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VICE PRESIDENT

TELEPHONE
AREA CODE 716 546-2700

July 21, 1977

Director of Nuclear Reactor Regulation
Attn: A. Schwencer, Chief
Operating Reactors Branch #1
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Design Analysis for the Addition of a Second Level of Undervoltage Protection

Dear Mr. Schwencer:

In conformance with your request of June 3, 1977 we have performed and are enclosing a Design Analysis discussing the inclusion of a second level of undervoltage protection at Ginna Station.

Currently, Ginna has an undervoltage protection system designed to detect a complete loss of offsite power. This system was described in our letter of September 30, 1976. In addition, as described in our September 30 letter, detection and correction of a sustained degraded voltage condition at voltages above the automatic protection system is accomplished by operator action via an emergency procedure.

Based on preliminary engineering, it has been determined that the Station's susceptibility to a sustained degraded voltage can be further reduced through the use of relays (second level of protection). Specifically, the present undervoltage (loss of voltage) protection system will be retained and two additional relays (per bus) will be added to detect a sustained degraded bus voltage condition. It is expected that these additional relays will be CV-7 relays. Their set points and time lever systems will be selected to give the required characteristics as discussed in the Design Analysis.

We expect that, following receipt of approval of the modification design by the NRC, detailed engineering and procurement of equipment will require approximately 9 months. This time estimate assumes that the type relay now being considered will meet the design requirements. Installation of the second level protection system must be performed during a cold or refueling shutdown in order to avoid a possible spurious trip and would require approximately 2 weeks.

The proposed system will assure that core cooling and long term equipment operability would be accomplished in the unlikely event of a design basis accident concurrent with a degraded bus voltage condition. Relay operability requirements to assure core cooling have been derived in the Design Analysis, however specific values for relay operability to assure long term equipment operability are not available. These values are being obtained from our supplier, Westinghouse Electric Corporation. Upon receipt of this information, we will provide that information to you and suggest specific relay setpoints for inclusion in the Technical Specifications. We expect to be able to supply that information by September 30, 1977.

As you requested, we are transmitting 39 additional copies of this letter and 40 copies of the report.

Very truly yours,

L. D. White, Jr.

L. D. White, Jr.

LDW/GSL:cem

Enclosure

R. E. Ginna Unit #1

Docket No. 50-244

Second Level Under Voltage Protection

Design Analysis

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Design Analysis

1.0 Objective/Scope

A second level of undervoltage protection will be added to the 480 volt safeguard buses that will detect and take corrective action on a degraded voltage condition. This second level of protection will be in the form of redundant relaying systems. These relays will automatically disconnect, after a time delay, the safeguard buses from the degraded "offsite" power source and place them on the "on site" sources. Once operational, these relays will be coordinated with the existing undervoltage relays to afford complete protection from a sustained low voltage condition as well as complete loss of voltage. The new protection system should not increase the possibility of spurious undervoltage operation nor degrade the present system reliability in any way. Presently, this action is achieved by plant emergency procedures which require operator action to manually transfer the safeguards loads to onsite generation.

2.0 Design Inputs

2.1 Safety Evaluation and Statement of Staff Positions with attached letter from A. Schwencer, NRC, to L. D. White, Jr. RGE, dated June 3, 1977, relative to the Emergency Power Systems for Operating Reactors.

2.2 Ginna FSAR Chapter 8.

3.0 Referenced Documents

3.1 Safety Evaluation and Statement of Staff Positions Relative to Emergency Power Systems for Operating Reactors

4.0 Assumptions

4.1 Minimum bus voltage for continuous motor operation is assumed to be 90% of nameplate voltage rating.

4.2 Minimum bus voltage for full starting capability is 80% of nameplate voltage.

4.3 A degraded voltage condition is assumed when voltage is less than the minimum for continuous motor operation and greater than the minimum voltage insuring full flow with acceptable acceleration time (i.e. - 80% of nameplate voltage base). Refer to specific data below:

Description Safeguards Motor	Nameplate Voltage	Min. Voltage Continuous (90%)	Min. Starting Voltage (80%)
Auxiliary Feed Pump	440 Volts	396 Volts	352 Volts
High Head Safety Injection Pump	440 Volts	396 Volts	352 Volts
Service Water Pump	440 Volts	396 Volts	352 Volts
Air Recirculation Fans	440 Volts	396 Volts	352 Volts
Component Cooling Water Pump	440 Volts	396 Volts	352 Volts
Containment Spray Pump	460 Volts	414 Volts	368 Volts
RHR	460 Volts	414 Volts	368 Volts

Loss of Voltage Relay @ 90% of setpoint 300 volts

The two safeguards motors rated at 460 volts will be used in the analysis, thereby identifying the degraded voltage condition to be in the range from 414 volts down to 368 volts.

