Service and Operations Manual

for the

TSC-400

Quad Turbine Speed Controller

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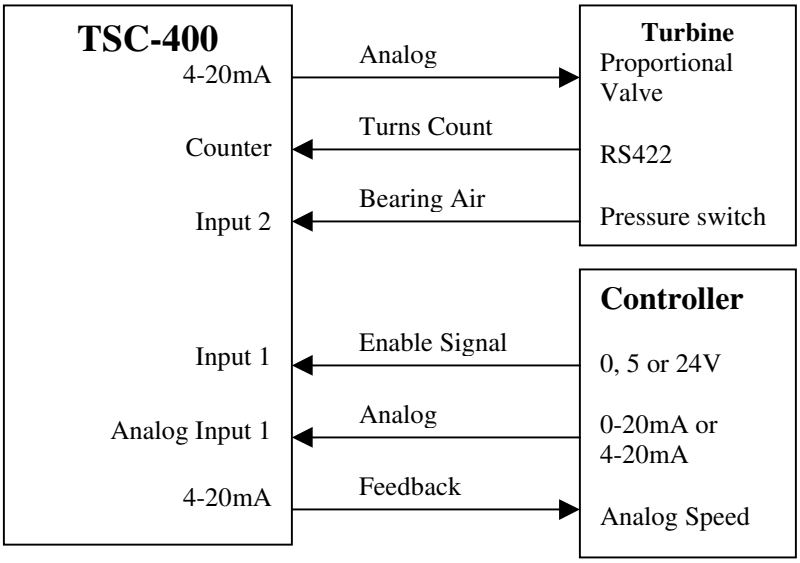
1 Description

The TSC-400 is a key element in a modern turbine atomizing finishing system. Its purpose is to accurately control the rotational speed of up to four turbines. Precise speed control is accomplished by varying the flow of air that drives each turbine. Proportional Integral Derivative (PID) control allows the system to maintain consistent and repeatable atomization and distribution of a painting substance. The TSC-400 is capable of controlling speed over a range of 100 to 99,900 RPM. It incorporates state of the art safety features and fail-safes to both protect the equipment and provide for a safe operating environment. Features include:

- Over/under speed detection and fault indication
- Turbine speed sensor failure shutdown
- Turbine maximum speed limit ceiling
- Turbine speed runaway prevention
- Fiber-optic and acoustic transducer support
- Bearing air detection
- Configurable relays for “ready”, “fault” and other conditions

The TSC-400 is capable of being operated by a Central Controller in a fully automated system or by using the front panel controls. Furthermore, the TSC-400 has remote and local data communication capabilities (RS232 and RS422), allowing for remote management of the system.

The TSC-400 has a convenient three-button front panel interface for adjusting the system’s most critical operating parameters. A front panel data port allows access to additional options, diagnostics, and reporting features. Remote operation of the controller eliminates the need for personnel to enter the paint booth for setting and checking parameters.



1.1 Features

Fully independent control of four turbines

- Accurate Proportional, Integral, Derivative speed control
- Special mode for fast initial spin-up
- Supports acoustic or fiberoptic speed sensor
- Safety Features
    - Maximum turbine speed limiting
    - Use of braking air for fast spin down
    - Bearing air interlock
    - Control fault detection and interlock
    - Tachometer sensor failure interlock

For each Turbine

- Analog 4-20mA for proportional valve control
- Analog 4-20mA for turbine speed feedback
- 24V+ supply for external proportional valve
- Analog Input for turbine speed selection
    - 0-20mA
    - 4-20mA
- Enable/Disable signal input
- Air Bearing pressure detection input
- Pulse sensor input for turbine revolution detection
- 24V+ supply for external sensor
- Two multi-purpose SPDT relays
    - Ready signal
    - Fault signal
    - Speed reached signal
    - In-Tolerance signal
    - Brake control
- Large bright LED digital turbine speed readout

Front panel RS-232 ASCII console management

- Easy to use menu driven interface
- Time-stamped event log
- Installation Tests
    - Relay on/off tests
    - Manual analog output controls
    - Input displays
- Detailed PID parameter adjustments
- PID control loop monitor
- Relay customization
- Enable input customization
- Bearing air input customization

2 Installation

The TSC-400 fits into a standard 6U – 19" rack that is installed and wired into the painting system before installing the TSC-400. The rack provides a set of connectors (DIN 41612) for the TSC-400 to plug into. Each slot is wired differently; take care to install the TSC-400 into the proper slot. Before installing for the first time, verify that the slot is correctly wired for the TSC-400. Please refer to sections 7.1 and 7.3 for the correct pin outs.

The TSC-400 is specifically engineered for the EFC 4X4 rack. This 6-slot rack is designed to contain four UP-200 High-Voltage Power Supplies, one TSC-400 Quad Turbine Speed Controller, and one TSC-400 Quad Air Flow Controller giving a complete Electrostatic/Turbine solution for four robots. For more detail, refer to the EFC 4X4 Rack Installation Manual.

When placing the TSC-400 into the rack, be careful that the connectors mate before pushing the unit completely into the slot. When theTSC-400 is completely seated, lock the unit in place with the four quick-turn latches. The latches look like normal screws, but require only a ¼ turn to secure the unit in its slot. Install filler panels into unused slots.

After placing the TSC-400 into the rack, use the front panel switch to power-on the unit. The system should flash its indicators and finally result in all four tachometer displays showing 00.0. If the nothing happens, recheck the power wiring on connector B and verify that the rack itself has power.

Prior to using the system, use the built-in installation tests to verify that the TSC-400 is correctly integrated into the painting system and will be able to safely control each turbine. Before performing the tests, refer to section 3 to gain familiarity with the front panel and console interface features. See section 4.10.14 for more detail on the Installation Tests.

Attach a terminal (or a laptop running HyperTerminal) to the DB-9 Local Data Port on the front panel of the TSC-400. Press enter (or return) to see the TSC-400 Monitor Menu scroll up.

