INSTRUCTION MANUAL

For

FREQUENCY TEST SET

MODEL FTS-300

SERIAL NO.
It is essential that this instruction book be read thoroughly before putting the equipment in service.

IMPORTANT

The information and data contained within this instruction manual are proprietary with MULTI-AMP Corporation. The equipment described herein may be protected by one or more U.S. letters patent. MULTI-AMP specifically reserves to itself all rights to such proprietary information as well as all rights under any such patent, none of which is waived by the submission of this instruction manual to anyone.

The recipient, if a Government agency, acknowledges that this instruction book and the equipment described were procured with "Limited Rights" to technical data as described in ASPR 9-203 (b).
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SAFETY PRECAUTIONS

Please read manual carefully prior to using this unit. Read and understand all safety, caution and operation instructions before attempting to use this test set. Should a situation arise that is not covered in the general or specific safety precautions, contact your local Multi-Amp Representative or Multi-Amp Corporation, Dallas, Texas.

Repairs should be made with the unit disconnected from the power source. Should repair or adjustment of energized equipment be required, under no circumstance should the work be attempted without additional personnel present to render aid if required.

Many Multi-Amp units have a separate chassis grounding point, check to ensure it is properly grounded. Most adjustments can be made with one hand, keep the other hand free and clear of the unit. When using a test instrument without insulation, make certain to ground the instrument case.

Observe the following precautions:

1. Use only the supplied line cord with a ground connection.

2. Make certain that the outlet of the main supply is actually grounded.

3. Repairs should be made by factory technicians or qualified personnel only.

4. Use only the fuses with the correct rating.
DESCRIPTION OF CONTROLS

Refer to Figure 5A at the end of this section for position of the controls on the front panel.

1. Power input connection - Connects to power cord to provide input power to the test set.

2. Main power switch - Controls input power into the test set, and also serves as main breaker in case of an accidental fault or short circuit. Switch illuminates to indicate that the test set is energized.

3. FUNCTION Switch - Selects operating mode of the test set. The following chart indicates the test set functions in each mode.

4. A.C. signal outputs - Provide the A.C. output signal from the test set. The outputs are isolated from input and protected from any internal D.C. bias.

5. OUTPUT Voltage Controls - Adjust the amplitude of the A.C. output signal. The OUTPUT CONTROL knob consists of two concentric pots; the outer knob adjusts the magnitude of the normal voltage, and the inner knob adjusts the magnitude of the fault voltage. The READ FAULT VOLTAGE Button enables the fault voltage to be present in the SET FAULT Mode before switching to the test position.

* In SET FAULT Mode, fault voltage may be channeled across the A.C. outputs by depressing the momentary READ FAULT VOLTAGE Button, in order to preset a fault voltage. This is described in further detail on the next page.

<table>
<thead>
<tr>
<th>Position</th>
<th>NORMAL</th>
<th>SET FAULT</th>
<th>TEST</th>
<th>TARGET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Frequency</td>
<td>Normal</td>
<td>Normal</td>
<td>Fault</td>
<td>Fault</td>
</tr>
<tr>
<td>Digital Meter Display</td>
<td>Normal Frequency</td>
<td>Fault Frequency</td>
<td>Elapsed Time</td>
<td>Fault Frequency</td>
</tr>
<tr>
<td>A.C. Output Voltage</td>
<td>Normal</td>
<td>*See Above</td>
<td>Fault</td>
<td>Fault</td>
</tr>
<tr>
<td>Circuit Across Red &amp; Yellow</td>
<td>Contact Sensing</td>
<td>Contact Sensing</td>
<td>Contact Sensing</td>
<td>Target Current</td>
</tr>
</tbody>
</table>
NOTE: The READ FAULT VOLTAGE Button only works in the SET FAULT Mode.

6. Output voltage meter - Monitors the amplitude of the A.C. signal voltage present at the A.C. signal outputs.

7. Frequency RANGE Switch - Selects the proper output frequency range: 40-70Hz for most applications and 360-440Hz for aircraft and military applications (other frequency ranges optional).

8. Frequency adjust controls - Fifteen turn potentiometers which independently adjust the NORMAL and FAULT FREQUENCIES over the selected output range.

9. Frequency meter/timer - Displays either normal frequency, fault frequency, or time, depending on the operating mode of the test set. The twin LED's directly underneath the meter marked HERTZ and SECONDS indicate whether the meter is displaying frequency or time.

10. CONTACTS/D.C. Power Supply Terminals - Red and yellow terminals are used to monitor dry or SCR contact status in NORMAL, SET FAULT and TEST Modes. Contact closure is indicated by the CONTACTS CLOSED LED. In TEST mode, contact closure (or opening) may be used to stop the timer for performing time delay tests. In TARGET Mode, a D.C. current source is switched across these terminals for performing target pick-up and seal-in tests.

11. D.C. POWER SUPPLY Controls - Selects the D.C. output voltage present across the red and black terminals. Three voltages (48, 125, and 250 V) are available, depending on the input voltage required by the relay under test. The ON/RESET Indicator is an orange LED which illuminates whenever voltage is present at the D.C. outputs. The supply is overload and short-circuit protected by an internal relay which shuts-down the supply when the output current on any range exceeds 600 milliamperes. This relay is reset by depressing the LED, which is also a momentary pushbutton.

12. Contact mode select switch - Determines whether the presence or removal of a short circuit across the red and yellow terminals will stop the timer in TEST Mode. Used to select either normally open (N.O.) or normally closed (N.C.) contacts for monitoring time delay tests.

13. Contact status indicator - LED which illuminates to indicate a short circuit across the red and yellow terminals.

14. TARGET CURRENT Control/Range Switch - Outer knob is a switch which selects the desired range for the D.C. ammeter (0.3 or 3 amperes full scale). Inner knob is a pot which adjusts the magnitude of the D.C. current in the TARGET Mode.

15. D.C. ammeter - Monitors the current drawn from the internal D.C. supply in the NORMAL, SET FAULT, and TEST Modes, and measures magnitude of D.C. current across red and yellow binding posts in the TARGET Mode.
FIGURE 5A - FRONT PANEL
OPERATING INSTRUCTIONS

CAUTION

Before attempting to test relays using the FTS-300, the test technician should have read and understood the manufacturer's instruction bulletins for relays being tested. Failure to do so may result with incorrect hookups which can potentially cause damage to the relay and/or the test set.

WARNING

At any time connections are being made to a relay, the test set should be turned off. Even with the D.C. Power supply turned off, a voltage may remain on the main output capacitor for a short period of time and the potential exists for electric shock to the user.

1. GENERAL FREQUENCY RELAY TEST PROCEDURES

A. Before making any connections, make sure that the test set is turned off, both OUTPUT VOLTAGE controls and the TARGET CURRENT control are turned fully counterclockwise, and the D.C. POWER SUPPLY is turned OFF. Place the FUNCTION Switch in the NORMAL Position. Select the desired frequency range, either 40-70 Hz or 360-440 Hz.

B. Connect leads from the outputs of the FTS-300 to the relay in the following manner.

1. Connect OUTPUT terminals to the frequency input (P.T.) terminals of the relay. If the relay is three phase, it will be necessary to test each phase individually.

2. Connect top and center (red and yellow) CONTACTS terminals to relay contacts. Place the CONTACT MODE SELECT Switch in either N.O. or N.C. position, depending on whether normally open or normally closed contacts are being monitored.

3. For relays requiring 48, 125 or 250 V D.C. for operation, connect the top (red) terminal to the positive input, and the bottom (black) terminal to the negative input of the relay.

NOTE: For relays requiring an A.C. source, a D.C. source with voltages other than 48, 125, or 250 V or a greater ampacity than 500 milliamperes, an external power source must be used. If this is necessary, make connections in the following manner:

* Connect A.C. OUTPUTS to relay P.T. terminals as described below.

* Connect the necessary external D.C. or A.C. supply across the appropriate power supply inputs to the relay.
* Connect the top and center CONTACTS Terminals of the FTS-300 to the contacts terminals on the relay. If one side of the relay contacts is tied or wired externally to D.C. voltage, this side **must** be connected to the top (red) terminal. If the relay contacts are dry or otherwise isolated from all other circuits within the relay, the connection to the test set will not be critical.

* Make no connections to the bottom contact binding post of the FTS-300. This will allow the contact and target circuits to float to the operating voltage of the relay contacts as necessary.