4.4 A loss of voltage condition is assumed when bus voltage is below the minimum required to achieve full flow.

4.5 Time Delays:

In order to prevent spurious tripping of the voltage degradation relays due to transient voltage dips, a time delay will occur between the detection of a degraded voltage condition and the opening of the off-site feeder breaker. The allowable time delay will be constrained by the following assumptions:

(a) A safety injection signal may be received at any time, prior, during, or after the occurrence of the degraded voltage condition.

(b) Normal functioning of engineered safety features is assumed when bus voltage is above the minimum voltage required for full starting capability (80% nameplate voltage).

(c) No credit is taken for engineered safety features operation when bus voltage is at or below the minimum voltage for full starting capability.

(d) The allowable time delay, when the voltage is degraded, but above the minimum voltage for full starting capability, is constrained by the maximum time that the motor can operate in this voltage region, without thermal degradation.

(e) The allowable time delay, when the voltage is degraded, and at or below the voltage for full starting capability is constrained by the maximum time delay that is assumed in the FSAR accident analysis. This time delay is specified in Table 8.2-4 of the Ginna FSAR, and requires safeguards buses to be energized 10 seconds after the safety injection signal.

(f) The time delay will include the tolerances for relay operation.

(g) The time delay will exceed the duration of transient voltage drops due to loading of safety or non safety equipment on the safeguards buses, with sufficient margin to assure that spurious tripping of the voltage degradation relays will be highly unlikely.

(h) When the diesel generator is operating at rated speed and voltage, a time delay of 1 1/2 seconds is required for the transfer of the safeguards bus from offsite power to the diesel generator. This time delay is required to allow residual bus voltage to decay sufficiently to allow an out-of-synchronization transfer without the danger of damaging overvoltage.

The delay times associated with the degraded voltage range defined in Section 4.3 are as follows:

Bus Voltage (degraded condition)	Desired Time Delay (prior to detection)	Comments
Bus $\geq$ 414 volts	$t = \infty$	Normal continuous operation
414 > Bus > 368 volts	t_T >t > 8.5 seconds	Full flow insured Degraded Voltage Region. Meets the 10 second delay of 8.2-4 of Ginna FSAR
Bus $\leq$ 368 volt	t $\leq$ 8.5 seconds	Loss of voltage protection
Bus $\leq$ 300 volts	t $\leq$ 4 seconds	Present loss of voltage time delay

*t_T = maximum time for motor operation without thermal degradation.

5.0 Computer Codes

N/A.

6.0 Analysis

6.1 A decreasing grid voltage results in a decreasing voltage on the safeguards buses. Since motor output torque is a function of the voltage squared and since all A.C. contactors in the IE motor control centers have a minimum pickup voltage rating, both are directly affected by decreasing bus voltages. Ginna Station has primarily d.c. type contactors which are unaffected by a degraded a.c. system. However, should a.c. contactors be utilized in the future, their pick-up voltage will be consistent with the proposed second level protection system. Therefore, this analysis will only be concerned with safeguards motors performance.

As presently configured, Ginna Station has two redundant undervoltage relays (type CV-7) per bus and each relay has a setpoint of 82 volts (secondary) with either a 1 or 1 1/4 time lever setting (TLS). Figure I shows the operating characteristics for this device, while Figure II includes a plot of the 82 volt - 1 TLS setpoint. From Figure II it can be seen that the bus voltage must drop to 300 volts or below for this loss of voltage system to operate in under four seconds. For an instantaneous loss of bus voltage (including the natural decay time of the system) the relay will operate in .75 - 1.25 seconds depending on the time lever setting and the bus loading. This system will be retained to afford loss of voltage protection. The setpoint may be changed to achieve better coordination with the proposed second level system. Also shown on Figure II is an alternate setpoint of 93 volts. This gives the system a faster response to a loss of voltage.

The degraded voltage has been identified as bus voltages less than 414 volts but greater than 368 volts. The time at which the bus will be permitted to remain within this degraded voltage range will be 8.5 seconds at 368 volts and then gradually increased to allow long term operation at 414 volts. The justification for the 8.5 second limit is discussed in Section 6.2. If both the degraded voltage range and the allowable times permitted within this range are translated onto a relay curve, the dotted limits shown on Figure II are obtained.

