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Westinghouse Astronuclear Laboratory

Operational Manual for ETS-1 TSCS Drum Control and Sub-Power
Controller Chassis

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Drum Control and Sub-Power Controller
Chassis

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DRUM CONTROL AND SUB-POWER CONTROLLER OPERATIONAL MANUAL

1.0 INTRODUCTION

This operational manual contains the general description, theories of operation, calibration procedures, maintenance and repair data for the WANL Drum Control and Sub-Power Controller Chassis.

1.1 General Description

The WANL Drum Control and Sub-Power Controller Chassis is a rack mounted, all solid-state control unit for manually checking out, from the test cell building, the actuators and drums of the test NERVA engine. Controls and indications are provided for selecting, unlocking and exercising individual drums. Conveniently located test jacks permit the introduction of forcing function input signals, as well as the measuring of the response and other signals in the drums control system.

The Drum Control and Sub-Power Controller provides signals for the Actuator Amplifier Units which, in turn, command and control the actuators and drums of the NERVA engine.

2.0 GENERAL DATA

2.1 Safety Precautions

No special safety precautions need to be observed since the only voltages present are 28VDC, ± 15 VDC, and ± 10 VDC. Corrective maintenance, component removal, or servicing should be performed with the cables disconnected from their plugs and sockets.

2.2 Weight and Dimensions

The WANL Drum Control and Sub-Power Controller Chassis has the following physical characteristics:

Weight 26.0 lbs.

Size 19.0" wide

7.0" high

23.0" deep

2.3 Power Requirements

Power requirements for the WANL Drum Control Chassis are as follows:

28VDC at 2.0 amps

+15VDC at .5 amps

-15VDC at .25 amps

+10VDC at .012 amps

-10VDC at .012 amps

Power is supplied to the chassis by means of the power cable W98 plugged into connector J1 at the rear of the chassis.

2.4 Heat Dissipation

No special heating or cooling methods or systems are required for the Drum Control Chassis. Solid-state devices mounted on printed circuit cards and assembled in rows allow a free flow of air through the chassis drawer.

2.5 Design Characteristics

The Drum Control and Sub-Power Controller Chassis design incorporates solid-state devices with their inherent long life and reliable operation. Using good commercial practices as well as the high standards of military specifications insures a long, trouble-free operation.

3.0 DRUM CONTROL CHASSIS DETAILED DESCRIPTION

3.1 The Drum Control and Sub-Power Controller Chassis contains modular circuitry mounted on pluggable printed circuit cards. The major functional circuits are Averaging Amplifier, Buffer Amplifier, Relay Trigger, and Amplifier (Operational). WANL Drawing 937J903 shows the locations of these modules as well as other mechanical details.

3.2 Resistors

Resistors are military standard (1% RN) wire wound where indicated.

3.3 Capacitors

Capacitors are military standard or better.

3.4 Transistors and Diodes

All transistors and diodes are silicon, military standard or better.

3.5 Operational Amplifiers

All operational amplifiers are highest grade, certified and tested for maximum reliability and performance.

3.6 Relays

All relays are approved, military standard or better, certified and tested for maximum reliability and performance.

3.7 Chassis

The chassis is fabricated of sheet stock aluminum alloy and assembled with machine screws and rivets.

4.0 INSTALLATION

Install the removable parts of the chassis slides at the desired level in the 19-inch equipment rack. WANL Drawing 937J903 shows the mounting and construction details of the chassis, front panel, and connector locations.

WANL Drawing 937J904 (Schematic Diagram) shows the internal wiring as well as the external connections that need to be made to the Drums Control Chassis.

5.0 PRINCIPLES OF OPERATION

The Drum Control and Sub-Power Controller Chassis provides signals and indications for locally (from the Test Cell Building) unlocking and locking a single, selected actuator and drum, and rotating it from 0 to 180°. A function generator signal may be used to check the frequency response of the control loop.

An averaging circuit is provided to take the average of the position feed-back signals of all 12 drums for display at the control console in the Control Point Building.

Trigger Relay circuits, A-1 through A-12, are adjusted to sense a Demand Signal greater than 0.8VDC. Larger signals operate these circuits and their relays open the drum unlocking circuits.

The Drum Control Chassis also contains circuitry for remotely, semi-automatically, driving the drums out, and the reactor up, to a desired power level with an adjustable period setting. This is done from the control console in the Control Point Building.

5.1 Drum Lock and Unlock Controls

WANL Drawing 937J904 is the overall schematic diagram of the Drum Control and Sub-Power Controller Chassis. With the key Mode switch S-1 in the TCB position and Drum Selector switch S-2 set to the desired drum position (1 to 12 inclusive), pressing the alternate action LOCK/UNLOCK switch S-3 once, will unlock the selected drum (provided Drum Control potentiometer R-1 is at its full counter-clockwise setting). The lighted indicators on the LOCK/UNLOCK switch will give the state of the drum locking pin in accordance with the commands.

5.2 Drum Control Amplifier

Unity gain Amplifier A-15 receives a positive 10 volt signal from the Drum Control potentiometer R-1, inverts it and feeds the position command to the selected drum through the actuator amplifier in the Actuator Amplifier Chassis. TP-20 (EXT INPUT) is provided for the application of a function generator signal for frequency response measurements. The corresponding drum position is displayed on Drum Position meter M-1.

5.3 Averaging Amplifier

The averaging amplifier A-14 takes 1/12 of each of the position feed-back signals from the 12 drums, sums and reverses this Average Drum Position signal for display on the control console at the Control Point Building.

