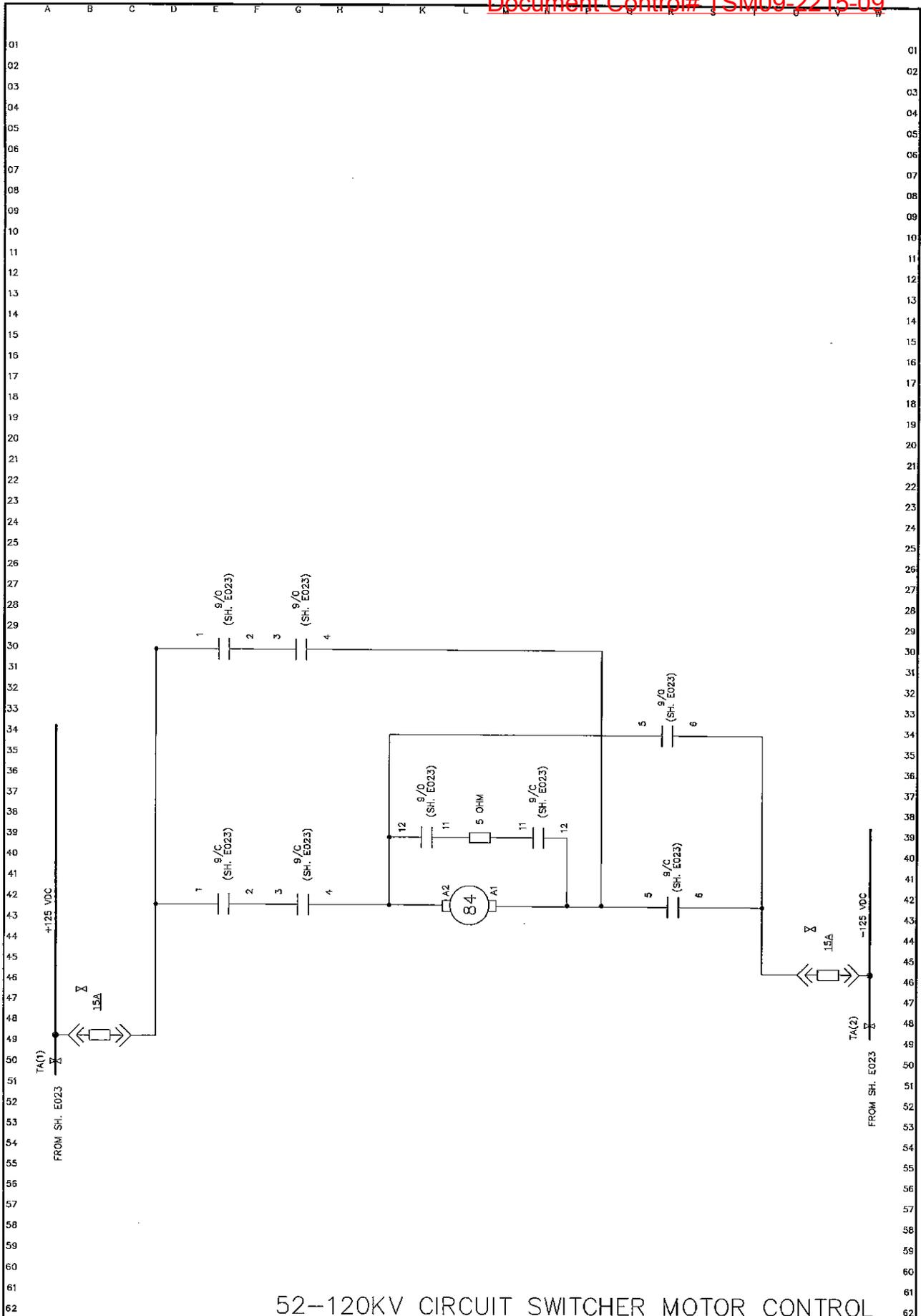


52-120KV CIRCUIT SWITCHER

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP053.DWG	8-23-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. E024 SH. NO. E023



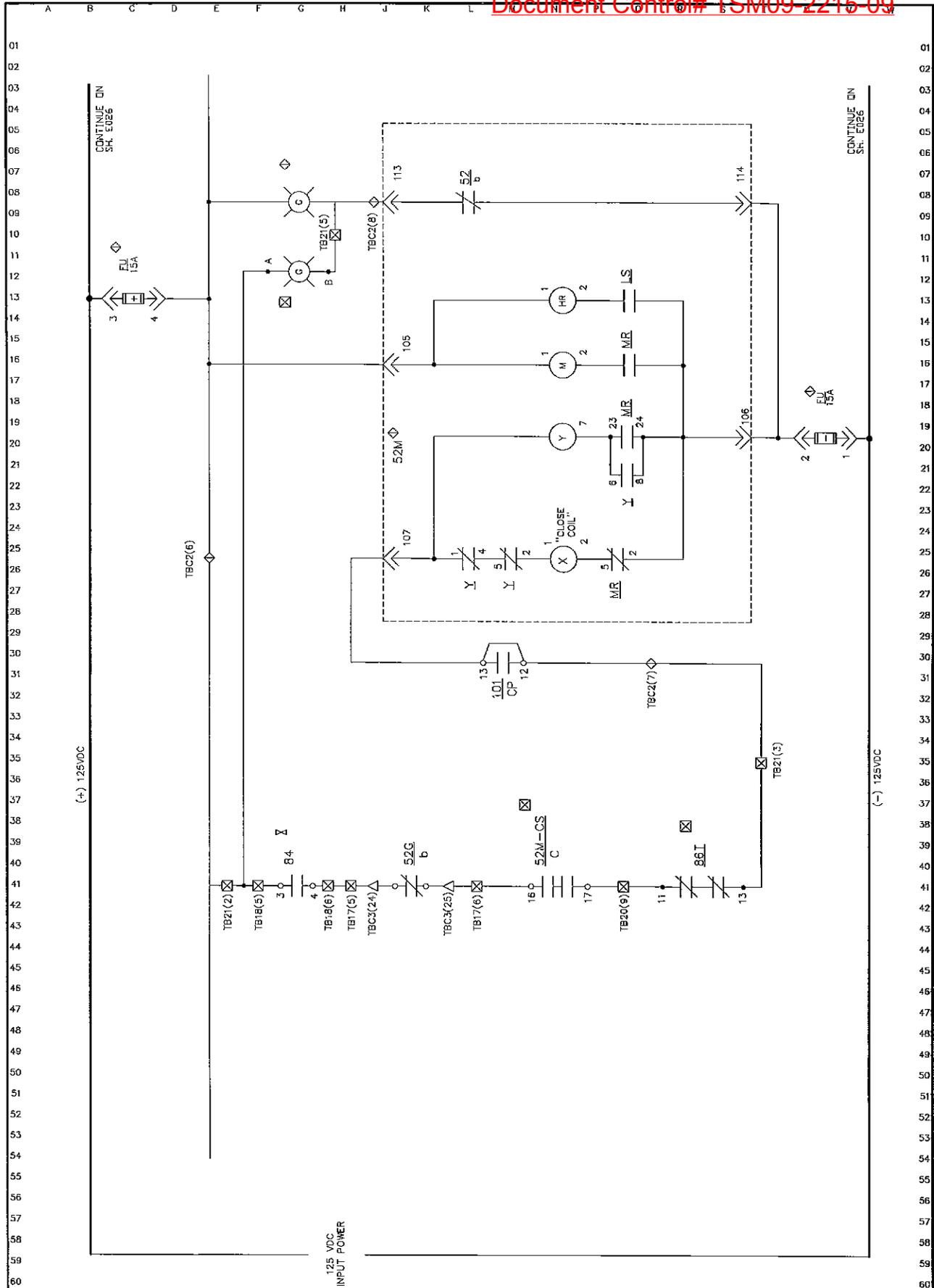


52-120KV CIRCUIT SWITCHER MOTOR CONTROL

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	10-5-01	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP055.DWG	8-23-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA	CONT. OR SH. E025 SH. NO. E024

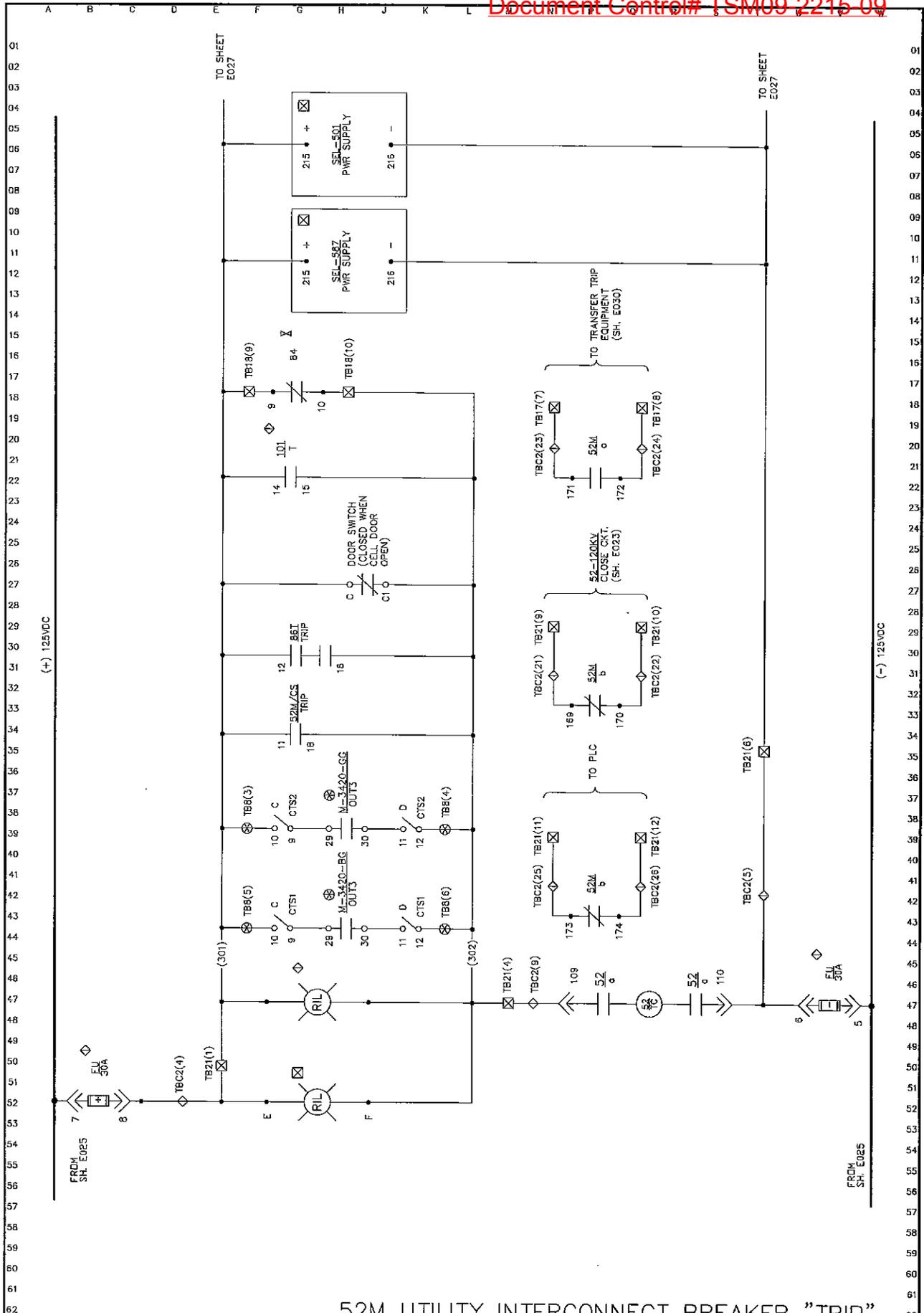




52M UTILITY INTERCONNECT BREAKER "CLOSE"

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	10-5-01	APPROVALS		ELEMENTARY DIAGRAM
REV. 4	01MCP045.DWG	8-8-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	E <sup>2</sup> PSI	2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA	Power Systems, Inc.	CONT. ON SH. E026 SH. NO. E025