C. Connect the FTS-300 to line power, and turn the main circuit breaker on.

Circuit breaker will illuminate, the digital counter will display frequency, and the HERTZ Lamp should illuminate. Allow test set to warm up until frequency stabilizes (about two minutes).

NOTE: The circuit breaker may trip once or twice while attempting to turn the test set on. This is due to transformer inrush current, and is not a defect in the test set.

D. Select proper voltage on the D.C. POWER SUPPLY Control. If no voltage is required by the relay itself, set the supply at 48 volts, as a voltage is needed across the output to operate the contact sensing circuit. Allow a few seconds for the voltage to stabilize.

The LED next to the D.C. POWER SUPPLY Control will illuminate. If LED does not come on, depress LED to reset the power supply. If LED still fails to illuminate, or if the main circuit breaker trips out, the relay may be drawing too much power, and an external power supply may be necessary.

E. Adjust NORMAL FREQUENCY Control to the normal operating frequency of the relay, and adjust the normal OUTPUT VOLTAGE Control (outer knob) to the operating voltage for the relay.

F. To test **pick-up function**:
Slowly adjust the normal frequency past the pick-up frequency of the relay. Relay contacts should close (or open), and CONTACTS CLOSED Light should indicate change of status. The frequency where the light just flickers is the pick-up frequency.

G. To test the **time delay** characteristic:
1. Readjust the NORMAL FREQUENCY Control to normal operating frequency.
2. Position FUNCTION Switch to SET FAULT. Adjust the FAULT FREQUENCY Control to the desired fault frequency. The normal frequency will remain at the output, while the fault frequency can be monitored on the meter.
3. Depress the READ FAULT VOLTAGE Button. The voltage indicated on the output voltage meter is the voltage present at the output. Adjust the inner knob on the OUTPUT VOLTAGE CONTROL to read the desired fault voltage. For testing frequency relays, this will normally be the same as the normal voltage. Release the button to return to normal voltage. Allow relay to stabilize in normal condition.

4. Switch FUNCTION Switch to TEST Position. SECONDS LED should illuminate, and counter will reset to zero and start counting seconds. The output frequency and voltage will automatically switch to their preset fault states upon switching to test position, simultaneously with the starting of the timer. As contacts change status, timer will stop and display elapsed time.

5. By returning to SET FAULT Condition, allowing relay to stabilize, and then switching back to TEST Position, the timing test can be repeated as many times as desired. For relays with an inverse time characteristic, testing at several different frequency points may be recommended.

H. To test for **target pick-up**:

1. Switch to TARGET Position, the A.C. OUTPUTS will continue to provide fault frequency and voltage, and the fault frequency will be displayed on the meter. The CONTACTS CLOSED Lamp will not function in this mode.

2. Select proper current range on the TARGET CURRENT Range Switch (0.3A or 3A), depending on whether the target coil on the relay is rated at 0.2 or 2 amperes.

3. Increase TARGET CURRENT slowly until target contacts close, and the flag or light on the relay indicates target pick-up.

I. To test **seal-in function**:

1. Increase TARGET CURRENT above pick-up point to rated value.

2. Adjust the FAULT FREQUENCY Control into the normal operating range. Check to see that the contacts remain closed by noting the continuation of D.C. current on the ammeter. Slowly decrease until it suddenly drops to zero. This is the "Drop-out" point.

J. Turn all outputs fully counterclockwise, turn off D.C. POWER SUPPLY, and turn the test set off, before disconnecting leads.
2. TESTING VOLTAGE RELAYS WITH THE FTS-300.

A-E. Perform steps A-E in the procedure for testing frequency relays.

F. To test **pick-up function**:

   Slowly adjust the normal voltage past the pick-up voltage for the relay. As pick-up voltage is passed, relay contacts should close (or open) and CONTACTS CLOSED Light should indicate change of status. The voltage where the light just flickers is the pick-up voltage.

   **NOTE:** For overvoltage relays, the test set is only rated to produce 125 volts maximum at full load. For relays requiring fault voltages greater than 125 volts for testing, the FTS-300 may not be sufficient.

G. To test **time delay characteristic**:

   1. Adjust normal voltage control to normal operating voltage.

   2. Switch FUNCTION Switch to SET FAULT Position. Adjust FAULT FREQUENCY Control to the same frequency as the NORMAL FREQUENCY.

   3. Depress the READ FAULT VOLTAGE Button. Adjust the inner knob on the OUTPUT VOLTAGE Control to read the desired fault voltage. Release the button to return to normal voltage. Allow relay to stabilize in normal condition.

   4. Switch FUNCTION Switch to TEST Position. Voltage will drop to preset fault voltage, and timer will start simultaneously. As relay contacts change status, timer will stop, indicating elapsed time.

   5. By returning to SET FAULT Condition, allowing relay to stabilize, and then switching back to TEST Position, the timing test can be repeated as many times as desired.

H. To test for **target pick-up**:

   1. Switch to TARGET Position. Fault voltage will remain at the A.C. OUTPUTS. CONTACTS CLOSED Lamp will not function.

   2. Select proper current range on the TARGET CURRENT Range Switch.

   3. Increase target current slowly until target contacts close, and the flag or light on the relay indicates target pick-up.

I. To test **seal-in function**:

   1. Increase current above pick-up point to rated value.
2. Adjust FAULT VOLTAGE Control (inner knob) into the normal operating range. Check to see that the contacts remain closed, by noting the continuation of D.C. current on the ammeter. Slowly decrease the current until it suddenly drops to zero. This is the "drop-out" point.

J. Turn all outputs fully counterclockwise, turn off the D.C. power supply, and turn the test set off before disconnecting leads.

3. OTHER USES OF THE FTS-300

A. Testing over and under excitation relays:

These relays, such as the General Electric Type STV, sense a change in the volts-to-hertz ratio, rather than simply a change in frequency and are calibrated and tested in much the same manner as are frequency relays. The only difference is that instead of setting a specified fault frequency, a suitable voltage and frequency will have to be determined given a specified fault ratio. By suitable voltage and frequency, it is meant that the values chosen both normal and fault ratios.

B. Military and Aircraft applications:

The FTS-300 also supplies a variable frequency voltage source ranging from 360-440 Hz. In addition, the FTS-300 can be used as a portable field unit for checking 400 Hz instrumentation.
4. TESTING SPECIFIC RELAYS

A. WESTINGHOUSE type CF-1, UNDER OR OVERFREQUENCY RELAY

Test Procedures

Always refer to manufacturer's literature before testing.

Equipment Required

Multi-Amp Model FTS-300 Frequency Test Set

Types of Tests

Pick-up
Time Delay
Target Pick-Up and Seal-In

Set-Up of Controls Before Test

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>POSITION</th>
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<tbody>
<tr>
<td>Main POWER Switch</td>
<td>OFF</td>
</tr>
<tr>
<td>FUNCTION Switch</td>
<td>NORMAL</td>
</tr>
<tr>
<td>OUTPUT CONTROL Voltage Adjust</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>Frequency RANGE Switch</td>
<td>40-70 Hz</td>
</tr>
<tr>
<td>Frequency Adjust Control</td>
<td>Mid-Range</td>
</tr>
<tr>
<td>Contact Mode Select Switch</td>
<td>N.O.</td>
</tr>
<tr>
<td>TARGET CURRENT Range Switch</td>
<td>As Desired</td>
</tr>
<tr>
<td>TARGET CURRENT Control</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>D.C. POWER SUPPLY</td>
<td>OFF</td>
</tr>
</tbody>
</table>
TESTING PICK-UP

1. Connect line cord to FTS-300 power input connection and suitable line power source.

2. Connect FTS-300 OUTPUT Terminals to relay terminals 8 and 9.

3. Connect FTS-300 CONTACTS Terminals (top and center of contacts/D.C. POWER SUPPLY Binding Posts) to relay terminals 1 and 10.

4. Put main power switch in ON Position.

5. Rotate OUTPUT CONTROL clockwise until output voltmeter reads relay rated input voltage.

6. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

7. Adjust NORMAL FREQUENCY Control for frequencies approaching anticipated relay pick-up frequency until relay pick-up point is determined, shown by flickering of CONTACTS CLOSED Indicator (increasing frequencies for overfrequency relay and decreasing frequencies for under frequency relay). Record corresponding frequency meter reading as relay pick-up frequency.

