

HIGH VOLTAGE

CALCULATIONS / EVALUATIONS

*West Virginia Office of Miners'
Health, Safety
& Training*



*Helping You To Work
More Safely In The
Mining Industry*

DISCLAIMER

The West Virginia Office of Miners' Health, Safety and Training publishes this booklet. The material should be used by mine electricians to assist in selecting the proper protective settings for over current, short circuit, and ground fault protection. The material is not all-inclusive and should be used only as an aide in gaining compliance with the regulations. This material is based upon several different publications including West Virginia State Mining Regulations, The National Electrical Code, Title 30 CFR, and the Program Policy Manual. Only two manufacturers of high voltage over current relays are listed; however, products of other manufacturers can easily be cross-referenced to those listed. Nothing herein should be construed as recommending any manufacturer's products.

Visit our website

www.wvminesafety.org

**West Virginia Office of Miners'
Health, Safety and Training**

Doug Conway
Director

C.A. Phillips
Deputy Director

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Benny Comer
Danny Cook
Don Crawford
Tom Harmon
John Scott
Kendall Smith
Randy Smith
Bobby Thornsby
Electrical Inspectors

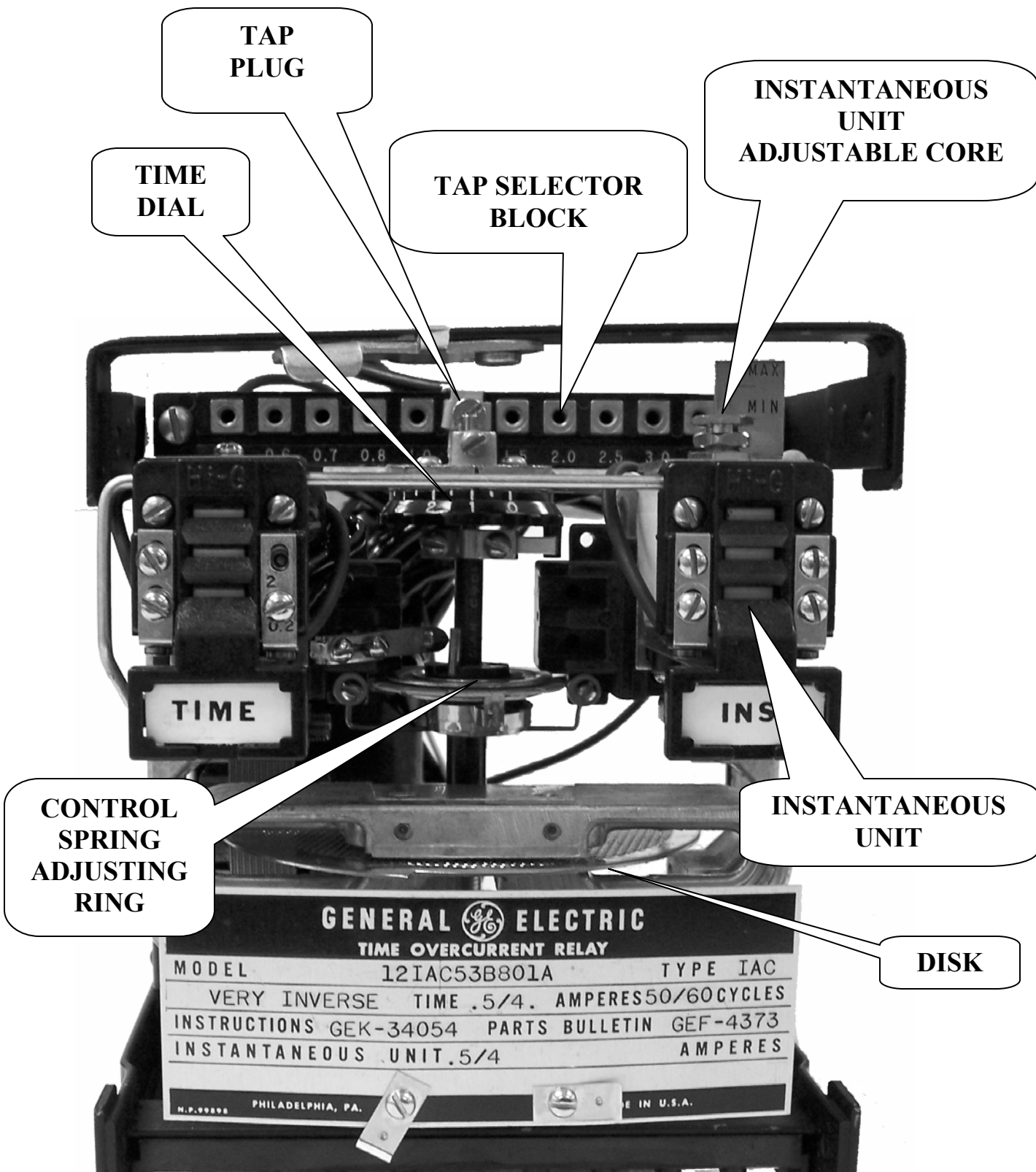
**Mine Safety and Health Administration
District 4**