The second level of undervoltage protection will be a device (relay) that will follow this limit line and will allow operation on degraded offsite power for only those combinations of voltage and time illustrated by the curve labeled "Proposed Second Level Curve" shown on Figure II.

It is anticipated that a CV-7 relay can be used in this application with a setpoint of 105 volts and time lever setting of 2. This 105 volt setpoint corresponds to a primary voltage of 420 volts which is slightly higher than the 414 volt minimum level permitted for continuous operation.

It should be noted that if the second level detection system is in fact a CV-7 relay or similar device, it will be operating in a region higher than 90% of its setpoint. The actual inherent time delay of such a device in this region can only be determined by test. After making the necessary adjustments to the relays proposed for second level detection, the time responses will be faster than the maximum times that the safeguards motors can operate in this voltage region without thermal degradation.

Figure II illustrates both the proposed second level system as well as the existing loss of voltage system and expresses bus voltage in terms of secondary voltage (i.e. 120 volt base). The following conversions are offered for convenience:

Primary Safeguards Bus Voltage	Corresponding Secondary Voltage	Comments
480 volts	120 volts	Rated bus voltage
414 volts	103 volts	Minimum voltage for continuous operation
368 volts	92 volts	Minimum bus voltage in the degraded rang 8.5 second maximum allowable time at this point
less than 368 volts	less than 92 volts	Loss of voltage range - allowable time in this range must be less than 8.5 seconds
420 volts	105 volts	Proposed setpoint of CV-7 relay used for second level detection

6.2 In order to evaluate the effect of the time delay on the operation of engineered safety features, an analysis was performed to determine the time history of the safeguards bus voltage during a degraded voltage occurrence with a safety injection signal occurring simultaneously, before, or after. In accordance with the assumptions of section 4.2, no credit was taken for engineered safety features operation when bus voltage is below 80% of nominal motor base. When bus voltage is above 80% but below 90% nominal, in accordance with section 4.2, it is assumed that engineered safety features function normally and that the time delay is constrained by the requirement that no thermal degradation occur to the motor. Only the case of voltage degradation below 80% nominal is addressed in the following analysis.

In general, the time period in which the safeguards bus is deenergized, is given by the following relation with the time at which the safety injection signal occurs as the independent variable.

$T_L = T_D + T_T$	$t_s < t_v$
$T_L = t_v + T_D + T_T - t_s$	$t_v + (T_D + T_T) - \tau > t_s \geq t_v$
$T_L = \tau$	$t_v + T_D > t_s \geq t_v + (T_D + T_T) - \tau$
$T_L = t_v + T_D + \tau - t_s$	$t_v + T_D + \tau > t_s \geq t_v + T_D$
$T_L = 0$	$t_s \geq t_v + T_D + \tau$

where,

T_L = time safeguards bus deenergized (dependent variable)

T_D = voltage degradation relay time delay

T_T = transfer time

τ = time for diesel generator to reach rated speed and voltage.

t_v = time at which degraded voltage condition occurs

t_s = time at which safety injection signal occurs (independent variable)

In the Ginna Nuclear Plant design, the values of τ and T_T are fixed at 10 and 1.5 seconds, respectively. To assure that the safeguards bus is never deenergized (or degraded below 80% nominal voltage) for more than 10 seconds, the allowable time delay, T_D, must not be more than 8.5 seconds at the 80% nominal voltage level.

Using these parameters, the relation described above is shown in Figure V. From the figure it is seen that the time during which the safeguards busses are unavailable is never more than 10 seconds, as required in section 4.5.

6.3 Figure III shows the existing, two per bus, loss of voltage relays as 27 and 27B. The proposed second level relays are also shown as 27SL and 27B-SL. The logic as shown can be achieved by directly paralleling the existing CV-7 relays with the CV-7 second level relays on each of the four safeguards buses.

6.4 Figure IV shows the voltage profile for each safeguards train while the loads are being sequenced onto the diesel generators. From these curves it can be seen that the bus voltage drops into the degraded range during load sequencing. However, there is insufficient time for the second level relays to operate since they have a programmed time delay of 8.5 seconds at 80% of 460 volts or 77% of 480 volts. Therefore, the anticipated time for second level operation at 82.5% is much greater than 8.5 seconds (approximately 15 seconds.)

These second level relays also have a reset time of approximately 6 seconds so that as the bus voltage continually dips and recovers as each of the seven motors are started in the sequence, there will not be a time delay accumulating effect, that is, time delay sufficient to produce a trip.

6.5 Since the second level relays will be parallel to the loss of voltage relays, they too will be reinstated once the diesel generators are connected to the safeguards loads. This reinstatement is consistent with Staff position 2 and does not increase the possibility of spurious tripping during load sequencing.