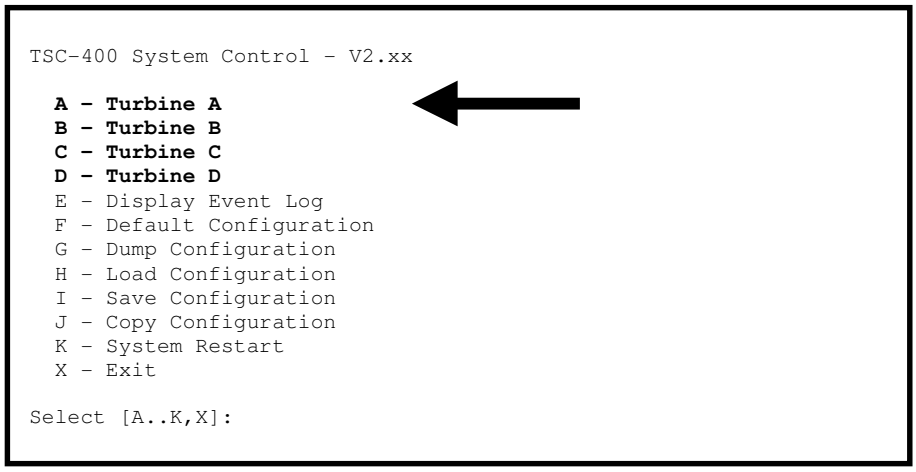
```
TSC-400 Monitor Menu - V2.xx

  A - Turbine A
  B - Turbine B
  C - Turbine C
  D - Turbine D
  E - System Control

Select [A..E]:
```

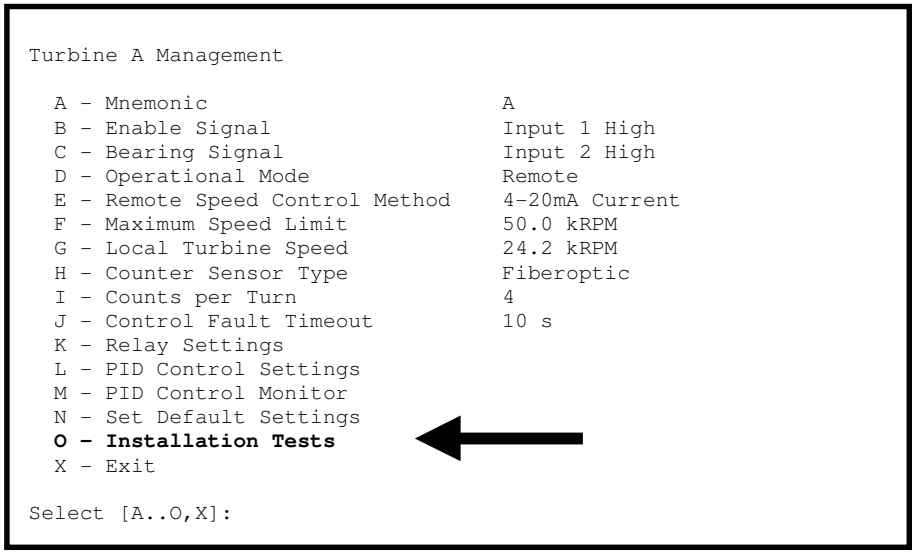
If you don't see anything, verify that the RS232 setup is 9600 bps, 8-bits, 1-stop, No parity. Also, check to make sure that the cable being used is straight through and disable any flow control settings on the terminal. If using HyperTerminal, verify that Scroll Lock is off. See sections 7.4 and 7.5 for more information on the Local Data Port RS232 connector.

Select item E on the Monitor menu to cause the TSC-400 to display the System Control menu.



From the System Control menu, select the turbine to be configured by pressing the A, B, C or D keyboard key. The other selections available from the System Control menu are described in section 4.2.

From the Turbine Management menu, select the Installation Tests. The other Turbine Management selections are described in section 4.10.



The Installation Test menu provides options to allow quick verification that the TSC-400 is correctly integrated into the rest of the painting system.

```
Turbine A Installation Testing

  A - Set Relay 1
  B - Clear Relay 1
  C - Set Relay 2
  D - Clear Relay 2
  E - Manual Analog PV Control
  F - Manual Analog Feedback Control
  G - Display All Inputs
  H - Remote Teach
  X - Exit

Select [A..H,X]:
```

First, use selections A-D to turn each relay on and off to verify that the TSC-400 can control or signal external equipment. The correct action depends upon the installation – so your results may vary. By default, the Relay 1 (R1) is used to control braking air. If this is the case, turning on relay 1 should light the front panel R1 LED and turn on braking air. See section 4.10.11 for a complete description of the relay settings.

Test the proportional valve (PV) output to verify that it controls the flow of air to the turbine. Increasing the output current delivered by the TSC-400 should cause the PV to open and air to flow. It is recommended to perform this test before attaching a turbine. Before spinning up the turbine, verify that that turbine is ready to spin and that bearing air is present. Be conservative when applying current, as there is no feedback mechanism to limit the turbine speed. Exit the test once it is verified that increasing current to 5 or 6mA causes the turbine to spin.

Testing of the proportional feedback current is done similarly to the PV test. The feedback is used to inform the controller of the actual turbine speed. It may be possible to vary the feedback output and observe a speed display on the controller or GUI. Use an ammeter if necessary.

The Display All Inputs displays the state of the various input signals to the TSC-400 that is updated twice per second. Use this display to verify that:

- Enable signal (Input 1) works correctly.
- Bearing Air signal (Input 2) works as expected.
- Analog command current speed control works as expected.
- The tachometer detects turbine rotation
- The tachometer sensor is working correctly

Testing the tachometer requires spinning the turbine. This can be done by hand, or by using the Manual Analog PV Control to spin up the turbine and then flip back to the Display All Inputs to watch the turbine spin down. The tachometer works by counting pulses from the acoustic or fiberoptic sensor attached to the turbine. The over or under-counts are due to excessive sensor noise. If these are observed, verify that the pickup is working correctly.

```
Turbine A Input Display

Turbine A
Enable    Bearing   Analog Input   Tach   Over     Under
Input 1   Input 2   ADC/Units      kRPM   Counts   Counts

Low       High      1f4/20.0mA     00.0   0        0
Low       High      1f4/20.0mA     00.0   0        0
Low       High      1f4/20.0mA     00.0   0        0
Low       High      1f4/20.0mA     00.0   0        0
Low       High      1f4/20.0mA     00.0   0        0
Low       High      1f4/20.0mA     00.0   0        0
```

If the tachometer shows 00.0, check that the fiberoptic or acoustic sensor is properly installed. If using an acoustic pickup, some tuning of the microphone air may be necessary to optimize the signal. Make a note that the tachometer reading is stable, as noise from the microphone may give false speed indications. See sections 4.10.8 and 4.10.9 for information on Counter Sensor Type and Counts per Turn settings that affect tachometer operation and performance.