Larry Cook
Supervisor Electrical Engineer

Marcus Smith
Electrical Engineer

National Mine Health and Safety Academy

Sandy Neal
Graphic Arts



**TAP
PLUG**

**TIME
DIAL**

**TAP SELECTOR
BLOCK**

**INSTANTANEOUS
UNIT
ADJUSTABLE CORE**

**CONTROL
SPRING
ADJUSTING
RING**

**INSTANTANEOUS
UNIT**

DISK

GENERAL ELECTRIC

TIME OVERCURRENT RELAY

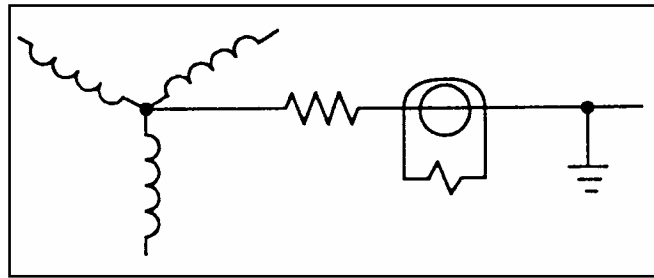
MODEL 12IAC53B801A TYPE IAC
VERY INVERSE TIME .5/4. AMPERES 50/60 CYCLES
INSTRUCTIONS GEK-34054 PARTS BULLETIN GEF-4373
INSTANTANEOUS UNIT .5/4 AMPERES

N.P. 99898

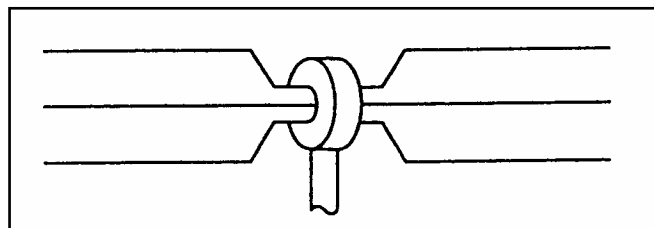
PHILADELPHIA, PA.

MADE IN U.S.A.

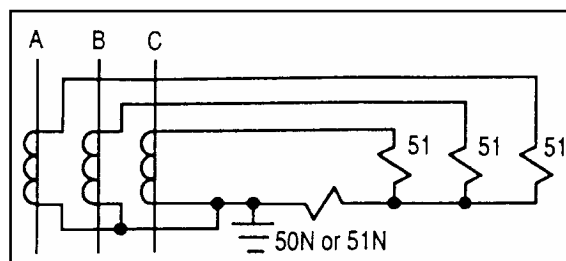
Direct Relaying. In this method, grounded-phase current is detected directly with a current transformer installed in the grounded neutral conductor.



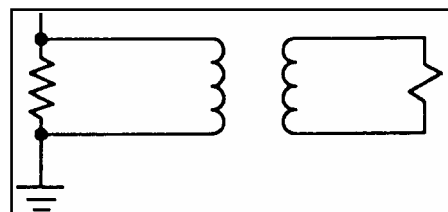
Balance Flux Relaying. In this method, grounded-phase current is detected by a doughnut-type current transformer installed around the three phase conductors. **Note:** The equipment grounding conductors (including conductor shields) must not be installed through the current transformer.



Residual Trip Relaying. In this method, grounded-phase current is detected as the unbalance in the current produced by the phase current transformers.



Potential Relaying. In this method, grounded-phase current is detected as the voltage drop across the grounding resistor. An advantage of this method over the three previous methods is that grounded-phase protection is still provided even if the grounding resistor is open. For this reason, potential relaying is often used to provide backup grounded-phase protection for resistance-grounded systems.



OVERCURRENT RELAY

4160 volt system phase to phase

2/0 AWG cable 5 KV rating at 90 degree insulation

Cable rated for 287 amps X 125% = 359 amps

Current transformer ratio 80:1

Tap bar range 2.0 to 16

80:1 X tap 4 = 320 amps

SHORT CIRCUIT

Using a breaker, the short circuit is set no greater than 600% X cable ampacity of 287 amps. (287 X 6 = 1722 amps)

This setting is achieved by adjusting the instantaneous unit adjustable core screw.

GROUND FAULT

4160 volts phase to phase

2400 volts phase to neutral

25 amp grounding resistor 96 ohms

Tap bar range 0.5 to 2.0

Ground fault current is set at no more than 50% of the amp rating of the resistor

Current transformer ratio is 10:1

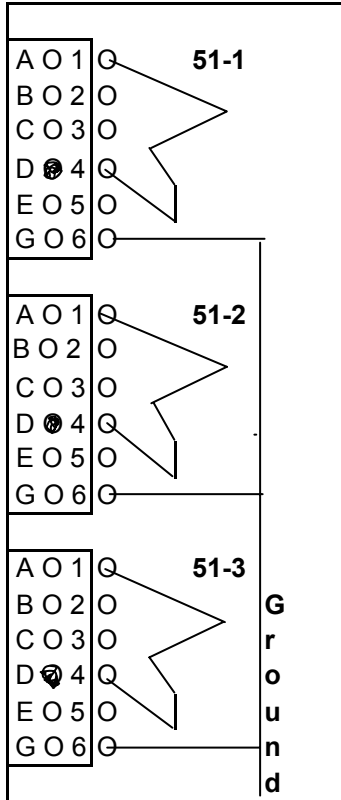
Current transformer ratio 10:1 set on tap 1.2 (10 X 1.2 = 12 amps) which is less than 50% of the 25 amp grounding resistor.