5.4 Trigger Relay Circuits

Trigger Relay Circuits A-1 through A-12 are modified Schmidt trigger circuits for sensing voltage levels. Transistors Q-1 and Q-2 form a Darlington amplifier circuit giving a high gain and a high input impedance, thereby providing minimum loading of the driving circuits. Potentiometer R-7 provides an adjustment of the hysteresis, or sensitivity, of operation. Potentiometer R-1 sets the triggering voltage level. Under normal conditions (no input signal) transistors Q-1 and Q-2 are conducting while Q-3 is not conducting, with Relay K-1 de-energized. When the input signal reaches the triggering level, Q-1 and Q-2 stop conducting and abruptly turn on Q-3 which operates Relay K-1 by completing its return circuit path to signal common. Removing the input signal restores the Trigger Relay Circuit to its normal quiescent state.

5.5 Sub-Power Controller

Operational Amplifiers A-13 and A-16 form the Sub-Power Controller circuit for bringing the NERVA Reactor up to a selected power output at a selectable period rate. Amplifier A-16 provides a gain factor

of 100, with provisions for accepting an input error signal from Amplifier A-13. Amplifier A-13 operates as an integrator with a time constant of 8.45 seconds. Zener diodes A16-CR1 and CR2 limit the output of Amplifier A-16 to plus or minus 5.0VDC as long as an error signal is present on its input. An external Period potentiometer on the control console in the Control Point Building determines the fractional output voltage of Amplifier A-16 (corresponding to the desired Period rate of reactor power build-up) to be fed to the input of integrator A-13. This voltage then produces the desired volt-seconds output (LnNd) of the integrator A-13. Remotely operated relays A-19, A-20, and A-21 determine the mode of operation of the Sub-Power Controller.

5.6 Special Purpose Relays

Relays K-1 through K-5 are special make-before-break relays. The normally open contacts close before the normally closed contacts are opened by relay action. These relays are in the Drum Demand Signal circuits and transfer control to manual potentiometers when remotely operated. The make-before-break feature allows a bump-less transfer of control from manual to automatic.

6.0 FRONT PANEL

6.1 MODE Switch

This is a key operated selector switch with the key captive in CP and TCB positions. The first split-screen indicator lights for each position of the MODE switch.

6.2 Indicators and Push-Button Switches

The first indicator CP/TCB/OFF is an indicator only. It shows the position of the MODE switch.

Pressing the LAMP VERIFY switch will light (if the bulbs are good) all of the indicators except the indicator fuses. It is a momentary action push-button switch.

As the name suggests, the LOCK/UNLOCK push-button switch unlocks and locks the selected drum.

6.3 Individual Drum Selector

The Individual Drum Selector switch is a 13-position rotary selector switch. It selects the desired drum for testing.

6.4 Individual Drum Position

The Individual Drum Position meter calibrated in degrees from 0 to 180, gives the selected drum's angular position.

6.5 Individual Drum Control

The Individual Drum Control is a locking, ten-turn potentiometer used to turn the selected drum to desired angular positions.

6.6 Lighted Indicating Fuses

The fuse holders along the bottom of the front panel contain the fuses for the circuits supplied by the indicated power supplies. Encapsulated circuitry adapted to each fuse holder, lights its respective holder when a fuse blows. The fuses are readily accessible and replaceable from the front of the chassis.

6.7 Chassis Handles

The left-hand handle has a push-button to release the chassis from its stowed position in the equipment rack.

The right-hand handle has a key-locking mechanism to lock the chassis into position after checkout and calibration procedures are completed.

7.0 COMPONENT PANEL

The Component Panel, WANL Drawing 937J903, located on the top front of the chassis is accessible when the drawer is pulled out. This panel contains 80 test point jacks useful for initial calibration and setting up, and for trouble-shooting the system during maintenance periods.

Referring to WANL Drawing 937J904, TP-1 through TP-12 provide for the measurement of signals from the individual manual demand potentiometers located on the control console at the Control Point Building, or allow test signals to be

applied to the actuator amplifiers, provided that Signal Cable W-101 is removed from connector J-4 and the respective relay (K-1 through K-12) is operated locally by means of jumpers on the test point panel as explained in the next paragraph.

TP-21 through TP-32 along with TP-41 through TP-52 provide for measuring of, or applying, 28VDC signals to the special purpose, make-before-break relays K-1 through K-12, for transferring individual drums from gang control to individual control.

TP-61 through TP-72 provide for the measuring of, or applying, Drum Demand signals to the actuator amplifiers in the Actuator Amplifier Chassis.

TP-13 through TP-T15, TP-33 through TP-35. TP-53 through TP-55, and TP-73 through TP-75 provide for measuring of, or applying, 28VDC signals to the Drum unlocking solenoids at the Test Stand.

TP-16 through TP-19, TP-38 through TP-40 and TP-58 through TP-60 provide for measuring of, or applying, signals to the Sub-Power Controller portion of the Drum Control Chassis.

The remainder of the test points provide means for measuring the signals or supply voltages indicated. In making analog signal measurements, TP-80 is the common reference test point, while for 28VDC measurements, some of these signals are isolated and others are referenced to TP-57, the 28VDC return test point.

8.0 OPERATIONAL CHECKOUT AND SET-UP

Using a Simpson Multi-meter or equivalent DC voltmeter, measure the power supply voltages as present at the test points on the Test Point Panel.

All of the operational amplifier circuits have voltage and current offset adjustment potentiometers. The procedures for their adjustments is given in the Acceptance Testing Procedures section.

The set-up procedure for the trigger relay circuit is given in the Acceptance Testing Procedures section.

Procedures for checking the fuse light indicators is given in the Acceptance Testing Procedures.

Pressing the LAMP VERIFY push-button, lamp tests all of the indicators and lighted push-button switches.