The Analog Input columns display the “raw” analog to digital converter (ADC) input readings along with the current or voltage value and the corresponding target kRPM. Varying the current (0-20mA or 4-20mA) that is used to control the turbine speed should cause these numbers to change. If they don’t change, verify the analog input connections. If possible, verify that when the system controller requests a particular speed, that this value appears in the kRPM column. Check that the Remote Speed Control Method (4.10.5) and Maximum Turbine Speed settings (4.10.6) are correct before calibrating.

3 Controls and Operation

3.1 Front Panel Description

The TSC-400 front panel features a digital tachometer for each of the four turbines labeled A-D. Associated with each turbine is a set of status indicators. A row of three buttons provides for selecting and setting operational parameters. A front panel data port provides craft management access to TSC-400 operational status and parameters.

3.1.1 Turbine Digital Tachometer Windows

The front panel displays each turbine's speed ranging from 00.0 to 99.9 kRPM. The tachometer window is also used to display operational parameters. When using an acoustic sensor, the tachometer display is blank when a turbine is disabled or stopped.

3.1.2 Turbine Status LEDs

Next to each Tachometer Window are three indicator LEDs that show status information of the associated Channel.

- **SEL** indicates which turbine is selected for control or modification.
- **R1** indicates that relay 1 is set/engaged.
- **R2** indicates that relay 2 is set/engaged.

The purpose and meaning of the relay activation is configurable to suit the application. See section 4.10.11 for relay actuation options.

3.1.3 Up Arrow, Down Arrow, and SET Buttons

The three buttons are used both for selecting a parameter to view as well as to modify its value.

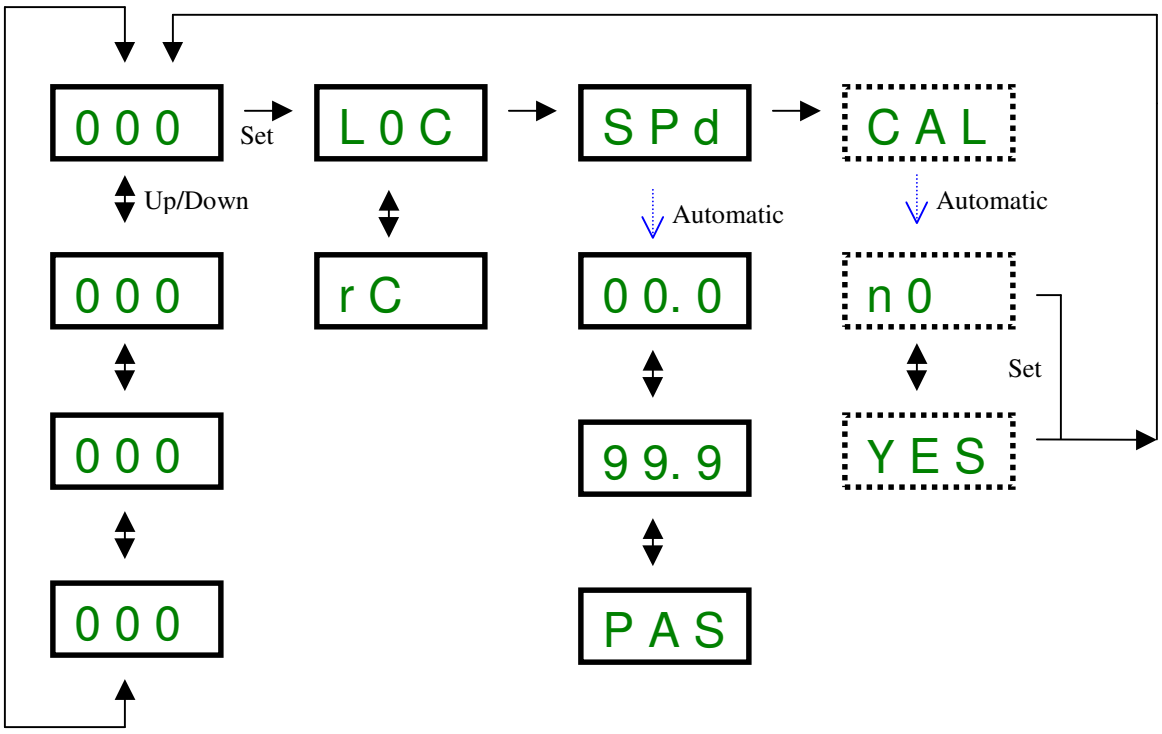
When navigating, the ↑and ↓buttons cause the front panel SEL indicator to move up and down along the four turbines. When changing an operational parameter, the Up Arrow causes the value to increase, and the Down Arrow decreases the value. The SET button is pressed to select a channel, confirm the value for a parameter, or continue to the next operational parameter.

After the TSC-400 is first powered on, the front panel is in turbine select mode. In this mode, the Up and Down Arrow buttons cause the SEL status LED to light next to the selected turbine's tachometer window. While in select mode, pressing the SET button causes the control mode (rC for remote, LOC for local) to be displayed in the tachometer window of the selected turbine.

- LOC / rC - Local or Remote Control
- SPd, followed by a number - This is the Local Speed.

The Local Speed is the target speed of the turbine when the system is enabled in Local mode. See section 4.10.4 for more detail about the Operational Mode.

When setting the Local Speed, press and hold the Up/Down buttons to engage an auto-repeat that will rapidly change the value. When close to the value, individual button presses will increment or decrement the speed. Once the desired value is obtained, press the SET button to save the new setting for Local Speed. After a few seconds, the setting is saved into flash memory so that the same setting will be used after the next power-off. Pressing SET will cause the front panel to flash SEL and then display the turbine speed.



The front panel transceiver calibration control is only displayed if one of the relays on the selected turbine is set to provide a transceiver calibration function. To cause the fiberoptic transceiver to recalibrate, select a turbine and then press SET until the TSC-400 flashes CAL and then displays nO in the tachometer window. At this point, pressing SET will skip the transceiver calibration. To cause a transceiver calibration action, press ↓to cause the display to show YES, and then press SET. The turbine must be spinning when initiating the transceiver calibration. After calibration completes, the front panel will be returned to displaying RPMx1000.

3.1.4 Power On/Off Switch

The main power switch on the front panel controls the incoming AC power. When in the off position, all power to the TSC-400 is turned off. When off, all relays are reset and proportional current outputs are 0 mA.