TESTING TIME DELAY

1. Turn on D.C. supply voltage to operate contact/timing circuitry.

2. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

3. Put FUNCTION Switch in SET FAULT Position.

4. Adjust FAULT FREQUENCY Control for frequency meter reading of desired fault frequency at which relay is to be timed.

5. Put FUNCTION Switch in TEST Position. Frequency meter will now display a running time count. When relay picks up, timer will read trip time.

6. Relay trip time at fault frequency (step 3) may be re-checked by returning the FUNCTION Switch to SET FAULT Position, allowing sufficient relay contact stabilization time, then switching back to test position.

7. Repeat steps 2 through 5 for other desired fault frequencies at which relay is to be timed.
TESTING D.C. TARGET PICK-UP AND SEAL-IN

1. Put FUNCTION Switch in TARGET Position.

2. Rotate TARGET CURRENT Control clockwise until relay target contacts pick-up and target falls.

3. Rotate TARGET CURRENT Control back and forth and determine minimum current at which target contacts consistently pick-up. Record target current ammeter reading as target pick-up value.

NOTE: Reset flag each time target contacts drop out as flag affects target pick-up value.

4. If target has seal-in feature, rotate TARGET CURRENT Control clockwise for up to full scale target current ammeter reading. If not, proceed to step 7.

5. Adjust FAULT FREQUENCY Control for frequency meter reading of relay rated normal frequency.

6. Look to verify that the target contacts have sealed in.

7. Return TARGET CURRENT Control to zero, fully counterclockwise. Verify that the relay drops out.

8. Return OUTPUT CONTROL to zero, fully counterclockwise.

B. GE type CFF-12A AND CFF-12C, UNDERFREQUENCY RELAY

Test Procedures

Always refer to manufacturer's literature before testing.

Equipment Required

Multi-Amp Model FTS-300 Frequency Test Set

Types of Tests

Underfrequency Pick-Up
Time Delay
Target Pick-Up and Seal-In
Restore Frequency

Set-Up of Controls Before Test

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Power Switch</td>
<td>OFF</td>
</tr>
<tr>
<td>FUNCTION Switch</td>
<td>NORMAL</td>
</tr>
<tr>
<td>OUTPUT CONTROL Voltage Adjust</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>Frequency RANGE Switch</td>
<td>40-70 Hz</td>
</tr>
<tr>
<td>Frequency Adjust Controls</td>
<td>Mid-Range</td>
</tr>
<tr>
<td>Contact Mode Select Switch</td>
<td>N.O.</td>
</tr>
<tr>
<td>TARGET CURRENT Range Switch</td>
<td>As Desired</td>
</tr>
<tr>
<td>TARGET CURRENT Control Switch</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>D.C. POWER SUPPLY Switch</td>
<td>OFF</td>
</tr>
</tbody>
</table>
TESTING UNDERFREQUENCY PICK-UP

1. Connect line cord to FTS-300 power input connection and suitable power source.

2. Connect FTS-300 signal output terminals to relay terminals 5 and 6.

3. Jumper relay terminals 5 to 7 and 6 to 8.

4. Connect FTS-300 top CONTACTS/D.C. power supply binding post to relay terminal 1.

5. Connect FTS-300 middle CONTACTS/D.C. power supply binding post to relay terminal 2.

6. If relay is CFF-12A, connect bottom CONTACTS/D.C. power supply binding post to relay terminal 4, then jumper relay terminals 1 to 3.

7. Put main power switch in ON position.

8. Turn D.C. POWER SUPPLY ON to rated CFF-12 buss supply.

9. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

10. Adjust NORMAL FREQUENCY Control for decreasing frequencies until relay pick-up point is reached, shown by illumination of contact status indicator. Now adjust NORMAL FREQUENCY Control back and forth and determine maximum frequency for which relay consistently picks up. Record corresponding frequency meter reading as relay pick-up value.

TESTING TIME DELAY

1. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

2. Put FUNCTION Switch in SET FAULT Position.

3. Adjust FAULT FREQUENCY Control for frequency meter reading of desired fault frequency at which relay is to be timed.

4. Put FUNCTION Switch in TEST Position. Frequency meter will now display a running time count. When relay picks up, timer will read relay time to trip.

5. Relay trip time at step 3 fault frequency may be re-checked by returning FUNCTION Switch to SET FAULT Position, allowing sufficient relay contact
stabilization time, then switching back to test position.

6. Repeat steps 2 through 5 for other fault frequencies at which relay is to be timed.

TESTING D.C. TARGET PICK-UP AND SEAL-IN

1. Put FUNCTION Switch in TARGET Position.

2. Rotate TARGET CURRENT Control clockwise until relay target contacts pick-up and target falls.

3. Rotate TARGET CURRENT Control back and forth and determine minimum current at which target contacts consistently pick-up. Record target current ammeter reading as target pick-up value.

NOTE: Reset flag each time target contacts drop out as flag affects target pick-up value.

4. If target has seal-in feature, rotate TARGET CURRENT Control clockwise for up to full scale target current ammeter reading. If not, proceed to step 7.

5. Adjust FAULT FREQUENCY Control for frequency meter reading of relay rated normal frequency.

6. Look to verify that the target contacts have sealed in.

7. Return TARGET CURRENT Control to zero, fully counterclockwise. Verify that the relay target drops out.

8. Return OUTPUT CONTROL to zero, fully counterclockwise.

9. Put main power switch in OFF position.

TESTING RESTORE FREQUENCY

1. Re-position all controls as in initial control set-up.

2. Switch lead at relay terminal 1 to relay terminal 9.

3. Switch lead at relay terminal 2 to relay terminal 10.

4. If relay is CFF-12A, remove terminal 1-3 jumper and place between relay terminals 9 and 3.

5. Put main power switch in ON position.
6. Rotate OUTPUT CONTROL clockwise until output voltmeter reads relay rated input voltage.
7. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay underfrequency pick-up value, as determined in step 9 of underfrequency pick-up test procedure, minus 0.5 Hz. Now adjust NORMAL FREQUENCY Control for increasing frequencies until relay normal frequency contacts close, shown by contact status indicator illumination.

8. Repeat step 6 several times and determine minimum frequency at which relay normal frequency contacts consistently pick-up. Record corresponding frequency meter reading as relay normal frequency restore value.

9. Return OUTPUT to zero, fully counterclockwise.

10. Put main power switch in OFF position.
C. GE type CFF-12B and CFF-12D, OVERFREQUENCY RELAY

Test Procedures

Always refer to manufacturer's literature before testing.

Equipment Required

Multi-Amp Model FTS-300 Frequency Test Set.

Types of Tests

Overfrequency Pick-up
Time Delay
Target Pick-Up and Seal-In
Normal Frequency Restore

Set-Up of Controls Before Test

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<td>TARGET CURRENT Range Switch</td>
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</tr>
<tr>
<td>TARGET CURRENT Control</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>D.C. POWER SUPPLY</td>
<td>OFF</td>
</tr>
</tbody>
</table>
TESTING OVERFREQUENCY PICK-UP

1. Connect line cord to FTS-300 power input connection and suitable line power source.

2. Connect FTS-300 signal OUTPUT Terminals to relay terminals 5 and 6.

3. Jumper relay terminals 5 to 7 and 6 to 8.

4. Connect FTS-300 top CONTACTS/D.C. power supply binding post to relay terminal 1.

5. Connect FTS-300 middle CONTACTS/D.C. power supply binding post to relay terminal 2.

6. If relay is CFF-12A, connect bottom CONTACTS/D.C. power supply binding post to relay terminal 4, then jumper relay terminals 1 to 3.

7. Put main power Switch in ON Position.

8. Turn D.C. supply on to rated bus supply.

9. Rotate OUTPUT CONTROL clockwise until voltmeter reads relay rated input voltage.

10. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

11. Adjust NORMAL FREQUENCY Control for increasing frequencies until relay pick-up point is reached, shown by illumination of contact status indicator. Now adjust NORMAL FREQUENCY Control back and forth and determine minimum frequency for which relay consistently picks up. Record corresponding frequency meter reading as relay overfrequency pick-up value.

TESTING TIME DELAY

1. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay's rated normal frequency.