Turning the MODE key switch to the TCB, lights the TCB indicator and places the Drum Control and Sub-Power Controller Chassis in the forward Test Cell Building, or local control mode. Moving the Drum Selector switch to the desired drum position, pressing the UNLOCK alternate action push-button allows the selected drum to be controlled to any angular position, as indicated on the Drum Position meter. After the drum is returned to its 0° position, pressing the LOCK button once again, locks the drum. If the drum is not commanded back to the 0° position and locked as above, but the Drum Selector switch moved to another drum, the previous drum will drift back to the 0° position and lock itself. The new drum will not respond to any commands, as shown by the LOCKED light remaining lit and the Drum Position meter indicating 0° . The Drum Control potentiometer must be returned to its fully counter-clockwise position before a desired drum may be unlocked. Since the LOCK/UNLOCK push-button is an alternate action switch, it may already be in the UNLOCK position as indicated by the UNLOCK light lighting when the Demand Control is returned to the zero position. After each test, the Drum Control potentiometer should be returned to its fully counter-clockwise position, the UNLOCK push-button pressed once to the LOCK position, and the Drum Selector switch set to the OFF position.

The MODE key switch should be left in OFF position if testing is completed or to the CP position if remote operation is desired.

9.0 MAINTENANCE INSTRUCTIONS

9.1 Preventive Maintenance

Under normal conditions, no routine replacement of components is necessary. Periodic cleaning and dusting should also be required very minimally with the air-conditioned environment present in the Test Cell Building.

9.2 Corrective Maintenance

Detailed corrective maintenance should be performed at WANL or by its field representative. Local corrective measures, if necessary, may be performed by the skilled technician. Standard trouble-shooting procedures and techniques are applicable.

Blown fuses should be replaced, but if the replacement blows also, trouble is indicated and will have to be corrected. Since all of the circuitry is on printed circuit boards which are plugged into sockets, removing cards and replacing with spare cards is an approved method of trouble shooting. The faulty card then should be identified and reported to WANL through the proper channels.

10.0 ACCEPTANCE TEST PROCEDURE-DRUM CONTROL AND SUB-POWER CONTROLLER

10.1.0 SCOPE

This document contains the procedures for acceptance testing the Drum Control and Sub-Power Controller (WANL Drawing 937J903) of the ETS-1 Test Stand Control System in accordance with the Acceptance Test Specification.

10.2.0 VISUAL EXAMINATION

The equipment under test shall be presented in its final form together with the applicable schematic, wiring diagram, and assembly drawing. The visual examination shall consist of the following parts:

10.2.1 Workmanship, Assembly, and Fit

The inspector shall inspect the equipment for workmanship to WANL requirements, and to assure that the overall chassis is of the proper dimensions per the assembly drawing, Westinghouse Drawing Number 937J903. Workmanship OK _____

10.2.2 Materials, Parts, and Finishes

The equipment shall be inspected to assure that the materials, parts, and finishes are in accordance with the applicable assembly drawings. Incoming inspection records on materials, parts, and finishes shall be utilized to determine conformance to the assembly drawings where possible.

Materials OK _____

10.3.0 APPLICABLE DOCUMENTS

- 3.1 Drawing 937J903 - Drum Control and Sub-Power Controller
- 3.2 Drawing 937J904 - Schematic Diagram
- 3.3 Drawing 937J905 - Wiring Diagram
- 3.4 NDC-118A NERVA Design Criteria ETS-1 TSCS (AGC)

10.4.0 EQUIPMENT REQUIRED

- 4.1 Multimeter (Simpson 269 or equivalent)
- 4.2 28VDC $\pm$ 2VDC power source
- 4.3 -10VDC power source with $\pm 0.05\%$ regulation and 1 mv ripple max.
- 4.4 -10VDC power source with $\pm 0.05\%$ regulation and 1 mv ripple max.
- 4.5 +15VDC power source with $\pm 0.05\%$ regulation and 1 mv ripple max.
- 4.6 -15VDC power source with $\pm 0.05\%$ regulation and 1 mv ripple max.
- 4.7 -1-.2000 ohm, 10 turn potentiometer, 2.0 watts min.
- 4.8 -1-20,000 ohm, 10 turn potentiometer, 2.0 watts min.
- 4.9 Recorder (Multi-channel Visicorder or equivalent).
- 4.10 Adjustable DC Power Supply 0-30VDC.

11.0 ACCEPTANCE TEST SPECIFICATION-DRUM CONTROL AND SUB-POWER CONTROLLER

11.1.0 SCOPE

This document contains the requirements for the acceptance testing of the Drum Control and Sub-Power Controller (WANL Drawing 937J903) of the ETS-1 Test Stand Control System.

11.2.0 REQUIREMENTS

11.2.1 The acceptance test shall consist of the following:

11.2.2.1 Visual Examination - To be performed by Quality Control.

11.2.2.2 Weights and Dimensions - To be performed by Quality Control.

11.2.2.3 Functional Test - To be performed by Instrumentation and Control and witnessed by Quality Control.

11.2.2 The acceptance test shall be performed in the order of and as specified in the procedure. Discrepancies found during the visual examination shall be corrected and reinspected before performing the functional test. Failure or inability to obtain a required measurement during formal functional testing shall result in establishing a "hold" on the test. The failure or inadequacy shall be recorded by Quality Control and shall be reviewed by the WANL Engineering Review Board (ERB). The equipment shall be repaired and sections of the test repeated as determined by the ERB. Visual examination shall be performed on the reworked or repaired areas before resuming testing.

11.2.3 Treatment for Prevention of Corrosion

The equipment shall be inspected to assure that the coatings for prevention of corrosion have not been impaired during the manufacturing cycle. Treatment OK _____

11.2.4 Safety Requirements

The equipment shall be inspected to insure that no safety hazard, such as sharp edges, etc., exist on the equipment which are potential hazards to personnel operating or maintaining the equipment. Safety OK _____

11.2.5 Marking

The markings on the equipment shall be inspected to ensure conformance to the applicable drawings and to assure that they are acceptable as to permanence and readability. Marking OK _____

11.2.6 Indicator Lamps and Fuses

The indicators, switches, and fuses shall be inspected to insure that the proper lamps and filters are installed. Do not install fuses at this time, but replace the holders into their sockets without fuses.