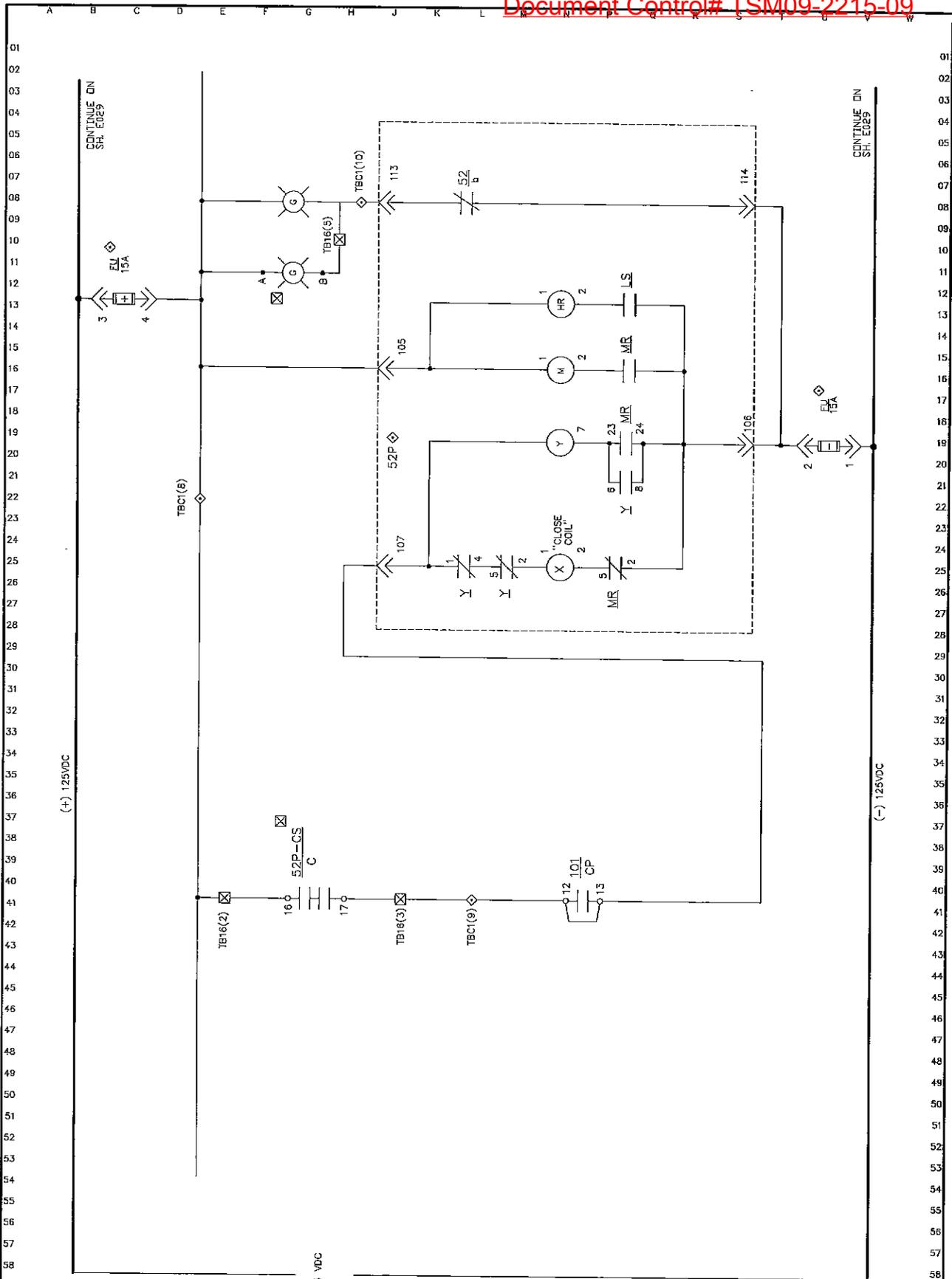
### 52M UTILITY INTERCONNECT BREAKER "TRIP"

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E. SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
	10-5-01	9-05-01	<i>[Signature]</i>	2127T1794
REV. 4	01MCP046.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. SH. E027 SH. NO. E026





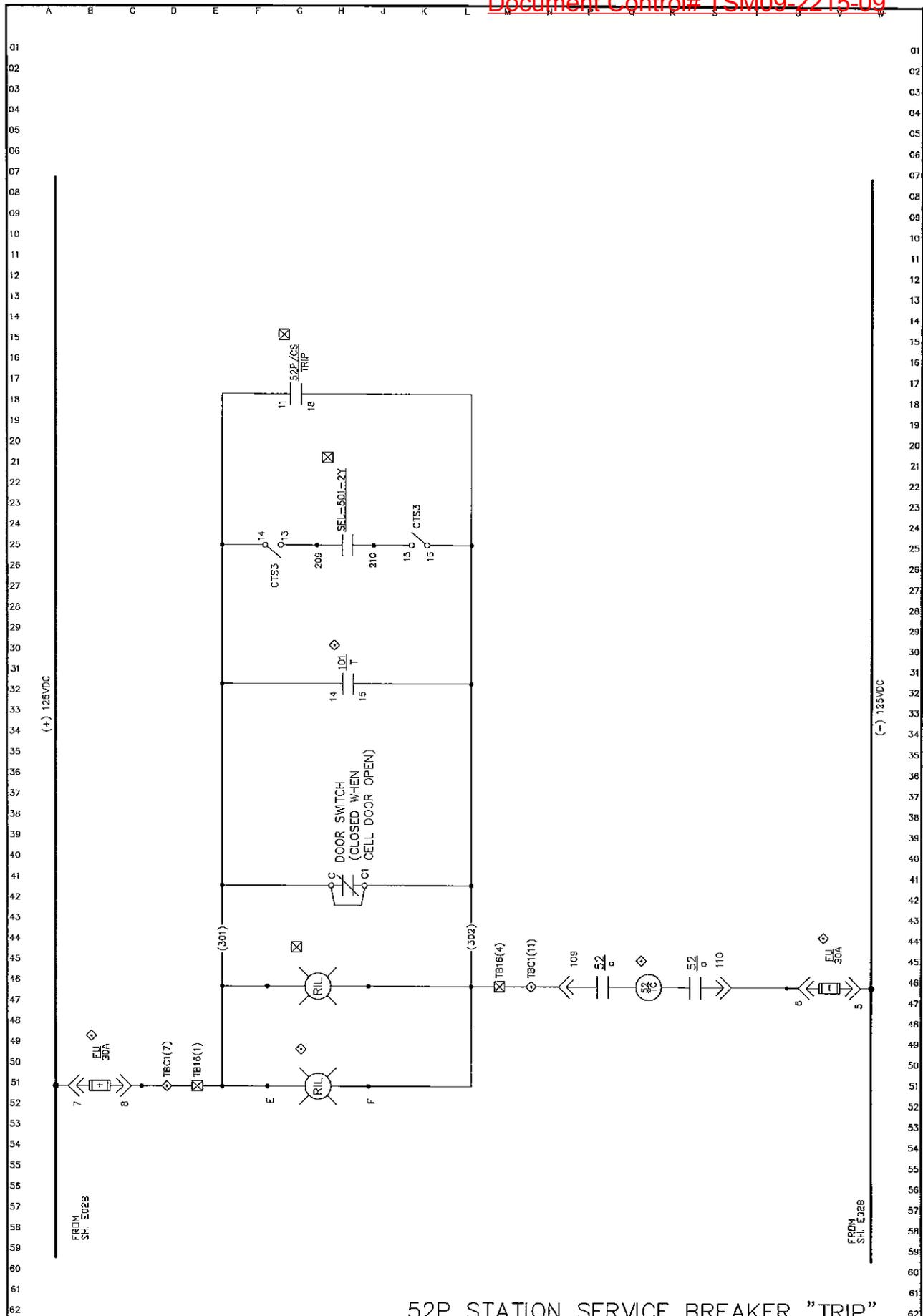


52P STATION SERVICE BREAKER "CLOSE"

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	10-5-01	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP043.DWG	8-8-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA	CONT. ON SH. E029 SH. NO. E028





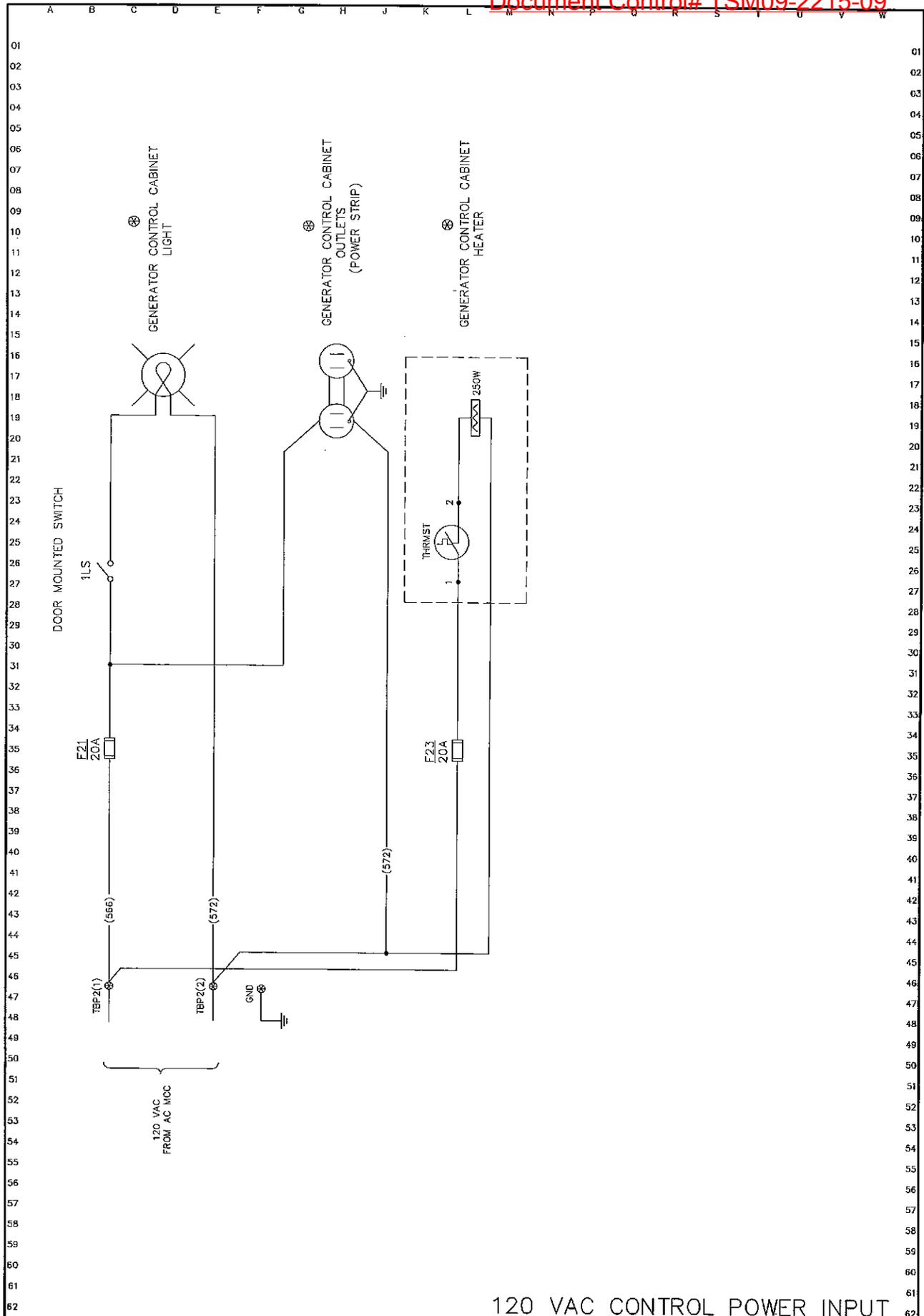
52P STATION SERVICE BREAKER "TRIP"

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	10-5-01	APPROVAL	ELEMENTARY DIAGRAM
REV. 4	01MCP044.DWG	8-8-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR			FELLOWS, CA	CONT. ON SH. E030 SH. NO. E029





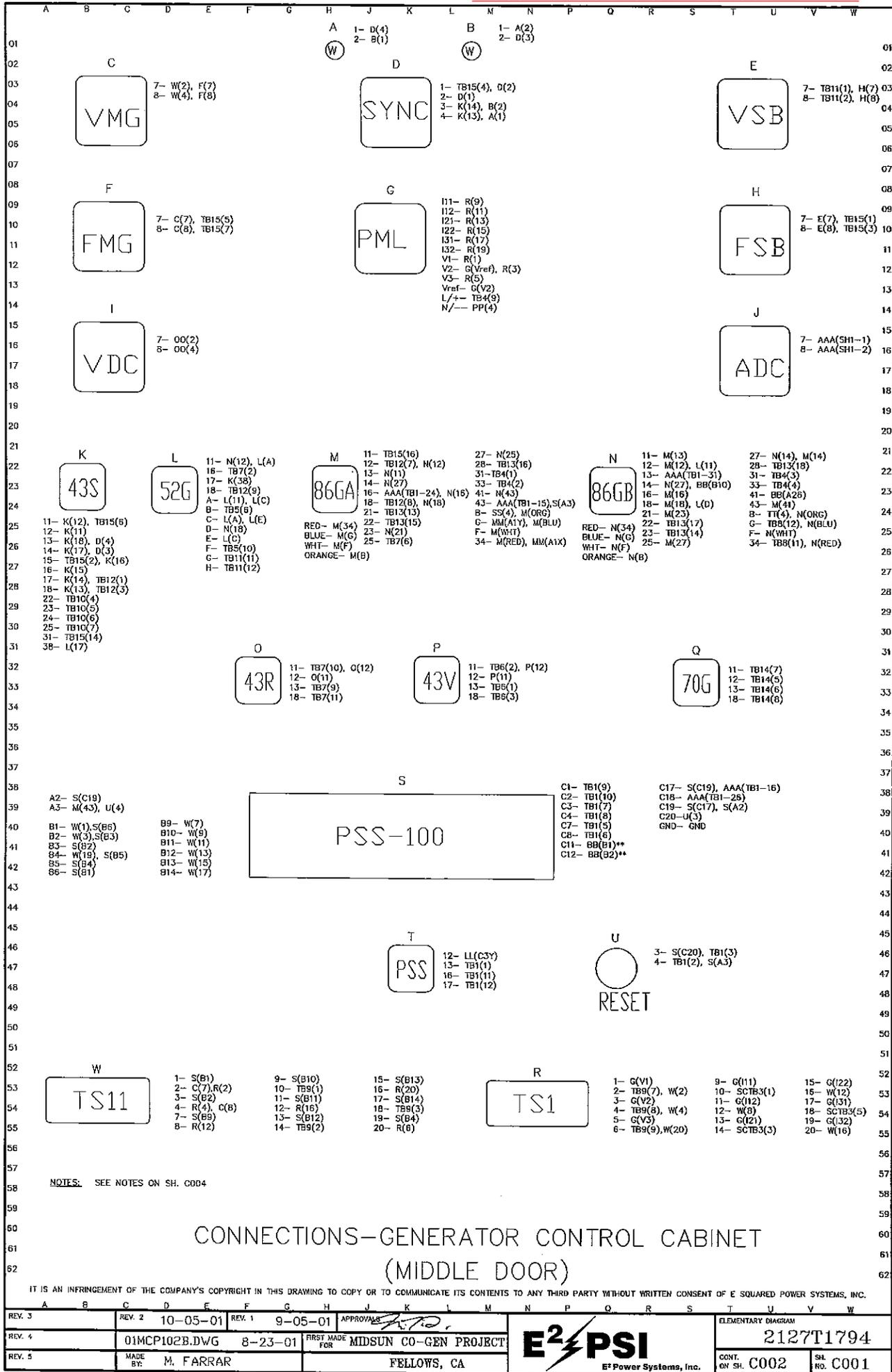


120 VAC CONTROL POWER INPUT

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVALS <i>[Signature]</i>	ELEMENTARY DIAGRAM
REV. 4	01MCP051.DWG	8-8-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. FNL SH. NO. E031





