EE 5223 - Lecture 8 Wed Jan 25, 2023

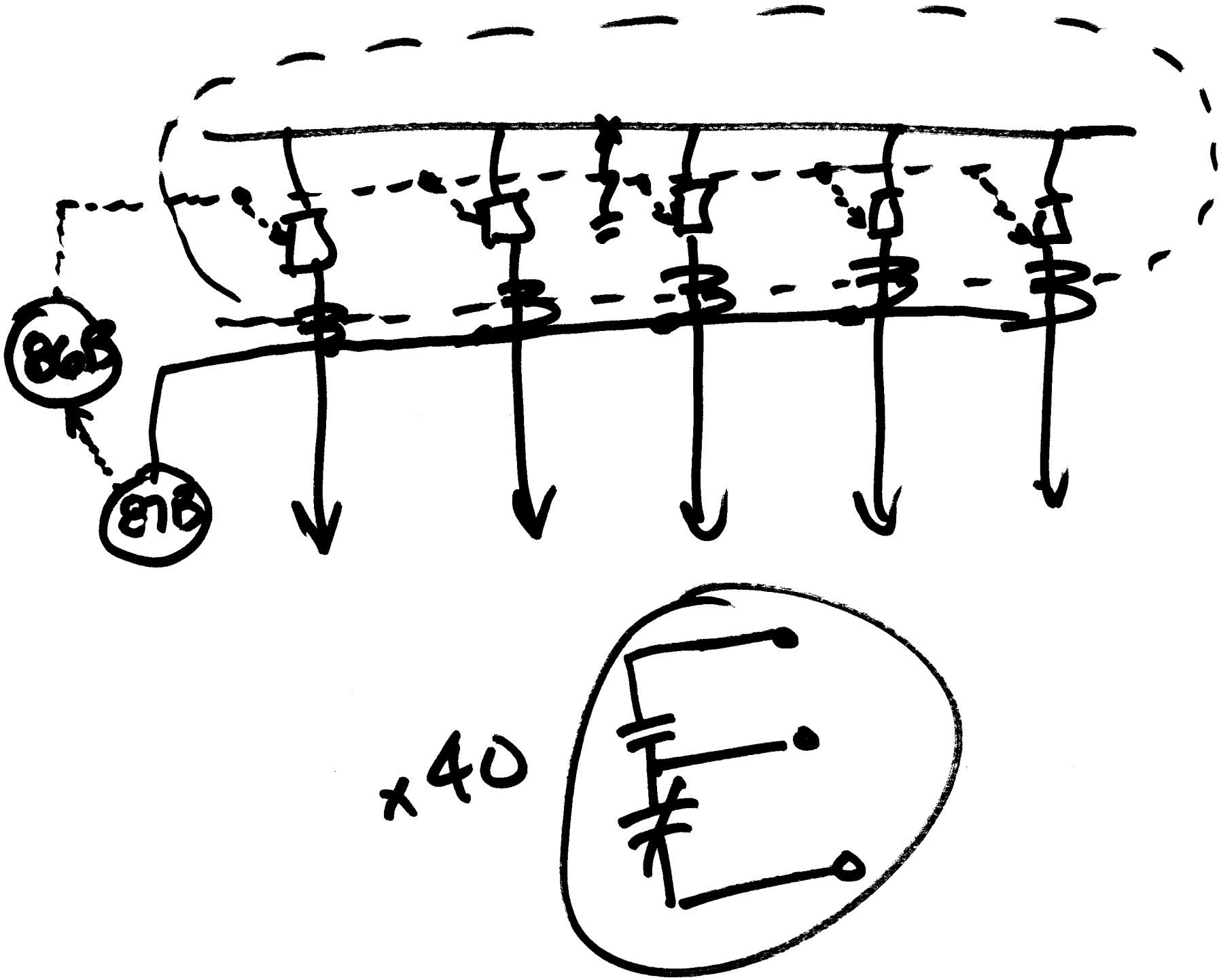
Ongoing List of Topics:

- No homework Feb 6-10th. "What can I do that is productive?"
  - Pre-req concepts, form 3-person team, Homeworks 3A, 3B.
  - EE5200 web page - 6 review videos on circuits https://pages.mtu.edu/~bamork/ee5200/#PreReq
  - EE5200 web page - review lecture on short circuit analysis

    http://www.ece.mtu.edu/faculty/bamork/ee5200/ET1_Session3_Makram_Bohmann1.pdf
- URL: https://pages.mtu.edu/~bamork/EE5223/index.htm
- Labs - EE5224 - Lab 1 ongoing. Pre-lab > Lab > Report...
- Software - Aspen Remote Desktop, ECE Computer Labs
- Radial Protection (read sections 12.5, 12.6, also G&S Ch.10)
- Coordinated operation of Recloser, sectionalizer(s), fuses
- Simple example of relay coordination (Homework 4)
- CT saturation & accuracy, ratios, multi-ratio CTs
- MOCTs - Magneto-Optic Current Transformers

...there are two essential requirements for being successful in business:

1) Never tell anyone everything you know.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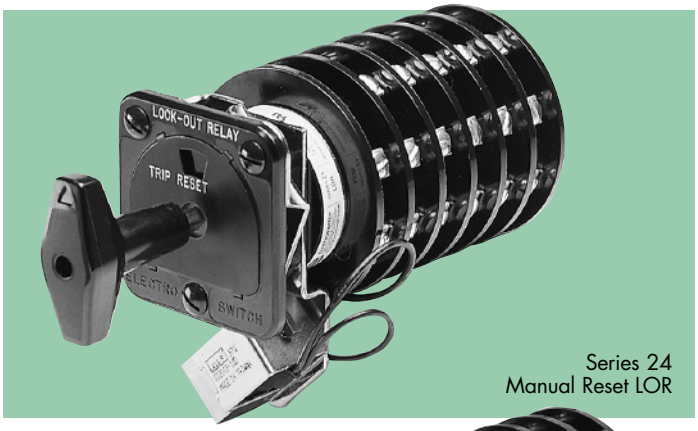
LOCK-OUT RELAYS

By definition the Lock-Out Relay plays a pivotal role in the most crucial utility applications. In an emergency, Lock-Out Relay performance can spell the difference between a routine outage and the destruction of expensive equipment. Protect your system and safeguard your personnel with the industry standard for safety and reliability. There's NEVER A DOUBT with the Electroswitch family of Lock-Out Relays.

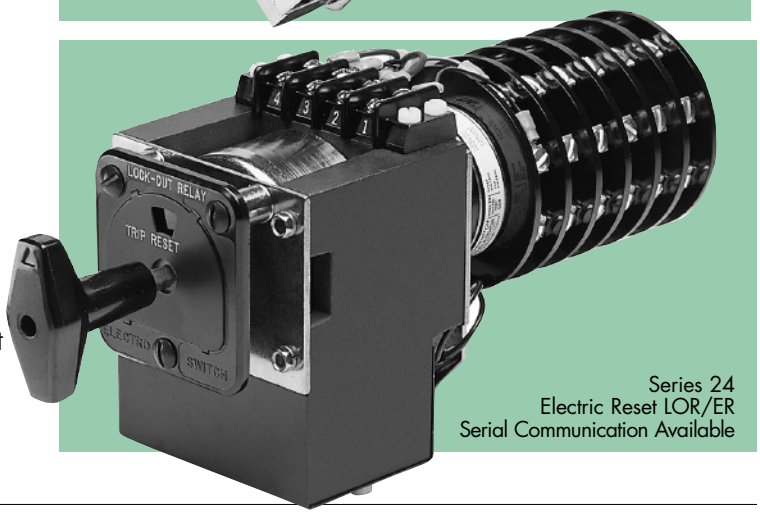
Note: The Series 24 LOR Class 1E utility products comply with the following Nuclear Standards: ANSI/IEEE C37.90, ANSI/IEEE C37.90.01, ANSI/IEEE C37.98, ANSI/IEEE C37.105, ANSI/IEEE 323, ANSI/IEEE 344, ANSI/ASME NQA -1.

The Series 24 Lock-Out Relays

HIGH QUALITY	• Designed and manufactured to the highest standards in the industry • Qualified to UL, CSA
VERSATILITY	• 9 Different trip coils to choose from • Up to 20 N/O and 20 N/C contacts in one standard LOR. • Available with electric reset capability • Available with built-in coil monitoring and fault signal detection/indication
HIGH SPEED	• Transition times of less than 8mSec (less than 1/2 cycle) are standard
SAFETY	• Series 24 - 1E Nuclear Qualified, UL, CSA
AVAILABILITY	• Virtually all Series 24 Manual Reset LORs are available from stock for immediate delivery • The most popular Electric Reset LOR/ERs are also in stock
SERVICE	• The Electroswitch team of Customer Service and Applications Professionals stand behind every Electroswitch product. Let us put over 50 years of know-how to work for you!



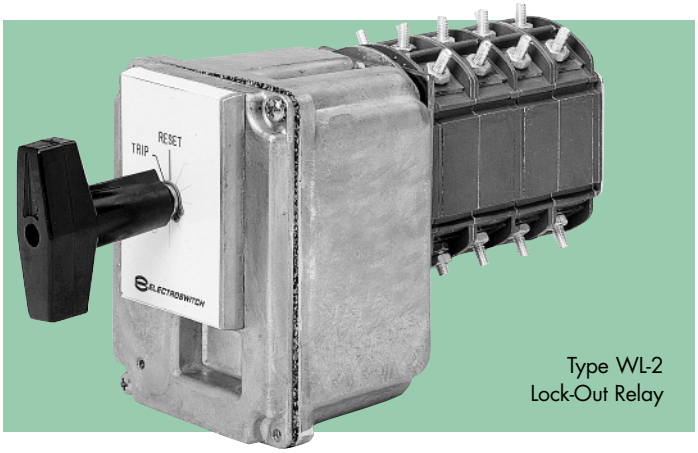
Series 24
Manual Reset LOR



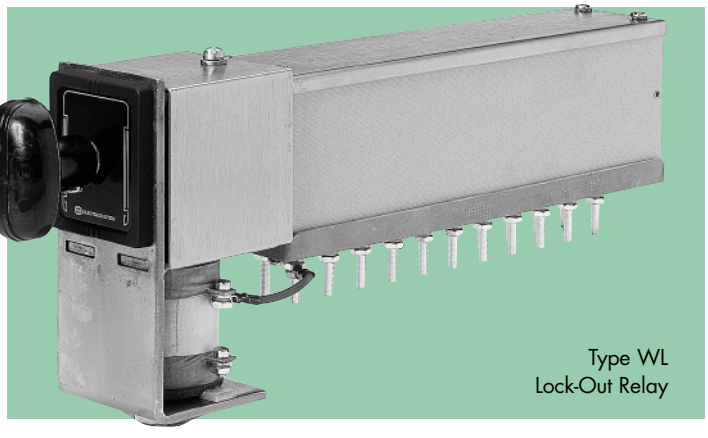
Series 24
Electric Reset LOR/ER
Serial Communication Available

Type WL-2 and WL Lock-Out Relays

Since 1988 Electroswitch has been the source for the Type WL-2 and WL Lock-Out Relays. These rugged, dependable devices, designed and originally manufactured by Westinghouse, have stood the test of time in utility and industrial applications worldwide. Now they are available for either new applications or replacement, backed by the industry leading Electroswitch commitment to Quality and Service.