11.2.7 Visual Examination Review

After the visual examination of the equipment has been completed, all deficiencies shall be reviewed by WANL Engineering and Quality Control and corrected by one of the following methods:

- a. Drawing changes where drawing deficiencies are noted.
- b. Design changes if necessitated.
- c. Rework of the parts affected.

11.3.0 WEIGHTS AND DIMENSIONS

11.3.1 The unit shall be weighed and the weight shall be recorded.

Weight _____ lbs.

11.3.2 The unit shall be measured and the overall dimensions of width, height, and depth recorded.

Width _____ in.

Height _____ in.

Depth _____ in.

11.4.0 FUNCTIONAL TESTS

11.4.1 Set Drum Selector Switch to OFF, key Mode Selector Switch to OFF, and Drum Control to extreme counter-clockwise.

11.4.2 Connect power cable to J1. Do not connect signal cable.

11.4.3 All lighted fuse holders light.

11.4.4 Install proper fuses into the respective fuse holders.

11.4.5 OFF indicator lights.

11.4.6 Press Lamp Verify Switch. Lighted switches and indicators light.
(Lighted fuse indicators light only when their fuses open.)

11.4.7 Preset all R7 potentiometers on modules A1 through A12 by first turning the screwdriver-adjust screws clockwise at least twenty-five (25) turns and then counter-clockwise four (4) complete turns. (These are 25 turn potentiometers.)

11.4.8 TCB indicator lights with key Mode Switch in TCB position.

11.4.9 CP indicator lights with key Mode Switch in CP position.

11.4.10	<u>Measure</u>	<u>Between</u>	<u>AND</u>
	15 $\pm$ 1VDC _____	TP-78(+)	TP-80(-)
	15 $\pm$ 1VDC _____	TP-80(+)	TP-79(-)
	10 $\pm$ 1VDC _____	TP-76(+)	TP-80(-)
	10 $\pm$ 1VDC _____	TP-80(+)	TP-77(-)
	28 $\pm$ 1VDC _____	TP-56(+)	TP-57(-)

- 11.4.11 Set key Mode Switch in TCB position, Drum Selector to position 1, and jumper between TP-20 and TP-80.
- 11.4.12 Adjust Amplifier A15 voltage (R-1) and current (R-2) offset for 0.0VDC between TP-61 and TP-80. _____.
- 11.4.13 Set Drum Control (Front) for a voltmeter reading of 0.85VDC. _____.
- 11.4.14 With the voltmeter test leads between TP2 (+) on module A1 and TP-80 common (-), adjust potentiometer R1 on module A1 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Make this adjustment several times from different settings of potentiometer (clockwise and counterclockwise from desired setting).
- 11.4.15 Set Individual Drum Selector to position 2. With the voltmeter test leads between TP-2 (+) on module A2 and TP-80 common (-), adjust potentiometer R1 on module A2 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.
- 11.4.16 Set Individual Drum Selector to Position 3. With the voltmeter test leads between TP-2 (+) on module A3 and TP-80 common (-), adjust potentiometer R1 on module A3 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.
- 11.4.17 Set Individual Drum Selector to Position 4. With the voltmeter test leads between TP-2 (+) on module A4 and TP-80 common (-), adjust potentiometer R1 on module A4 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.
- 11.4.18 Set Individual Drum Selector to Position 5. With the voltmeter test leads between TP-2 (+) on module A5 and TP-80 common (-),

11.4.18 (Continued)

adjust potentiometer R1 on module A5 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.

11.4.19 Set Individual Drum Selector to Position 6. With the voltmeter test leads between TP-2 (+) on module A6 and TP-80 common (-), adjust potentiometer R1 on module A6 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.

11.4.20 Set Individual Drum Selector to Position 7. With the voltmeter test leads between TP-2 (+) on module A7 and TP-80 common (-), adjust potentiometer R1 on module A7 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.

11.4.21 Set Individual Drum Selector to Position 8. With the voltmeter test leads between TP-2 (+) on module A8 and TP-80 common (-), adjust potentiometer R1 on module A8 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.

11.4.22 Set Individual Drum Selector to Position 9. With the voltmeter test leads between TP-2 (+) on module A9 and TP-80 common (-), adjust potentiometer R1 on module A9 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.

11.4.23 Set Individual Drum Selector to Position 10. With the voltmeter test leads between TP-2 (+) on module A10 and TP-80 common (-), adjust potentiometer R1 on module A10 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.

- 11.4.24 Set Individual Drum Selector to Position 11. With the voltmeter test leads between TP-2 (+) on module A11 and TP-80 common (-), adjust potentiometer R1 on module A11 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.
- 11.4.25 Set Individual Drum Selector to Position 12. With the voltmeter test leads between TP-2 (+) on module A12 and TP-80 common (-), adjust potentiometer R1 on module A12 until the voltmeter reading jumps from 15VDC to less than 1.0VDC. Repeat this adjustment as in Step 4.14.
- 11.4.26 Return Drum Selector to OFF position. Remove patch between TP-20 and TP-80.
- 11.4.27 Adjust the current and voltage offsets of amplifiers A13, A14, and A16 for 0.0VDC output. See Steps 4.108, 4.109, and 4.110.
- 11.4.28 Set Drum Selector to Position 1. Patch TP-56 to pin J2-A. LOCK indicator lights. Patch TP-56 to pin J2-g. UNLOCK indicator lights. Apply 8.0VDC between TP-80 (+) and pin J2-g (-). Drum Position meter reads 144.0 degrees _____. (If not, adjust calibration potentiometer or meter card for 144.0 degrees.)
- 11.4.29 Measure DC voltage between TP-37 (+) and TP-80 (-). $0.66 \pm .1$ VDC. _____.
- 11.4.30 Set Drum Selector to Position 2. Patch TP-56 to pin J2-B. LOCK indicator lights. Patch TP-56 to pin J2-r. UNLOCK indicator lights. Apply 8.0VDC between TP-80 (+) and pin J2-G (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.31 Measure DC voltage between TP-37 (+) and TP-80 (-). $0.66 \pm .1$ VDC. _____.
- 11.4.32 Set Drum Selector to Position 3.
Patch TP-56 to pin J2-C. LOCK indicator lights.
Patch TP-56 to pin J2-Z. UNLOCK indicator lights.
Apply 8.0VDC between TP-80 (+) and pin J2-P (-) Drum Position Meter reads 144.0 degrees. _____