4160 volt system phase to phase
 2/0 AWG cable 5KV volt rating 90c insulation
 Current Transformer 50:1 ratio
 25 amp grounding resistor rated at 96 ohms
 Current tap block 2 - 16 amps.
 Instantaneous unit adjustable from 20-40 amps

2001 - 8000 VOLTS			
AWG	75c	85c	90c
2	170	182	188
X125%	213	228	235
X600%	1020	1092	1128
1	196	210	217
X125%	245	263	271
X600%	1176	1260	1302
1/0	226	242	249
X125%	283	303	311
X600%	1356	1452	1494
2/0	260	278	287
X125%	325	348	359
X600%	1560	1668	1722
3/0	299	320	329
X125%	374	400	411
X600%	1794	1920	1974
4/0	343	367	379
X125%	429	459	474
X600%	2058	2202	2274

8001 - 15000 VOLTS			
AWG	75c	85c	90c
2	168	187	194
X125%	210	234	243
X600%	1008	1122	1164
1	192	215	221
X125%	240	268	276
X600%	1152	1290	1326
1/0	221	247	254
X125%	276	309	318
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2/0	253	282	290
X125%	316	353	363
X600%	1518	1692	1740
3/0	290	324	334
X125%	363	405	418
X600%	1740	1944	2004
4/0	333	372	384
X125%	416	465	480
X600%	1998	2232	2304

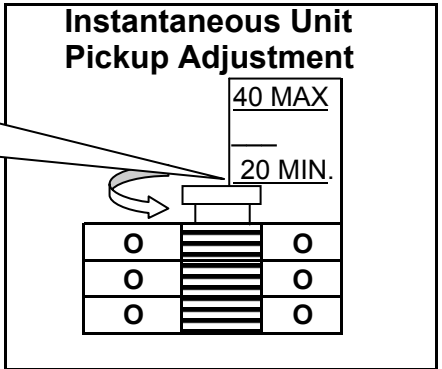
TAPS	RATIO
BC	10/1
AB	20/1
AC	30/1
DE	40/1
CD	50/1
BD	60/1
AD	80/1
CE	90/1
BE	100/1
AE	120/1



TIME OVERCURRENT RELAY	
MODEL 000000000000	TYPE IAC
INVERSE TIME 2 - 16 AMPERES 60 CYCLES	
INSTRUCTIONS 00000000 PARTS BULLETIN	
INSTANTANEOUS UNIT 20 - 40 AMPERES	

Current Tap Block										
0	0	0	0	0	0	0	0	0	0	
2	3	4	5	6	7	8	10	12	14	16

Cable Ampacity
 $287 \times 6 = 1722 \text{ Max. SC}$
 $1722 \text{ Divided by } 80:1 \text{ CT}$
 Ratio = 21.5 Amps Max.



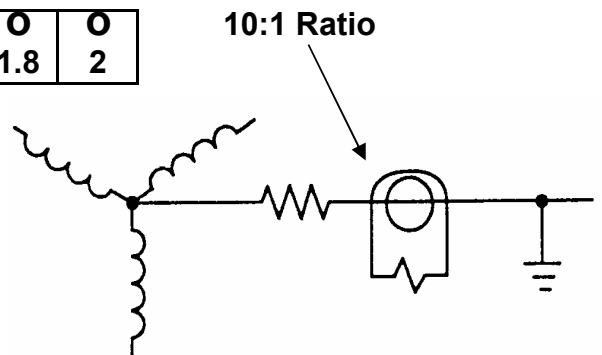
OVERCURRENT & SHORT CIRCUIT PROTECTION

Cable ampacity 287 amps X 125% = 359. Set the taps on A and D on the multi-tap CT to obtain a 80:1 ratio.
 Which tap on the multi-tap block would be used to obtain the highest allowable setting for the 2/0 AWG cable? 4 What is the actual ampacity set at? 320
 Set the short circuit instantaneous unit on the maximum allowable 1722 amps.
 Set the instantaneous unit core at 21.5 amps. (1722 Divided by 80:1 CT Ratio - 21.5)

Ground Fault Tap Block										
0	0	0	0	0	0	0	0	0	0	
0.5	0.6	0.7	0.8	0.9	1	1.2	1.4	1.6	1.8	2

Which tap on the multi-tap block would be used to obtain the highest allowable setting? 1.2

What is the actual setting? 12 amps.