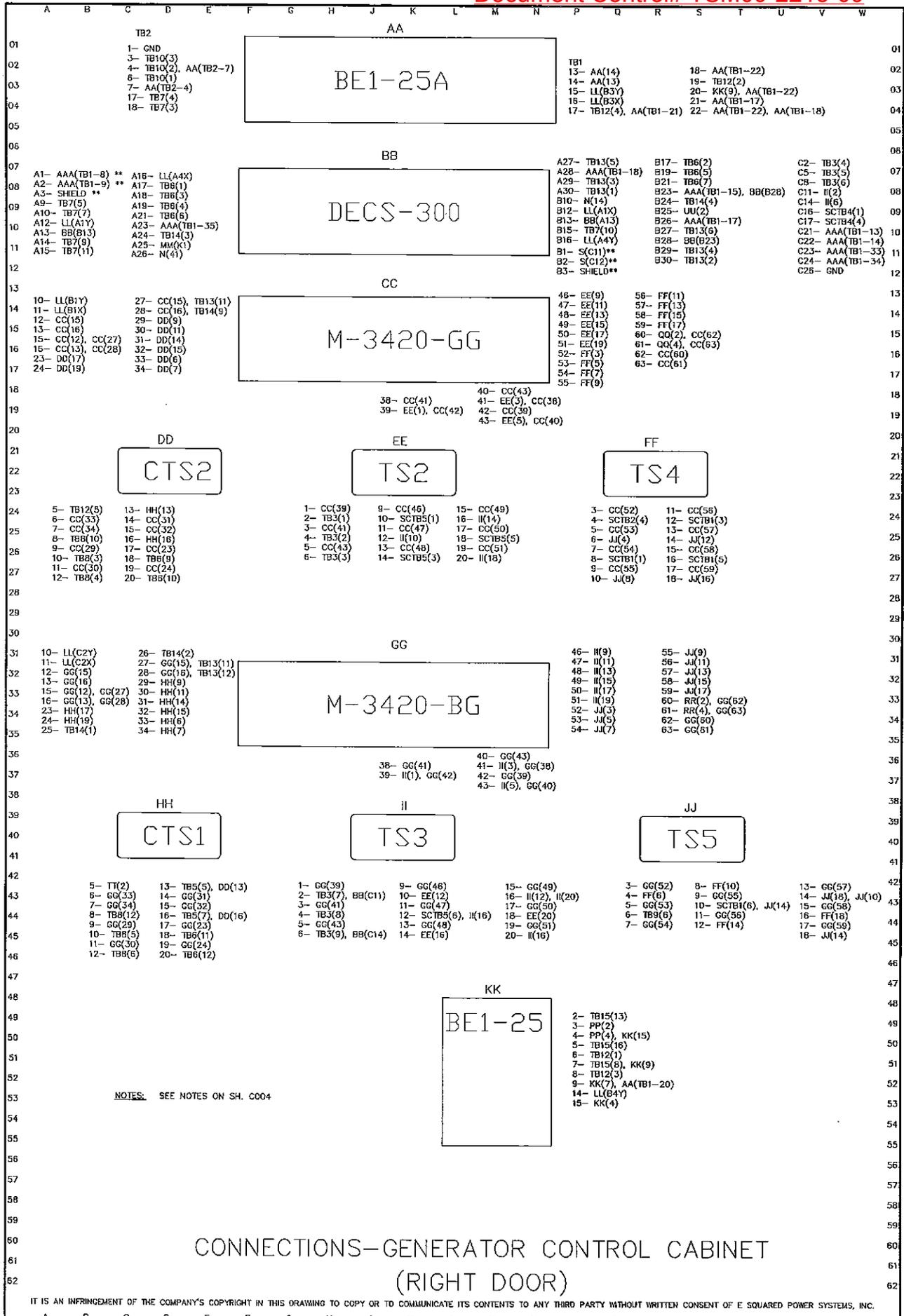
CONNECTIONS-GENERATOR CONTROL CABINET  
(MIDDLE DOOR)

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.

REV. 3	REV. 2	REV. 1	APPROVAL	ELEMENTARY DIAGRAM
	10-05-01	9-05-01	<i>[Signature]</i>	2127T1794
REV. 4	01MCP102B.DWG	8-23-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	CON. ON SH. C002
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	SH. NO. C001

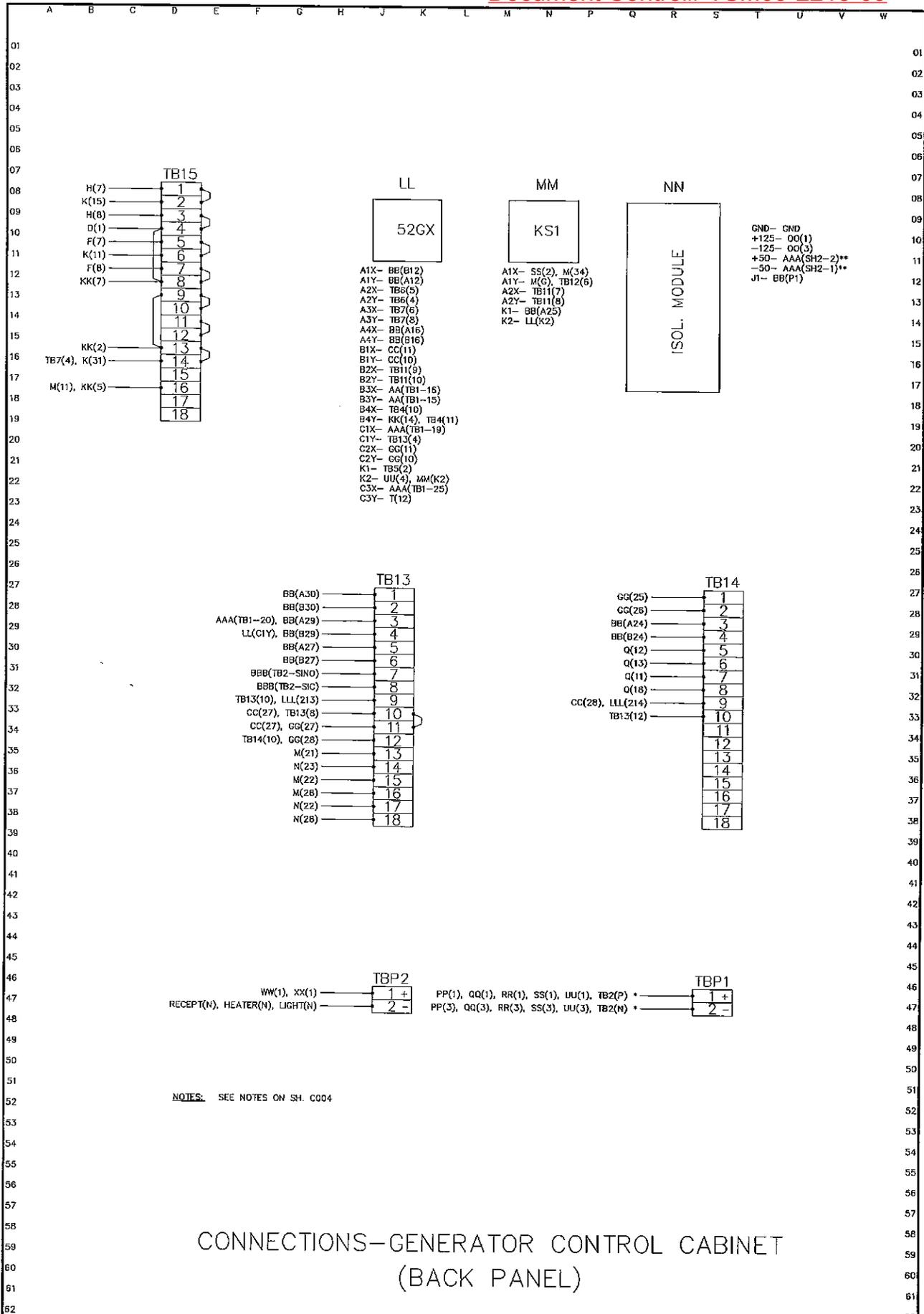


E<sup>2</sup> Power Systems, Inc.



REV. 3	REV. 2	REV. 1	9-05-01	APPROVED	 E Squared Power Systems, Inc.	ELEMENTARY DIAGRAM
REV. 4	01MCP103.DWG	8-23-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT		2127T1794
REV. 5	MADE BY	M. FARRAR		FELLOWS, CA		CONT. ON SH. C003A

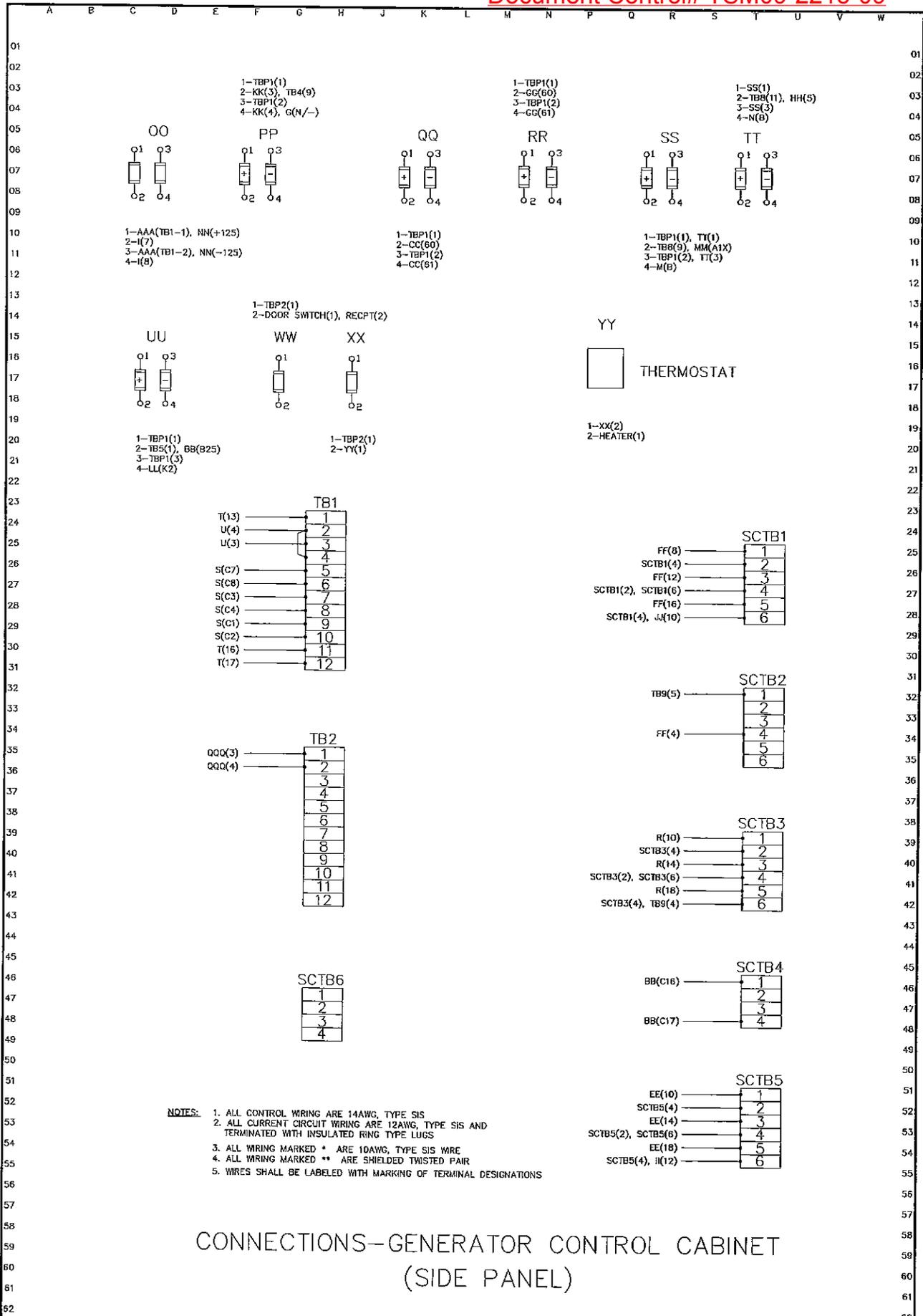




## CONNECTIONS-GENERATOR CONTROL CABINET (BACK PANEL)

IT IS AN INFRINGEMENT OF THE COMPANY'S COPYRIGHT IN THIS DRAWING TO COPY OR TO COMMUNICATE ITS CONTENTS TO ANY THIRD PARTY WITHOUT WRITTEN CONSENT OF E SQUARED POWER SYSTEMS, INC.											
REV. 3	REV. 2	REV. 1	9-05-01	APPROVED							
REV. 4	01MCP106.DWG	8-23-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT			<b>E<sup>2</sup> PSI</b>		ELEMENTARY DIAGRAM <b>2127T1794</b>		
REV. 5	MADE BY:	M. FARRAR		FELLOWS, CA			<b>E<sup>2</sup> PSI</b> E <sup>2</sup> Power Systems, Inc.		CONT. ON SH. C003C	SH. NO. C003B	