3.1.5 Local Data Port

This is the front panel interface to a terminal or PC running a terminal program like HyperTerminal. The interface is asynchronous RS232, 9600bps, 8 Bits, No Parity, 1 Stop Bit, Xon/Xoff flow control. For details of its operation, refer to Section 4. This port gives access to TSC-400 information and control via a laptop or other handheld terminal.

4 Console User Interface

The TSC-400 console user interface is accessed via the front panel Local Data Port. It is a simple scroll-up menu-driven interface. Attach a console (DTE) to the port and press the Return or Enter key to cause the System Control menu to be displayed. Asynchronous connection setup is 9600/8/None/1. See section 7.5 for the Local Data Port RS-232 communications settings.

4.1 Monitor Menu

```
TSC-400 Monitor Menu - V2.xx

  A - Turbine A
  B - Turbine B
  C - Turbine C
  D - Turbine D
  E - System Control

Select [A..E]:
```

The Monitor menu is the top-level menu of the console user interface. Select a turbine to monitor or the System Control Menu by pressing the appropriate key on the keyboard.

A. Turbine A	- Monitor status of turbine A
B. Turbine B	- Monitor status of turbine B
C. Turbine C	- Monitor status of turbine C
D. Turbine D	- Monitor status of turbine D
E. System Control	- Enter the System Control Menu

4.1.1 Turbine Control Loop Monitor

This display is useful for displaying the status of a turbine as well as evaluating the effectiveness of the PID Control Loop settings and understanding how the TSC-400 controls the turbine speed.

```
Turbine A PID Control Loop

tRPM    aRPM    PV/mA   Loop    P       I       D       (Turbine A)

-ebT-   00.0    16a/4   R       0       0       0
-ebT-   00.0    16a/4   R       0       0       0
-ebT-   00.0    16a/4   R       0       0       0
-ebT-   00.0    16a/4   R       0       0       0
-ebT-   00.0    16a/4   R       0       0       0
-ebT-   00.0    16a/4   R       0       0       0
-ebT-   00.0    16a/4   R       0       0       0
-ebT-   00.0    16a/4   R       0       0       0
-ebT-   00.0    16a/4   R       0       0       0
```

Columns are:

- **tRPM** – Target turbine speed based on the Operational Mode and perhaps the Analog Input voltage or current. In Local Mode, the target speed is the Local Speed. This column displays other information when the turbine is disabled.
  E/e Enabled/Disabled
  B/b Bearing air Present/Absent
  T/t Target speed is Non-Zero/Zero
  The target RPM will only be displayed when the turbine is Enabled, bearing air is present, and the target speed is greater than 0 kRPM.
- **aRPM** – Actual measured speed of the turbine in kRPM.
- **PV/mA** – The turbine air proportional valve (PV) setting (0 to fff) as well as the corresponding current output in milliamps.
- **Loop** – Indicates the state of the control loop. Indications are:
  R Reset. The turbine is disabled or in a fault condition.
  - Zero. The turbine is enabled, but the target speed is 00.0
  C Coarse control. The startup setting is in place.
  J Jump. The system is employing a learned PV setting.
  K Kick. The control loop is entering PID mode.
  P PID. Control by a Proportional Integral Derivative feedback loop.
- **P** – The instantaneous Proportional component of the PV setting
- **I –** The Integral component of the PV setting
- **D** – The Derivative component of the PV setting

4.2 System Control Menu

```
TSC-400 System Control - V2.xx

  A - Turbine A
  B - Turbine B
  C - Turbine C
  D - Turbine D
  E - Display Event Log
  F - Default Configuration
  G - Dump Configuration
  H - Load Configuration
  I - Save Configuration
  J - Copy Configuration
  K - System Restart
  X - Exit

Select [A..K,X]:
```

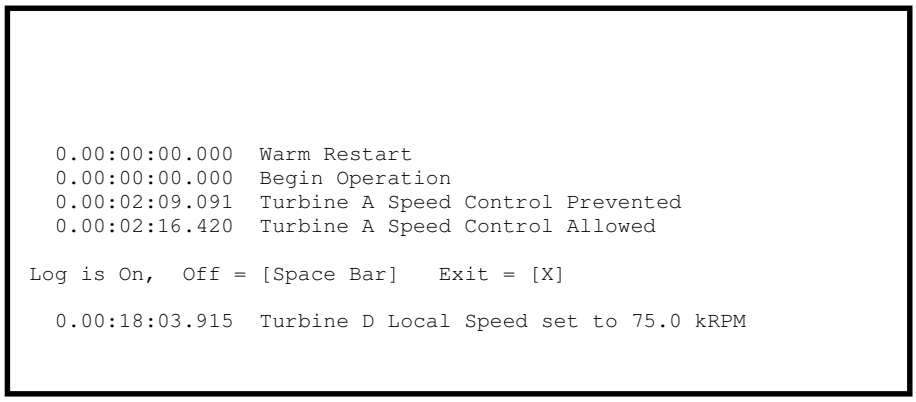
The System Control menu is the top-level control menu containing options for display and modification of all system parameters. Select a menu item by pressing the appropriate key. Most of the choices lead to other menus, and they are described in the following sections.

A. Turbine A - Control parameters for turbine A
B. Turbine B - Control parameters for turbine B

C. Turbine C - Control parameters for turbine C
D. Turbine D - Control parameters for turbine D
E. Display Event Log - Time stamped log of system events
F. Default Configuration - Restore factory default settings for all turbines
G. Dump Configuration - Print configuration for capture to a file
H. Load Configuration - Replay captured file to recover a configuration
I. Save Configuration - Persist configuration into flash memory
J. Copy Configuration - Copy one turbine's settings to another
K. System Restart - Restarts software and enters boot monitor program

4.3 Event Log

The Event Log is option E from the System Control menu. The log contains a record of system events. Each log entry consists of a timestamp and a textual message describing the event. The TSC-400 does not contain a real-time clock, so the timestamp is relative to the time the TSC-400 was turned on. The log is not persisted between restarts of the system.



If events are occurring too rapidly, the spacebar can be used to toggle the log display on and off. Press [X] or [Escape] to return to the System Control menu.

4.4 Default Configuration

Use this option restore all parameters to their original default values. This feature may be useful after experimenting to put the system into a known stable configuration setup. Also see section 4.6 for information on how to load a saved configuration.