Company				
Mine		I D Number		
Date		HV Underground Feeder Cable		
Fence Gate Shunted & Locked	Yes	Cable Size	2/0	
Fence: Grounded	Yes	Cable Temp. Rating	90c	
Danger HV Signs Posted	Yes	Cable KV Rating	5	
Fence: Height	6'	Cable Ampacity	287	
Metal Structures Grounded	Yes	Overcurrent Relays		
Insulated Mats	Yes	Cable Ampacity	287	X125% 359
Metal Grids Grounded	Yes	Relays	51/1	51/2 51/3
Voltage In	12,470	CT Ratio	80:1	80:1 80:1
Voltage Out	4,160	OL Tap Bar Range	2-16	2-16 2-16
Lightning Arrestors Primary	Yes	Tap Set On	4	4 4
Lightning Arrestors Secondary	Yes	Setting Actual Amps	320	320 320
Disconnects: Incoming Power	Yes	Max. Allow. Tap set.	4	4 4
Visual Disc. 100' Of Portal	Yes	Time Dial Setting	1	1 1
Primary Fuse Size	30	Short Circuit		
Transformer Connection	D / Y	Cable Ampacity	287	X600% 1,722
Neutral: Direct or Derived	Direct	CT Ratio	80:1	
Transformer KVA or Amps	5,000	Core Setting Range	20 - 40	
HV OCB / Vac Bkr. Identified	Yes	Core Set On	21.5	
OCB Amp Rating	600	Setting Actual Amps	1,722	
OCB Voltage Rating	15 KV	Max Allow. Core Set. Amps	21.5	
Vacuum Bkr. Amp Rating	N/A	Ground Fault Relay 51 - G		
Vacuum Bkr. Voltage Rating	N/A	Phase to Neutral Voltage	2,400	
Grounding Resistor Amps	25	CT Ratio	50:5	
Grounding Resistor Ohms	96	Grounding Resistor Amps	25	
Neutral GND Resistance Ohms	2	50% Resistor Rated Amps	12.5	
Station GND Resistance Ohms	3	Tap Bar Range	0.5-2	
Control Voltage	120	Tap Set On	1.2	
Monitor Amps	1	Setting Actual Amps	12	
Capacitors Primary	No	Max Allowable Tap Setting	1.2	
Capacitors Secondary	No	Time Dial Setting	0.5	

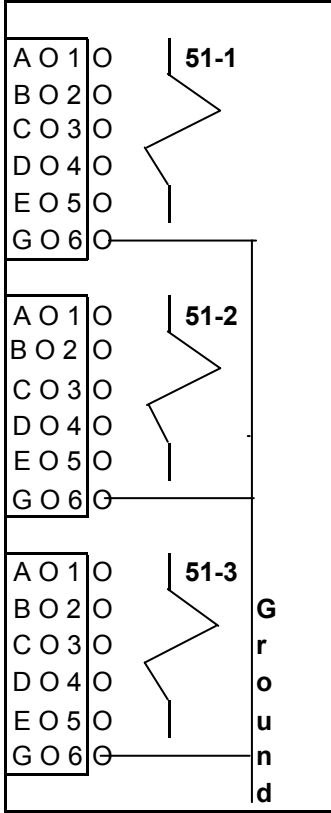
Company				
Mine		I D Number		
Date		HV Underground Feeder Cable		
Fence Gate Shunted & Locked		Cable Size		
Fence: Grounded		Cable Temp. Rating		
Danger HV Signs Posted		Cable KV Rating		
Fence: Height		Cable Ampacity		
Metal Structures Grounded		Overcurrent Relays		
Insulated Mats		Cable Ampacity	X125%	
Metal Grids Grounded		Relays	51/1	51/2
Voltage In		CT Ratio		
Voltage Out		OL Tap Bar Range		
Lightning Arrestors Primary		Tap Set On		
Lightning Arrestors Secondary		Setting Actual Amps		
Disconnects: Incoming Power		Max. Allow. Tap set.		
Visual Disc. 100' Of Portal		Time Dial Setting		
Primary Fuse Size		Short Circuit		
Transformer Connection		Cable Ampacity	X 600%	
Neutral: Direct or Derived		CT Ratio		
Transformer KVA or Amps		Core Setting Range		
HV OCB / Vac Bkr. Identified		Core Set On		
OCB Amp Rating		Setting Actual Amps		
OCB Voltage Rating		Max Allow. Core Set. Amps		
Vacuum Bkr. Amp Rating		Ground Fault Relay 51 - G		
Vacuum Bkr. Voltage Rating		Phase to Neutral Voltage		
Grounding Resistor Amps		CT Ratio		
Grounding Resistor Ohms		Grounding Resistor Amps		
Neutral GND Resistance Ohms		50% Resistor Rated Amps		
Station GND Resistance Ohms		Tap Bar Range		
Control Voltage		Tap Set On		
Monitor Amps		Setting Actual Amps		
Capacitors Primary		Max Allowable Tap Setting		
Capacitors Secondary		Time Dial Setting		

_____ volt system phase to phase
 _____ AWG cable _____ volt rating _____ c insulation
 Current Transformer _____ ratio
 _____ amp grounding resistor rated at _____ ohms
 Current tap block _____ amps.
 Instantaneous unit adjustable from _____ amps

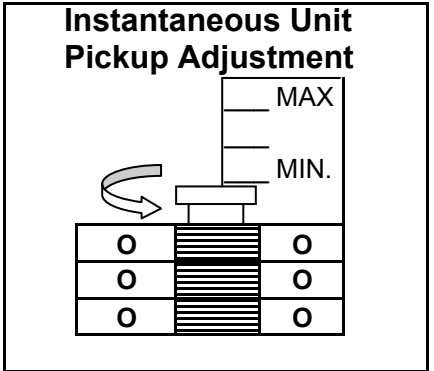
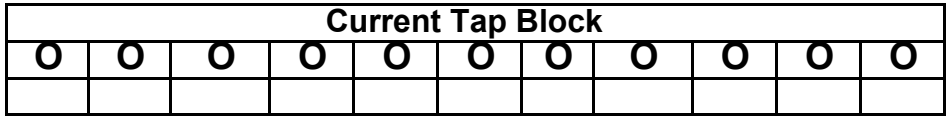
2001 - 8000 VOLTS			
AWG	75c	85c	90c
2	170	182	188
X125%	213	228	235
X600%	1020	1092	1128
1	196	210	217
X125%	245	263	271
X600%	1176	1260	1302
1/0	226	242	249
X125%	283	303	311
X600%	1356	1452	1494
2/0	260	278	287
X125%	325	348	359
X600%	1560	1668	1722
3/0	299	320	329
X125%	374	400	411
X600%	1794	1920	1974
4/0	343	367	379
X125%	429	459	474
X600%	2058	2202	2274