Type WL-2
Lock-Out Relay


Type WL
Lock-Out Relay

SERIES 24 LOR
With Lighted Target Nameplate

NEW PRODUCT

Lighted Target Nameplates Save Panel Space and Reduce Costs

The Electroswitch Series 24 Lock-Out Relay, the Utility Industry Standard for Quality and Reliability, is now available with:

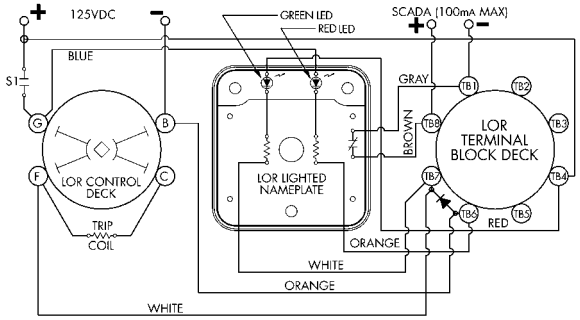
- Integral Coil Monitoring with LED Display and SCADA Feedback.
- LED Indication of Existing Fault Signal.

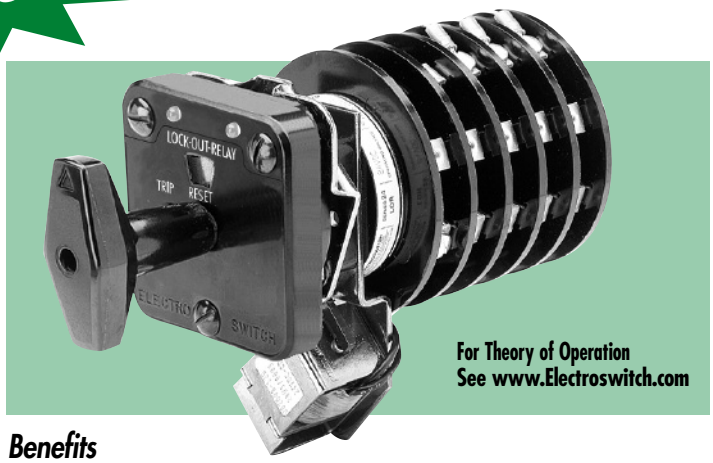
The Lock-Out Relay fills one of the most critical needs in the utility industry protection scheme. A fast, reliable Lock-Out Relay can mean the difference between a routine fault clearance and a disastrous loss of service, maintenance time and expensive equipment damage.

To assure that this crucial device is functioning and ready to operate, many utilities install pilot lamps on the panel to monitor the integrity of the LOR coil. This can involve expensive inter-wiring and use precious panel space. Because of this, Electroswitch has integrated these monitoring functions and more on a new electronic nameplate for the LOR.

Features

- Cost-effective Elimination of Additional Wiring and Lamps Needed to Perform this Function. Just Attach the Pre-wired Leads per the Enclosed Instructions.
- Save Valuable Panel Space. The Entire Package Fits in the Same Space as a Standard Mechanical LOR Nameplate.
- Both LOCAL (LED) and REMOTE (SCADA Signal) Indication is Provided; Reliable Protection for Unmanned Stations.
- Green LED indicates LOR Coil is Intact and Ready to Operate.
- Red LED Warns Against Resetting into an Existing Fault Signal and Possibly Damaging LOR Coils.
- Bright LEDs Visible Through 135˚, > 11 Year Life (Typical).
- LEDs are Field Replaceable From the Front of Panel.
- LEDs are Available in Different Colors (Red, Amber, Green, Blue, and White).
- DC Unit Covers IEEE 24VDC and 48V/125V Ranges (38 to 140VDC).
- The Monitoring Package can be Implemented with Little or no Operator Training.
- A Retrofit Kit is Available to Provide this Enhanced Protection Package to Series 24 Lock-Out Relays Already in the Field.
- This Product is Designed and Manufactured by Electroswitch to Work Flawlessly with the Ultra-reliable, High Speed Series 24 Lock-Out Relay.
- Optional Push-to-Test.





For Theory of Operation See www.Electroswitch.com

Benefits

- Provides Local and Remote (SCADA) Annunciation of an LOR Trip Coil Failure.
- Provides Clear Warning Against Closing into a Fault.
- Saves Panel Space.
- Reduces Purchase and Installation Cost.
- Easy to Use. . .No Special Operator Training.

How it Works

When the LOR is in the RESET position, one high visibility LED on the nameplate glows a continuous GREEN, giving local indication that coil continuity is intact and the Lock-Out Relay is ready to respond to a trip signal. Should the coil fail, the LED extinguishes and a built-in solid state contact closes, sending a warning signal to SCADA.

In the TRIP position, the red LED functions as a Trip Signal Monitor. As long as the Trip Signal is present on the LOR coil, the LED glows a continuous RED as a warning against resetting into a fault and possibly damaging the LOR coil. Other LED colors available (Amber, Blue and White).

The new design also retains the proven mechanical orange/black flag to indicate a trip. Contact your local Electroswitch Representative or call us directly for more details on how we can put the Electroswitch tradition of value and innovation to work for you.

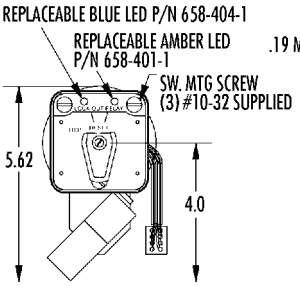
Ordering Information

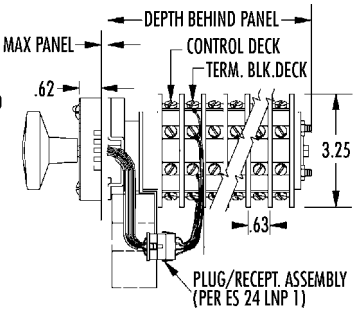
Part Numbers for the Series 24 LORs with Lighted Target Nameplate are fairly simple. Find the part number of the product you wish to order in the Electroswitch catalog, then simply add a two letter code after the second digit in its part number. The first letter of the two letter code will always be " P " indicating a Lighted Target Nameplate. The second letter of the code will change depending on the other options as follows.

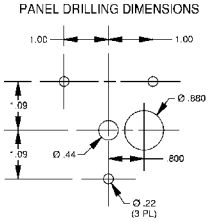
A = One LED, 48/125VDC **B** = Two LEDs, 48/125VDC **K** = Two LEDs, 24VDC
Please Specify LED Colors. **Color Options** - Red, Green, Amber, Blue and White.

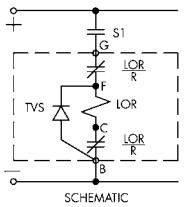
Example:
A Series 24 Manual Reset Lock-Out Relay with one deck and Trip Coil 'D' is part number **7801D.** The same Lock-Out Relay with a Lighted Target Nameplate, Two LEDs, and 48/125VDC LED voltage would become part number **78PB01D**.

Consult factory for 24VDC, 250VDC, and retrofit kits.







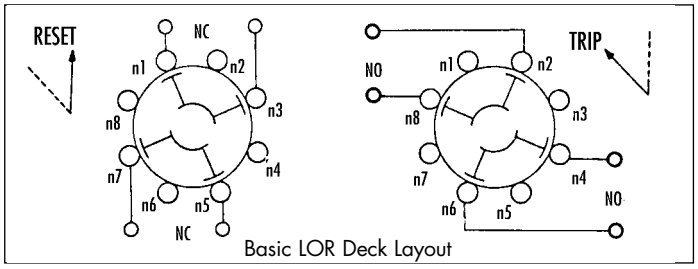


Depth Behind Panel

Decks	Depth
1	4.28
2	5.03
3	5.40
4	6.15
5	6.90
6	8.15
7	8.78
8	9.15
10	10.28

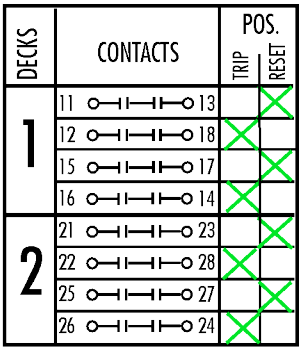
FEATURES

Typical Contact Deck Arrangement



Basic LOR Deck Layout

The blade and terminal configuration enables the use of multiple contacts in the same deck, and simple stacking procedures enable the fabrication of many independent contacts in one relay. Specifically, two N/O contacts and two N/C contacts are provided in each deck, and up to ten decks can be stacked, resulting in a relay with up to forty contacts (twenty N/O and twenty N/C). **For good practice, however, it is suggested that polarized voltages should not be used on adjacent contacts. This is because of the remote possibility of flashover during transition between adjacent contacts -- especially at the higher DC ratings, or in highly inductive circuits.** The illustration shows a single deck. For multideck units the second digit of the terminal number is the same as shown, but the first digit changes to denote the deck number. As an example, terminal 82 is in the eighth deck, directly under terminal 12 and is connected to terminal 88 in the trip position.



Contact Charts

The illustration shows decks one and two of a typical Series 24 LOR and graphically describes the operation of the contacts.

Target Used with Lock-out Relays

All the Lock-out Relays have a mechanical target as part of the nameplate – BLACK for RESET and ORANGE for TRIP. This indicates the condition of the LOR. The target resets when the LOR resets (with the exception of the high-speed trip electric-reset LOR/ER and self-reset LOR/SR where the memory target is manually reset).