2. Put FUNCTION Switch in SET FAULT Position.

3. Adjust FAULT FREQUENCY Control for frequency meter reading of desired fault frequency at which relay is to be timed.

4. Put FUNCTION Switch in TEST Position. Frequency meter will now display a running time count. When relay picks up, timer will read relay time to trip.
5. Relay trip time at step 3 FAULT FREQUENCY may be re-checked by returning function switch to set fault position, allowing sufficient relay contact stabilization time, then switching back to test position.

6. Repeat steps 2 through 5 for other fault frequencies at which relay is to be timed.

TESTING NORMAL FREQUENCY RESTORE

1. Re-position all controls as in initial control set-up.

2. Switch lead at relay terminal 1 to relay terminal 9.

3. Switch lead at relay terminal 2 to relay terminal 10.

4. If relay is CFF-12B, remove terminal 1-3 jumper and place between relay terminals 9 and 3.

5. Place main power switch in the ON Position.

6. Rotate OUTPUT Control clockwise until output voltmeter reads relay rated input voltage.

7. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay overfrequency pick-up value (recorded in step 11 of overfrequency pick-up test procedure) plus 0.5 Hz. Now, adjust NORMAL FREQUENCY Control for decreasing frequencies until relay normal frequency contacts close, shown by CONTACTS CLOSED Lamp.

8. Repeat step 6 several times and determine maximum frequency at which relay normal frequency contacts consistently pick-up. Record corresponding frequency meter reading as relay normal frequency restore value.

9. Return OUTPUT Control to zero, fully counterclockwise.

10. Put main power switch in OFF position.

TESTING D.C. TARGET PICK-UP and SEAL-IN

1. Put FUNCTION Switch in TARGET Position.

2. Rotate TARGET CURRENT Control clockwise until relay target contacts pick-up and target falls.
3. Rotate TARGET CURRENT Control back and forth and determine minimum current at which target contacts consistently pick-up. Record target current ammeter reading as target pick-up value.

NOTE: Reset flag each time target contacts drop out as flag affects target pick-up value.

4. If target has seal-in feature, rotate TARGET CURRENT Control clockwise for full scale target current ammeter reading. If not, proceed to step 7.

5. Adjust FAULT FREQUENCY Control for frequency meter reading of relay rated normal frequency.

6. Look to verify that the target contacts have sealed in.

7. Return TARGET CURRENT Control to zero, fully counterclockwise. Verify that the relay target drops out.

8. Return OUTPUT Control to zero, fully counterclockwise.

F. GE type CFF-14A, UNDERFREQUENCY RELAY

Test Procedure

Always refer to manufacturer's literature before testing.

Equipment Required

Multi-Amp Model FTS-300, Frequency Test Set

Types of Tests

Underfrequency Pick-Up
Restore Frequency
Time Delay
Target Pick-Up and Seal-In

Set-Up of Control Before Test

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Power Switch</td>
<td>OFF</td>
</tr>
<tr>
<td>FUNCTION Switch</td>
<td>NORMAL</td>
</tr>
<tr>
<td>OUTPUT CONTROL Voltage Adjust</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>Frequency RANGE Switch</td>
<td>40-70 Hz</td>
</tr>
<tr>
<td>Frequency Adjust Control</td>
<td>Mid-Range</td>
</tr>
<tr>
<td>Contact Mode Select Switch</td>
<td>N.O.</td>
</tr>
<tr>
<td>TARGET CURRENT Range Switch</td>
<td>As Desired</td>
</tr>
<tr>
<td>TARGET CURRENT Control</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>D.C. Power Supply</td>
<td>OFF</td>
</tr>
</tbody>
</table>
TESTING UNDERFREQUENCY PICK-UP

1. Connect the line cord to FTS-300 power input connection and suitable line power source.

2. Connect FTS-300 signal OUTPUT Terminals to relay terminals 5 and 8.

3. Connect FTS-300 top CONTACTS/D.C. power supply binding post to relay terminal 4.

4. Connect FTS-300 center CONTACTS/D.C. power supply binding post to relay terminal 9.

5. Connect FTS-300 bottom CONTACTS/D.C. power supply binding post to relay terminal 3.

6. Jumper relay terminal 2 to 4, and 6 to 8 to 10.

7. Turn on D.C. supply to rated bus supply.

8. Rotate OUTPUT Control clockwise until output voltmeter reads relay rated input voltage.

9. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

10. Adjust NORMAL FREQUENCY Control for decreasing frequencies until relay pick-up point is reached, shown by illumination of contact status indicator. Now adjust NORMAL FREQUENCY Control back and forth and determine maximum frequency for which relay consistently picks up. Record corresponding frequency meter reading as relay underfrequency pick-up value.

TESTING RESTORE FREQUENCY

1. Set output frequency to a value below the relay's set-point (determined in UNDERFREQUENCY PICK-UP test procedure) using the NORMAL FREQUENCY Control. Observe frequency value on frequency meter.

2. Adjust NORMAL FREQUENCY Control for increasing frequencies until relay drop-out point is reached, shown by extinguishment of CONTACTS CLOSED Indicator.

3. Now adjust NORMAL FREQUENCY Control back and forth and determine minimum frequency for which relay consistently drops out. Record corresponding frequency meter reading as relay normal frequency restore value.
4. Return OUTPUT Control to zero, fully counterclockwise.

5. Put main power switch in OFF Position.

**TESTING TIME DELAY**

1. Remove lead from relay terminal 9 and attach to relay terminal 7.

2. Jumper relay terminal 1 to 3.

3. Put main power switch in ON Position.

4. Rotate OUTPUT Control clockwise until output voltmeter reads relay rated input voltage.

5. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.


7. Adjust FAULT FREQUENCY Control for frequency meter reading of desired fault frequency at which the relay is to be timed.

8. Put FUNCTION Switch in TEST Position. Frequency meter will now display a running time count. When relay picks up, timer will read time to trip.

9. Relay trip time at step 3 fault frequency may be re-checked by returning FUNCTION Switch to SET FAULT Position, allowing sufficient relay contact stabilization time, then switching back to TEST Position.

10. Repeat steps 2 through 5 for other desired fault frequencies at which relay is to be timed.

**TESTING D.C. TARGET PICK-UP AND SEAL-IN**

1. Put FUNCTION Switch in TARGET Position.

2. Rotate TARGET CURRENT Control clockwise until relay target contacts pick-up and target falls.

3. Rotate TARGET CURRENT Control back and forth and determine minimum current at which target contacts consistently pick-up. Record target current ammeter reading as target pick-up value.

**NOTE:** Reset flag each time target contacts drop out as flag affects target pick-up value.
4. If target has seal-in feature, rotate TARGET CURRENT Control clockwise for full scale target current ammeter reading. If not, proceed to step 7.

5. Adjust FAULT FREQUENCY Control for frequency meter reading of relay rated normal frequency.

6. Look to verify that the target contacts have sealed in.

7. Return TARGET CURRENT Control to zero, fully counterclockwise. Verify that the relay target drops out.

8. Return OUTPUT Control to zero, fully counterclockwise.

G. GE type IJF-51A and IJF-51B, UNDER OR OVERFREQUENCY RELAY

Test Procedure

Always refer to manufacturer's literature before testing.

Equipment Required

Multi-Amp model FTS-300 Frequency Test Set
External capacitor, to be found wired to relay case terminals.

Types of Tests

Pick-Up
Time Delay
Target Pick-Up and Seal-In

Set-Up of Controls Before Test

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Power Switch</td>
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<tr>
<td>OUTPUT CONTROL Voltage Adjust</td>
<td>Fully Counterclockwise</td>
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<tr>
<td>Frequency Range Switch</td>
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</tr>
<tr>
<td>Frequency Adjust Controls</td>
<td>Mid-Range</td>
</tr>
<tr>
<td>Contact Mode Select Switch</td>
<td>N.O.</td>
</tr>
<tr>
<td>TARGET CURRENT Range Switch</td>
<td>As Desired</td>
</tr>
<tr>
<td>TARGET CURRENT Control</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>D.C. Power Supply</td>
<td>OFF</td>
</tr>
</tbody>
</table>
TESTING PICK-UP

1. Connect line power cord to FTS-300 power input connection and suitable line power source.

2. Connect external capacitor between relay terminals 5 and 7.

3. Connect FTS-300 signal OUTPUT Terminals to relay terminals 7 and 8.

4. Connect FTS-300 CONTACTS Terminals (top and center of contacts/D.C. power supply binding posts) to relay terminals 1 and 2.