4.5 Dump Configuration

The Dump Configuration is used to make a recording of TSC-400 configuration. This recording can be recovered by using the Load Configuration feature. Selecting the Dump Configuration option causes the following prompt to be displayed:

```
Prepare PC/HyperTerminal to receive configuration file.

Press any key to continue:
```

At this point, prepare the terminal program to receive a text file then press **Enter** to cause the TSC-400 to start transmitting its configuration. The output will look something like the following:

```
<
0.Enable=Input 1 High
0.Bearing=Input 2 High
0.Mode=Remote
0.RCmode=4-20mA Current
0.Max=50.0
    •
    •
    •
3.Relay.1=Set for Braking Air
3.Relay.2=Set on Fault
3.mnemonic=D
>
```

When the output has completed, close the captured text file. The captured text file can be viewed and edited using any standard text editor (e.g. Notepad.exe). When editing, it is advantageous, though not necessary, to retain the beginning and ending < > characters, as these identify the start and end of the configuration data. See appendix

4.6 Load Configuration

The Load Configuration is used to recover a system configuration that was earlier saved using the Dump Configuration facility. Selecting the Load Configuration option causes the following prompt to be displayed:

```
Select [A..I,X]: G


Ready to receive configuration file
```

At this point, cause the terminal program to send the text file containing the TSC-400 configuration data. It will be necessary to control the flow of data to the TSC-400. Set flow control to xon/xoff, or modify the ASCII setting on HyperTerminal to add 200ms of delay between each line. During the load, all is well if a **$** is printed before the start of each line echoed by the TSC-400. An echoed **?** means that the line was misunderstood or there was some transmission error.

```
$0.Enable=Input 1 High
$0.Bearing=Input 2 High
$0.Mode=Remote
$0.RCmode=4-20mA Current
    •
    •
    •
$3.FaultTimeout=10
$3.Relay.1=Set for Braking Air
$3.Relay.2=Set on Fault
$3.mnemonic=D
$
```

When the file has been fully received, the System Control menu will be redisplayed. Examine the Event Log to see what configuration options where changed as a result of the load.

4.7 Save Configuration

The Save Configuration feature is used to force the immediate saving of the current configuration settings into permanent storage in flash memory. This feature is present for those who are in a hurry, as all changes made to the configuration are automatically saved within 30 seconds.

4.8 Copy Configuration

The Copy Configuration facility is used to copy one turbine's configuration settings to another. Once the optimum configuration settings are determined for one turbine, this feature can be used to quickly establish the same settings on the other turbines.

4.9 System Restart

Choosing the System Restart option from the top-level menu causes the TSC-400 to perform a warm restart of the system. Console control will fall back to the Boot Monitor software after the restart. The Boot Monitor interface contains some hardware self-diagnostic tests and allows for downloading/upgrading of the TSC-400 operational software.

4.10 Turbine Management

From the System Control menu, select options A-D to view and modify configuration settings for each individual turbine. There are effectively four independent Turbine Speed controllers in the system, each with individually adjustable configuration parameters.

```
Turbine A Management

  A - Mnemonic                        A
  B - Enable Signal                   Input 1 High
  C - Bearing Signal                  Input 2 High
  D - Operational Mode                Remote
  E - Remote Speed Control Method     4-20mA Current
  F - Maximum Speed Limit             50.0 kRPM
  G - Local Turbine Speed             24.0 kRPM
  H - Counter Sensor Type             Fiberoptic
  I - Counts per Turn                 4
  J - Control Fault Timeout           10 s
  K - Relay Settings
  L - PID Control Settings
  M - PID Control Monitor
  N - Set Default Settings
  O - Installation Tests
  X - Exit

Select [A..O,X]:
```

4.10.1 Mnemonic

This option allows changing a short designation of each turbine.

```
Turbine A Mnemonic

The mnemonic is a very short (up to 3 characters) name
used to identify the turbine in the system.

Enter new mnemonic for this turbine:
        A
```

The mnemonic can be up to 3 printable characters. The default value is A-D corresponding to turbine 1-4.

4.10.2 Enable Signal

This parameter selects the “polarity” of the control system signal to the TSC-400 that either enables or disables a turbine. When disabled, the turbine speed is set to 00.0 kRPM and any control system fault conditions are reset. When enabled, the system establishes the desired speed and monitors the performance of the PID control loop. The Enable Signal is on Input 1, and control of the turbine is enabled when when it is low, or high. When set to ***Input 1 Ignored***, the PID control loop ignores the state of Input 1 and the control loop is disabled by setting the desired speed to 00.0 kRPM.

```
Select Enable Signal Operation

  A - Input 1 High
  B - Input 1 Low
  C - Input 1 Ignored

Select [A..C]:
```

To change this parameter, press the A key on the console, then at the sub-menu, press the key [A, B, C] corresponding to the correct selection for the control system. Press Enter or Escape to leave the Enable Signal setting intact. The default setting is ***Input 1 High***.

4.10.3 Bearing Signal

This parameter allows the TSC-400 to work with the polarity of the signal from the turbine bearing air pressure monitor. The turbine will not be permitted to spin if the TSC-400 does not sense the presence of adequate bearing air pressure. The Bearing air presence signal is on Input 2, and can be interpreted as ***Present when Low***, ***Present when High*** or ***Not Present***. Choose ***Input 2 Ignored*** (i.e not present) only if the painting system cannot supply a bearing air presence signal to the TSC-400.

```
The Bearing Air Signal is used to detect the presence
or absence of bearing air pressure. The turbine should only
permitted to run if bearing air is present. Set to Ignored
only if the presence of bearing air is not detectable.

Bearing Air Signal is currently set to: Input 2 High

Select Bearing Air Present Signal Operation

  A - Input 2 High
  B - Input 2 Low
  C - Input 2 Ignored

Select [A..C]:
```

To change this parameter, press the key [A, B, C] corresponding to the correct selection for the control system. Press Enter or Escape to leave the Bearing Air Presence Signal setting intact. The default setting is ***Input 2 High***.

4.10.4 Operational Mode

This setting places a turbine under local or remote control. Choosing ***Local*** causes the TSC-400 to run turbine at the Local Turbine Speed when enabled. Choosing ***Remote*** causes the TSC-400 to control the turbine speed based upon the selected Remote Speed Control Method. In ***Transparent*** mode, the current received on analog input 1 is passed through to the proportional air valve/transducer allowing open-loop control of the turbine speed for diagnostics purposes.

```
Operational Mode

  A - Local
  B - Remote
  C - Transparent

Select [A..C]:
```

Select the Operational Mode by pressing the corresponding letter. Press Enter or Escape to leave the selection unchanged. The default Operational Mode is ***Remote***.