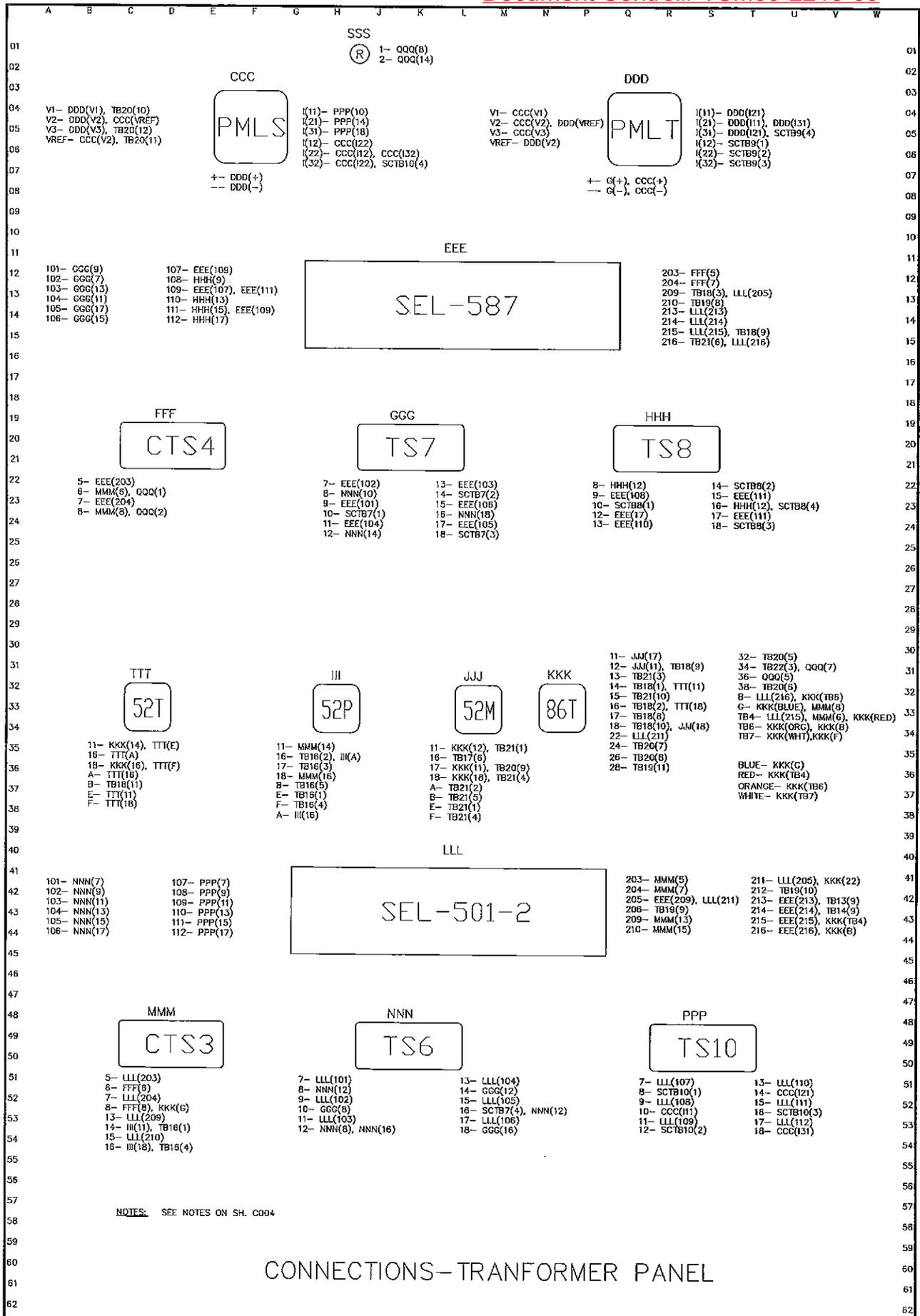




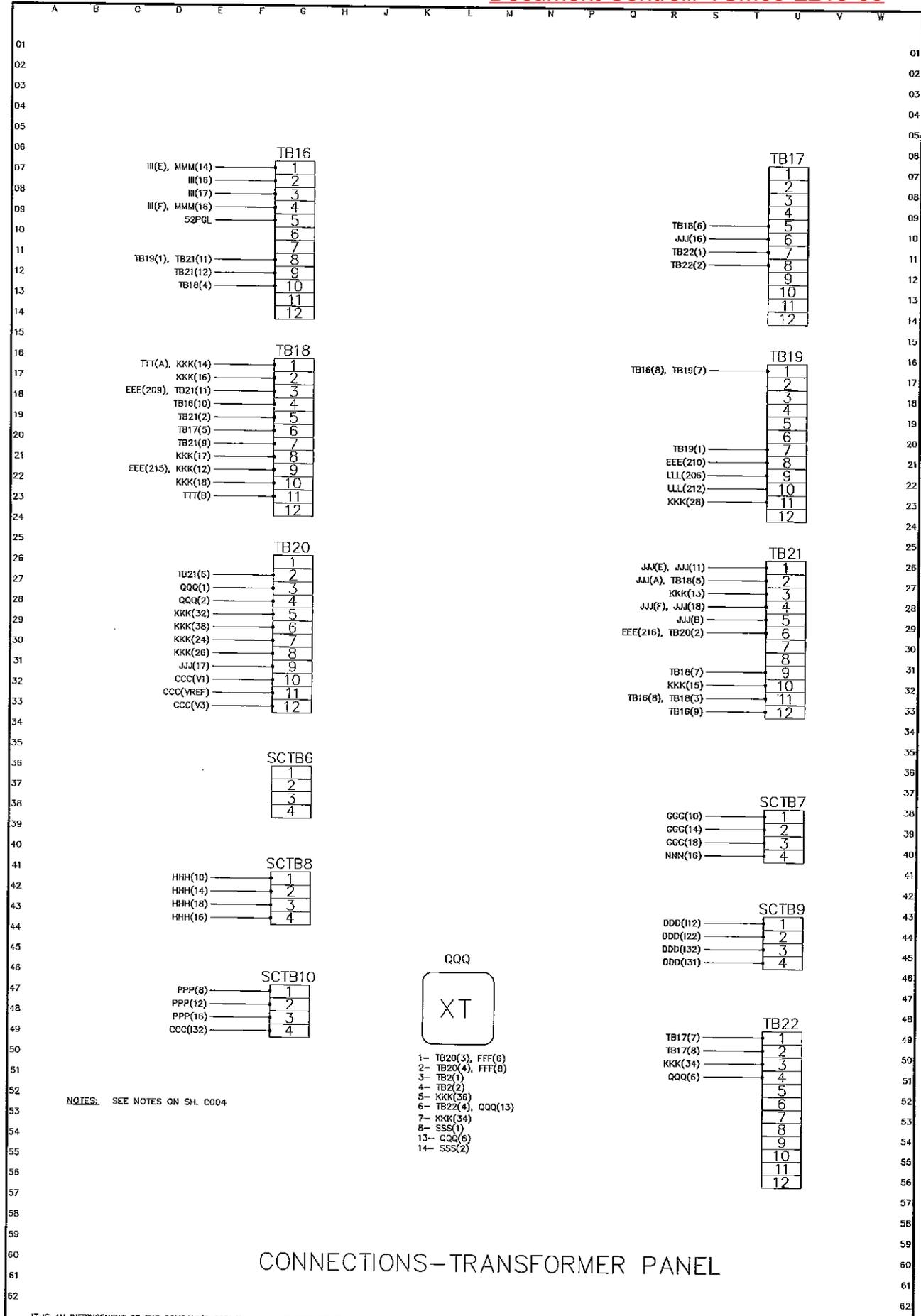
- NOTES:**
1. ALL CONTROL WIRING ARE 14AWG, TYPE SIS
  2. ALL CURRENT CIRCUIT WIRING ARE 12AWG, TYPE SIS AND TERMINATED WITH INSULATED RING TYPE LUGS
  3. ALL WIRING MARKED \* ARE 10AWG, TYPE SIS WIRE
  4. ALL WIRING MARKED \*\* ARE SHIELDED TWISTED PAIR
  5. WIRES SHALL BE LABELED WITH MARKING OF TERMINAL DESIGNATIONS

## CONNECTIONS-GENERATOR CONTROL CABINET (SIDE PANEL)

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REV. 3	REV. 2	REV. 1	APPROVALS								
REV. 4	01MCP105.DWG	8-23-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT							
REV. 5	MADE BY:	M. FARRAR	FELLOWS, CA	<b>E<sup>2</sup> PSI</b> E <sup>2</sup> Power Systems, Inc.				ELEMENTARY DIAGRAM 2127T1794		CONT. ON SH. C005 SIL. NO. C004	



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REV. 3	REV. 2	REV. 1	10-5-01	APPROVALS	ELEMENTARY DIAGRAM						
REV. 4	01MCP109.DWG	8-22-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794						
REV. 5	MADE BY	R. GLENN	FELLOWS, CA		E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.				CONT. ON SH. C005A	SH. NO. C005	

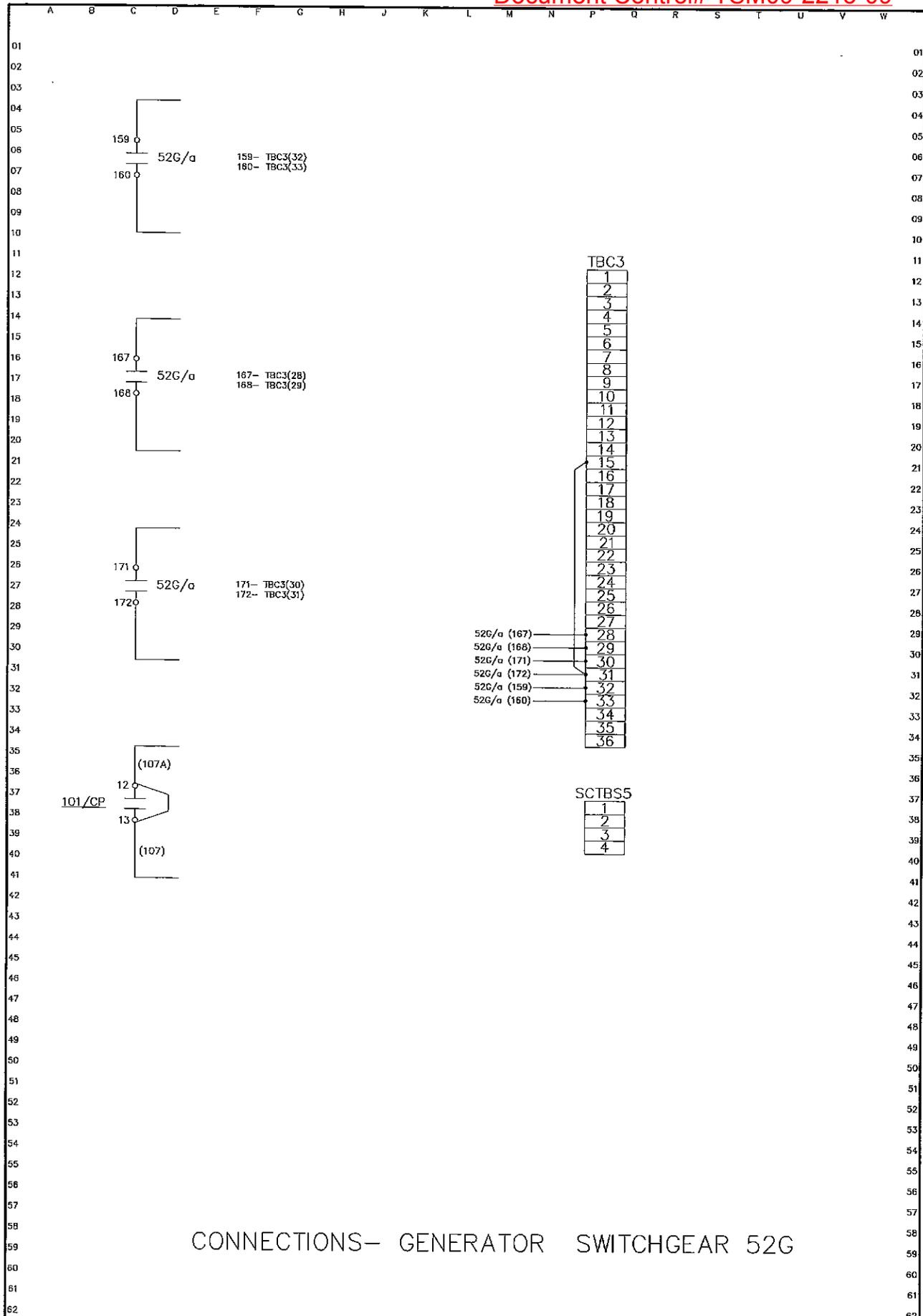


CONNECTIONS-TRANSFORMER PANEL

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REV. 3	REV. 2	REV. 1	10-5-01	APPROVALS																
REV. 4	01MCP111.DWG	8-22-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	<b>E<sup>2</sup> PSI</b>		ELEMENTARY DIAGRAM		2127T1794		CONF. ON SH. C006		SH. NO. C005A							
REV. 5	MADE BY: R. GLENN	FELLOWS, CA		<b>E<sup>2</sup> PSI</b>		E <sup>2</sup> Power Systems, Inc.														