Contact Ratings

Contact ratings for LOR

Contact Circuit Volts	Interrupting Rating (AMPS) Resistive Single Contact	Interrupting Rating (AMPS) Inductive* Single Contact	Short Time Rating** (AMPS)	Continuous Rating (AMPS)
125VDC	5	2	60	30
250VDC	3	1	60	30
120VAC	20	20	60	30
240VAC	15	10	60	30
480VAC	7.5	5	60	30
600VAC	6	5	60	30

* AC PF = 0.4; DC L/R = 0.04 ** Short time current is for one minute

The interrupting ratings are based on a 10,000 operation life at rated voltage with no extensive burning of contacts. Short time and continuous ratings are based on temperature rise in contact members and supporting parts not to exceed 50° above ambient.

UL file No. E80080

- IEEE Std. 323 - 1984
- IEEE Std. 344 - 1987
- CE

Trip Speed in Lock-Out Relays

The manual reset Series 24 LOR has a nominal trip speed of less than 8 milliseconds at rated voltage as tested on 10 deck units. There is very little difference in LORs with fewer decks.

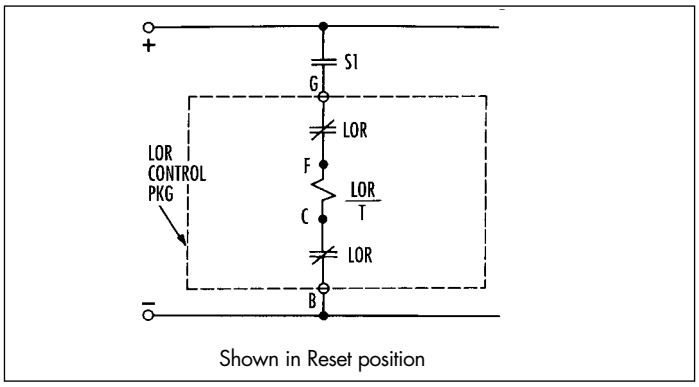
Both the Electric Reset and the Self Reset LORs are available in Standard Trip and High-Speed Trip configurations.

- **Standard Trip** models operate in approximately 12–15 mSec and come equipped with the standard LOR target nameplate or the optional LOR Monitor Nameplate.
- **High Speed Trip** LOR/ER models have the same 8 mSec trip speed as the Manual Reset LOR and come equipped with the Memory Target which displays an orange flag until it is manually reset.
- **Lighted Nameplate** with multiple LED indicators is available for all Series 24 LORs.

OPTIONS

Manual Reset LOR

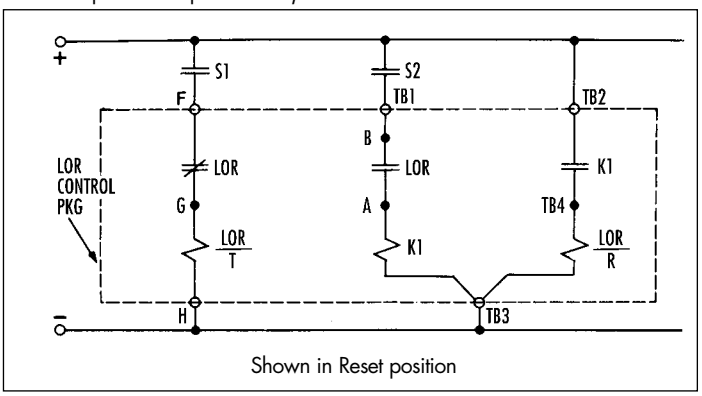
Closing S1 energizes the linear solenoid $\frac{LOR}{T}$ which releases the trigger mechanism and causes the LOR to snap to the Trip position. The control deck blades rotate to interrupt current flow to the coil.



Shown in Reset position

Electric Reset LOR

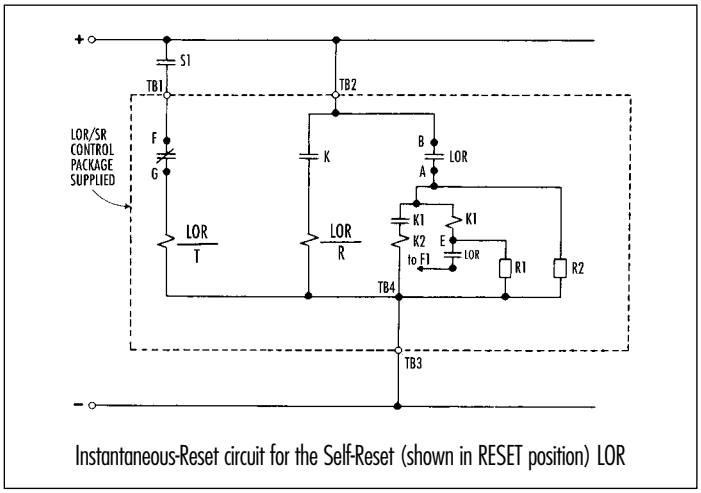
The Electric Reset LOR is tripped by the same method as the Manual Reset LOR. In the Trip position, closing S2 operates relay K1 which closes relay contact K1. The current then flows through solenoid $\frac{LOR}{R}$ which rotates the LOR/ER back into the reset position, while at the same time terminals A-B open to interrupt the K1 relay. Transition time is 80mSec.



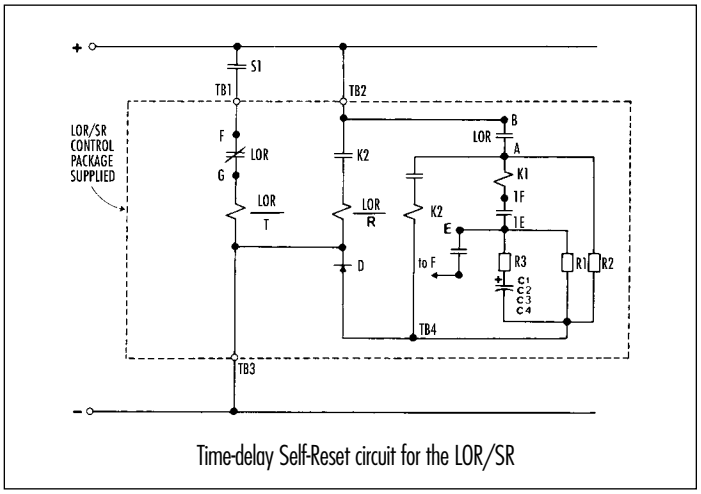
Shown in Reset position

Self Reset LOR

The Self Reset LOR is a special Electric Reset LOR which can be both TRIPPED and RESET from a single command contact. In both diagrams below, closing S1 will cause the LOR/SR to snap to the TRIP position. The unit will remain in TRIP as long as S1 remains closed. When S1 is opened, K1 is picked up and the LOR/SR returns to the reset position. The Instant Reset LOR/SR will reset itself within 80mS of the opening of S1. The Time Delay LOR/SR has factory preset circuitry which causes a time delay of .3 to .6 seconds from the time S1 opens until the LOR/SR contacts reclose.

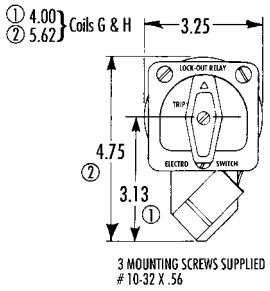


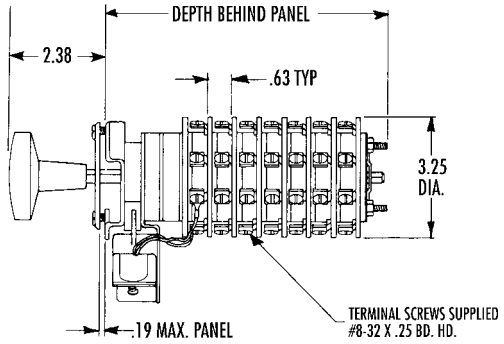
Instantaneous-Reset circuit for the Self-Reset (shown in RESET position) LOR

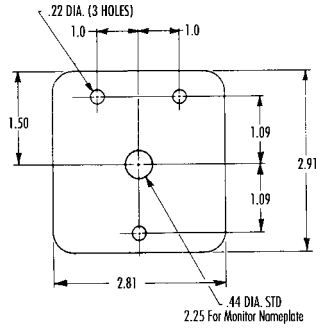


Time-delay Self-Reset circuit for the LOR/SR

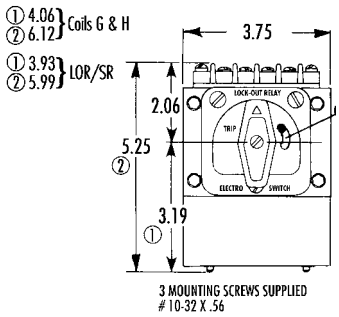
SERIES 24 MANUAL RESET LOR

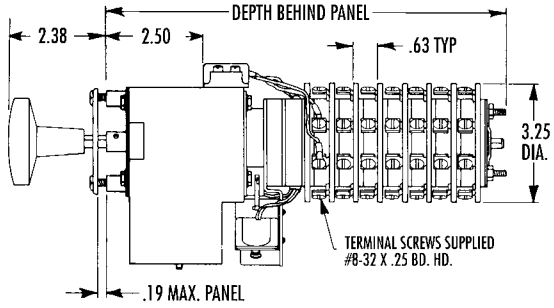


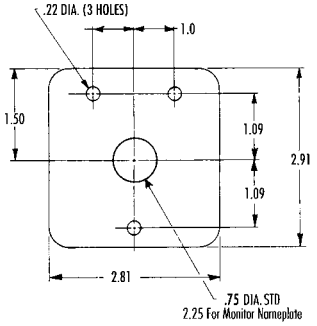




SERIES 24 LOR/ER, LOR/SR ELECTRIC RESET & SELF-RESET







DEPTH BEHIND PANEL

NO. OF DECKS	MAN. RESET LOR	HI SPEED TRIP LOR/ER	LOR/ER AND INSTANT LOR/SR TIME DELAY	RESET LOR/SR
1	3.63	–	–	–
2	4.38	–	–	–
3	4.75	8.00	8.00	8.63
4	5.50	–	–	–
5	6.25	9.75	9.75	10.38
6	7.50	–	–	–
7	8.13	–	–	11.63
8	8.50	11.63	11.63	–
10	9.63	12.90	–	–