8001 - 15000 VOLTS			
AWG	75c	85c	90c
2	168	187	194
X125%	210	234	243
X600%	1008	1122	1164
1	192	215	221
X125%	240	268	276
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X600%	1740	1944	2004
4/0	333	372	384
X125%	416	465	480
X600%	1998	2232	2304

TAPS	RATIO
BC	10/1
AB	20/1
AC	30/1
DE	40/1
CD	50/1
BD	60/1
AD	80/1
CE	90/1
BE	100/1
AE	120/1



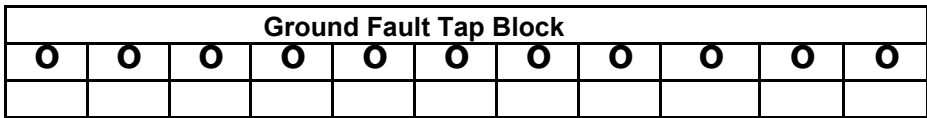
TIME OVERCURRENT RELAY	
MODEL 000000000000	TYPE I A C
INVERSE TIME	AMPERES 60 CYCLES
INSTRUCTIONS 00000000	PARTS BULLETIN
INSTANTANEOUS UNIT	AMPERES



OVERCURRENT & SHORT CIRCUIT PROTECTION

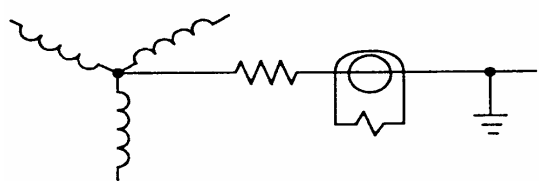
Cable ampacity _____ amps X 125% = _____. Set the taps on _____ and _____ on the multi-tap CT to obtain a _____ ratio.
 Which tap on the multi-tap block would be used to obtain the highest allowable setting for the _____ AWG cable? _____ What is the actual ampacity set at? _____
 Set the short circuit instantaneous unit on the maximum allowable _____ amps.
 Set the instantaneous unit core at _____ amps. (_____ amps Divided by _____ CT Ratio _____ amps)

GROUND FAULT PROTECTION

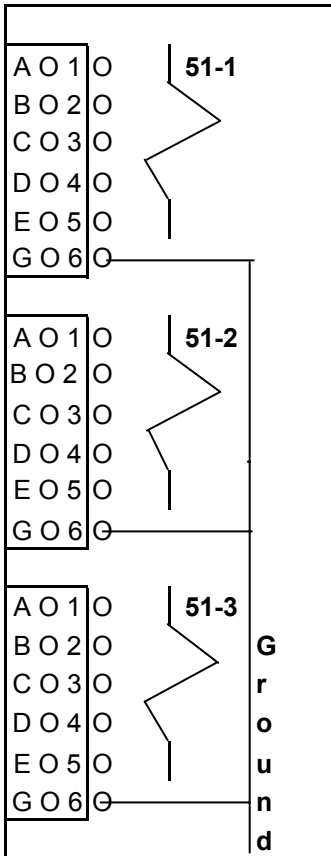


_____ CT RATIO

Which tap on the multi-tap block would be used to obtain the highest allowable setting? _____
 What is the actual setting? _____ amps.



____ volt system phase to phase
 ____ AWG cable ____ volt rating ____ c insulation
 Current Transformer _____ ratio
 ____ amp grounding resistor rated at ____ ohms
 Current tap block _____ amps.
 Instantaneous unit adjustable from ____ amps

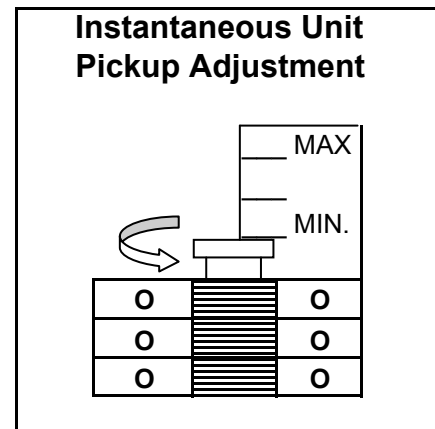
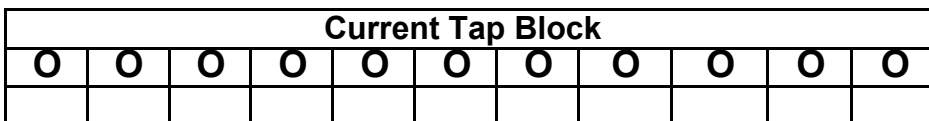