- 11.4.33 Measure DC voltage between TP-37 (+) and TP-80 (-). $0.66 \pm .1$ VDC. _____.
- 11.4.34 Set Drum Selector to Position 4.
- Patch TP-56 to pin J2-U. LOCK indicator lights.
- Patch TP-56 to pin J2-E. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (+) and pin J2-i (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.35 Measure DC voltage between TP-37 (+) and TP-80 (-). $0.66 \pm .1$ VDC. _____.
- 11.4.36 Set Drum Selector to Position 5.
- Patch TP-56 to pin J2-V. LOCK indicator lights.
- Patch TP-56 to pin J2-S. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (+) and pin J2-x (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.37 Measure DC voltage between TP-37 (+) and TP-80 (-). $0.66 \pm .1$ VDC. _____.
- 11.4.38 Set Drum Selector to Position 6.
- Patch TP-56 to pin J2-W. LOCK indicator lights.
- Patch TP-56 to pin J2-m. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (+) and pin J2-w (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.39 Measure DC voltage between TP-37 (+) and TP-80 (-). $0.66 \pm .1$ VDC. _____.
- 11.4.40 Set Drum Selector to Position 7.
- Patch TP-56 to pin J2-X. LOCK indicator lights.
- Patch TP-56 to pin J2-AA. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (+) and pin J2-y (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.41 Measure DC voltage between TP-37 (+) and TP-80 (-). $0.66 \pm .1$ VDC. _____.
- 11.4.42 Set Drum Selector to Position 8.
- Patch TP-56 to pin J2-Y. LOCK indicator lights.
- Patch TP-56 to pin J2-BB. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (+) and pin J2-d (-). Drum Position meter reads 144.0 degrees. _____

- 11.4.43 Measure DC voltage between TP-37 (+) and TP-80 (-). 0.66⁺.1VDC. _____.
- 11.4.44 Set Drum Selector to Position 9.
- Patch TP-56 to pin J2-D. LOCK indicator lights.
- Patch TP-56 to pin J2-CC. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (+) and pin J2-H (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.45 Measure DC voltage between TP-37 (+) and TP-80 (-). 0.66⁻.1VDC. _____.
- 11.4.46 Set Drum Selector to Position 10.
- Patch TP-56 to pin J2-T. LOCK indicator lights.
- Patch TP-56 to pin J2-s. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (+) and J2-N (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.47 Measure DC voltage between TP-37 (+) and TP-80 (-).
- 11.4.48 Set Drum Selector to Position 11.
- Patch TP-56 to pin J2-n. LOCK indicator lights.
- Patch TP-56 to pin J2-a. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (+) and J2-h (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.49 Measure DC voltage between TP-37 (+) and TP-80 (-). 0.66⁻.1VDC.
- 11.4.50 Set Drum Selector to Position 12.
- Patch TP-56 to pin J2-p. LOCK indicator lights.
- Patch TP-56 to pin J2-F. UNLOCK indicator lights.
- Apply 8.0VDC between TP-80 (=) and J2-g (-). Drum Position meter reads 144.0 degrees. _____
- 11.4.51 Measure DC voltage between TP-37 (+) and TP-80 (-). 0.66⁻.1VDC. _____.
- 11.4.52 Return Drum Selector Switch to OFF position.
- 11.4.53 Set key Mode Switch in CP position.

FIGURE 1

OPERATIONAL CHECKOUT OF SUB-POWER CONTROLLER

- * 4.66 VDC = 1.0 SEC. PERIOD
- 2.56 VDC = 5.0 SEC PERIOD
- .466 VDC = 10.0 SEC PERIOD

	<u>APPLY</u>	<u>BETWEEN</u>	<u>AND</u>	<u>MEASURE</u>	<u>BETWEEN</u>	<u>AND</u>
11.4.54				For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-A " pin J2-k(+)	pin J3-B(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.55	5.0VDC	TP-80(+)	TP-1(-)	0.0VDC _____	TP-80(+)	TP-61(-)
11.4.56	Patch and	TP-41 TP-21	TP-57 TP-56	28^{+1} VDC _____ $5.0^{+1.5}$ VDC _____ Inf. resist. _____	pin J2-k(+) TP-80(+) TP-13	TP-57(-) TP-61(-) pin J3-B
11.4.57				*For resist. _____ Rev. resist. _____ 0.0VDC _____	J4-B " pin J2-z(+)	pin J3-C(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.58	5.0VDC	TP-80(+)	TP-2(-)	0.0VDC _____	TP-80(+)	TP-62(-)
11.4.59	Patch and	TP-42 TP-22	TP-57 TP-56	28^{+1} VDC _____ $5.0^{+1.5}$ VDC _____ Inf. resist. _____	pin J2-z(+) TP-80(+) TP-14	TP-57(-) TP-62(-) pin J3-C
11.4.60				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-C " pin J2-GG(+)	pin J3-U(< 100 ohm) " (> 1 megohm) TP-57(-)
11.4.61	5.0VDC	TP-80(+)	TP-3(-)	0.0VDC _____	TP-80(+)	TP-63(-)
11.4.62	Patch and	TP-43 TP-23	TP-57 TP-56	28^{+1} VDC _____ $5.0^{+1.5}$ VDC _____ Inf. resist. _____	pin J2-GG(+) TP-80(+) TP-15	TP-57(-) TP-63(-) pin J3-U
11.4.63				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-U " pin J2-HH(+)	pin J3-V(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.64	5.0VDC	TP-80(+)	TP-4(-)	0.0VDC _____	TP-80(+)	TP-64(-)