COIL BURDEN DATA

COIL	COIL CIRCUIT VOLTS	TRIP COIL		RESET COIL	
		COIL CIRCUIT DC OHMS @25°C	BURDEN (AMPS) AT RATED VOLTAGE	COIL CIRCUIT DC OHMS @25°C	BURDEN (AMPS) AT RATED VOLTAGE
A	24VDC	3.3	7.3	.7	33.8
B	24VDC	7.7	3.1	–	–
C	48VDC	13.0	3.7	3.0	15.9
D	125VDC	27.0	4.6	12.4	10.1
E	125VDC	50.0	2.5	–	–
F	250VDC	104.0	2.4	80.6	3.1
G	125VDC	27.0	4.6	–	–
H	250VDC	104.0	2.4	–	–
K	125VDC	27.0	4.6	–	–

TRIP COIL VOLTAGE DATA

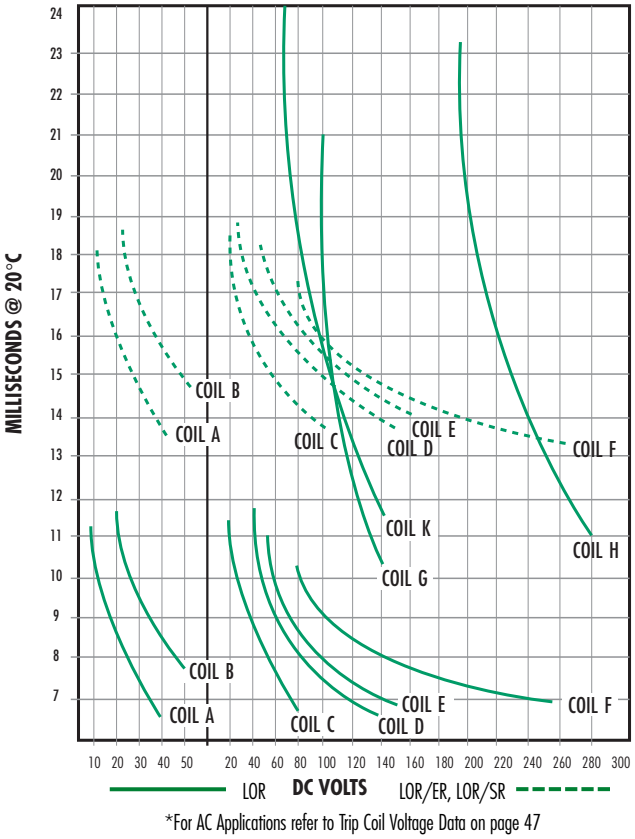
Coil	Nominal Voltage	Threshold Voltage	Operating Range
A	24VDC	6VDC	10 - 40VDC
B	24VDC	9VDC	18 - 50VDC
C	48VDC	12VDC	24 - 70VDC
D	125VDC 120VAC	16VDC 20VAC	30 - 140VDC 30 - 140VAC
E	125VDC	23VDC	45 - 140VDC
F	250VDC 240VAC	33VDC 40VAC	70 - 280VDC 60 - 280VAC
G	125VDC	70VDC	90 - 140VDC
H	250VDC	140VDC	180 - 280VDC
K	125VDC	16VDC	100-150VDC

RESET COIL VOLTAGE DATA

Coil	Nominal Voltage	Normal Voltage Operating Range
A	24VDC	19.2 to 28VDC
C	48VDC	38.4 to 57.6VDC
D	125VDC	100 to 150VDC
F	250VDC	200 to 275VDC

LOR RESPONSE TIMES*

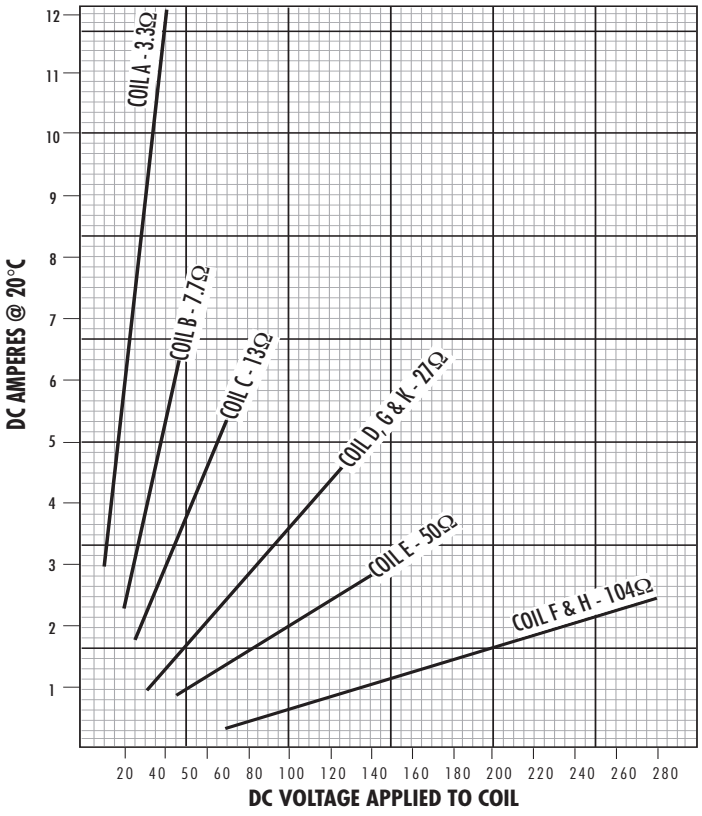
Time to Close Normally Open Contacts



*For AC Applications refer to Trip Coil Voltage Data on page 47

LOR CURRENT

Voltage Characteristics Of The Trip Coils



ORDERING INFORMATION

Selecting a Series 24 Lock-Out Relay:

1. Select type of LOR (Manual Reset, Electric Reset or Self Reset).
2. Fill out appropriate ordering matrix.
3. When selecting Trip and Reset Coils use information from tables below.
4. Contact factory for custom features and nonstandard configurations.

Manual Reset LOR

78 □□ □

Model
78 = LOR

No. of Decks
03 = 3 08 = 8
05 = 5 10 = 10

Trip Coil *(See Page 47)*
A = Coil A D = Coil D G = Coil G
B = Coil B E = Coil E H = Coil H
C = Coil C F = Coil F K = Coil K

Electric Reset LOR/ER

78 □ □ □ □

Model
78 = LOR

Configuration
2 = Std. Trip LOR/ER
3 = Hi-Spd. Trip LOR/ER

No. of Decks
3 = 3
5 = 5
8 = 8
(10 Consult Factory)

Trip Coil *(See Page 47)*
A = Coil A F = Coil F
B = Coil B G = Coil G
C = Coil C H = Coil H
D = Coil D K = Coil K
E = Coil E

Reset Coil
A = 24VDC D = 125VDC
C = 48VDC F = 250VDC

Self Reset LOR/SR

78 □ □ □ **D**

Model
78 = LOR

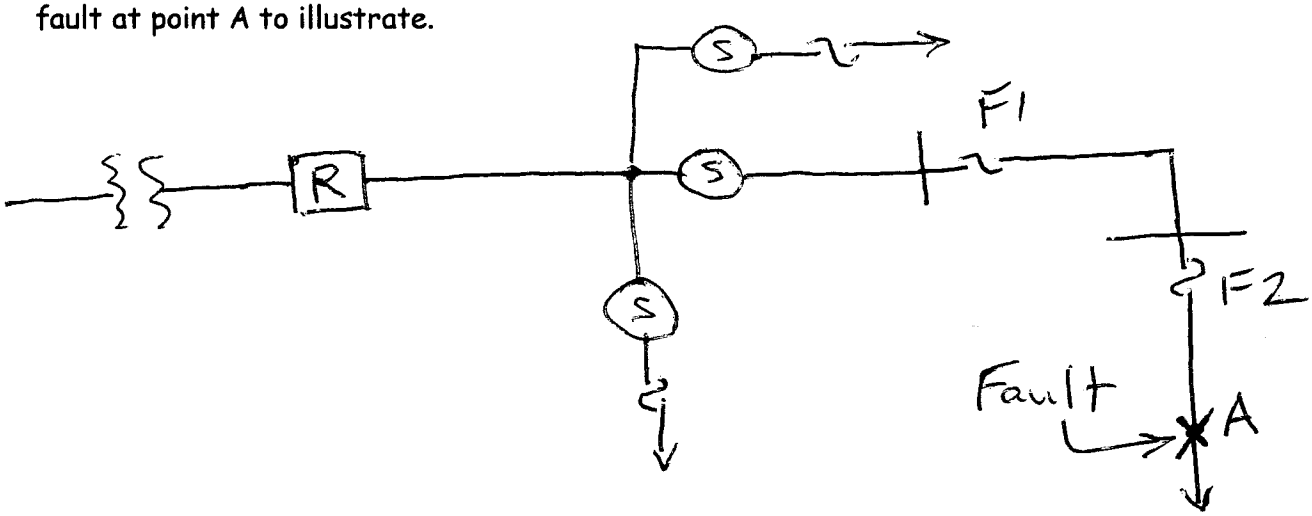
Configuration
4 = Std. Trip, Instant Reset, LOR/SR
5 = Std. Trip, Time Delay Reset, LOR/SR
6 = Hi-Spd. Trip, Instant Reset, LOR/SR
7 = Hi-Spd. Trip, Time Delay Reset, LOR/SR