TAPS	RATIO
BC	10/1
AB	20/1
AC	30/1
DE	40/1
CD	50/1
BD	60/1
AD	80/1
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X125%	363	405	418
X600%	1740	1944	2004
4/0	333	372	384
X125%	416	465	480
X600%	1998	2232	2304

TIME OVERCURRENT RELAY			
MODEL	12IAC51B108A	TYPE	IAC
INVERSE TIME	AMPERES	60	CYCLES
INSTRUCTIONS	GEH-1753	PARTS BULLETIN	
INSTANTANEOUS UNIT	AMPERES		



OVERCURRENT & SHORT CIRCUIT PROTECTION

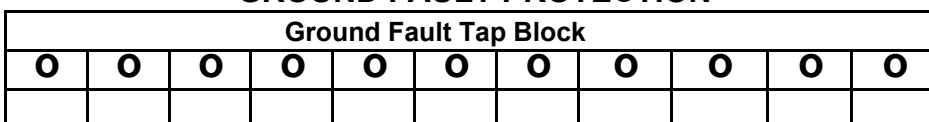
Cable ampacity _____ amps X 125%= _____. Set the taps on _____ and _____ on the multi-tap CT to obtain a _____ ratio.

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Set the instantaneous unit core at _____ amps. (_____ amps Divided by _____ CT Ratio _____ amps)

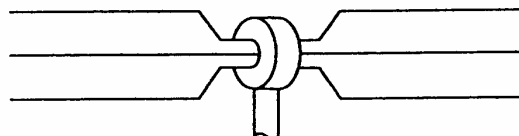
GROUND FAULT PROTECTION



_____ CT RATIO

Which tap on the multi-tap block would be used to obtain the highest allowable setting? _____

What is the actual setting? _____ amps.

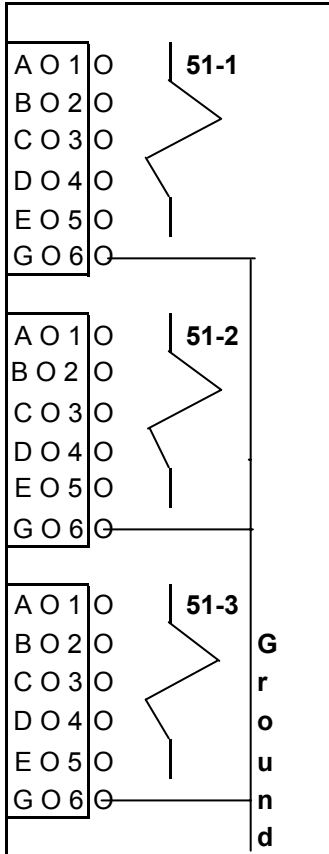


____ volt system phase to phase
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 Current Transformer _____ ratio
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 Current tap block _____ amps.
 Instantaneous unit adjustable from ____ amps

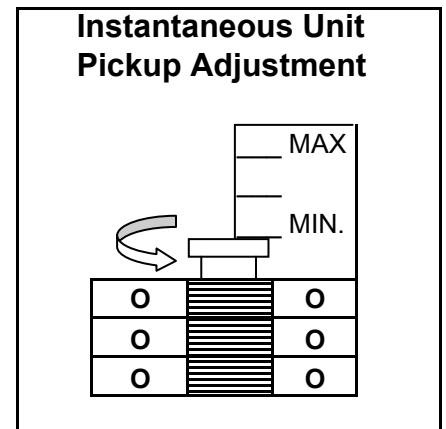
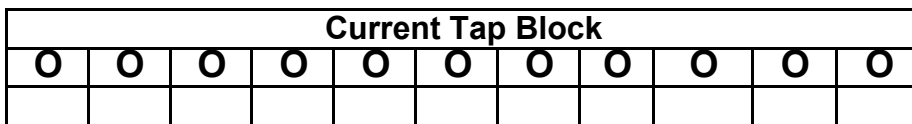
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CD	50/1
BD	60/1
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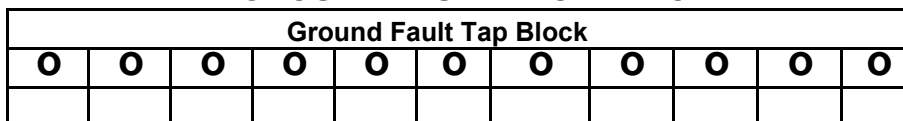
TIME OVERCURRENT RELAY	
MODEL 000000000000	TYPE I A C
INVERSE TIME	AMPERES 60 CYCLES
INSTRUCTIONS 00000000	PARTS BULLETIN
INSTANTANEOUS UNIT	AMPERES



OVERCURRENT & SHORT CIRCUIT PROTECTION

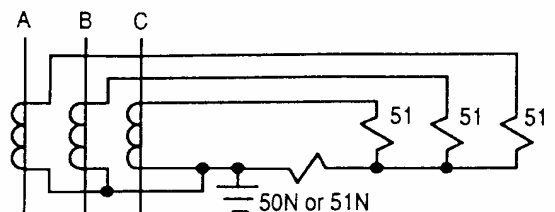
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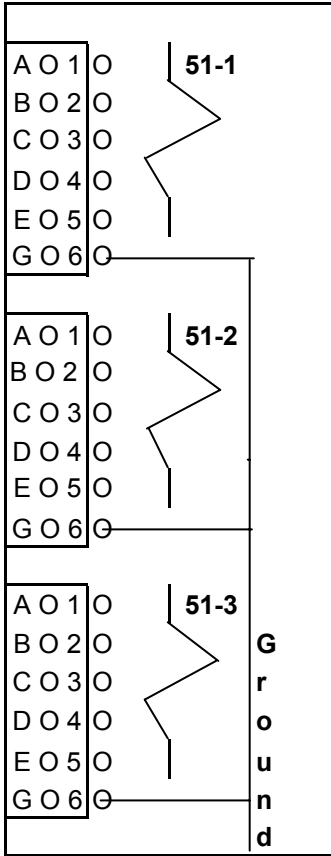


_____ CT RATIO

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 What is the actual setting? _____ amps.