4.10.5 Remote Speed Control Method

When Operational Mode is set to Remote, this setting specifies how a turbine's desired speed is determined. There are two methods supported by the TSC-400:

```
Remote Speed Control Method

  A - 0-20mA Current
  B - 4-20mA Current

Select [A..B]:
```

Each method allows an external controller to continuously vary the speed of the turbine by varying current. Press Enter or Escape to leave the selection unchanged.

The lowest current will set the speed to 00.0 kRPM, and 20 milliAmperes will set the speed to maximum. The default setting is ***4-20mA Current***.

4.10.6 Maximum Turbine Speed

This parameter specifies the highest selectable speed for the turbines. This will be the highest speed permitted by the control system. When Operational Mode is set to Remote, maximum input 20mA will set the turbine to the Maximum Turbine Speed. Similarly, when the turbine speed has reached the maximum speed, the feedback current will be 20mA.

```
Enter new Setting for Maximum Turbine Speed (kRPM)
        50.0
```

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default value is 50.0 kRPM.

4.10.7 Local Turbine Speed

This parameter specifies the desired speed of a turbine when the turbine is enabled in Local mode.

```
Enter new Setting for Local Turbine Speed (kRPM)
        24.0
```

To enter a new speed value in kRPM, backspace over the number and type in a new value. Pressing Enter or Escape leaves the Local Turbine Speed unchanged. The default value for Local Turbine Speed is 24.0 kRPM.

4.10.8 Counter Sensor Type

This parameter tells the TSC-400 what kind of pickup is being used to detect the revolution of the turbine. The system supports both fiber-optic and acoustic sensors. The use of a fiber-optic sensor allows the system to accurately determine turbine speeds below 00.5 kRPM. Acoustic sensors can be used, but are not very reliable below 10.0 kRPM.

```
Specify Counter Sensor Type

  A - Fiberoptic
  B - Acoustic

Select [A..B]:
```

Select the Counter Sensor Type by pressing the corresponding letter. Press Enter or Escape to leave the current selection unchanged. The default, and preferred, Sensor Type is ***Fiberoptic***.

4.10.9 Counts per Turn

This parameter specifies the number of "ticks" that the Counter Sensor will count during each revolution of the turbine. The TSC-400 is designed to interface with turbines with revolution sensors giving between 1 and 4 pulses per turn. More pulses per turn allows finer control by giving quicker indication of speed fluctuations.

```
Specify Number of Counts Per Turn

  A - 1
  B - 2
  C - 3
  D - 4

Select [A..D]:
```

Select the Number of Counts Per Turn by pressing the corresponding letter. Press Enter or Escape to leave the current selection unchanged. The default Counts per Turn is 4.

4.10.10Control Fault Timeout

This parameter specifies the maximum time that the control system is permitted to be out of tolerance. The timeout interval starts when the turbine is enabled and the desired speed is greater than 00.0 kRPM. The TSC-400 will signal a fault condition if it cannot achieve and maintain the desired turbine speed before the Control Fault Timeout interval. The inability of the TSC-400 to maintain the desired turbine speed is indicative of a flaw in overall system. See the section on fault determination and resolution for information on how to locate the root cause of the problem.

```
The Control System Timeout specifies the maximum number of
seconds that the system can take to establish the target
speed. If the control loop cannot reach the correct speed
then a fault condition is signaled.

Enter new value for the Control System Timeout (seconds):
        10
```

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default value is 10 seconds.

4.10.11Relay Settings

The flexible relay settings allow tailoring of the TSC-400 to the control system. There are two Single-Pole Dual Throw (SPDT) relays for each of the four turbines. When the system is off, all relays are in their reset position. When reset, the Common and Normally

Closed (NC) are connected. When a relay is set, the Common and Normally Open (NO) are connected.

```
Turbine A Relays

  A - Relay 1                          Set for Braking Air
  B - Relay 2                          Set on Fault
  X - Exit

Select [A..B,X]:
```

Each relay is independently configurable, and the same menu of options is presented for both relays.

```
Turbine A Relay 1 Mode is: Set for Braking Air

Select Relay Operation

  A - Unused
  B - Set on Fault
  C - Set while Ready
  D - Set within Tolerance
  E - Set when Speed Reached
  F - Set for Braking Air
  G - Transceiver Calibration

Select [A..G]:
```

A. ***Unused*** – The relay will remain in its reset position.
B. ***Set on Fault*** – The relay is set when a fault condition is detected. The relay will be reset when the turbine is disabled.
C. ***Set while Ready*** – The relay is set when the system is powered on and is not in a fault condition.
D. ***Set within Tolerance*** – The relay is set while the turbine is enabled and the speed is within tolerance. The relay is otherwise reset.
E. ***Set when Speed Reached*** – The relay is set after the turbine speed first reaches the desired speed, and remains set until the turbine is disabled.
F. ***Set for Braking Air*** – The relay is set when the control system applies braking to reduce the speed of the turbine.
G. ***Transceiver Calibration*** – When a transceiver reset is requested, the relay will be set for 2.5 seconds to cause an attached fiberoptic transceiver to initiate a "dynamic teach" operation. This operation allows the transceiver to recalibrate itself while the turbine is running. The transceiver calibration can be remotely engaged by driving the Enable signal through the following sequence:
    a. Enable for > 10s
    b. Disable for < 250ms
    c. Enable for less than 250ms
    d. Disable for > 500ms.

Select the Relay Mode by pressing the corresponding letter. Press Enter or Escape to leave the current selection unchanged. The default mode for Relay 1 is ***Set for Braking Air***. The default mode for Relay 2 is ***Set on Fault***.

4.10.12PID Control Settings

The turbine speed is controlled by a Proportional, Integral, Derivative (PID) feedback loop. The selection of the ideal PID parameters depends upon difficult to measure system characteristics like air pressure, turbine mass, and proportional valve latency and overall control system hysteresis.

```
Turbine A PID Control Settings

  A - Startup Setting               30%
  B - Startup Interval              2000 ms
  C - Braking Threshold             01.5 kRPM
  D - Control Loop Interval         25 ms
  E - Control Tolerance             +/- 05.0 kRPM
  F - Proportional Gain             5000
  G - Integral     Gain             100
  H - Derivative   Gain             5000
  X - Exit

Select [A..H,X]:
```

4.10.12.1 Startup Setting

This parameter establishes a fixed airflow setting to be applied when the turbine is enabled. This initial setting is applied for the Startup Interval before switching over to the PID feedback loop control. The purpose of the Startup Setting is to get the turbine spinning up quickly while the initial tachometer readings are being computed. It is especially important when using an acoustic sensor, as the turbine speed cannot be reliably determined until it is spinning at greater than 5 to 10 kRPM. A carefully tuned Startup Setting and Startup Interval can place the turbine at target speed more quickly than PID alone.

```
Enter new Setting for Startup Position (percent):
        30
```

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default Startup Setting is 30%.