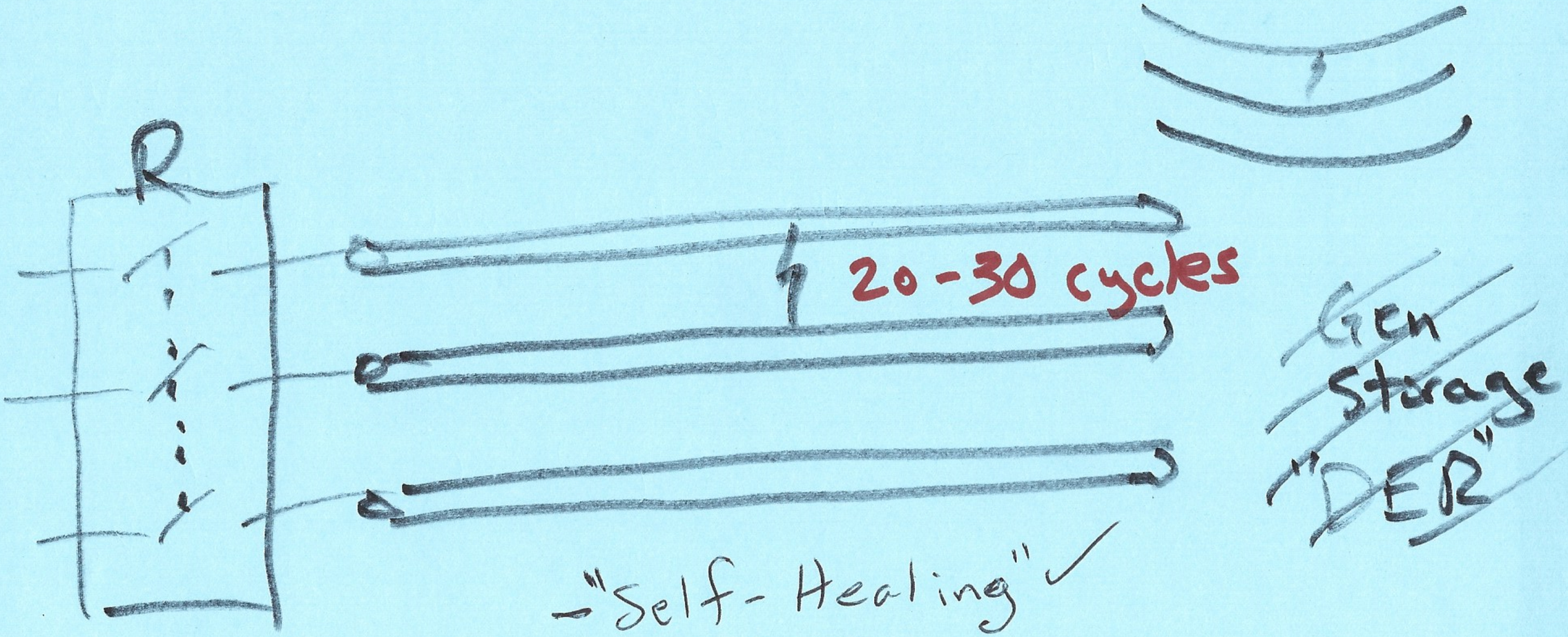
No. of Decks
3 = 3
5 = 5
7 = 7 *(time delay units only)*
8 = 8 *(instant reset units only)*

Trip Coil
D, E, F, G Available for Std. Trip LOR/SR
D, E, F Available for Hi-Spd. Trip LOR/SR

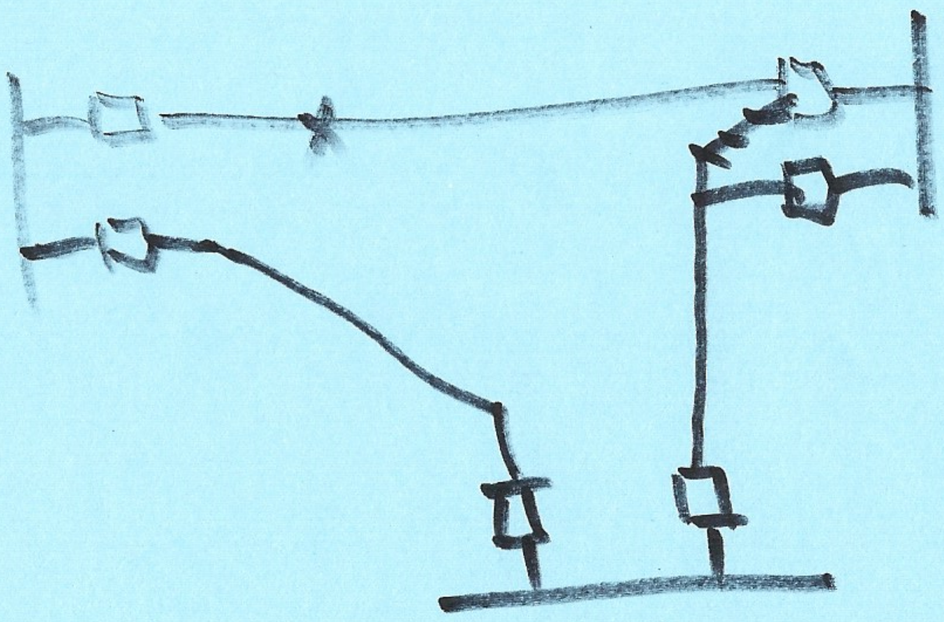
Reset Coil
D = 125VDC

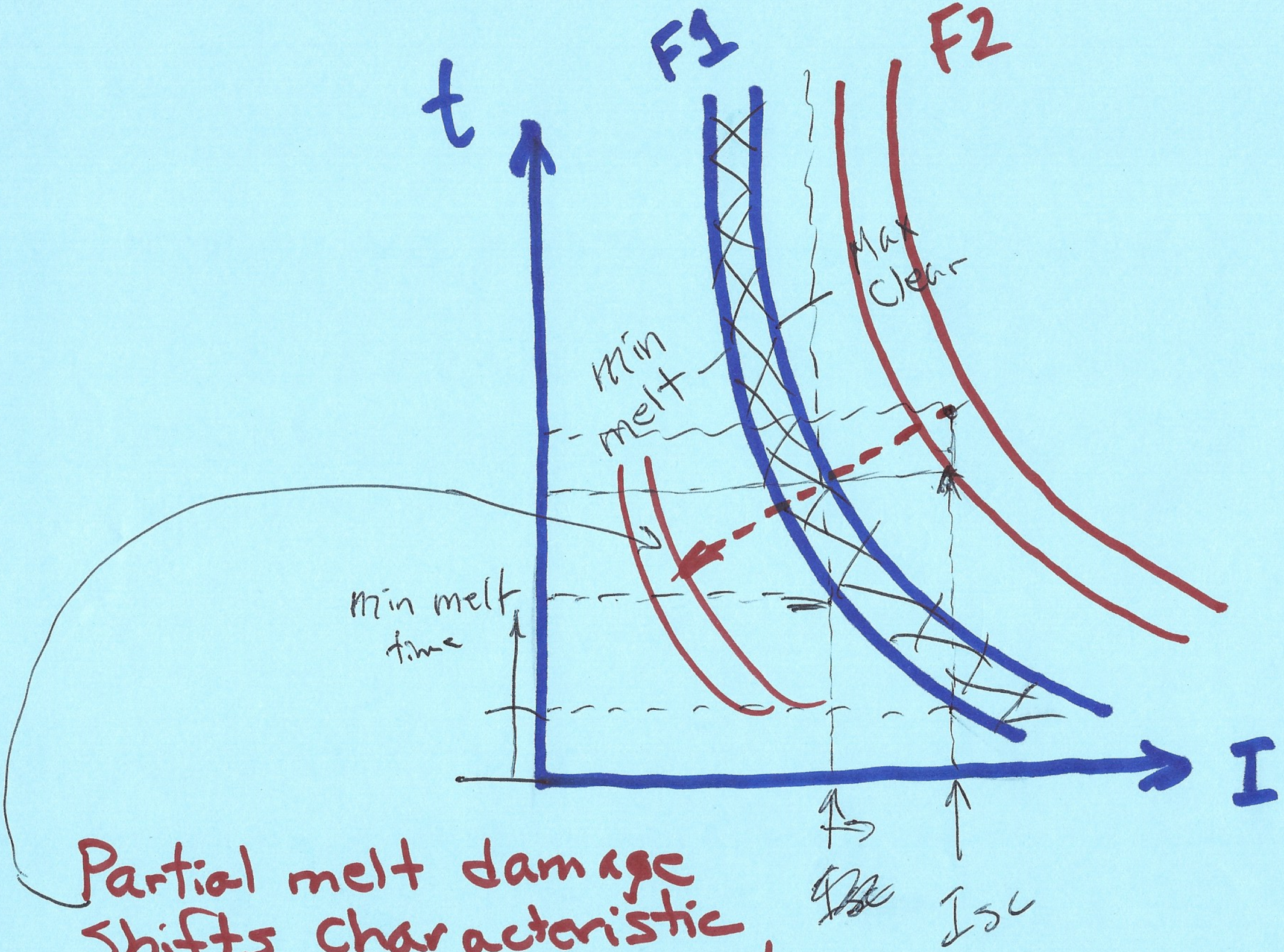
1. [13 pts] Explain how the recloser, sectionalizer, and fuses are coordinated. Use a fault at point A to illustrate.