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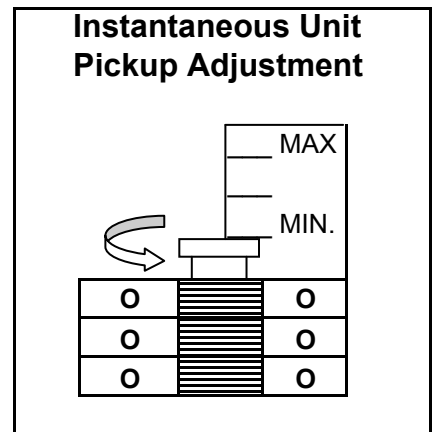
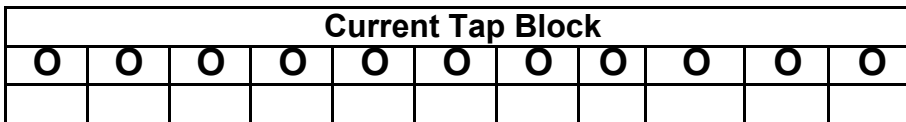


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X125%	283	303	311
X600%	1356	1452	1494
2/0	260	278	287
X125%	325	348	359
X600%	1560	1668	1722
3/0	299	320	329
X125%	374	400	411
X600%	1794	1920	1974
4/0	343	367	379
X125%	429	459	474
X600%	2058	2202	2274

8001 - 15000 VOLTS			
AWG	75c	85c	90c
2	168	187	194
X125%	210	234	243
X600%	1008	1122	1164
1	192	215	221
X125%	240	268	276
X600%	1152	1290	1326
1/0	221	247	254
X125%	276	309	318
X600%	1326	1482	1524
2/0	253	282	290
X125%	316	353	363
X600%	1518	1692	1740
3/0	290	324	334
X125%	363	405	418
X600%	1740	1944	2004
4/0	333	372	384
X125%	416	465	480
X600%	1998	2232	2304

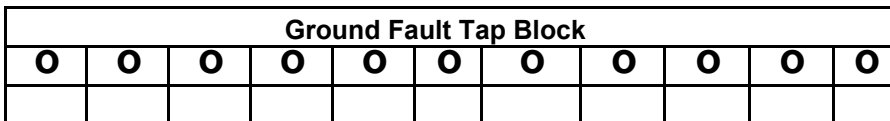
TIME OVERCURRENT RELAY	
MODEL 000000000000	TYPE I A C
INVERSE TIME	AMPERES 60 CYCLES
INSTRUCTIONS 0000000	PARTS BULLETIN
INSTANTANEOUS UNIT	AMPERES



OVERCURRENT & SHORT CIRCUIT PROTECTION

Cable ampacity _____ amps X 125% = _____. Set the taps on _____ and _____ on the multi-tap CT to obtain a _____ ratio.
 Which tap on the multi-tap block would be used to obtain the highest allowable setting for the _____ AWG cable? _____ What is the actual ampacity set at? _____
 Set the short circuit instantaneous unit on the maximum allowable _____ amps.
 Set the instantaneous unit core at _____ amps. (_____ amps Divided by _____ CT Ratio _____ amps)

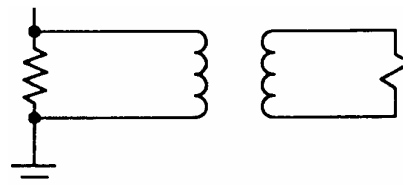
GROUND FAULT PROTECTION



H _____
 X _____

Which tap on the multi-tap block would be used to obtain the highest allowable setting? _____

What is the actual setting? _____ voltage.



COMPANY				Date	
MINE				ID #	
Underground splitter				Underground splitter	
HV Uderground Feeder Cable				HV Underground Feeder Cable	
Cable Size				Cable Size	
Cable Temp. Rating				Cable Temp. Rating	
Cable KV Rating				Cable KV Rating	
Cable Ampacity				Cable Ampacity	
Overcurrent Relays				Overcurrent Relays	
Cable Ampacity	X125%			Cable Ampacity	X125%
Relays	51/1	51/2	51/3	Relays	51/1 51/2 51/3
CT Ratio				CT Ratio	
OL Tap Bar Range				OL Tap Bar Range	
Tap Set On				Tap Set On	
Setting Actual Amps				Setting Actual Amps	
Max. Allow. Tap set.				Max. Allow. Tap set.	
Time Dial Setting				Time Dial Setting	
Short Circuit				Short Circuit	
Cable Ampacity	X 600%			Cable Ampacity	X 600%
CT Ratio				CT Ratio	
Core Setting Range				Core Setting Range	
Core Set On				Core Set On	
Setting Actual Amps				Setting Actual Amps	
Max Allow. Core Set Amps				Max Allow. Core Set. Amps	
Ground Fault Relay 51 - G				Ground Fault Relay 51 - G	
Phase to Neutral Voltage				Phase to Neutral Voltage	
C T Ratio				CT Ratio	
Grounding Resistor Amps				Grounding Resistor Amps	
50% Resistor Rated Amps				50% Resistor Rated Amps	
Tap Bar Range				Tap Bar Range	
Tap Set On				Tap Set On	
Setting Actual Amps				Setting Actual Amps	
Max Allowable Tap setting				Max Allowable Tap Setting	
Time Dial Setting				Time Dial Setting	