6.6 The new relays to be added for degraded voltage protection will be integrated into the existing undervoltage protection system, which was designed as part of the Class IE Power System. The new undervoltage relays will therefore be designed in accordance with IEEE Std. 308-1974, "IEEE Standard Criteria for Class IE Power Systems for Nuclear Power Generating Stations" rather than IEEE 279-1971.

7.0 Test Program

To insure proper operation of both the loss of voltage relays and the degraded voltage relays as well as proper coordination, a system test will be conducted on each train. In addition, a bus voltage simulator will be used that duplicates the voltage dips shown on Figure IV plus margins. This simulator will insure that the second level relays will not operate during load sequencing. Therefore, reinstating the two undervoltage systems (loss and second level) once on "on site power" will not cause spurious tripping.

8.0 Conclusion

8.1 Based on this analysis, the proposed second level system of protection can be designed to detect a degraded voltage condition as defined herein and limit the time the safeguards buses can remain in this region so as to insure proper equipment operation without thermal degradation. This design therefore, meets the intent of Staff position 1 except for 1-e which is addressed in Section 6.6, as well as all other criteria referenced in Section 2.

8.2 Since the performance of the relaying system will be verified by tests and since the actual voltage profiles will be simulated in these tests, the possibility of a spurious undervoltage operation when on the diesel generators is greatly reduced, thus conforming to Staff positions 2 and 3.

8.3 Based on the above two paragraphs (a) the probability of an undetected undervoltage condition of any type occurring is greatly reduced and (b) the probability of a spurious operation of these protection systems is not increased.