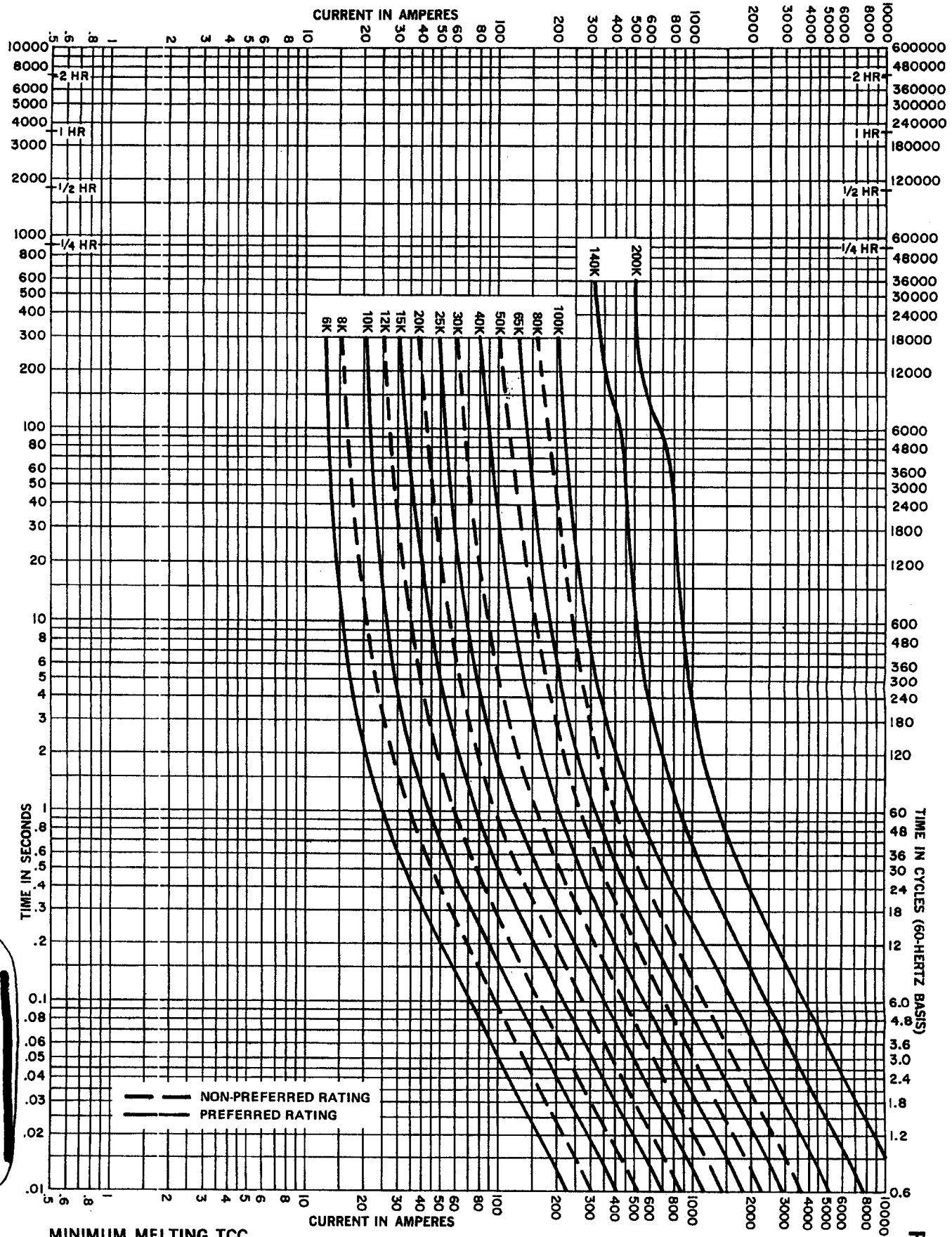


- "Self-Healing" ✓
- "Non self-healing"





Partial melt damage shifts characteristic an unknown amount!



MIN MELT

MINIMUM MELTING TCC

Curves of M-E fuse links in M-E cutouts • Basis for data: NEMA Standard SG2
Tests at 240 Volts ac, high pf, starting at no initial load, 25C
Minimum test points plotted so variations should be plus

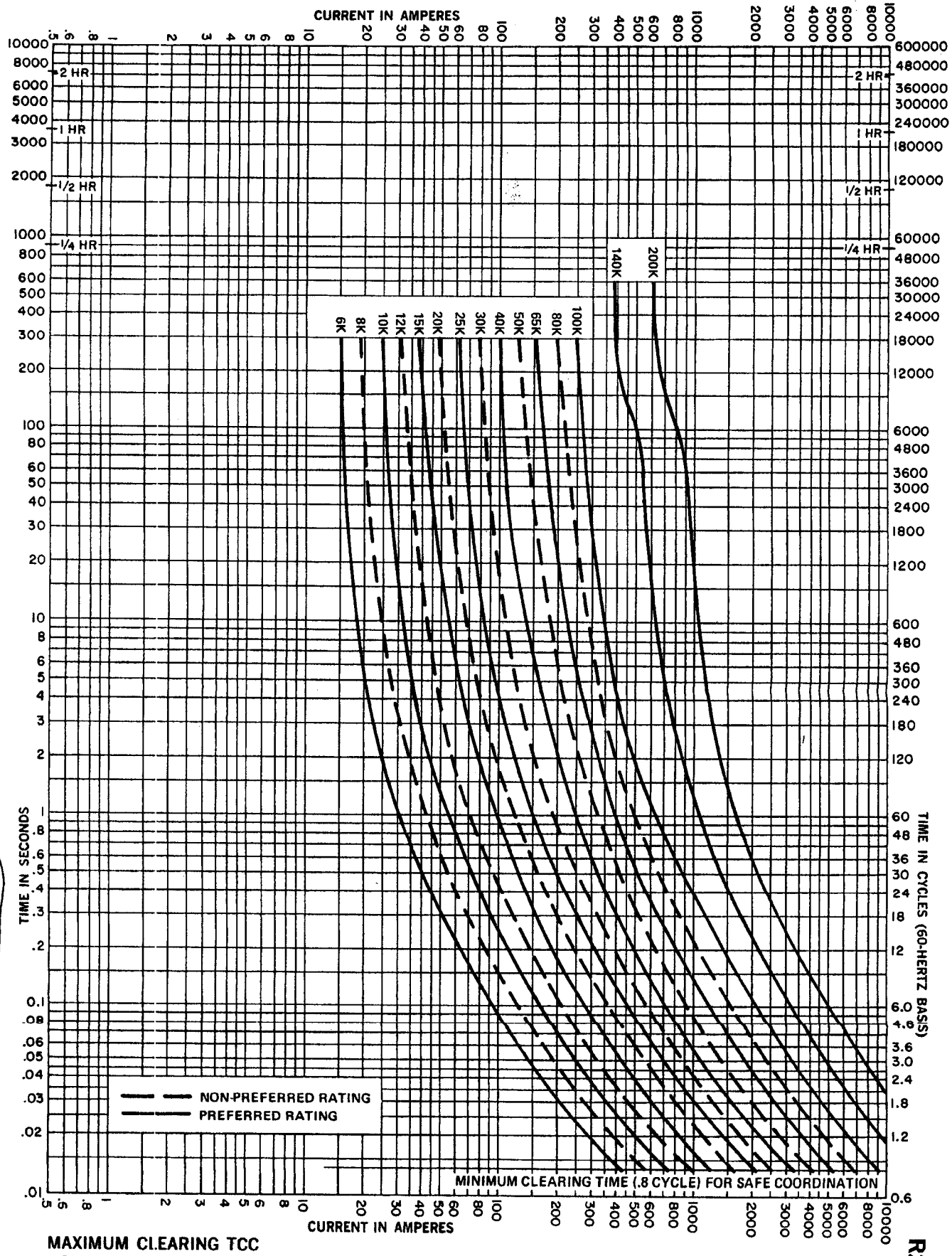
EEI-NEMA TYPE K-TIN

FL1B

McGraw-Edison Company
Power Systems Division

February 1970

Reference Data
R240-91-1
Page 1



MAX CLEAR

MAXIMUM CLEARING TCC

Curves of M-E fuse links in M-E cutouts • Basis for data: NEMA Standard SG2
Tests at rated-cutout Volts ac, low pf, starting at no initial load, 25C
Maximum test points plotted so variations should be minus