5. Jumper relay terminals 6 to 8.

6. Put main power switch in ON Position.

7. Rotate OUTPUT FREQUENCY Clockwise until output voltmeter reads relay rated input voltage.

8. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

9. Adjust NORMAL FREQUENCY Control just below anticipated relay pick-up frequency until relay set-point is determined, shown by flickering of contact status indicator (increasing frequencies for overfrequency relay and decreasing frequencies for underfrequency relay). Record corresponding frequency meter reading as relay set-point.

TESTING TIME DELAY

1. Turn D.C. supply voltage on to operate contacts/timing circuitry.

2. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

3. Put FUNCTION Switch in SET FAULT Position.

4. Adjust FAULT FREQUENCY Control for frequency meter reading of desired fault frequency at which relay is to be timed.

5. Put FUNCTION Switch in TEST Position. Frequency meter will now display a running time count. When relay picks up, timer will read relay trip time.

6. Relay trip time at step 3 fault frequency may be re-checked by returning FUNCTION Switch to SET FAULT Position, allowing sufficient relay contact stabilization time, then switching back to TEST Position.
7. Repeat steps 2 through 5 for other desired fault frequencies at which relay is to be timed.

TESTING D.C. TARGET PICK-UP AND SEAL-IN

1. Put FUNCTION Switch in TARGET Position.

2. Rotate TARGET CURRENT Control clockwise until relay target contacts pick-up and target falls.

3. Rotate TARGET CURRENT Control back and forth and determine minimum current at which target contacts consistently pick-up. Record target current ammeter reading as target pick-up value.

NOTE: Reset flag each time target contacts drop out as flag affects target pick-up value.

4. If target has seal-in feature, rotate TARGET CURRENT Control clockwise for full scale target current ammeter reading. If not, proceed to step 7.

5. Adjust FAULT FREQUENCY Control for frequency meter reading of relay rated normal frequency.

6. Look to verify that the target contacts have sealed in.

7. Return TARGET CURRENT Control to zero, fully counterclockwise. Verify that the relay target drops out.

8. Return OUTPUT Control to zero, fully counterclockwise.

F. **WESTINGHOUSE type KF, UNDERFREQUENCY RELAY**

**Test Procedure**

Always refer to manufacturer's literature before testing.

**Equipment Required**

Multi-Amp Model FTS-300 Frequency Test Set.

**Types of Tests**

Pick-Up
Time Delay
Target Pick-Up and Seal-In

**Set-Up of Controls**

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Power Switch</td>
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</tr>
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<td>FUNCTION Switch</td>
<td>NORMAL</td>
</tr>
<tr>
<td>OUTPUT CONTROL Voltage Adjust</td>
<td>Fully counterclockwise</td>
</tr>
<tr>
<td>Frequency RANGE Switch</td>
<td>40-70 Hz</td>
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<tr>
<td>Frequency Adjust Controls</td>
<td>Mid-Range</td>
</tr>
<tr>
<td>Contact Mode Select Switch</td>
<td>N.O.</td>
</tr>
<tr>
<td>TARGET CURRENT Range Switch</td>
<td>As Desired</td>
</tr>
<tr>
<td>TARGET CURRENT Control</td>
<td>Fully counterclockwise</td>
</tr>
<tr>
<td>D.C. Power Supply</td>
<td>OFF</td>
</tr>
</tbody>
</table>
TESTING PICK-UP

1. Connect line cord to FTS-300 power input connection and suitable line power source.

2. Connect FTS-300 signal OUTPUT Terminals to relay terminals 8 and 9.

3. Connect FTS-300 top CONTACTS/D.C. power supply binding post to relay terminal 10.

4. Connect FTS-300 center CONTACTS/D.C. power supply binding post to relay terminal 1.

NOTE: Step 5 is for relays with a D.C. time delay unit only. For A.C. time delay unit, proceed to step 6.

5. Connect FTS-300 bottom CONTACTS/D.C. power supply binding post to relay terminal 4.

6. Turn D.C. supply on to rating D.C. supply voltage.

7. Put main power switch in ON Position.

8. Rotate OUTPUT Control clockwise until output voltmeter reads relay rated input voltage.

9. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

10. Adjust NORMAL FREQUENCY Control for decreasing frequencies until relay picks up, shown by flickering of contact status indicator. Record corresponding frequency meter reading as relay pick-up frequency.

TESTING TIME DELAY

1. Turn D.C. supply voltage ON to operate contacts/timing circuitry.

2. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

3. Put FUNCTION Switch in SET FAULT Position.

4. Adjust FAULT FREQUENCY Control for frequency meter reading of desired fault frequency at which relay is to be timed.

5. Put FUNCTION Switch in TEST Position. Frequency meter will now display a
running time count. When relay picks up, timer will read relay trip time.

6. Relay trip time at step 3 fault frequency may be re-checked by returning FUNCTION Switch to SET FAULT Position, allowing sufficient relay contact stabilization time, then switching back to test position.

7. Since KF relay time delay is fixed rather than change of frequency dependant, it is necessary to time relay at one fault frequency only.

**TESTING D.C. TARGET PICK-UP AND SEAL-IN**

1. Put FUNCTION Switch in TARGET Position.

2. Rotate TARGET CURRENT Control clockwise until relay target contacts pick-up and target falls.

3. Rotate TARGET CURRENT Control back and forth and determine minimum current at which target contacts consistently pick-up. Record target current ammeter reading as target pick-up value.

**NOTE:** Reset flag each time target contacts drop out as flag affects target pick-up value.

4. If target has seal-in feature, rotate TARGET CURRENT Control clockwise for full scale target current ammeter reading. If not, proceed to step 7.

5. Adjust FAULT FREQUENCY Control for frequency meter reading of relay rated normal frequency.

6. Look to verify that the target contacts have sealed in.

7. Return TARGET CURRENT Control to zero, fully counterclockwise. Verify that the relay target drops out.

8. Return OUTPUT CONTROL to zero, fully counterclockwise.

G. **WESTINGHOUSE type SDF-1, UNDERFREQUENCY RELAY**

**Test Procedure**

Always refer to manufacturer's literature before testing.

**Equipment Required**

Multi-Amp Model FTS-300 Frequency Test Set

**Types of Tests**

Pick-Up
Time Delay
Target Pick-Up and Seal-In

**Set-Up of Controls Before Test**

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>POSITION</th>
</tr>
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<tbody>
<tr>
<td>Main Power Switch</td>
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<td>FUNCTION Switch</td>
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</tr>
<tr>
<td>OUTPUT CONTROL Voltage Adjust</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>Frequency RANGE Switch</td>
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</tr>
<tr>
<td>TARGET CURRENT Range Switch</td>
<td>As Desired</td>
</tr>
<tr>
<td>TARGET CURRENT Control</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>D.C. Power Supply</td>
<td>OFF</td>
</tr>
</tbody>
</table>
TESTING PICK-UP

1. Connect line cord to FTS-300 power input connection and suitable line power source.

2. Connect FTS-300 signal OUTPUT Terminals to relay terminals 8 and 9.

3. Connect FTS-300 top CONTACTS/D.C. power supply binding post to relay terminal 4.

4. Connect FTS-300 center CONTACTS/D.C. power supply binding post to relay terminal 1.

5. Connect FTS-300 bottom CONTACTS/D.C. power supply binding post to relay terminal 2.


7. Put main power switch in ON Position.

8. Turn D.C. supply on to rated bus voltage.

9. Rotate OUTPUT CONTROL clockwise until output voltmeter reads relay rated input voltage.

10. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

11. Adjust NORMAL FREQUENCY Control for decreasing frequencies until relay picks up, shown by contact status indicator illumination. Relay time delay at pick-up may be as much as 100 system cycles, so adjustment of NORMAL FREQUENCY Control to either side of relay pick-up frequency for several trials will be required. Record corresponding frequency meter reading as relay pick-up frequency.

TESTING TIME DELAY

1. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.

2. Put FUNCTION Switch in SET FAULT Position.

3. Adjust FAULT FREQUENCY Control for frequency meter reading of desired fault frequency at which relay is to be timed.

4. Put FUNCTION Switch in TEST Position. Frequency meter will now display a
running time count. When relay picks up, timer will read relay trip time.
5. Relay trip time at step 3 fault frequency may be re-checked by returning FUNCTION Switch to SET FAULT Position, allowing sufficient relay contact stabilization time, then switching back to TEST Position.