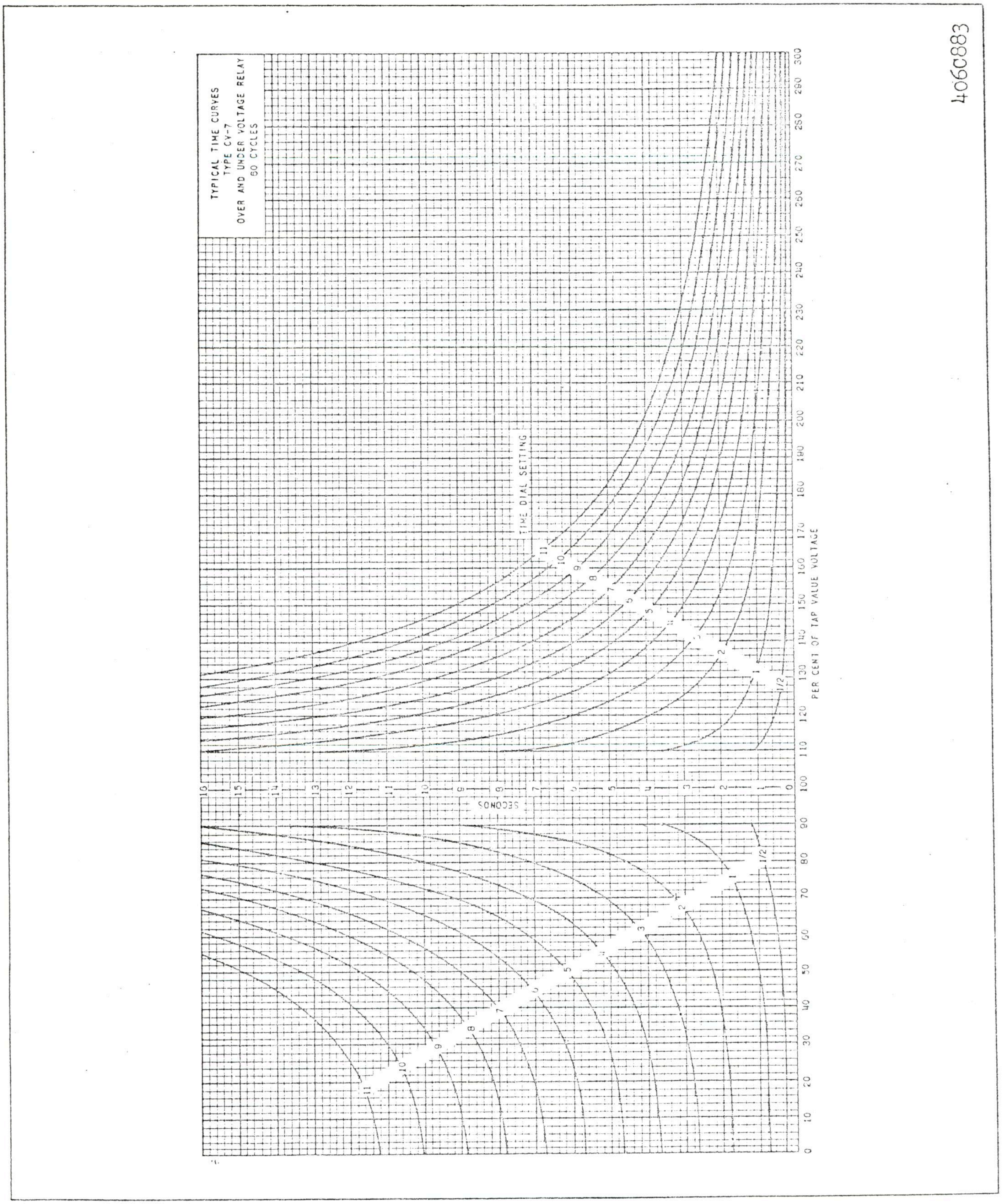


Fig. 14. Typical 60-cycle time curves of the type CV7 Short Time Over and Undervoltage Relay.