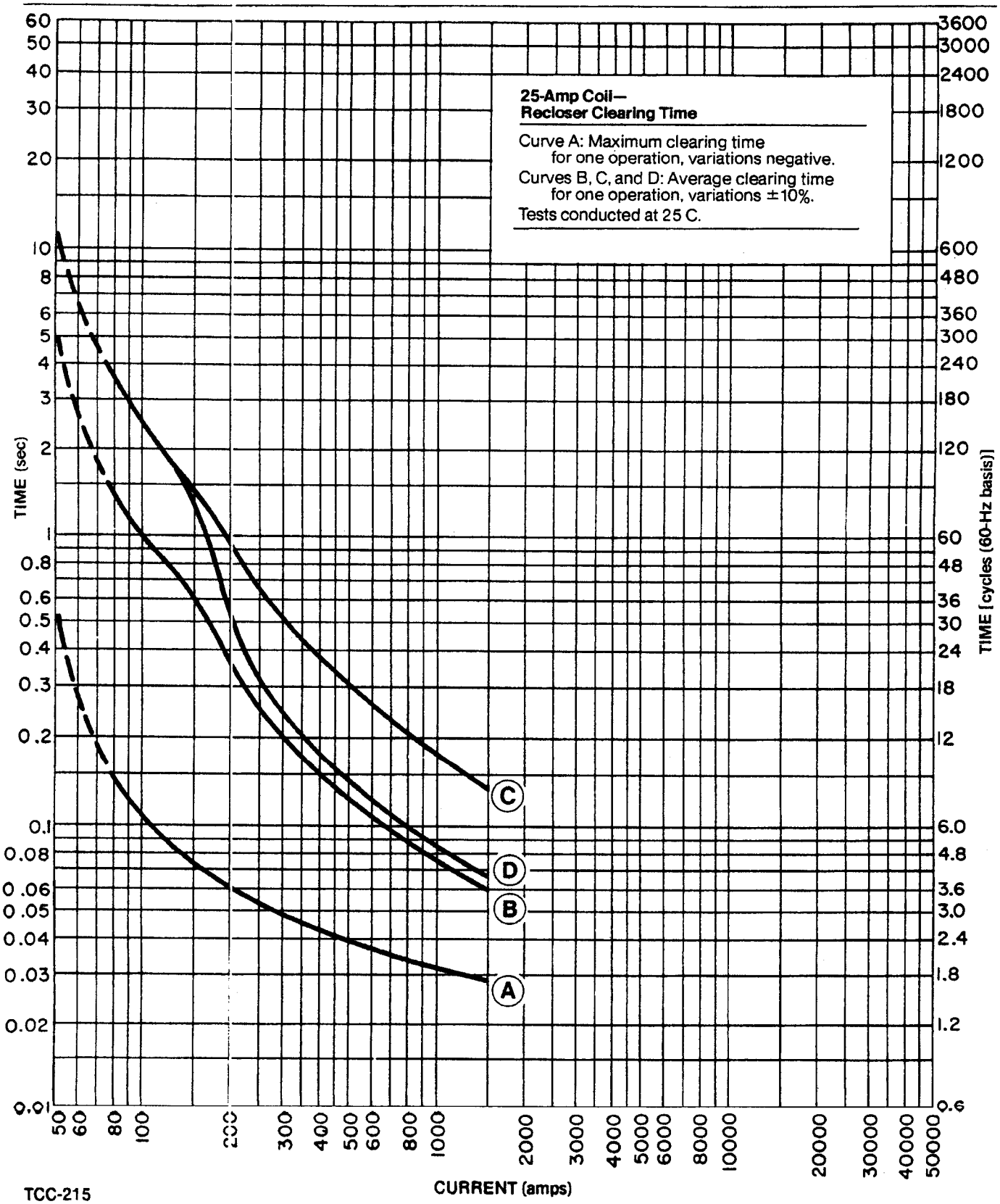
EEI-NEMA TYPE K-TIN

R240-9

Referenc

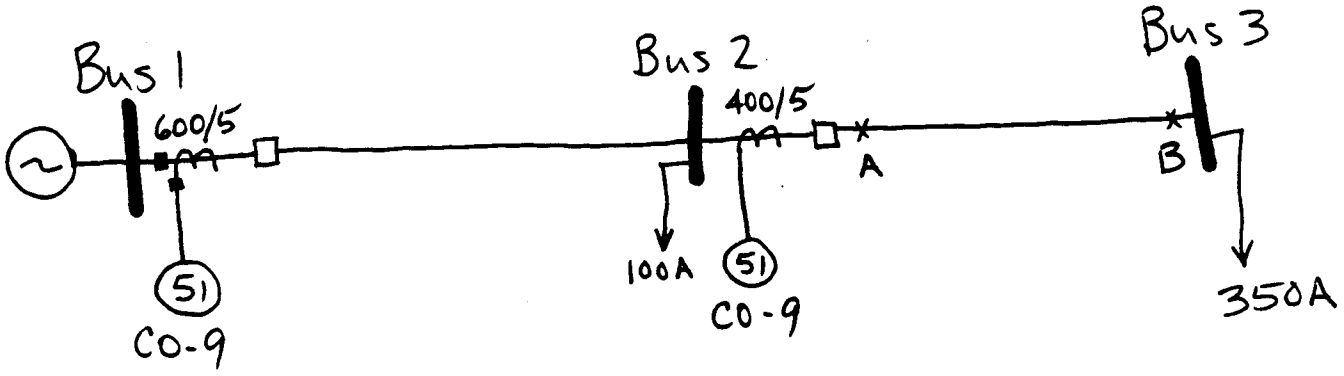
Reclosers
Type L
Time-Current Curves

R280-91-3
Reference Data



TCC-215

2. [20 pts] Two time-overcurrent relays protect adjacent sections of a radial system. Bus 3 is at the **end** of the radial line. 7000 amps of fault current will flow for a fault at point A; 5000 amps for a fault at point B. Load currents at buses 2 and 3 are 100A and 350A respectively. Loads at buses 2 and 3 have the same power factor.



a) Determine the tap settings for the relays at buses 1 and 2. Assume that taps can be set so they are just above rated load current. Available tap settings are: 1.0, 1.2, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 5.0, 6.0, 7.0, 8.0, 10.0, and 12.0 amps.

b) Keeping in mind that the relay at bus 2 protects the last section at the end of the line, what must its time dial setting be? Why?

c) Based on the fault at point A, what should the time dial setting be for the relay at bus 1? Assume that the circuit breakers operate in 4 cycles, and that the CTI is 0.25 seconds.

d) How long will it take for the relay at bus 1 to pick up for a fault at point B if the relay at bus 2 fails to operate?

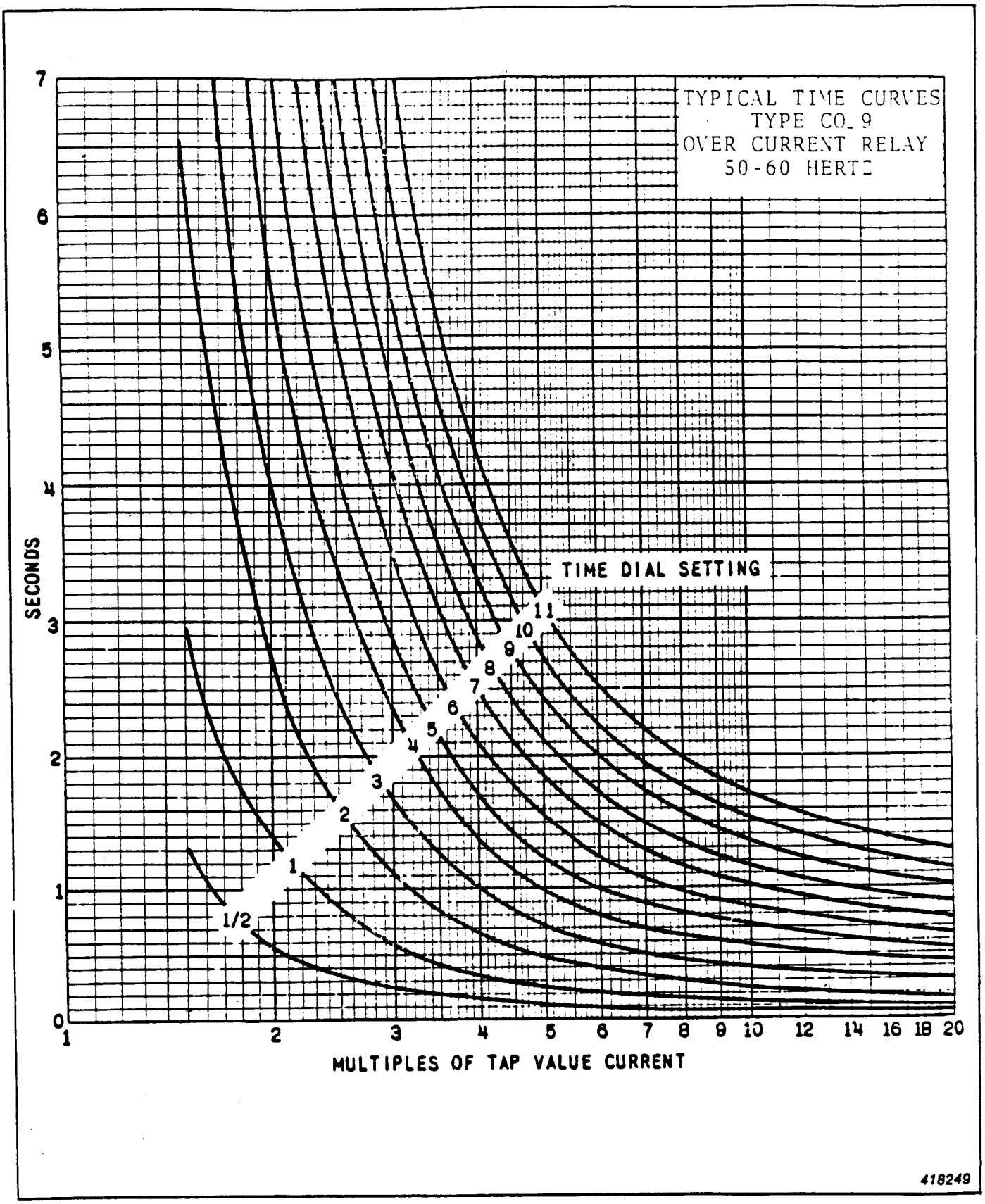
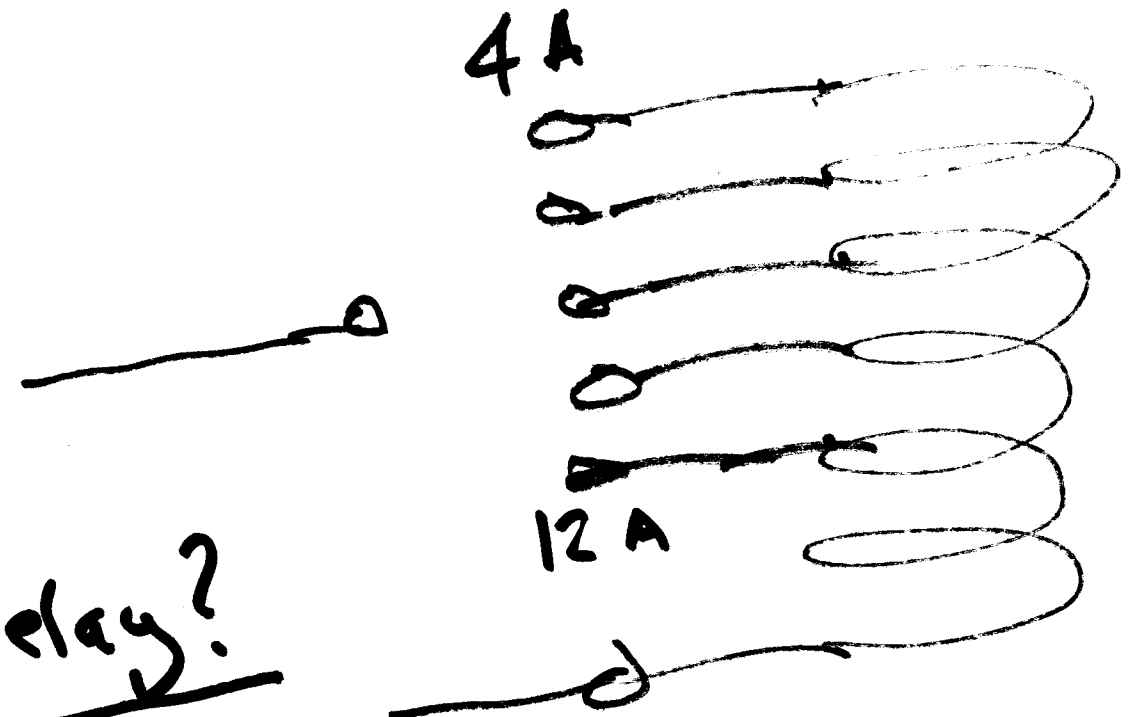


Fig. 15. Typical Time Curve of the Type CO-9 Relay

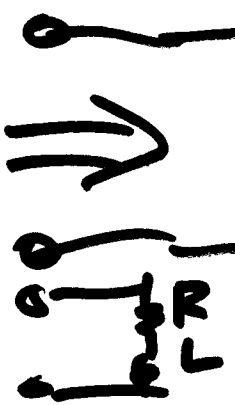


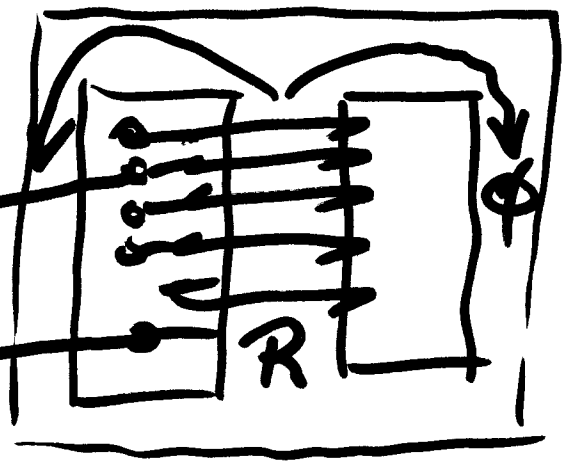
$Z_0 \Rightarrow$ Relay?