	<u>APPLY</u>	<u>BETWEEN</u>	<u>AND</u>	<u>MEASURE</u>	<u>BETWEEN</u>	<u>AND</u>
11.4.65	Patch and	TP-44 TP-24	TP-57 TP-56	28 ⁺¹ VDC _____ 5.0 [±] .5 VDC _____ Inf. resist. _____	pin J2-HH(+) TP-80(+) TP-33	TP-57(-) TP-64(-) pin J3-V
11.4.66				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-V " pin J2-DD(+)	pin J3-W(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.67	5.0VDC	TP-80(+)	TP-5(-)	0.0VDC _____	TP-80(+)	TP-65(-)
11.4.68	Patch and	TP-45 TP-25	TP-57 TP-56	28 ⁺¹ VDC _____ 5.0 [±] .5 VDC _____ Inf. resist. _____	pin J2-DD(+) TP-80(+) TP-34	TP-57(-) TP-65(-) pin J3-W
11.4.69				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-W " pin J2-t(+)	pin J3-X(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.70	5.0VDC	TP-80(+)	TP-6(-)	0.0VDC _____	TP-80(+)	TP-66(-)
11.4.71	Patch and	TP-46 TP-26	TP-57 TP-56	28 ⁺¹ VDC _____ 5.0 [±] .5 VDC _____ Inf. resist. _____	pin J2-t(+) TP-80(+) TP-35	TP-57(-) TP-66(-) pin J3-X
11.4.72				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-X " pin J2-b(+)	pin J3-Y(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.73	5.0VDC	TP-80(+)	TP-7(-)	0.0VDC _____	TP-80(+)	TP-67(-)
11.4.74	Patch and	TP-47 TP-27	TP-57 TP-56	28 ⁺ VDC _____ 5.0 [±] .5 VDC _____ Inf. resist. _____	pin J2-b TP-80(+) TP-53	TP-57(-) TP-67(-) pin J3-Y
11.4.75				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-Y " pin J2-R(+)	pin J3-D(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.76	5.0VDC	TP-80(+)	TP-8(-)	0.0VDC _____	TP-80(+)	TP-68(-)

	<u>APPLY</u>	<u>BETWEEN</u>	<u>AND</u>	<u>MEASURE</u>	<u>BETWEEN</u>	<u>AND</u>
11.4.77	Patch and	TP-48 TP-28	TP-57 TP-56	28 ⁺¹ ₋₁ VDC _____ 5.0 ⁺¹ ₋₁ VDC _____ Inf. resist. _____	pin J2-R TP-80(+) TP-54	TP-57(-) TP-68(-) pin J3-D
11.4.78				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-D " pin J2-j(+)	pin J3-T(< 100 ohms) " (> 1 megohm) TP-57
11.4.79	5.0VDC	TP-80(+)	TP-9(-)	0.0VDC _____	TP-80(+)	TP-69(-)
11.4.80	Patch and	TP-49 TP-29	TP-57 TP-56	28 ⁺¹ ₋₁ VDC _____ 5.0 ⁺¹ ₋₁ VDC _____ Inf. resist. _____	pin J2-j(+) TP-80(+) TP-55	TP-57(-) TP-69(-) pin J3-T
11.4.81				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-T " pin J2-y(+)	pin J3-n(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.82	5.0VDC	TP-80(+)	TP-10(-)	0.0VDC _____	TP-80(+)	TP-70(-)
11.4.83	Patch and	TP-50 TP-30	TP-57 TP-56	28 ⁺¹ ₋₁ VDC _____ 5.0 ⁺¹ ₋₁ VDC _____ Inf. resist. _____	pin J2-y(+) TP-80(+) TP-73	TP-57(-) TP-70(-) pin J3-n
11.4.84				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-n " pin J2-FF(+)	pin J3-p(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.85	5.0VDC	TP-80(+)	TP-11(-)	0.0VDC _____	TP-80(+)	TP-71(-)
11.4.86	Patch and	TP-51 TP-31	TP-57 TP-56	28 ⁺¹ ₋₁ VDC _____ 5.0 ⁺¹ ₋₁ VDC _____ Inf. resist. _____	pin J2-FF(+) TP-80(+) TP-74	TP-57(-) TP-71(-) pin J3-p
11.4.87				*For. resist. _____ Rev. resist. _____ 0.0VDC _____	J4-p " pin J2-EE(+)	pin J3-q(< 100 ohms) " (> 1 megohm) TP-57(-)
11.4.88	5.0VDC	TP-80(+)	TP-12(-)	0.0VDC _____	TP-80(+)	TP-72(-)