4.10.12.2 Startup Interval

This parameter limits how long the Startup Setting will be applied before switching over to PID feedback loop control. A carefully tuned Startup Setting and Startup Interval can place the turbine at target speed more quickly than PID alone.

```
The Startup Interval is used to get the turbine running.
When Enabled, the Proportional Valve is set to the Startup setting
for the number of milliseconds specified for Startup Interval.
The acoustic tachometer becomes useful after initial spin-up
```

```
of the turbine.

Enter new value for the Startup Interval (milliseconds):

         2000
```

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default Startup Interval is 2000 milliseconds.

When using a fiberoptic sensor, the TSC-400 will work the startup interval more efficiently. When using a fiberoptic sensor, the TSC-400 will ignore the Startup Setting and always apply 100% at startup. It will automatically drop into PID after the startup interval elapses, or when the speed reaches 2 kRPM below the target set point. After startup, and before starting the PID closed loop control, the TSC-400 will set the proportional valve to either the configured Startup Setting or an optimal setting learned during previous activation of the turbine.

4.10.12.3 Braking Threshold

In systems that support braking air, the TSC-400 can employ braking to assist in turbine speed control as well as to spin down the turbine quickly after it is disabled. The braking air will be applied whenever the actual speed of the turbine exceeds the target speed by the Braking Threshold. It may be necessary to increase this value from the default setting in situations where the braking air is very strong.

```
The Braking Threshold is the minimum overspeed before braking air
is applied to the turbine. This value may need to be increased for
systems with exceptionally powerful braking air. To prevent braking
set this value to 0.

Enter new value for the Braking Threshold (kRPM)
        01.5
```

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default setting is 01.5 kRPM.

4.10.12.4 Control Loop Interval

This parameter sets the frequency at which turbine speed is monitored and adjustments are made to control airflow to the turbine. The proper interval depends upon the counts/turn provided by the turbine as well as the inherent hysteresis in the control system. Setting this value too high can result in oscillation, too low will unnecessarily slow system response.

```
Enter new value for Control Loop Interval (ms):
        25
```

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default value of 25ms is recommended for a 4 counts/turn system. Use a 50ms for 2 counts/turn, and 100ms for a system that provides only 1 count/turn from the turbine rotational sensor. See section 4.10.9 for information on counts per turn setting.

4.10.12.5 Control Tolerance

This parameter specifies the allowed speed control tolerance. If the TSC-400 cannot reliably maintain the turbine speed within this range, then it will indicate a fault condition. A fault will cause the turbine to spin down until it is disabled and re-enabled. Failure to control turbine speed is indicative of a failure somewhere in the painting system. Please see the troubleshooting section for suggestions on how to locate the cause of the fault.

```
Enter new Setting for Speed Control Tolerance (+/- kRPM)
        05.0
```

To enter a new speed value in kRPM, backspace over the number and type in a new value. Pressing Enter or Escape leaves the Control Tolerance unchanged. The default value is +/- 5.0 kRPM.

4.10.12.6 Proportional Gain

This parameter determines how strongly the PID feedback control loop will react when correcting for instantaneous speed errors. Correction will be proportional to the difference between the measured speed and the desired speed of the turbine. Setting this value too high can result in over-correction of speed errors, leading to oscillation around the target speed. Too low a setting will result in weak response and slow turbine speed adjustment.

```
Enter new value for Proportional Gain:
         5000
```

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default value is 5000

4.10.12.7 Integral Gain

This parameter is similar to proportional gain, but weights the control system's response to the sum of long-term speed errors. The Proportional Gain gets the system close, and the Integral Gain provides the ultimate convergence to the target speed

```
Enter new value for Integral Gain:
       100
```

Setting this value larger will make the system converge more quickly to a stable target speed, too much yields oscillation. When tuning the PID, some experimentation will be required, but start with the following steps:

1. Start with a 20 for Integral Gain, set Derivative Gain to 0.
2. Set the Proportional Gain to get good smooth response without oscillation.
3. Increase Integral Gain until oscillation is observed.
4. Back off both the Proportional and Integral Gain just enough to get stable operation.
5. Optimize by adding Derivative Gain.
6. Repeat steps 2 through 6 until satisfied.

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default value for the Integral Gain is 100.

4.10.12.8 Derivative Gain

This parameter affects how much weighting the control system will give to acceleration when computing turbine speed airflow adjustments. Increasing Derivative Gain adds damping to the system. Correct settings for this value will allow larger Proportional and Integral gain values to be used, allowing stronger speed control and quicker system response.

```
Enter new value for Derivative Gain:
        5000
```

To change this parameter, backspace over the number and type in a new value. Pressing Enter or Escape leaves the setting unchanged. The default value for the Derivative Gain is 5000.

4.10.13Set Default Settings

This option allows recovering of factory default settings for the turbine.

```
Confirm Default Settings?

  A - Yes
  B - No

Select [A..B]:
```

Press A to set all settings to defaults. Any other key will return to the Turbine Management menu.

4.10.14Installation Tests

This menu contains options that are useful during installation for testing the TSC-400 interfaces with the rest of the painting system. See section 2 for details on how these tests can be used during installation.

```
Turbine A Installation Testing

  A - Set Relay 1
  B - Clear Relay 1
  C - Set Relay 2
  D - Clear Relay 2
  E - Manual Analog PV Control
  F - Manual Analog Feedback Control
  G - Display All Inputs
  H - Remote Teach
  X - Exit

Select [A..H,X]:
```

4.10.14.1 Set Relay 1

Sets, or engages Relay 1 (R1). By default, this relay is used to control Braking Air, but may be used for other purposes if the system does not support or provide for turbine braking. Setting the relay will light the associated front panel R1 indicator. When setting and clearing the Relay, it should also be possible to hear the relay switch.

4.10.14.2 Clear Relay 1

Resets Relay 1 (R1) and turns off the associated R1 indicator on the front panel.