6. Since SDF-1 relay time delay is fixed rather than change of frequency dependant, it is necessary to time relay at one fault frequency only.

**TESTING D.C. TARGET PICK-UP AND SEAL-IN**

1. Put FUNCTION Switch in TARGET Position.

2. Rotate TARGET CURRENT Control clockwise until relay target contacts pick-up and target falls.

3. Rotate TARGET CURRENT Control back and forth and determine minimum current at which target contacts consistently pick-up. Record target current ammeter reading as target pick-up value.

**NOTE:** Reset flag each time target contacts drop out as flag affects target pick-up value.

4. If target has seal-in feature, rotate TARGET CURRENT Control clockwise for full scale target current ammeter reading. If not, proceed to step 7.

5. Adjust FAULT FREQUENCY Control for frequency meter reading of relay rated normal frequency.

6. Look to verify that the target contacts have sealed in.

7. Return TARGET CURRENT Control to zero, fully counterclockwise.

8. Return OUTPUT Control to zero, fully counterclockwise.

H. GE type STV-11A, STATIC OVEREXITATION RELAY

Test Procedure

Always refer to manufacturer's literature before testing.

Equipment Required

Multi-Amp Model FTS-300 Frequency Test Set.

Types of Tests

Pick-Up
Time Delay
Target Pick-Up and Seal-In

Set Up of Controls Before Test

<table>
<thead>
<tr>
<th>CONTROL</th>
<th>POSITION</th>
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<tr>
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</tr>
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<td>Frequency Adjust Control</td>
<td>Mid-Range</td>
</tr>
<tr>
<td>Contact Mode Select Switch</td>
<td>N.O.</td>
</tr>
<tr>
<td>TARGET CURRENT Range Switch</td>
<td>As Desired</td>
</tr>
<tr>
<td>TARGET CURRENT Control</td>
<td>Fully Counterclockwise</td>
</tr>
<tr>
<td>D.C. Power Supply</td>
<td>OFF</td>
</tr>
</tbody>
</table>
TESTING PICK-UP

1. Connect line cord to FTS-300 power input connection and suitable line power source.

2. Connect FTS-300 signal OUTPUT Terminals to relay terminals 6 and 7.

3. Connect FTS-300 top CONTACTS/D.C. power supply binding post to relay terminal 10.

4. Connect FTS-300 center CONTACTS/D.C. power supply binding post to relay terminal 4.

5. Connect FTS-300 bottom CONTACTS/D.C. power supply binding post to relay terminal 9.


7. Put main power switch in ON Position.

8. Turn D.C. supply on to rated D.C. supply bus.

9. Adjust NORMAL FREQUENCY Control for frequency meter reading corresponding to frequency at which relay pick-up is to be checked.

10. Rotate OUTPUT Control clockwise until relay picks up, shown by the contact status indicator illumination.

11. Rotate OUTPUT Control back and forth and determine minimum setting for which relay consistently picks up. Record corresponding output voltmeter reading as relay pick-up voltage for step 8 frequency setting.

12. Repeat steps 8 through 10 for one other frequency value.

13. Return OUTPUT Control to zero, fully counterclockwise.


NOTE: Calculate experimental pick-up volts per hertz ratio as follows:

\[ \frac{V}{Hz} = \frac{\text{step 10 voltage}}{\text{step 8 frequency}} \]

TESTING TIME DELAY

1. Remove jumper from relay terminals 5 and 10.
2. Remove lead from relay terminal 4 and connect to relay terminal 3.

3. Jumper relay terminal 1 to 10.
4. Put main power switch in ON Position.
5. Rotate OUTPUT Control clockwise until output voltmeter reads relay rated input voltage.
6. Adjust NORMAL FREQUENCY Control for frequency meter reading of relay rated normal frequency.
7. Calculate frequency corresponding to V/Hz ratio at which relay is to be timed (must be slightly above experimental relay V/Hz ratio as determined in pick-up test procedure).

\[
F = V \times (V/Hz + 0.1)^{-1}
\]
Where:
- \(F\) = Test frequency from 7 above
- \(V\) = Test voltage from 5 above
- \(V/Hz\) = Relay experimental V/Hz pick-up value
9. Adjust FAULT FREQUENCY Control for frequency meter reading of test frequency calculated in step 7 above.
10. Put FUNCTION Switch in TEST Position. Frequency meter will now display a running time count. When relay picks up, timer will read relay time to trip.
11. Relay trip time (step 9 V/Hz parameters) may be re-checked by returning FUNCTION Switch to SET FAULT Position, allowing sufficient relay contact stabilization time, then switching back to test position.
12. Since relay TU function has a fixed time delay rather than V/Hz dependent, it is necessary to perform the timing test for one V/Hz value only.

**TESTING D.C. TARGET PICK-UP AND SEAL-IN**

1. Put FUNCTION Switch in TARGET Position.
2. Rotate TARGET CURRENT Control clockwise until relay target contacts pick-up and target falls.
3. Rotate TARGET CURRENT Control back and forth to determine the minimum current at which target contacts consistently pick-up. Record target current ammeter reading as target pick-up value.
NOTE: Reset flag each time target contacts drop out as flag affects target pick-up value.
4. If target has seal-in feature, rotate TARGET CURRENT Control clockwise for full scale target current ammeter reading. If not, proceed to step 7.

5. Adjust FAULT FREQUENCY Control for frequency meter reading of relay rated normal frequency.

6. Look to verify that target contacts have sealed in.

7. Return TARGET CURRENT Control to zero, fully counterclockwise. Verify that relay target drops out.

8. Return OUTPUT Control to zero, fully counterclockwise.

CONCEPT OF OPERATION

Refer to Figure A on the following page for simplified block diagram on the FTS-300.

The A.C. OUTPUT of the test set is generated by one of two independent oscillators, one for NORMAL and one for FAULT FREQUENCY. These oscillators operate at a high multiple of the output frequency to enable frequency resolution of 0.001 Hz. The signals are divided down and sent to the sine synthesizer to be converted to a 64-step wave. Filtering on the output brings the distortion well within acceptable limits.

The main power supply provides necessary power for all internal test set functions. This supply comes off the main input transformer, which can be wired for either 120 V or 240 V operation.

The D.C. POWER SUPPLY provides either 48, 125, or 250 VDC for operation of solid state relays. This voltage is channeled through the contact interface board to provide operating voltage for the contact-sensing circuit. In addition to the contact circuits, the contact interface board provides a current source capable of supplying up to 4 volts and 3 amperes for performing target tests. The positive rails of the D.C. power supply and current source are tied together, in order to provide target current at the necessary voltage for SCR type contacts. The two circuits are floating, and isolated from the switching logic.

The frequency monitoring circuit works as follows:

The timer control generates a gate to the input of the counter (timer) for 125/256 of a second. Since the oscillators are oscillating at 2,048 times the output frequency, a gate of 125/256 seconds times 2,048 cycles/second results in a count of 1,000 times the actual output frequency at the input to the counter, to provide 0.001 Hz resolution. At this point, the control circuit generates an inhibit pulse for 3/256 of a second, causing the counter to stop counting. Simultaneously, a store pulse (which has held the previous count on the display) goes low for 1/256 of a second, allowing the new count to be transferred to the display. This store pulse again goes high, and in the remaining 2/256 of a second, a reset pulse resets the counter. The reset pulse goes low, and when the inhibit pulse comes low at 128/256 (1/2) of a second, the entire process begins again. This sequence allows for continuous 1/2 second updates of the output frequency.

When the test set is in the TIMING Mode, the inhibit and store pulses are no longer generated, and a 1 KHz signal is fed through to the counter to provide timing resolution to 0.001 second. A microsecond reset pulse is generated at the instant of switching to clear the previous frequency from the counter.
FIGURE A
SIMPLIFIED BLOCK DIAGRAM
The proper gating to pass the NORMAL and FAULT frequencies to their desired locations (output or display, or both) is controlled by the presence of the proper logic levels generated by the FUNCTION Switch. The proper control signals to stop the timer upon contact closure (or opening) are generated by the combination of signals from the normally open/normally closed switch and the presence or absence of current through the opto-isolator across the contact circuit.

The oscillator signal which is channelled to the sine synthesizer is divided by 64, and the resulting signal is used to generate a step-function sine wave of the desired frequency. This output frequency is filtered, and then fed to the output amplifier.