	<u>APPLY</u>	<u>BETWEEN</u>	<u>AND</u>	<u>MEASURE</u>	<u>BETWEEN</u>	<u>AND</u>
11.4.89	Patch and	TP-52 TP-32	TP-57 TP-56	Inf. resist. _____ 28 $\pm$ 1 VDC _____ 5.0 $\pm$.5 VDC _____	TP-75 pin J2-EE(+) TP-80(+)	pin J3-q TP-57(-) TP-72(-)
11.4.90				Inf. resist. _____ Inf. resist. _____ Zero resist. _____	pin J3-DD pin J3-c pin J3-d	TP-37 pin J3-d pin J3-e
11.4.91	28VDC	pin J3-N(+)	pin J3-P(-)	Zero resist. _____ Zero resist. _____ Inf. resist. _____	pin J3-DD pin J3-c pin J3-d	TP-37 pin J3-d pin J3-e
11.4.92				Inf. resist. _____ Zero resist. _____ Inf. resist. _____ Zero resist. _____ Inf. resist. _____ Zero resist. _____ Inf. resist. _____ Zero resist. _____ Inf. resist. _____ Zero resist. _____ Inf. resist. _____ Inf. resist. _____	pin J3-v pin J3-f pin J3-x pin J3-g pin J3-EE pin J3-h pin J3-t TP-17 pin J2-K pin J2-K	pin J3-w pin J3-w pin J3-y pin J3-y pin J3-FF pin J3-FF pin J3-u TP-18 TP-17 TP-18
11.4.93	Patch and	TP-58 TP-38	TP-57 TP-56	Zero resist. _____ Inf. resist. _____ Zero resist. _____ Inf. resist. _____ Inf. resist. _____	pin J3-v pin J3-f TP-17 pin J2-K pin J2-K	pin J3-w pin J3-w TP-18 TP-18 TP-17
11.4.94	Patch and	TP-59 TP-39	TP-57 TP-56	Zero resist. _____ *Inf. resist. _____ Zero resist. _____ Inf. resist. _____ Inf. resist. _____	pin J2-K pin J2-K pin J3-x pin J3-g TP-18	TP-18 TP-17 pin J3-y pin J3-y TP-80
11.4.95	Patch and	TP-60 TP-40	TP-57 TP-56	Zero resist. _____ Inf. resist. _____ Zero resist. _____ **Zero resist. _____ * Inf. resist. _____	pin J3-EE pin J3-h pin J3-t TP-18 TP-17	pin J3-FF pin J3-FF pin J3-u TP-80 TP-18

	<u>APPLY</u>	<u>BETWEEN</u>	<u>AND</u>	<u>MEASURE</u>	<u>BETWEEN</u>	<u>AND</u>
11.4.96	Patch Patch and	TP-58 TP-38 TP-19	TP-57 TP-56 TP-80			
11.4.97	.05VDC	TP-16(+)	TP-80(-)	* 5.0VDC _____	TP-80(+)	TP-17(-)
11.4.98	.05VDC	TP-80(+)	TP-16(-)	5.0VDC _____	TP-17(+)	TP-80(-)
11.4.99	.1VDC	TP-80(+)	TP-16(-)	5.4 ⁺ .5 VDC _____	TP-17(+)	TP-80(-)
11.4.100	.1VDC	TP-16(+)	TP-80(-)	5.4 ⁺ .5 VDC _____	TP-80(+)	TP-17(-)
11.4.101	Patch and	TP-59 TP-39	TP-57 TP-56			
11.4.102	2.0VDC	TP-80(+)	TP-18(-)	10.0VDC _____ after 42.25 sec. _____	TP-19(+)	TP-80(-)
11.4.103	0.0VDC	TP-80(+)	TP-18(-)	13 ⁺ -2 VDC _____	TP-19(+)	TP-80(-)
11.4.104	100 ohms	TP-19	TP-80			
11.4.105	2.0VDC	TP-18(+)	TP-80(-)	10.0VDC _____ after 42.25 sec. _____	TP-80(+)	TP-19(-)
11.4.106	0.0VDC	TP-18(+)	TP-80(-)	13 ⁺ -2 VDC _____	TP-80(+)	TP-19(-)
11.4.107	100 ohms	TP-19	TP-80	Apply Momentarily to Discharge Capacitor A13C1		

*If not 5.0VDC, Adjust R-4 on A-16

11.4.108 Adjustment of Amplifier A-13

- 1.0 Insert card extender between amplifier A-13 and its socket J-17.
- 2.0 Jumper Al3C1 with a 100K ohm resistor.
- 3.0 Patch TP-18 to TP-80
- 4.0 Connect digital VTVM between TP-19 and TP-80.
- 5.0 Adjust current and voltage offsets for 0.0VDC. _____
- 6.0 Remove jumpers and reinsert card in its normal position.

11.4.109 Adjustment of Amplifier A-14

- 1.0 Insert card extender between amplifier A-14 and its socket J-18.
- 2.0 Jumper (-) summing junction of amplifier A-14 to common, TP-1 on A-14.
- 3.0 Connect digital VTVM between TP-37 and TP-80.
- 4.0 Adjust current and voltage offsets for 0.0VDC. _____
- 5.0 Remove jumpers and reinsert card in its normal position.

11.4.110 Adjustment of Amplifier Al6

- 1.0 Insert card extender between amplifier Al6 and its socket J-20.
- 2.0 Patch TP-16 to TP-80 and TP-19 to TP-80.
- 3.0 Connect digital VTVM between TP-17 and TP-80.
- 4.0 Adjust current and voltage offsets for 0.0VDC. _____
- 5.0 Remove jumpers and reinsert card in its normal position.