H P 9 9 5	F L C	1 2 5 %	2 5 0 %	4 0 0 %	7 0 0 %	1 3 0 0 %	H T S Z	S T S Z
100	48	60	120	192	336	624		
125	60	75	150	240	420	780		
150	72	90	180	288	504	936		
200	96	120	240	384	672	1248		
250	120	150	300	480	840	1560		
300	144	180	360	576	1008	1872		
350	168	210	420	672	1176	2184		
400	192	240	480	768	1344	2496		
450	216	270	540	864	1512	2808		
500	240	300	600	960	1680	3120		
600	288	360	720	1152	2016	3744		
700	336	420	840	1344	2352	4368		
800	384	480	960	1536	2688	4992		

H P 2 3 0 0	F L C	1 2 5 %	2 5 0 %	4 0 0 %	7 0 0 %	1 3 0 0 %	H T S Z	S T S Z
100	24	30	60	96	168	312		
125	30	38	75	120	210	390		
150	36	45	90	144	252	468		
200	48	60	120	192	336	624		
250	60	75	150	240	420	780		
300	72	90	180	288	504	936		
350	84	105	210	336	588	1092		
400	96	120	240	384	672	1248		
450	108	135	270	432	756	1404		
500	120	150	300	480	840	1560		
600	144	180	360	576	1008	1872		
700	168	210	420	672	1176	2184		
800	192	240	480	768	1344	2496		

H P 4 1 6 0	F L C	1 2 5 %	2 5 0 %	4 0 0 %	7 0 0 %	1 3 0 0 %		
100	14	18	35	56	98	182		
125	18	23	45	72	126	234		
150	21	26	53	84	147	273		
200	28	35	70	112	196	364		
250	35	44	88	140	245	455		
300	42	53	105	168	294	546		
350	49	61	123	196	343	637		
400	56	70	140	224	392	728		
450	63	79	158	252	441	819		
500	70	88	175	280	490	910		
600	84	105	210	336	588	1092		
700	98	123	245	392	686	1274		
800	112	140	280	448	784	1456		

H P 7 2 0 0	F L C	1 2 5 %	2 5 0 %	4 0 0 %	7 0 0 %	1 3 0 0 %		
100	8	10	20	32	56	104		
125	10	13	25	40	70	130		
150	12	15	30	48	84	156		
200	16	20	40	64	112	208		
250	20	25	50	80	140	260		
300	24	30	60	96	168	312		
350	28	35	70	112	196	364		
400	32	40	80	128	224	416		
450	36	45	90	144	252	468		
500	40	50	100	160	280	520		
600	48	60	120	192	336	624		
700	56	70	140	224	392	728		
800	64	80	160	256	448	832		

Date					
Company					
Mine Name					
Mine ID Number					
VOLTS					
HORSEPOWER					
MOTOR FLC					
FLC X 125%					
CABLE SIZE					
CABLE AMPACITY					
FLC X 250%					
FLC X 400%					
THERM BKR OR FUSE SZ					
FLC X 700%					
FLC X 1300%					
BKR. TRIP RANGE					
TRIP RANGE SETTING					
CT RATIO					
HEATER SIZE					
HEATER AMPS					
STARTER SIZE					

Date	
Company	
Mine Name	
Mine ID Number	

NO . BELT DRIVE				BELT TAKE UP No.	
VOLTS				VOLTS	
MOTOR FLC				HORSEPOWER	
MOTOR FLC X 125%				MOTOR FLC	
FLC + (FLC X 125%)				FLC X 125%	
FEEDER SIZE				CABLE SIZE	
FEEDER AMPACITY				CABLE AMPACITY	
TRIP RANGE				FLC X 250%	
TRIP RANGE SETTING				FLC X 400%	
FUSE OR TH BKR SZ				THERMAL BKR OR FUSE SIZE	
HORSEPOWER				FLC X 700%	
MOTOR FLC				FLC X 1300%	
MOTOR FLC X 125%				BKR TRIP RANGE	
BR CIR CABLE SIZE				TRIP RANGE SETTING	
BR CIR CABLE AMP.				CT RATIO	
FLC X 250%				HEATER SIZE	
FLC X 400%				HEATER AMPS	
FLC X 700%				STARTER SIZE	
FLC X 1300%				<i>LENGTH OF BELT</i>	
CT RATIO				<i>WIDTH OF BELT</i>	
HEATER SIZE				<i>AVG. % GRADE</i>	
HEATER AMPS				<i>NO. 1 MOTOR AMPS</i>	
STARTER SIZE				<i>NO.2 MOTOR AMPS</i>	