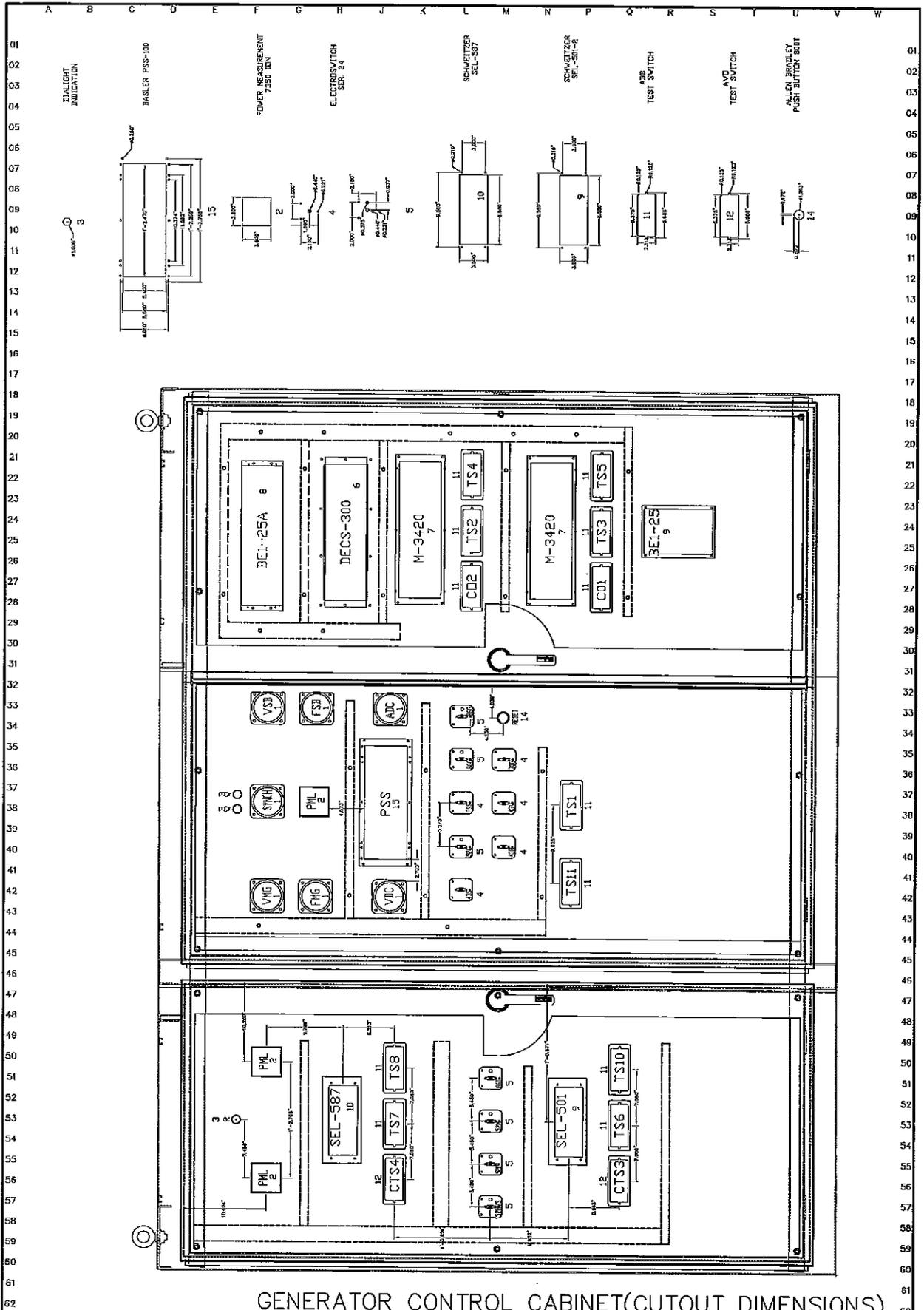




CONNECTIONS- GENERATOR SWITCHGEAR 52G

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REV. 3	REV. 2	REV. 1	10-5-01	APPROVALS	 E² Power Systems, Inc.	ELEMENTARY DIAGRAM	2127T1794
REV. 4	01MCP113.DWG	8-28-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT		CONT. ON SH. CP01	SH. NO. C007
REV. 5	MADE BY:	M. FARRAR	FELLOWS, CA				



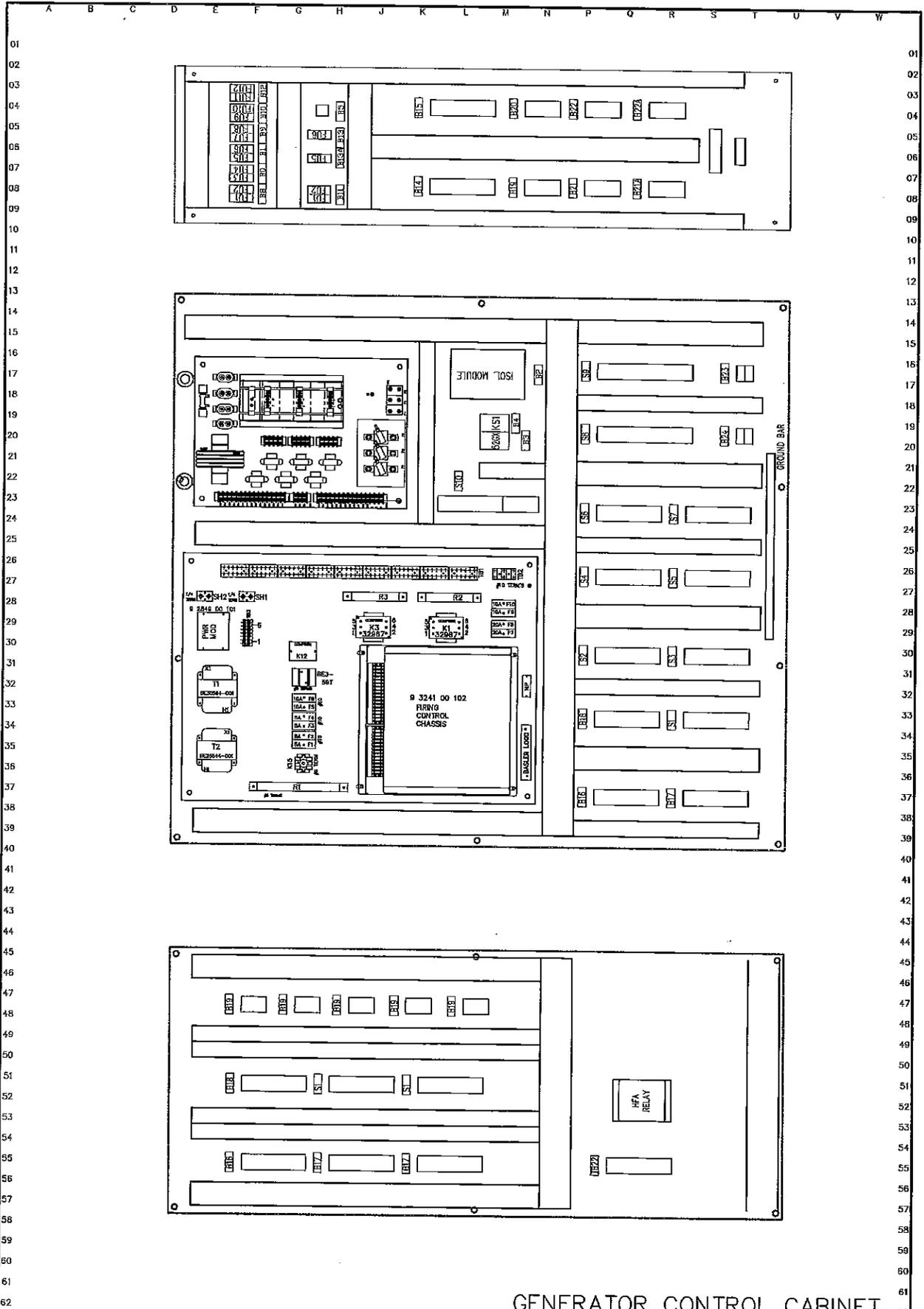
GENERATOR CONTROL CABINET(CUTOUT DIMENSIONS)

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REV. 3	REV. 2	REV. 1	APPROVAL	ELEMENTARY DIAGRAM
REV. 4	01MCP412.DWG	8-22-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: D. KAUFMAN		FELLOWS, CA	CONT. ON SH. CP02 SH. NO. CP01



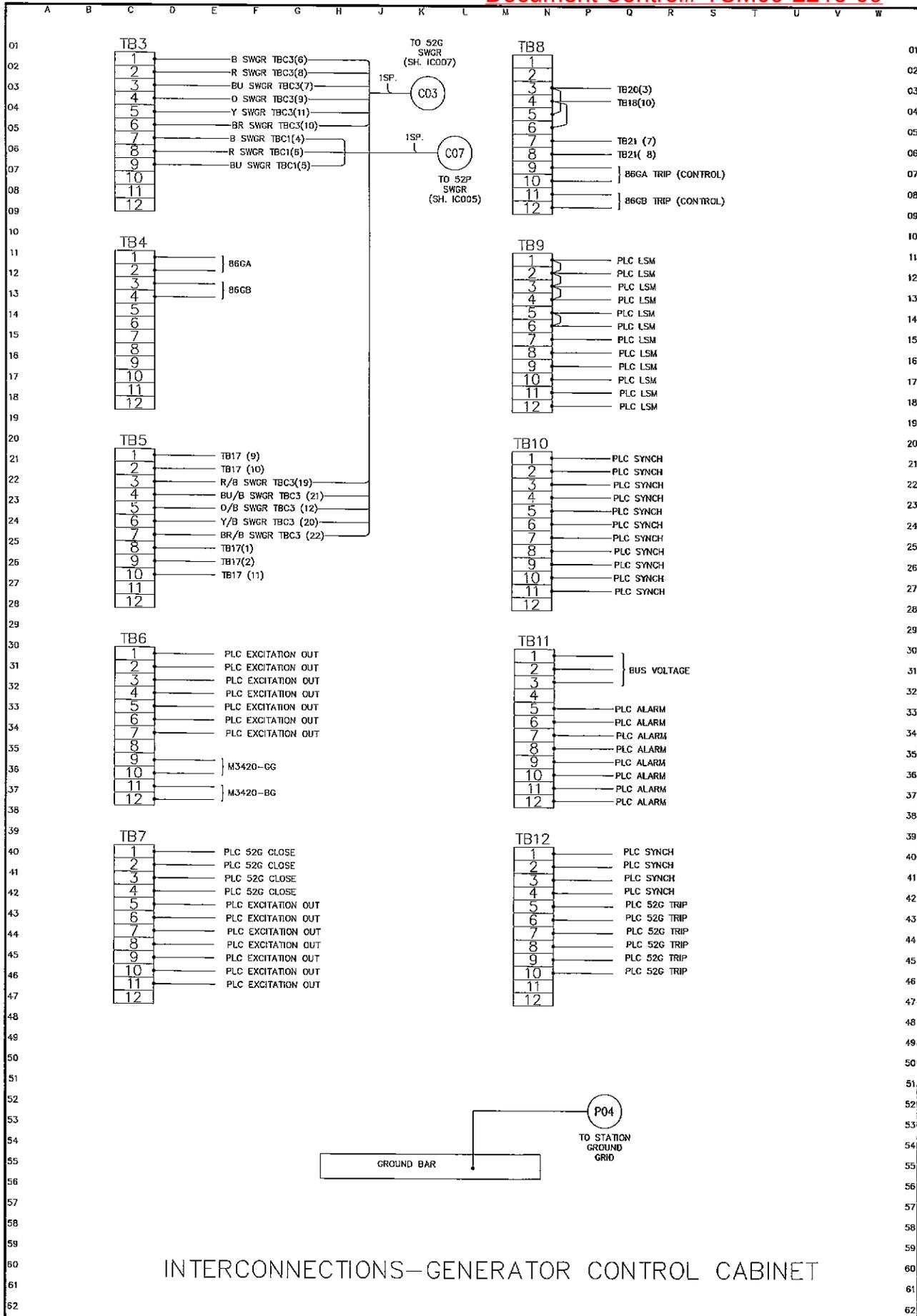
E<sup>2</sup> Power Systems, Inc.



GENERATOR CONTROL CABINET

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REV. 3	REV. 2	REV. 1	APPROVAL	ELEMENTARY DIAGRAM	
REV. 4	01MCP110.DWG	8-22-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: R. GLENN		FELLOWS, CA	E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. IC001 SH. NO. CP02



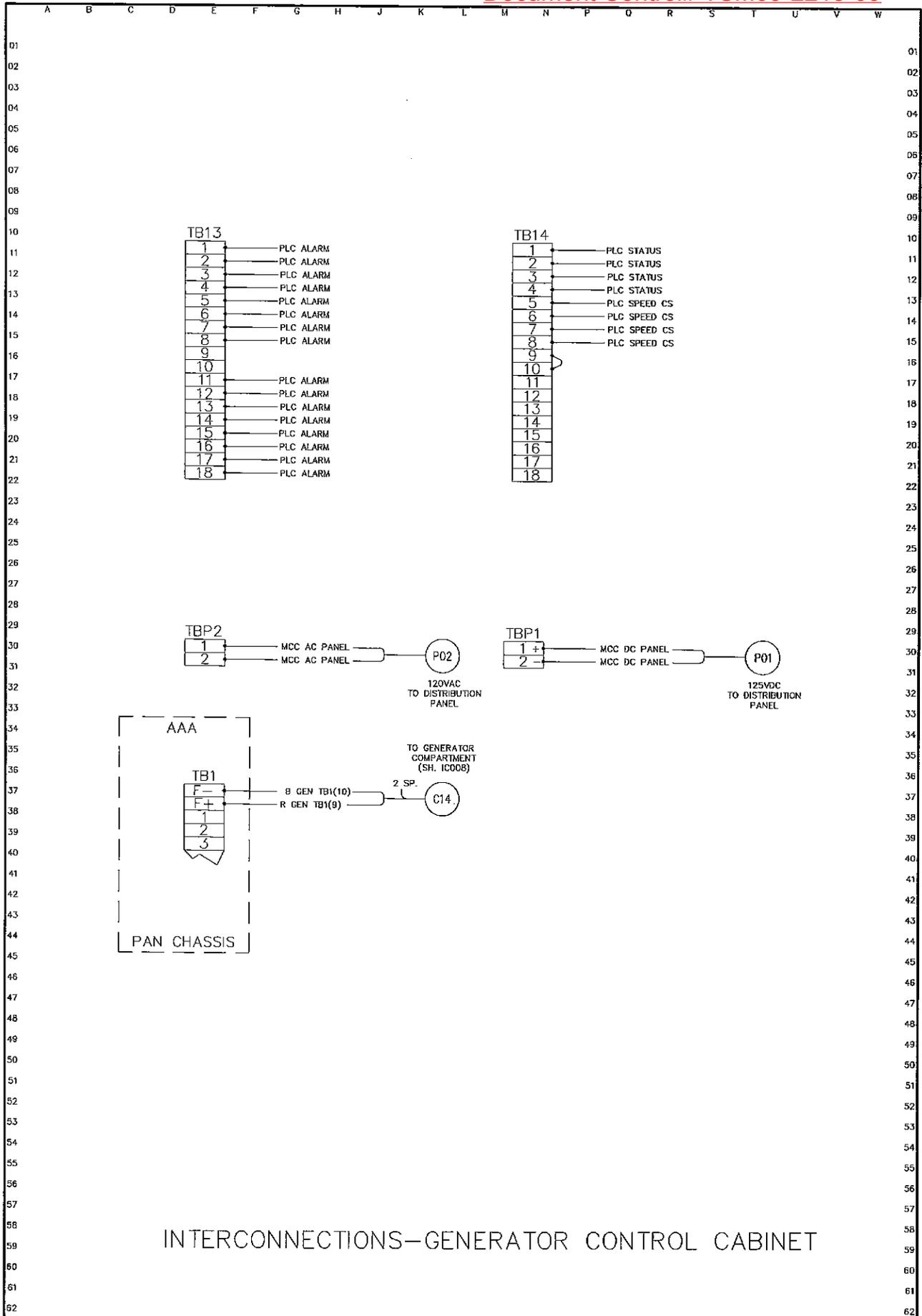
# INTERCONNECTIONS-GENERATOR CONTROL CABINET

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP200.DWG	8-28-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. OR SH. IC002 SH. NO. IC001



E<sup>2</sup> Power Systems, Inc.