The output amplifier uses a high power operational amplifier capable of producing a signal of up to 50 VA at 24 volts RMS. The amplifier is designed to operate on a +/- 37 volt supply. The output of the amplifier feeds a special wide range, dual secondary transformer which may be connected for 0-120 or 0-240 volts output over the given primary voltage range. The output voltage is read on the A.C. voltmeter.

A more detailed description of each of the individual printed circuit boards is given below.

POWER SUPPLY BOARD

A +/- volt supply for the output amplifier is generated from a 38 volt A.C. supply, rectified and filtered. The supply is regulated by a dual switching network. The positive half works as follows:

A voltage divider between the +35 and -15 volt supplies is connected to the inverting input of an LM 358 operational amplifier. This reference voltage is zero when the positive rail is 35 volts. If the OUTPUT voltage drops below this point, the inverting input goes negative causing the output of the op-amp to go positive. A positive feedback loop causes the non-inverting input to rise to a positive voltage of 250 millivolts.

The positive output turns on an NPN transistor which turns on the main output transistor. This increases the voltage on the positive rail. When the OUTPUT reaches 35.5 volts, the output transistor is turned off. A 6.4 millihenry inductance in series with the OUTPUT prevents large current surges and stores energy to stabilize power flow when the transistor is turned off. When the OUTPUT voltage drops below 35 volts, the sequence repeats itself.

+/- 15 and +5 volt supplies are also provided to power internal control circuitry.

ADDITIONAL POWER SUPPLY

The circuit is powered by approximately 270 VA.C., which is full-wave-rectified by CR6, and also applied to the primary of transformer T1. The output of T1 is converted to approximately 20 V.D.C. by a full-wave center-tap rectifier circuit and filter capacitor. A 12 V.D.C. regulated voltage is produced by VR1, which supplies power and reference voltage to the rest of the circuit.
The full-wave rectified high voltage (approximately 380 V peak) is applied to load resistor R4 and a voltage divider with clamping diodes to the inverting input of the first op-amp, U1. The non-inverting input is connected to a reference voltage of approximately 350 mV, so that it's output produces a narrow positive pulse during the zero-crossing of the input A.C. waveform. When the pulse is high, it triggers U2 to a low output state and discharges capacitor C4. When the pulse goes low, C4 is allowed to charge through R8, producing a positive-going ramp for each half-cycle of applied voltage. When the ramp voltage reaches the voltage at the non-inverting input of U3, it generates a negative transition at it's output, which generates a positive pulse at the gate of SCR1, causing it to turn on. This allows the remainder of the A.C. half-cycle to flow through R6 and CR4 into an external filter capacitor, and through a small surge limiting resistor to the OUTPUT. The OUTPUT voltage is sensed by a voltage divider and compared to one of three adjustable reference voltages, and produces an error-correction voltage from U4 into U3, which adjusts the firing point of the SCR. A load resistor R14 holds the cathode of SCR1 at ground potential during it's off-time, and the OUTPUT voltage monitored by a front panel LED driven by R27.

Load current is sensed by R26, designed for 600 mA DC current limit. When it's voltage exceeds approximately 0.6 V DC, transistor Q1 turns on, which pulls in relay K1, inhibiting further pulses to the SCR, and latching in this disabled condition. Reset is accomplished by breaking the latching circuit to the relay coil via an external reset switch.

**TIMER CONTROL BOARD**

All timing circuitry is derived from a 4 MHz crystal oscillator. By processing this signal through appropriate divide down circuitry, a 256 Hz signal is generated to control gating functions, and a 1 KHz signal is generated for timing in the test mode. The 1 KHz signal is run directly from the timer control board, through the dual-oscillator board to the timer.

The 256 Hz signal is fed through a counter and a series of logic gates to generate the timer control pulses described previously. With the FUNCTION Switch in TEST Position, these control pulses are all disabled, save for the microsecond reset pulse (generated on the dual-oscillator board) which is passed through the timer control board as the test set switches to the TIMING Mode.

**DUAL-OSCILLATOR BOARD**

The dual-oscillators are XR2207 voltage controlled oscillators. Their frequency of oscillation is determined by external capacitance and one of two timing resistances selected by means of binary keying inputs. The low-frequency range (40-70 Hz) is set by selection of a 0.0015 microfarad NPO capacitor and adjusted by a network of resistors, including the front panel control. The high-frequency range is set by selection of a 150 microfarad NPO capacitor and a separate network of resistors, also including the front panel control. Each oscillator is separately adjustable over a limited range.

In the high-range, the output is buffered by exclusive-or gate, and doubled frequency by means
of a second exclusive-or gate having one input delayed by means of series resistance and input capacitance. In the low-range, the buffered output is not doubled by means of holding the otherwise delayed input of the second exclusive-or gate to ground through a transistor.

The desired NORMAL or FAULT VCO output is channelled to the counter in all but the TEST Position where the 1 KHz signal from the timer control board is applied to the counter for timing purposes. The selected VCO output is also divided by a factor of 64 and fed to the sine synthesizer board. The logic circuitry also generates a reset pulse of approximately 1 microsecond, which is used to reset the timer when the CONTROL Switch is set to the TEST Position.

All switching logic from the FUNCTION Switch is generated by this board, which also incorporates necessary debouncing circuitry to ensure correct operation of the counter in both timing and frequency measurement modes.

SINE SYNTHESIZER BOARD

The voltage steps which make up the synthesized sine wave are picked off a voltage divider network. This network is connected between ground and the output of an op-amp whose output is a 15 volt square wave, oscillating at the output frequency.

The incoming oscillator signal (which has already been divided by 64) is input to a binary counter to produce the necessary gating signals to the voltage divider network. The outputs of the counter are passed through an exclusive-or network, which counts up to 16, and then down to zero to complete the positive cycle of the sine wave. This four-bit signal is decoded, and the proper voltage from the divider network is selected to send to the output. These voltages can be fine-tuned by adjustable pots to minimize harmonic distortion. After the positive cycle (180°) has been generated in 32 steps, the square wave output of the operational amplifier (also generated by the binary counter) comes low, causing the output to go negative, so that the decoder now selects negative voltages from the divider network for the negative, half of the sine wave. The output is fed through a buffer amplifier, and an active filter to round-off switching spikes.

CONTACTS INTERFACE BOARD

The Contacts Interface Board provides:

A. Switching logic to generate a signal to stop the timer in the TEST Mode.

B. Signal for the CONTACTS CLOSED Light.

C. D.C. target current.
When a power supply voltage of either 48, 125, or 250 volts is present at the board (due to contact closure), this turns on an MCT-26 opto-isolator. This opto-isolator turns on a transistor with a 5 volt LED in its emitter circuit.

Two (2) other logic states, generated by resistor-transistor logic, are controlled by the closure circuit. One of the logic states is high for closure and low for opening, and the other is the inverse of the first. The proper state is chosen by the normally open/normally closed switch so that when the relay (under test) operates and the contacts either open or close, a high level is passed to a set-reset flip-flop, generated at the instant of switching to the test mode, which is also used to reset the timer.
TROUBLESHOOTING GUIDE

The following is a procedure to identify some of the more basic problems that may be encountered when using the FTS-300 over an extended period of time. Refer to the functional schematic (in the appendix) for color codes to properly identify the internal wires which interconnect all the major components. Printed circuit board identification is as follows:

- **Power Supply Board (PCB #1)**: Mounted on left side panel.
- **Sine Synthesizer Board (PCB #2)**: Top right back panel, second board from the right.
- **Dual Oscillator Board (PCB #3)**: Top right back panel, first board from the right.
- **Timer Control Board (PCB #4)**: Top right back panel, third board from the right.
- **Contact Interface Board (PCB #5)**: Top right back panel, fourth board from the right.
- **Additional Power Supply Board (PCB #6)**: Top left back panel, second from the left.

The power amplifier is mounted on the heat sink on the brackets extending from the exhaust fan.

Use extreme care at all times when going into the unit to do any troubleshooting. If you are at all unsure about what you are doing, it is recommended that the unit be sent back to the manufacturer. **Any parts which must be replaced during the warranty period** (with the exception of fuses) **must be done at the factory**.

Troubleshooting procedures provided on the following pages for each of the given problems should be performed in the order listed. If the result of the check is positive, perform the recommended corrective action. If the check is negative, move to the next step.