	<u>CONTROL</u>	<u>POSITION</u>	<u>MEASURE</u>	<u>BETWEEN</u>	<u>AND</u>
11.4.111	Key Mode Switch	CP	28+1VDC _____ and 28-1VDC _____	J4-w(+) _____ J2-f(+) _____	TP-57(-) _____ TP-57(-) _____
11.4.112	Key Mode Switch Drum Selector and LOCK/UNLOCK	TCB 1 UNLOCK	28+1VDC _____ 28-1VDC _____ (If no reading, press LOCK/UNLOCK again.)	J2-u(+) _____ TP-13(+) _____	TP-57(-) _____ TP-57(-) _____
11.4.113	Drum Selector	2	28+.VDC _____	TP-14(+)	TP-57(-)
11.4.114	" "	3	28+.VDC _____	TP-15(+)	TP-57(-)
11.4.115	" "	4	28+1VDC _____	TP-33(+)	TP-57(-)
11.4.116	" "	5	28-1VDC _____	TP-34	TP-57(-)
11.4.117	" "	6	28+1VDC _____	TP-35	TP-57(-)
11.4.118	" "	7	28-1VDC _____	TP-53	TP-57(-)
11.4.119	" "	8	28+1VDC _____	TP-54	TP-57(-)
11.4.120	" "	9	28+1VDC _____	TP-55	TP-57(-)
11.4.121	" "	10	28-1VDC _____	TP-73	TP-57(-)
11.4.122	" "	11	28+1VDC _____	TP-74	TP-57(-)
11.4.123	" "	12	28+1VDC _____	TP-75	TP-57(-)
11.4.124	" " Key Mode and LOCK/UNLOCK	OFF OFF LOCK (Press Once)			
11.4.125	Key Mode Switch	OFF	Inf. resist. _____ Inf. resist. _____	pin J4-G pin J3-b	pin J3-b TP-80

	<u>CONTROL</u>	<u>POSITION</u>	<u>MEASURE</u>	<u>BETWEEN</u>	<u>AND</u>
11.4.126	Key Mode Switch	CP	Zero resist. _____ Inf. resist. _____	pin J4-G pin J4-G	pin J3-b TP-80
11.4.127	Key Mode Switch	TCB	Zero resist. _____ Inf. resist. _____	pin J3-b pin J4-G	TP-80 pin J3-b
11.4.128	Key Mode Switch	CP	Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____ Zero resist. _____	pin J4-c TP-36 TP-36 TP-36 TP-36 TP-36 TP-36 TP-36 TP-36 TP-36 TP-36 TP-36 TP-36 TP-36 TP-36	TP-36 pin J3-r pin J3-z pin J3-E pin J3-S pin J3-m pin J3-AA pin J3-BB pin J3-CC pin J3-s pin J3-a pin J3-F pin J3-k
11.4.129	Key Mode Switch	OFF			

11.4.130 Make the following continuity checks:

<u>Measure</u>	<u>Between</u>	<u>And</u>
Zero resist. _____	TP-1	pin J4-q
" " _____	TP-21	pin J4-z
" " _____	TP-41	pin J4-H
" " _____	TP-2	pin J4-r
" " _____	TP-22	pin J4-GG
" " _____	TP-42	pin J4-J
" " _____	TP-3	pin J4-Z
" " _____	TP-23	pin J4-HH
" " _____	TP-43	pin J4-K
" " _____	TP-4	pin J4-E
" " _____	TP-24	pin J4-DD
" " _____	TP-44	pin J4-L
" " _____	TP-5	pin J4-S
" " _____	TP-25	pin J4-t
" " _____	TP-45	pin J4-M
" " _____	TP-6	pin J4-m
" " _____	TP-26	pin J4-b
" " _____	TP-46	pin J4-N
" " _____	TP-7	pin J4-AA
" " _____	TP-27	pin J4-R
" " _____	TP-47	pin J4-P
" " _____	TP-8	pin J4-BB
" " _____	TP-28	pin J4-i
" " _____	TP-48	pin J4-d
" " _____	TP-9	pin J4-CC
" " _____	TP-29	pin J4-y

<u>Measure</u>	<u>Between</u>	<u>And</u>
Zero resist. _____	TP-49	pin J4- <u>e</u>
" " _____	TP-10	pin J4- <u>s</u>
" " _____	TP-30	pin J4-FF
" " _____	TP-50	pin J4- <u>f</u>
" " _____	TP-11	pin J4- <u>a</u>
" " _____	TP-31	pin J4-EE
" " _____	TP-51	pin J4- <u>g</u>
" " _____	TP-12	pin J4-F
" " _____	TP-32	pin J4- <u>u</u>
" " _____	TP-52	pin J4- <u>h</u>
" " _____	TP-37	pin J3-A
" " _____	TP-16	pin J2-L
" " _____	TP-38	pin J3-G
" " _____	TP-58	pin J3-H
" " _____	TP-39	pin J3-J
" " _____	TP-59	pin J3-K
" " _____	TP-40	pin J3-L
" " _____	TP-60	pin J3-M
" " _____	TP-17	pin J3- <u>j</u>
" " _____	TP-19	pin J3-R

11.5.0 Operational Checkout of Sub-Power Controller

11.5.1 Patch TP-60 to TP-57

and TP-40 to TP-56

11.5.2 Patch TP-16 to TP-80

and TP-19 to TP-80

11.5.3 Adjust voltage and current offset of Amplifier A-16 for 0.0VDC between TP-17 (+) and TP-80 (-). (Amplifier A-16 has two current offsets and one voltage offset.)

11.5.4 Remove patches of Steps 5.1 and 5.2.

11.5.5 Patch TP-18 to TP-80

*11.5.6 Adjust voltage and current offset of Amplifier A-13 for 0.0VDC between TP-80 (+) and TP-19 (-).

11.5.7 Remove Patch of Step 5.5.

11.5.8 Connect the test circuit by patching the 2000 ohm and 20,000 ohm potentiometers as shown on Figure 1.

11.5.9 Make and record test runs for various settings of Power Limit and Period Demand per cognizant engineer. Attach recorder tapes to this report.

11.6.0 Safety Ground

Use an ohmmeter from connector pin J1-E to the chassis to verify that it is 0.0 ohms. _____

11.7.0 Isolation Test

Use an ohmmeter to measure the resistance between each connector pin and chassis ground to verify that the resistance is greater than 10 megohms. _____

* With a 100K ohm resistor jumped across C-1 of A-13