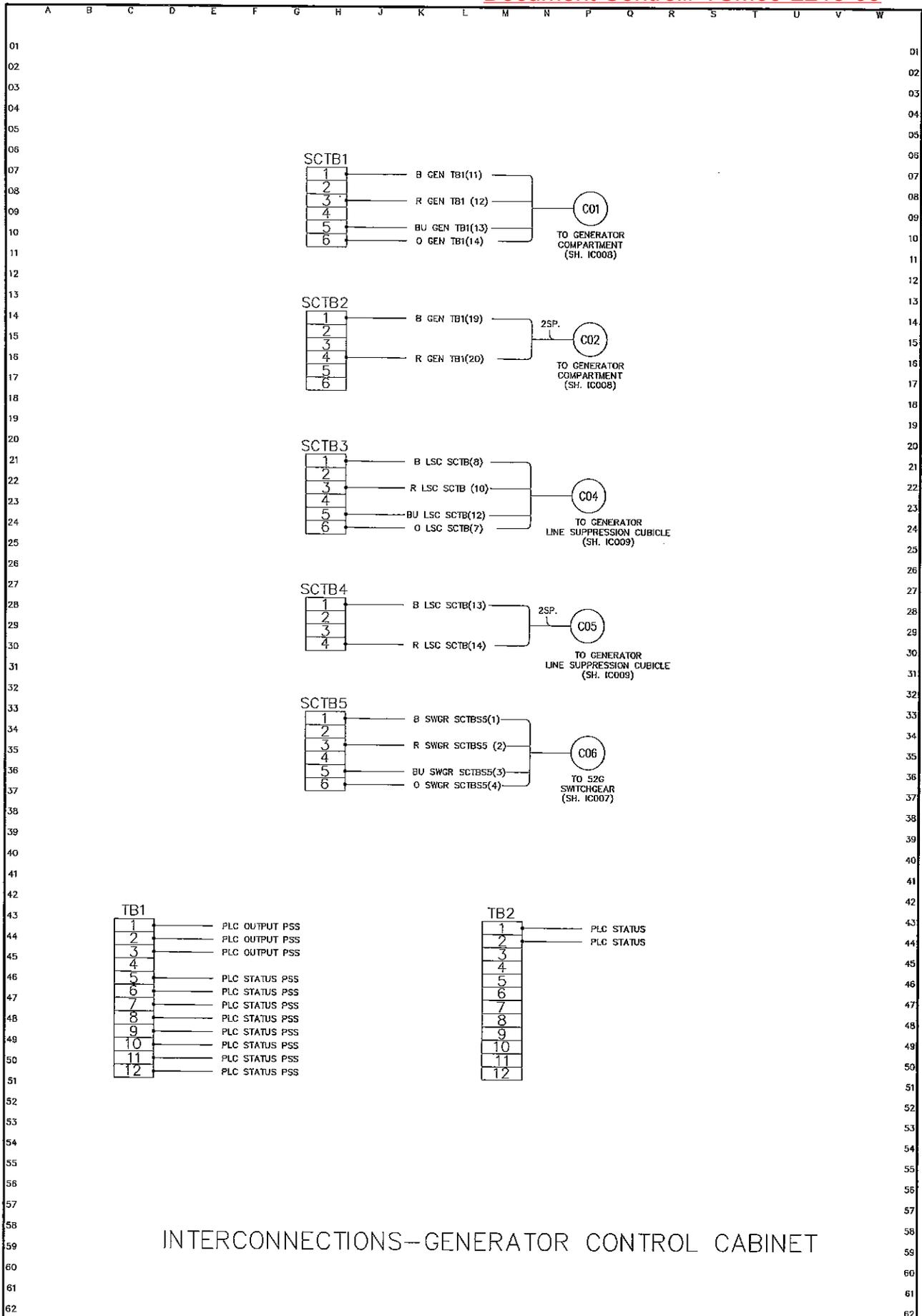
INTERCONNECTIONS-GENERATOR CONTROL CABINET

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REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP401.DWG	8-28-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	CONT. ON SH. IC003 SH. NO. IC002



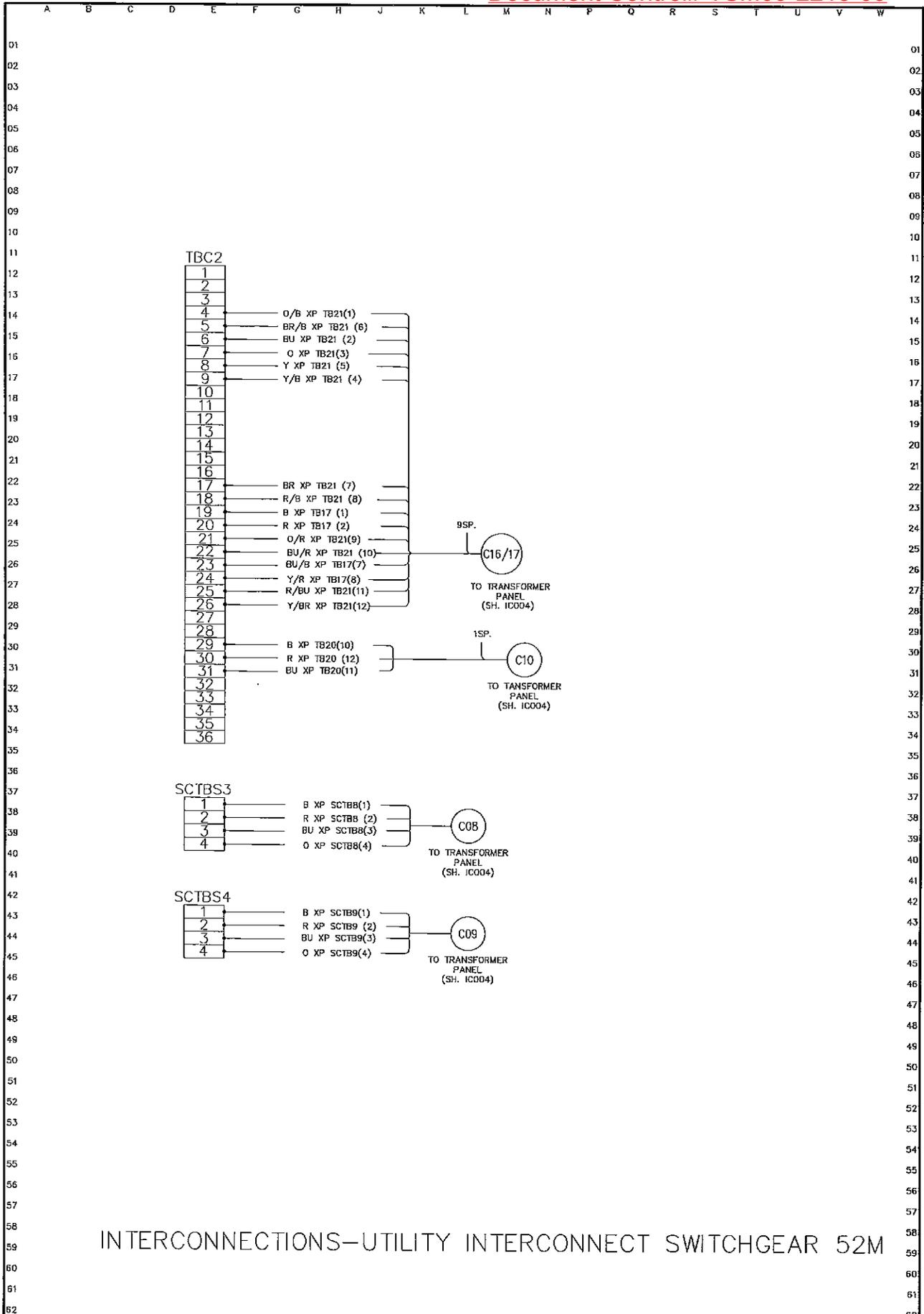
E<sup>2</sup> Power Systems, Inc.