**NOTE:** Do not make any adjustments or repairs while under warranty without consulting the manufacturer.
1. **POWER LIGHT FAILS TO LIGHT**

   **TEST**
   - A. Check 120 (240) VA.C. power to test set.
   - B. Check continuity of main breaker.

   **CORRECTIVE ACTION**
   - A. Troubleshoot power distribution system.
   - B. No continuity - replace defective breaker.

2. **COUNTER FAILS TO LIGHT**

   **TEST**
   - A. Check for presence of 120 VA.C. supply to counter.
   - B. Check for +5 VD.C. and +12 VD.C. at counter.

   **CORRECTIVE ACTION**
   - A. Check continuity of white and black wires from ON/OFF circuit breaker.
   - B. Consult manufacturer.

3. **NO VOLTAGE INDICATED ON METER AT FREQUENCY OUTPUTS**

   **TEST**
   - A. Check voltage across binding posts.
   - B. Check continuity across F3.
   - C. Check for presence of +/- 35 volts D.C. at the power amplifier.
   - D. Check for sine wave output from pin L sine synthesizer board (about 2-5 volts RMS).

   **CORRECTIVE ACTION**
   - A. Voltage okay - Check voltage across meter terminal. If voltage checks there, replace meter.
   - B. Replace fuse.
   - C. Replace F1 and F2.
   - D. Output okay - Replace output control pot.

   No output - Consult manufacturer.

4. **CONTACTS CLOSED LIGHT FAILS TO OPERATE OR MISOPERATES**

   **TEST**

   **CORRECTIVE ACTION**
A. Check to make sure FUNCTION Switch is not in TARGET Mode.

A. Switch to another mode.

B. Check for D.C. power supply switch to be turned to 48, 125, or 250 VD.C. with red indicator on and that indicated voltages appear at top and bottom CONTACTS binding posts.
B. Refer to procedure 6.

C. Check for proper starting and stopping of timer.

D. Check for presence of 5 volts across LED with top and center binding posts jumpered.

C. Circuitry problem - Consult manufacturer.

D. Voltage okay - Replace LED.

5. NO TARGET CURRENT INDICATED

<table>
<thead>
<tr>
<th>TEST</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Check to make sure FUNCTION Switch is in target mode.</td>
<td>A. Switch to TARGET Mode.</td>
</tr>
<tr>
<td>B. Check for proper connection across top and center binding posts for continuity.</td>
<td>B. Short circuit the top and center binding posts.</td>
</tr>
<tr>
<td>C. Check for continuity and proper operation of K1 (mounted next to binding posts, first one from the front).</td>
<td>C. Check for operating voltage and replace if bad.</td>
</tr>
</tbody>
</table>

Relay okay - Consult manufacturer.

6. D.C. VOLTAGE NOT PRESENT ACROSS TOP AND BOTTOM CONTACT BINDING POSTS

<table>
<thead>
<tr>
<th>TEST</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Check that D.C. power supply switch is turned to either 48, 125, or 250 VD.C.</td>
<td>A. Turn supply on.</td>
</tr>
<tr>
<td>B. Check for ON/RESET indicator light to be on.</td>
<td>B. Depress ON/RESET Switch.</td>
</tr>
<tr>
<td>C. Check that top and bottom binding posts are not shorted externally.</td>
<td>C. Remove short and depress ON/RESET Switch.</td>
</tr>
</tbody>
</table>

Consult manufacturer if voltage is still not available.
MAINTENANCE AND CALIBRATION

The FTS-300 is a ruggedly constructed piece of test equipment which should perform well under normal field use. Once in operation, the unit should only need to be regularly checked for proper operation and calibration. Since the unit is sealed from dust and moisture, the only reasons for going inside the unit will be to replace blown fuses, or to perform any required troubleshooting, outlined in the previous section. Occasionally, it may be desirable to clean the front panel with a dry, lint-free cloth to remove any accumulation of dust and dirt from the front panel and the cover glasses of the meters.

To remove the FTS-300 from the case, proceed as follows:

1. Remove the front cover, and all test and power leads.
2. Lay test set face down on a clean, dry work surface suitably covered to protect the meters and the front panel.
3. Remove the two (2) screws on either side of the case.
4. Gently raise the case vertically to free the test set. The unit is now open for inspection.

In order to troubleshoot circuits (see previous section), it may be necessary to separate the front panel from the chassis to permit easier access. This can be accomplished as follows:

1. Remove two (2) screws at top holding side rails to side of chassis.
2. Loosen two (2) screws at bottom holding the side rails.
3. Pivot front panel forward and down.
4. Reverse this procedure to re-assemble the unit.

All three (3) fuses (indicated on the functional schematic) are located on the lower right side of the chassis facing out. Their identification (looking at the right side from the outside) is F1, F2, and F3 (from left to right).

All instruments used as calibrational standards, such as the FTS-300, should have their own calibration checked at a maximum interval of twelve (12) months. For instruments used extensively in the field, it may be desirable to shorten this interval. Normal calibration accuracy will require that the following outputs be checked:

1. A.C. Voltmeter (frequency output) and D.C. Ammeter (target current output).

   These meters can be checked for range and accuracy (+/- 2% F.S.) using a portable digital multimeter.
2. **Frequency Meter/Timer**

   The output frequency is digitally locked into the correct frequency and should never go out of calibration. Calibration can be checked with a digital frequency standard capable of at least ten (10) parts per million resolution and accuracy.

3. **Output D.C. Voltage (48, 125, and 250 volts +/- 5% no load to full load).**

   Normally will be set at 48, 125, and 250 VD.C. If this voltage should drift consult manufacturer for recalibration and/or repair.

   **CAUTION**

   *Do not attempt to adjust any pots inside the test set. These adjustments must be set at the factory. Any unauthorized changes in these settings will void the warranty.*

2. **Sine Wave Distortion**

   This distortion is nulled by making adjustments in the analog to digital conversion network in the sine wave synthesizer. This distortion can be checked periodically in the field using a standard harmonic distortion analyzer across the frequency outputs, but should not drift out of specification during the expected lifetime of the unit. If, however, it ever becomes necessary to have this circuit re-adjusted, the sine wave synthesizer module should be sent back to the factory for adjustments.
FACTORY SERVICE AND REPAIR

SERVICING

This unit utilizes circuits and components which require little or no service except for routine cleaning, tightening of connections, etc. Should it become apparent from the display that a malfunction has occurred in the high tension system, the unit must be checked out by a service facility or by the manufacturer.

ELECTRICAL AND MECHANICAL PARTS

For replacement parts, contact Multi-Amp Corporation.

SERVICE AND REPAIR ORDER INSTRUCTIONS

If factory service is required or desired, contact the factory for return instructions.

A Service & Repair Order (SRO) number will be assigned for proper handling of the unit when it arrives at the factory.

If needed, a letter with the number and instructions can be provided.

Provide the factory with model number, serial number, nature of the problem or service needed, return address, your name, and where you can be reached should the factory need to contact you. A purchase order number, cost limit, billing, and return shipping instructions may also be provided if required.

If an estimate is requested, provide the name and contact information of the person with approval/disapproval authority.

Pack the equipment appropriately to prevent damage during shipment. If a reusable crate or container is used, the unit will be returned in it if in suitable condition.

Put the SRO number on the address label of the shipping container for proper identification and faster handling.

NOTE: Ship the equipment without instruction manuals or non-essential items such as test leads, spare fuses, etc. These items are not needed to conduct repairs.
WARRANTY STATEMENT

Multi-Amp Corporation warrants to the original purchaser that the product is free from defects in material and workmanship for a period of one (1) year from date of shipment. This warranty is limited and shall not apply to equipment which has damage, or cause of defect, due to accident, negligence, improper operation, faulty installation by purchaser, or improper service or repair by any person, company or corporation not authorized by the Multi-Amp Corporation.

Multi-Amp Corporation will, at its' option, either repair or replace those parts and/or materials that it deems to be defective. Any costs incurred by the purchaser for the repair or replacement of such parts and/or materials shall be the sole responsibility of the original purchaser.

THE ABOVE WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED ON THE PART OF THE MULTI-AMP CORPORATION, AND IN NO EVENT SHALL THE MULTI-AMP CORPORATION BE LIABLE FOR THE CONSEQUENTIAL DAMAGES DUE TO THE BREACH THEREOF.
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