FIGURE I

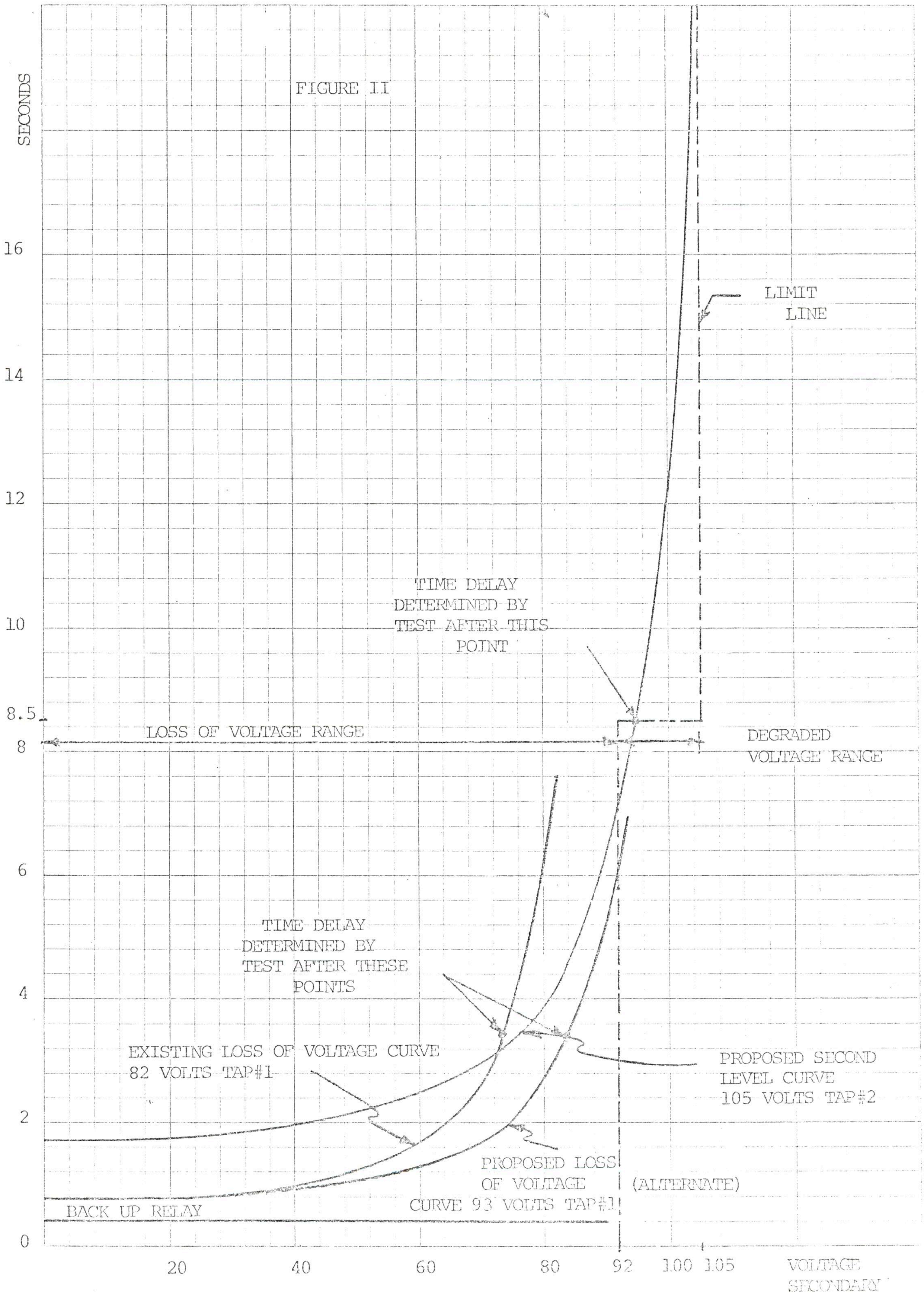
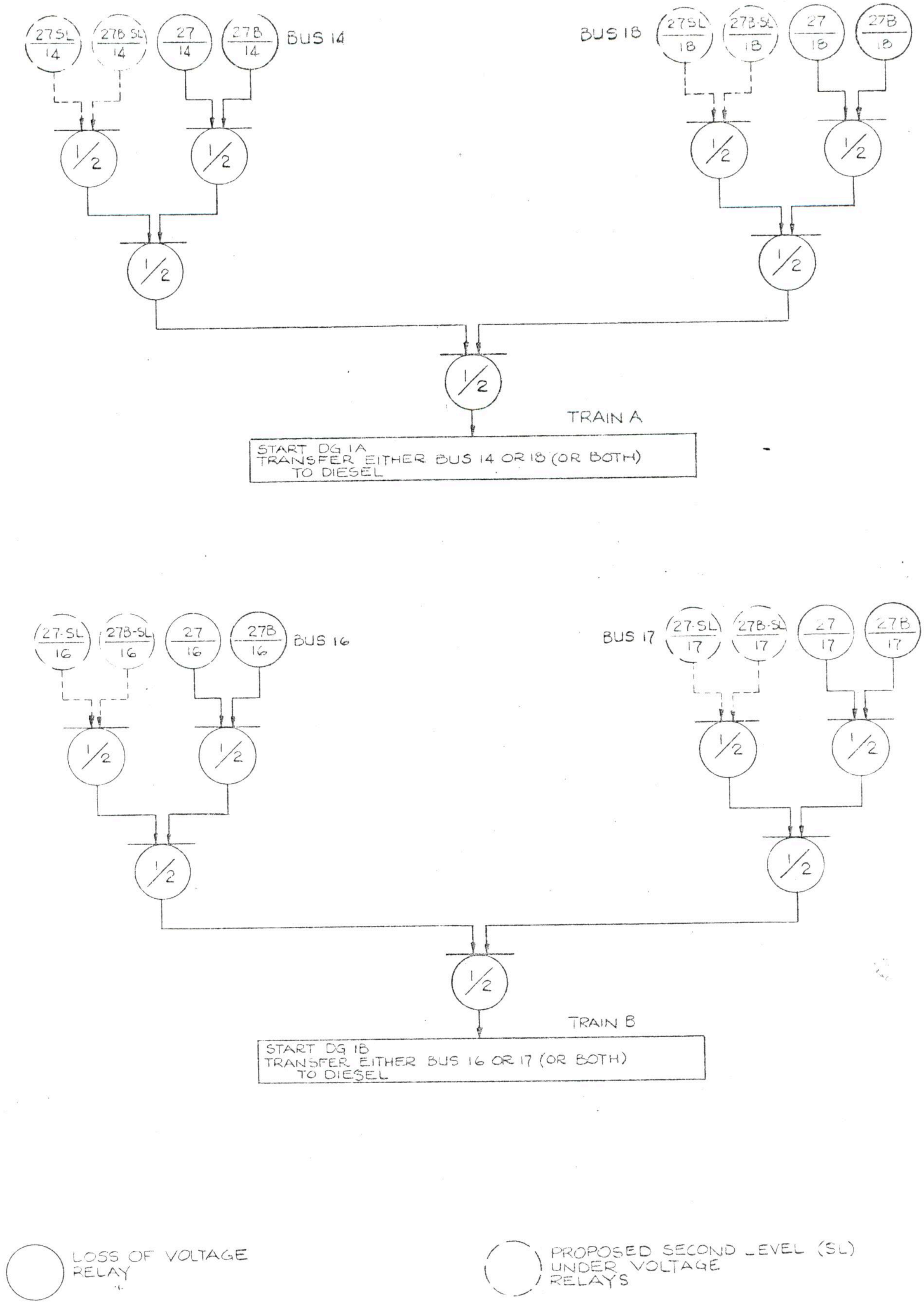