INTERCONNECTIONS--GENERATOR CONTROL CABINET



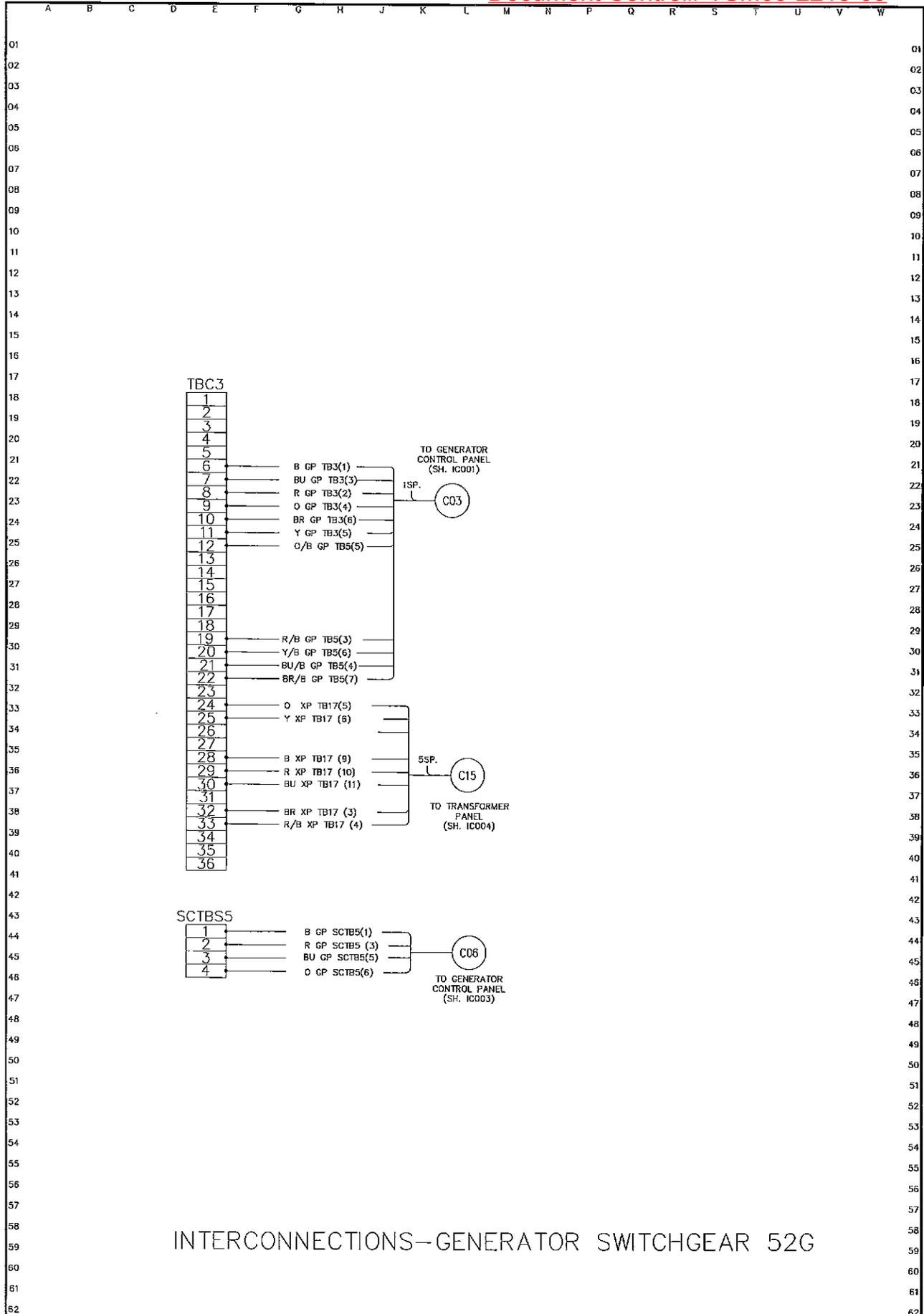




INTERCONNECTIONS—UTILITY INTERCONNECT SWITCHGEAR 52M

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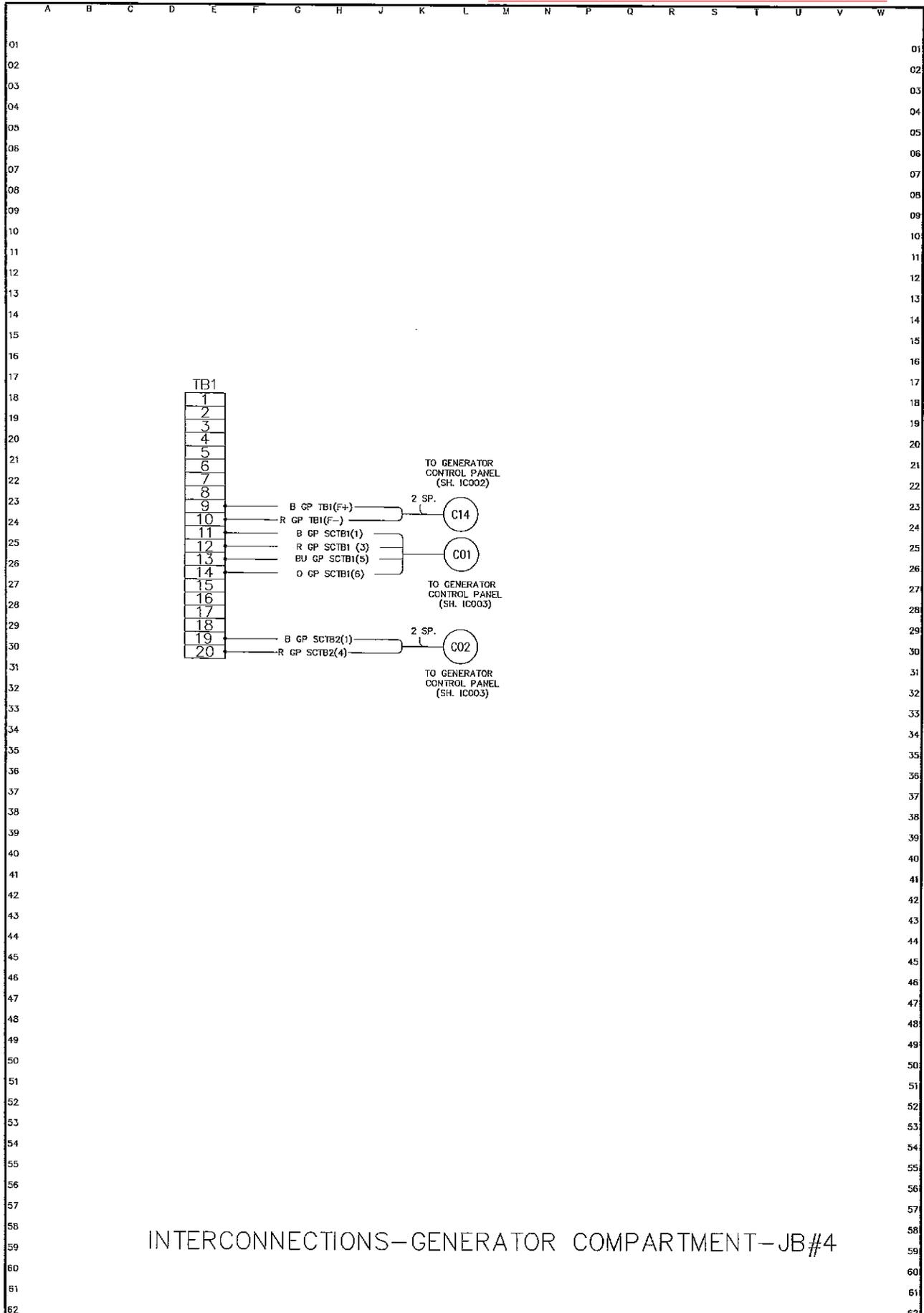
REV. 3	REV. 2	REV. 1	10-5-01	APPROVED	ELEMENTARY DIAGRAM
REV. 4	01MCP405.DWG	8-28-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY:	M. FARRAR	FELLOWS, CA		E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.
					CONT. ON SH. IC007 SH. NO. IC006



INTERCONNECTIONS-GENERATOR SWITCHGEAR 52G

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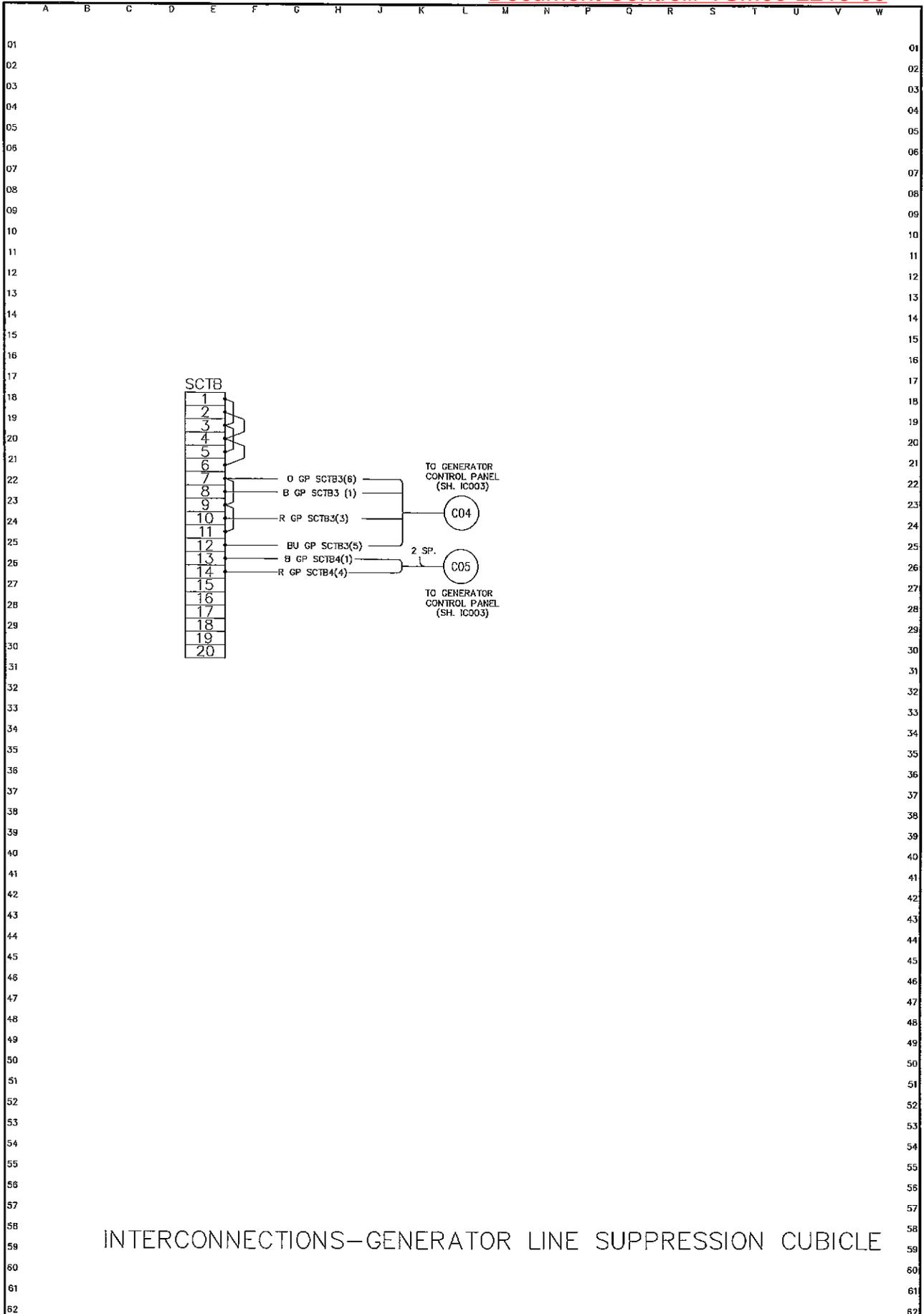
REV. 3	REV. 2	REV. 1	10-5-01	APPROVES	 E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.	ELEMENTARY DIAGRAM	
REV. 4	01MCP406.DWG	8-28-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT		2127T1794	
REV. 5	MADE BY:	M. FARRAR	FELLOWS, CA			CONL ON SH. IC008	SH NO. IC007



INTERCONNECTIONS-GENERATOR COMPARTMENT-JB#4

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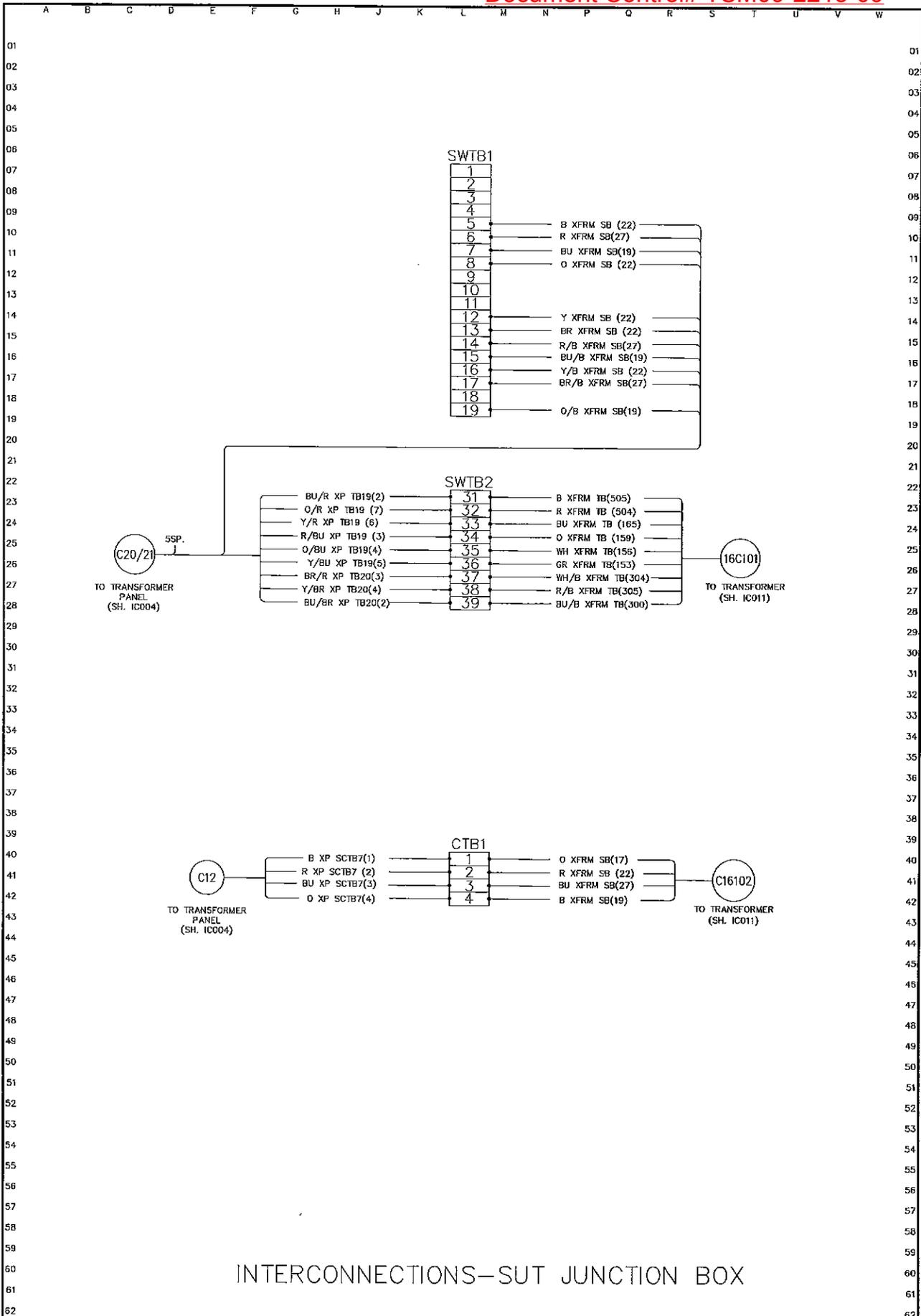
REV. 3	REV. 2	REV. 1	10-5-01	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP407.DWG	8-28-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR		FELLOWS, CA	E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. IC009 SH. NO. IC008



INTERCONNECTIONS-GENERATOR LINE SUPPRESSION CUBICLE

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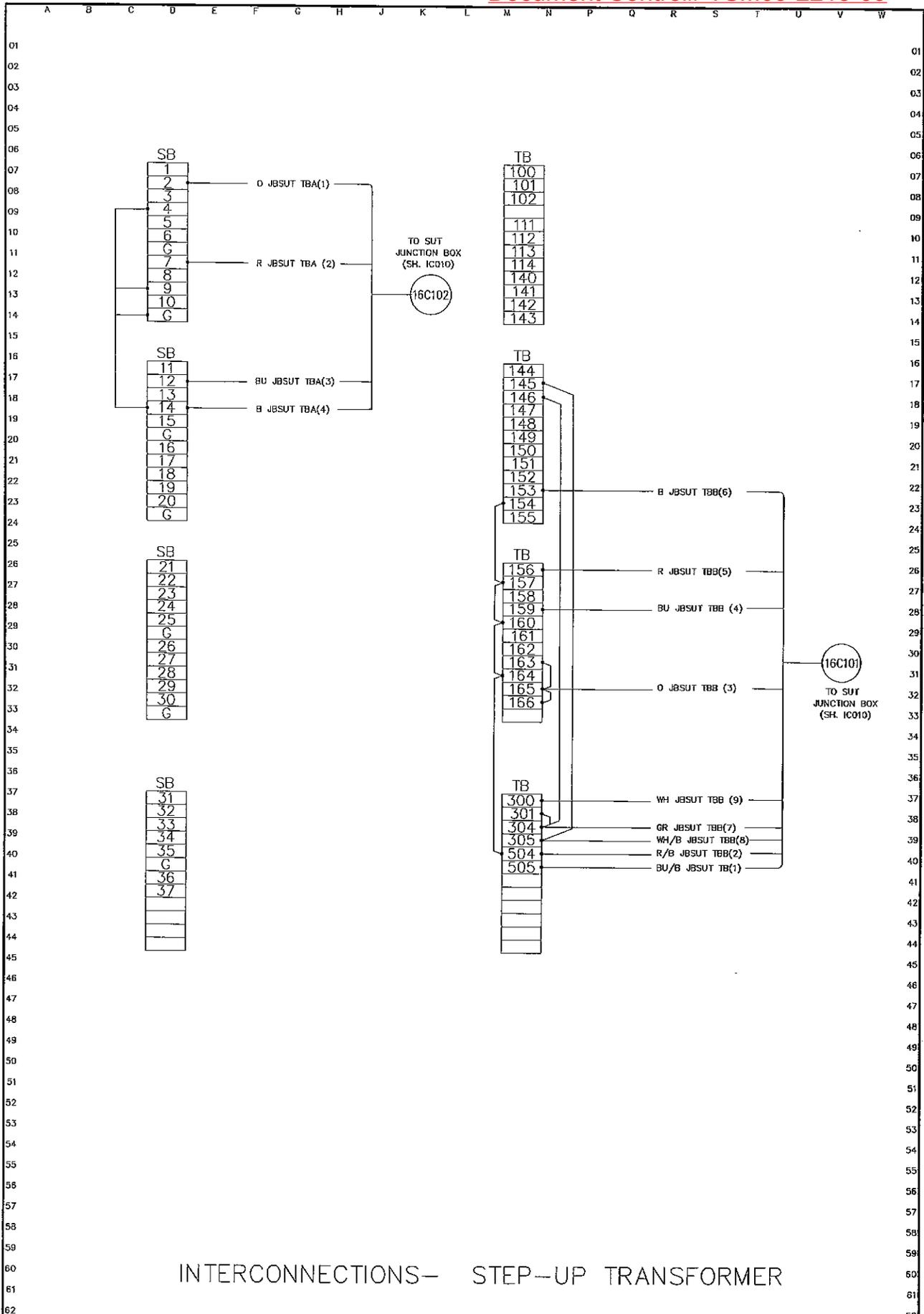
REV. 3	REV. 2	REV. 1	APPROVALS	ELEMENTARY DIAGRAM
REV. 4	01MCP408.DWG	8-28-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: M. FARRAR	FELLOWS, CA	E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. IC010 SH. NO. IC009