$L = \frac{N^2}{\mathcal{R}}$

$X_{60} = 2\pi f L$

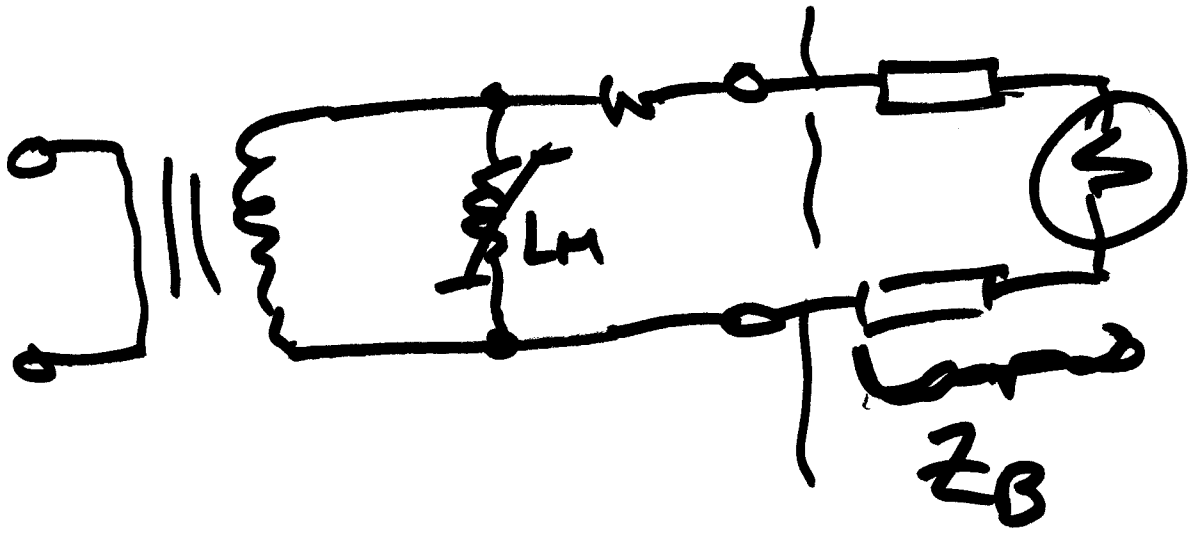
$Z_0 \Rightarrow$

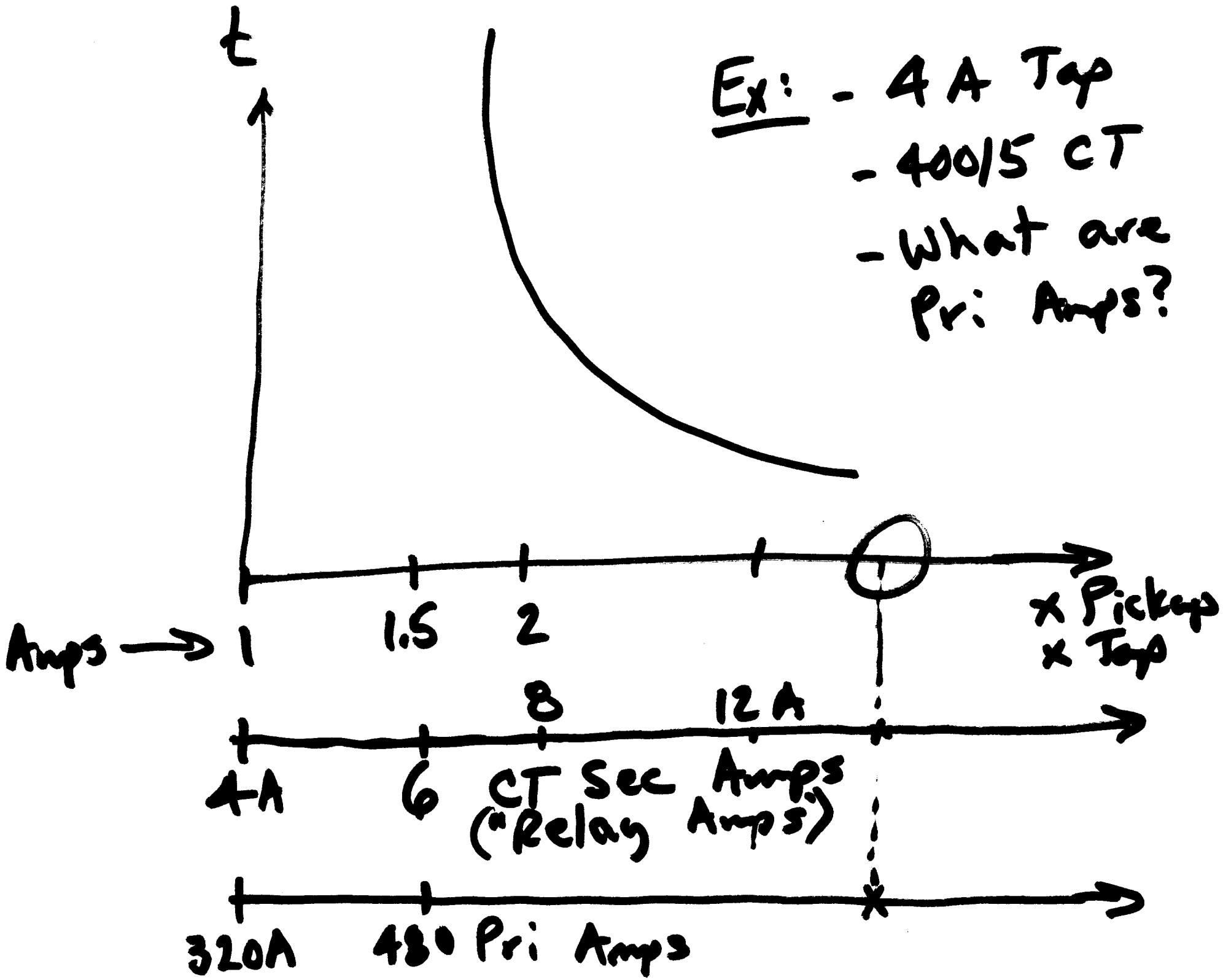


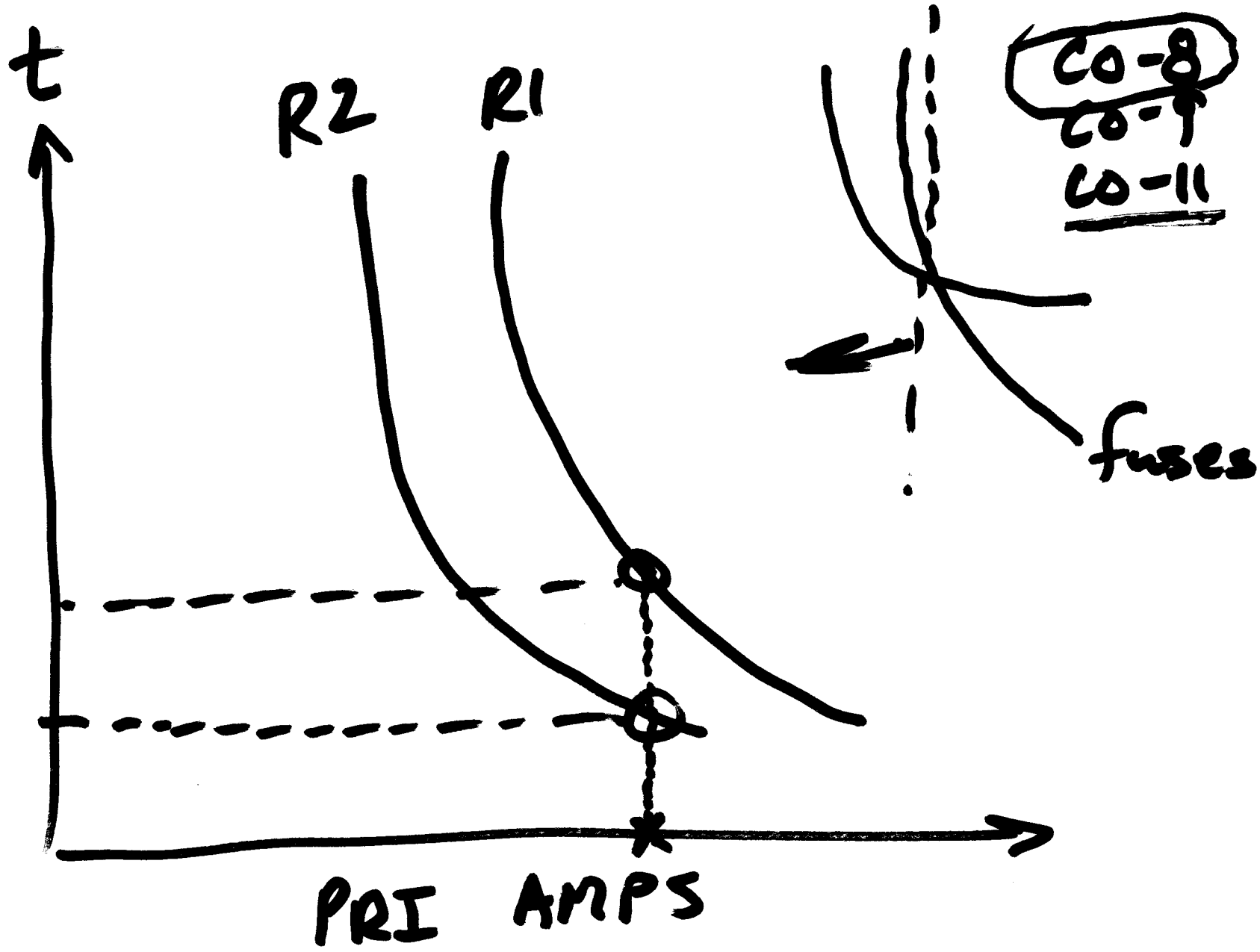


$\Phi = \frac{MMF}{\mathcal{R}}$

$= \frac{Ni}{\mathcal{R}}$


L_M
Z_B


t
Ex: - 4 A Tap
- 400/5 CT
- What are Pri Amps?
Amps →
1
1.5
2
x Pickup
x Tap
8
12 A
4 A
6
CT Sec Amps
("Relay Amps)
320 A
480 Pri Amps


t
R2
R1
CO-8
CO-9
CO-11
fuses
PRI AMPS