FIGURE II
SECONDS
16
14
12
10
8.5
8
6
4
2
0
LIMIT LINE
TIME DELAY DETERMINED BY TEST AFTER THIS POINT
LOSS OF VOLTAGE RANGE
DEGRADED VOLTAGE RANGE
TIME DELAY DETERMINED BY TEST AFTER THESE POINTS
EXISTING LOSS OF VOLTAGE CURVE 82 VOLTS TAP#1
PROPOSED SECOND LEVEL CURVE 105 VOLTS TAP#2
PROPOSED LOSS OF VOLTAGE CURVE 93 VOLTS TAP#1
(ALTERNATE)
BACK UP RELAY
20
40
60
80
92
100
105
VOLTAGE SECONDARY



UNDER-VOLTAGE LOGIC DIAGRAM

FIGURE III

FACILITY GINNA STA

SCALE NONE

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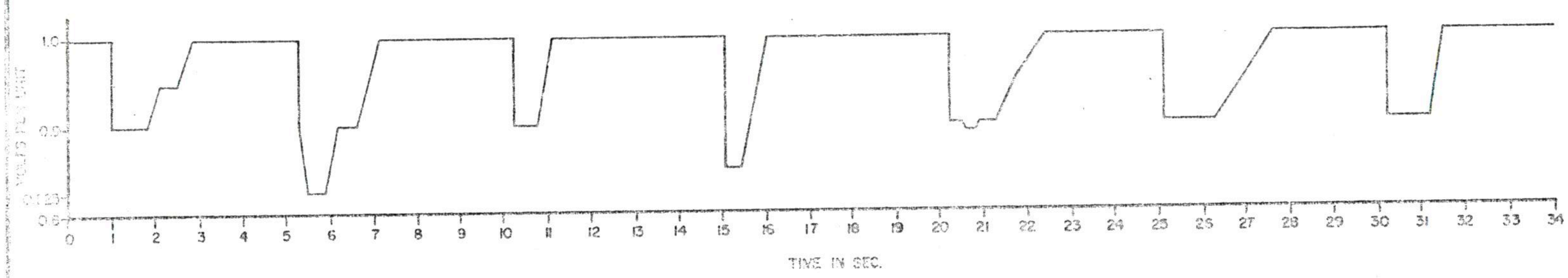
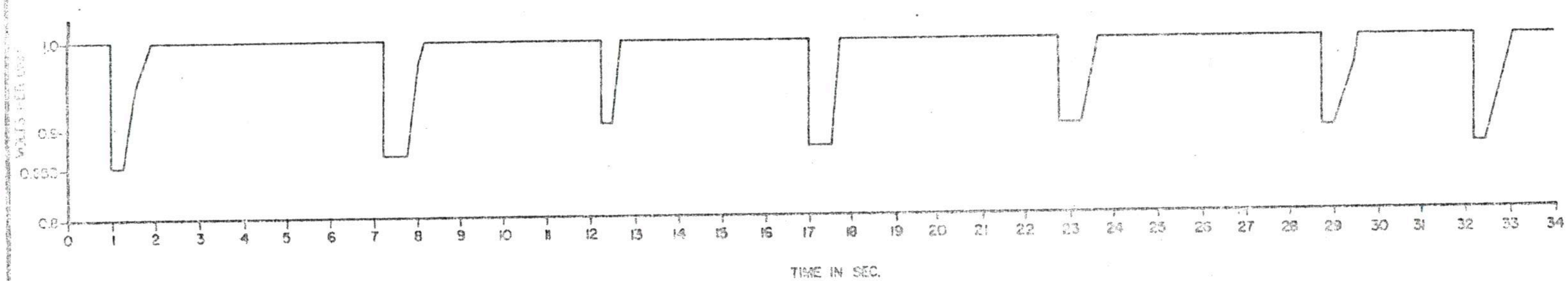
NUMBER	REVISION		DRAWN BY	CHECKED		ENG.	JOB NO.	DRAWING NO.	REV.
0	ORIGINAL	INITIAL / DATE	7-6-77					10904-43	0



TRAIN A



TRAIN B

NOTE: 1.0 PER UNIT VOLTAGE = 480 VOLTS

FIGURE IV

NUMBER	REVISION	DRAWN BY	CHECKED	RESP ENG	ENG MANGR
0	ORIGINAL — INITIAL / DATE				

FACILITY: GINNA STA.