INTERCONNECTIONS-SUT JUNCTION BOX

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REV. 3	REV. 2	REV. 1	10-5-01	APPROVALS	 E <sup>2</sup> Power Systems, Inc.	ELEMENTARY DIAGRAM	2127T1794
REV. 4	01MCP409.DWG	8-28-01	FIRST MADE FOR	MIDSUN CO-GEN PROJECT		CONT. ON SH. IC011	SH. NO. IC010
REV. 5	MADE BY: R. GLENN			FELLOWS, CA			



INTERCONNECTIONS- STEP-UP TRANSFORMER

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REV. 3	REV. 2	REV. 1	APPROVED	ELEMENTARY DIAGRAM
REV. 4	01MCP410.DWG	8-28-01	FIRST MADE FOR MIDSUN CO-GEN PROJECT	2127T1794
REV. 5	MADE BY: R. GLENN	FELLOWS, CA	E <sup>2</sup> PSI E <sup>2</sup> Power Systems, Inc.	CONT. ON SH. IC012 SH. No. IC011





**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

**July 31, 2001**

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**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

July 31, 2001

**Construction Schedule**

Construction schedule of panel is as follows:

Arrival of Panel and all components:	6/21/01
Begin mounting of components:	6/21/01
Mounting complete:	6/22/01
Begin Wiring:	6/25/01
Wiring complete:	7/16/01
Begin testing:	7/17/01
Testing complete:	7/20/01
Crating:	7/24/01
Panel Shipped:	7/24/01



**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

**July 31, 2001**

**Introduction**

The following are documents pertaining to the Generator Control and Protection Panel built by E Squared Power Systems, Inc. including all components of the panel and the test procedures used by E Squared Power Systems, Inc. The testing procedures used to verify correct design, construction and operation of the panel are the following:

- a. Continuity checks of wiring including CT circuits and point to point checks.
- b. Testing protection and metering with 125 VDC control power added to system.
  - i.
- c. 160 VAC injection load testing of Excitation and Synchronization.



## GENERATOR CONTROL AND PROTECTION ENCLOSURE TESTING PROCEDURES AND RESULTS

July 31, 2001

### I. Testing Procedures

The following is a list of **General Test Equipment** required in complete testing of the Control and Protection Panel:

- a. Digital Multimeter
- b. Power Supply, 125 Volts DC
- c. Variac, 3 Phase, 0-240 Volts AC, 60 Hz
- d. Oscilloscope (Fluke Scopemeter)
- e. 10 Ohm Resistor
- f. Laptop PC with Basler Bestcoms DECS-300 Software, Beckwith M-3420 Multifunction Relay Software and necessary communication cables
- g. Doble Test Set
- h. Start/Stop, AVR/FCR Test switch
- i. Inductor

#### Pre-Operational Checks

Conduct visual inspection. Look for loose or missing wires, any possible safety hazards. Ensure that all tools and other equipment have been removed. \_\_\_\_\_

\*Note: With each circuit test, a working copy of the elementary drawings should be used and each circuit highlighted after being successfully tested. This phase of testing is complete when all necessary circuits have been highlighted.

#### CT Circuit Tests

This test is to ensure that all CT circuits are wired correctly. Using digital multimeter, test for continuity between CT terminal blocks and all termination points within circuit. Additionally, check for proper function of any existing shorting blocks and test switches.  
\_\_\_\_\_

#### PT Circuit Tests

This test is to ensure that all PT circuits are wired correctly. Using digital multimeter, test for continuity between PT terminal blocks and all termination points within circuit. Additionally, check for proper function of any existing shorting blocks and test switches.  
\_\_\_\_\_



**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

**July 31, 2001**

Visually confirm that all required jumpers have been installed on all PT and CT input terminal blocks and on all digital control and multifunction relays involved in either circuit. \_\_\_\_\_



**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

**July 31, 2001**

**125 VDC Power Checks**

Before applying 125 VDC, all fuse blocks must be tested for shorts between positive and negative and also shorts to ground. If a short is discovered, investigate for wiring mistake and correct problem. \_\_\_\_\_

Using 125 VDC Power Supply, connect leads to proper external power input, ensuring that correct polarity is followed. \_\_\_\_\_

Begin with 125 VDC Auxiliary Control Power Fuses. Begin with fuses dedicated to Synch Check Relay and PML power. Confirm power to each and check polarity. Program settings into PML, inject 1 Amp on each phase. Apply 120 VAC to PT circuit.  
\_\_\_\_\_

Insert fuses dedicated to Control Relays. Check for power in control relays, confirm polarity. \_\_\_\_\_

Insert fuses dedicated to primary power of redundant Beckwith Multifunction Relay's. Confirm power and polarity. \_\_\_\_\_

Insert fuses dedicated to primary power of Voltage Regulator. Confirm power and polarity of DECS-300, Basler Power Supply Module, and Firing Circuit Chassis. Confirm functionality of DECS-300 Stop/Start, Buildup of Field, and FCR/AVR contacts. \_\_\_\_\_

Insert fuses dedicated to Field Flashing Power Input to Generator Field. Confirm power and polarity at Rectifier Chassis terminal points. \_\_\_\_\_

Insert fuses dedicated to 86G Lockout Relay(s). Confirm power at relay and any additional control circuits. \_\_\_\_\_

Insert fuses dedicated to 52G Close and Trip circuits. Confirm power and correct polarity in applicable circuits. \_\_\_\_\_

Confirm that all relay logic applicable to above circuits is correct; all relay's function according to design. \_\_\_\_\_



**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

**July 31, 2001**

**Digital Components**

With 125 VDC still providing primary power to all digital components, connect PC to Beckwith Multifunction Relay M-3420-GG. Input all known relay settings. Using the Doble Test Set, inject 1 Amp in one phase of first CT circuit. Verify secondary current on PC. Calculate primary current using CT ratio and verify on PC. Raise secondary current to 5 Amps. Verify primary and secondary currents on PC. Complete for all three phases. \_\_\_\_\_

Verify correct alarms on Beckwith (24-Volts per Hertz, 87-Phase Differential Current).  
\_\_\_\_\_

Complete the above test for all CT circuits. \_\_\_\_\_

Connect PC to Beckwith Multifunction Relay M3420-BG and complete tests as outlined above. \_\_\_\_\_

Connect PC to Basler DECS-300 Digital Excitation Controller. Input all known excitation settings. \_\_\_\_\_

Check Test Switches for proper function. Using multimeter, confirm continuity of voltage is lost when switches are open. Refer to schematic and highlight ever circuit upon it's successful testing. \_\_\_\_\_



**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

July 31, 2001

**Current Injection / Load Testing**

Using 3 Phase Variac, inject 160 VAC 3 Phase Power into Rectifier Chassis at Power Source from Excitation Transformer. Connect 6 Ohm resistor and inductor, in series with each other, to Rectifier Chassis Field Output to simulate field. Placed in parallel to resistor are two 100 Watt light bulbs to confirm field current, and the Fluke Industrial Scope Meter to measure quality of field. Disconnect Start/Stop and FCR/AVR output wires from DECS-300 and land appropriate wires from test switch. Place system in FCR mode. \_\_\_\_\_

Start system. Verify Ability to sustain 2 Amp Field Current, per bridge rating. \_\_\_\_\_

Check Field Voltage with scope for proper "sawtooth" pattern. Save and plot waveform for future reference. \_\_\_\_\_

System should automatically shutdown due to Failure to Build alarm. This is due to a lack of PT input. To null this alarm, a change in the DECS-300 Settings must be made. The Field Flash Level must be set to 0%. Give system start again and verify stability of Field Current. \_\_\_\_\_

Verify function of Raise and Lower Limits, using Voltage Raise and Lower switches.  
\_\_\_\_\_







**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

July 31, 2001

**Equipment Utilized in Panel**

Basler BE1-25	P/N- M1EAGPN4R0F	S/N- H00200242RN
Beckwith M3420-BG	P/N- M3420 #4382	S/N- 4096
Beckwith M3420-GG	P/N- M3420 #4382	S/N- 4150
Basler DECS-300	P/N- 9310300100	S/N- H00177104 RE9
Basler BE1-25A	P/N- BE125AA2F5V0D0	S/N- H00199975RW
Basler Pan Chassis	P/N- 9345300-100	S/N- 125
Basler Rectifier Chassis	P/N- 9261400-104	S/N- 325
Basler Firing Chassis	P/N- 9324100102	S/N- H00137185RA
Basler Field Isolation Module	P/N- 9322900102	S/N- H00187528R
Basler Overvoltage Relay	P/N- BE359T1A1N1	S/N- M37690202
Generator Volt Meter		
Generator Frequency Meter		
Field Volt Meter		
Synch Lights		
Syncroscope		
Digital Function Meter		
Bus Volt Meter		
Frequency Meter		
Field Ammeter		
43S-CS		
52G-CS		
86GA-CS		
86GB-CS		
43R-CS		
43V-CS		
70G		

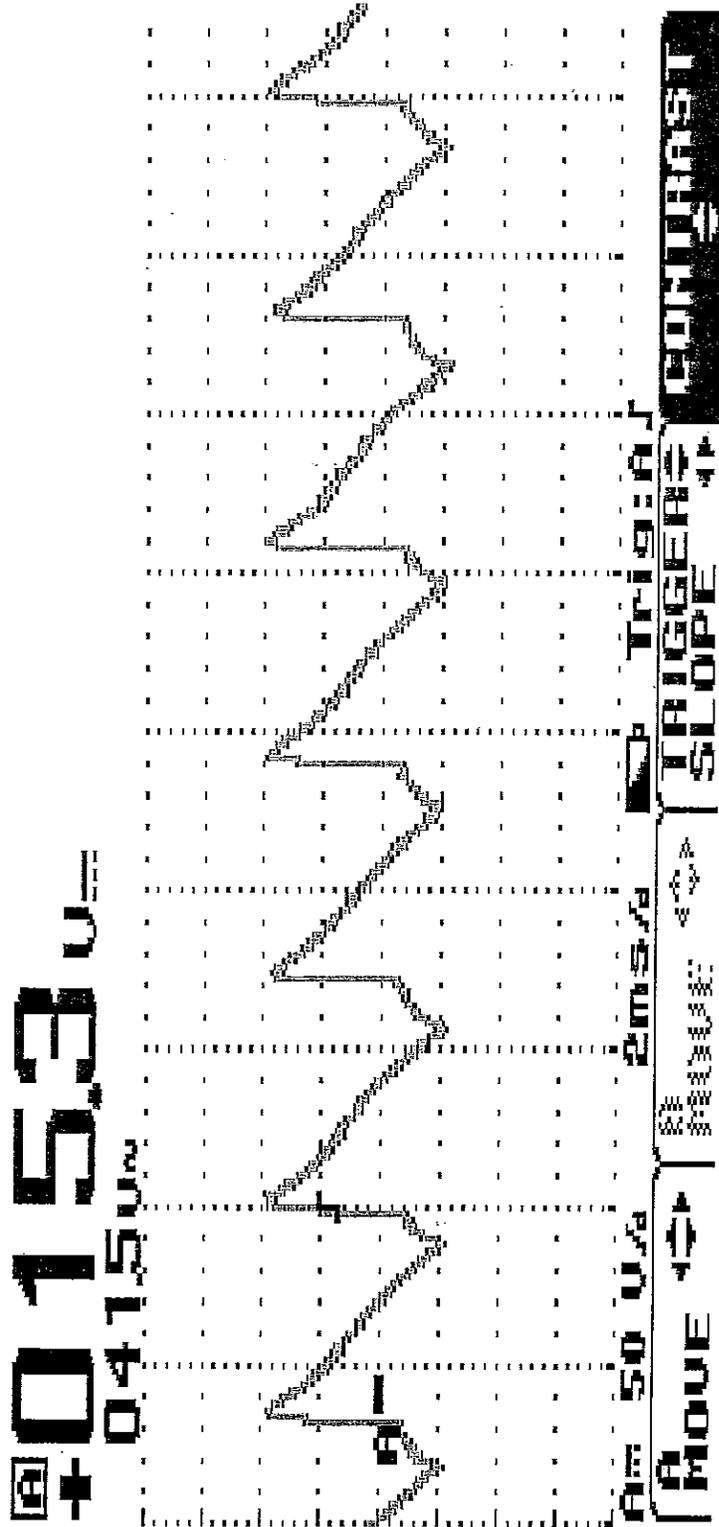


**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

July 31, 2001

**Appendix A**

**Plotted Data**



Stockton project.  
Field Voltage Output.  
FCR mode, Setpoint 2 ADC.



**GENERATOR CONTROL AND PROTECTION ENCLOSURE  
TESTING PROCEDURES AND RESULTS**

**July 31, 2001**

**Appendix A**

**Digital Photographs**