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ROCHESTER NEW YORK

SCALE

SAFEGUARDS BUS STARTING VOLTAGE PROFILE

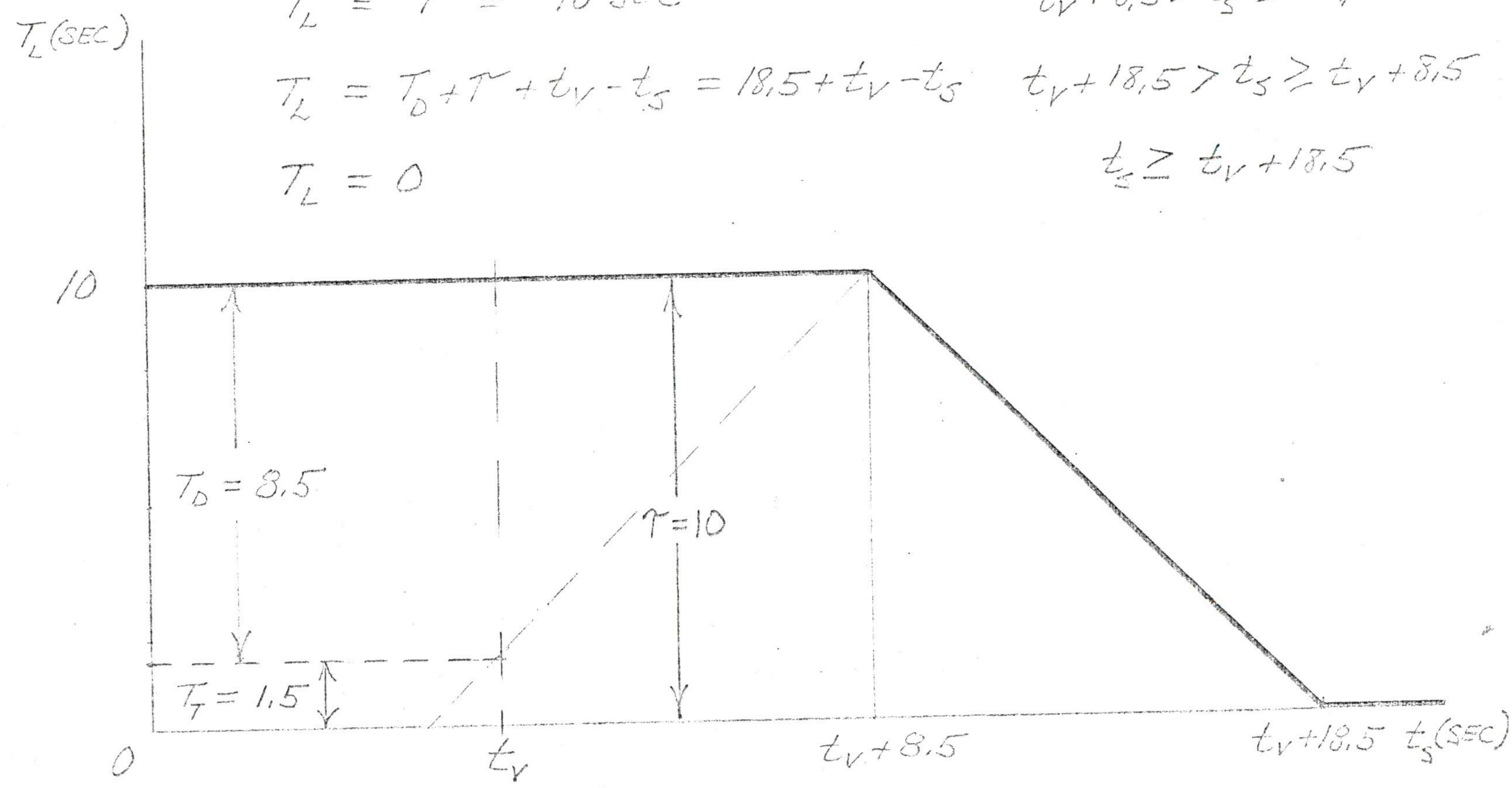
JOB NO	DRAWING NO	REV.
	SKETCH	

$$T_L = T_D + T_T = 10 \text{ SEC} \qquad t_S < t_V$$

$$T_L = \tau = 10 \text{ SEC} \qquad t_V + 8.5 > t_S \geq t_V$$

$$T_L = T_D + \tau + t_V - t_S = 18.5 + t_V - t_S \qquad t_V + 18.5 > t_S \geq t_V + 8.5$$

$$T_L = 0 \qquad t_S \geq t_V + 18.5$$



TIME DURATION OF DEGRADED SAFEGUARDS BUS VOLTAGE AS A FUNCTION OF THE TIME AT WHICH SAFETY INJECTION SIGNAL OCCURS

FIG V

ENG. DEPT.	STATION:	DATE:	PAGE OF
JOB:		MADE BY:	CK:

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