4.10.14.3 Set Relay 2

Sets, or engages, Relay 2 (R2). By default, this relay is used to indicate a Fault condition. However, the relay may be used for other purposes. See section 4.10.11 for relay options. Setting the relay will light the associated front panel R2 indicator. When setting and clearing the Relay, it should also be possible to hear the relay switch.

4.10.14.4 Clear Relay 2

Resets Relay 2 (R2) and turns off the associated R2 indicator on the front panel.

4.10.14.5 Manual Analog PV Control

This feature allows manual adjustment of the proportional valve (PV) control current. Use of this test can verify that turbine speed control air is working and that the TSC-400 has the capability of controlling it.

Caution: When manually controlling the PV output current there is no turbine speed governing in place. Take care to avoid running the turbine to excessive speeds.

```
Turbine A Manual PV Control

Use keyboard to adjust output current between 4 and 20 mA
  [-][+]   to decrement or increment by 1mA
  [X][Esc] to exit

PV output =  4 mA
```

The [+] and [-] keyboard keys are used to increment or decrement the output current at 1 mA steps. If the tachometer is working, the output current will be limited to prevent an accidental over-speed condition. Return to the Installation Test menu by pressing X or Escape.

4.10.14.6 Manual Analog Feedback Control

This feature allows manual adjustment of the analog feedback control current. This current is used to inform the system controller of the actual turbine speed. Use of this test can verify that the feedback signal is working and correctly calibrated. Feedback is intended to be 20mA at the configured Maximum Turbine Speed. See section 4.10.6 on how to set the Maximum Turbine Speed.

```
Turbine A Manual Feedback Control

Use keyboard to adjust output current between 4 and 20 mA
  [-][+]   to decrement or increment by 1mA
  [X][Esc] to exit

PV output =  4 mA
```

The [+] and [-] keyboard keys are used to increment or decrement the output current at 1 mA steps. Return to the Installation Test menu by pressing X or Escape.

4.10.14.7 Display All Inputs

Selecting this option from the Installation Tests starts a scroll-up display showing updated values for the input control signals associated with the turbine under test.

```
Turbine A Input Display

Turbine A
Enable    Bearing   Analog Input   Tach   Over     Under
Input 1   Input 2   ADC/Units      kRPM   Counts   Counts

Low       High      2f4/20.0mA     00.0   0        0
Low       High      2f4/20.0mA     00.0   0        0
Low       High      2f4/20.0mA     00.0   0        0
Low       High      2f4/20.0mA     00.0   0        0
Low       High      2f4/20.0mA     00.0   0        0
Low       High      2f4/20.0mA     00.0   0        0
```

Columns are:

- **Enable Input 1** State of the Enable signal.
- **Bearing Input 2** State of the Bearing Air signal
- **Analog Input** ADC reading (0 to fff) and associated voltage or current.
- **Tach kRPM** Measured speed of the turbine in RPM x 1000.
- **Over Counts** Too many pulses from sensor – probably noise.
- **Under Counts** Too few pulses from sensor – sensor or wiring problem.

Press Escape or X to return to the Installation Tests menu.

4.10.14.8 Remote Teach

This facility allows calibration of a Banner Engineering fiberoptic transceiver. The purpose of the calibration is to allow the transceiver to better differentiate light vs dark in low contrast situations. It is necessary for the turbine to be spinning, as the transceiver must see both dark and light transitions while calibrating. During calibration, the system will go open-loop, as the Banner transceiver will stop reporting turbine speed while it is recalibrating.

5 Troubleshooting

The TSC-400 is designed to provide as much information as possible in the case of non-operation or Fault conditions. The TSC-400 is engineered to be highly reliable; fault conditions are likely to be caused by external system issues.

5.1 Setup Problems

These problems usually indicate a problem in the setup:

Symptom	Action / Check
Front panel tachometers and LEDs are off	• Check front panel power switch. • Verify rack and card slot have AC power. • Verify that the TSC-400 is fully seated in its slot. • Check internal power fuse. • Look for bent power pins.
Flashes "-0-" on the front panel.	Indicates that the TSC-400 has turned off drive air because it cannot sense rotation of the turbine. Possible causes are: • Loss of signal from the microphone. • Loss of tachometer signal from the fiberoptic transceiver. • Loss of turbine drive air. • Stuck turbine. Check the following: • Attach a PC/HyperTerminal to the front panel and look at the Event Log to determine the cause. • Check that tachometer sensor/pickup is working and perform transceiver calibration (see section 3.1.3 for how to calibrate via the front panel). • Check that the fiberoptic cables are fully seated in the transceiver. • Verify that fiberoptic connections are clean. • If the transceiver shows low-contrast condition, change or clean the PEA
Flashes "nC " on the front panel.	Indicates that the TSC-400 has turned off drive air because it is unable to maintain turbine speed within the configured tolerance. Possible causes are: • Bad or noisy signal from the microphone or fiberoptic transceiver. • Insufficient turbine drive air pressure or flow. • PID parameters are incorrect. • Sticky turbine.

	Check the following: • Attach a PC/HyperTerminal to the front panel and look at the Event Log to determine the cause. • Check that tachometer sensor/pickup is working and perform transceiver calibration (see section 3.1.3 for how to calibrate via the front panel). • Verify that TSC-400 is fully seated in the rack. • Verify turbine drive air pressure is sufficient. • Check PID settings.
Tachometer display occasionally shows "SEn"	Indicates that the TSC-400 is detecting noise on the turbine rotation counter signal. • If using an acoustic pickup, verify that the microphone air is properly adjusted. • If using fiberoptic pickup, readjust the pickup to improve the quality of the signal. Remove kinks and sharp bends from the fiberoptic cable. • Use the front panel buttons to perform a transceiver calibration

5.2 System Problems

These problems usually indicate a problem with the TSC-400 itself:

Symptom	Action / Check
Front Panel LEDs and Tachometer displays flash on and off	Usually means that the microprocessor is malfunctioning. Return the TSC-400 for repair.
Tachometer displays show "FLt" and then the system resets.	Indicates a software problem. Return the TSC-400 for repair. If the system does not reset, then look at the event log to determine the cause of the fault.

5.3 Operational Problems

A control fault indicates a problem with the system's ability to control the speed of a turbine. The following table lists some items to check.

Possible Cause	Action / Check
Enable Signal	If incorrectly set, the TSC-400 will not spin-up the turbine, or may start spinning up the turbine when requested not to.

Bearing Air	First, verify that bearing air is present and has adequate pressure. Also, check that the Bearing Air Mode is configured correctly in the TSC-400. Try alternate settings. Test the bearing air pressure switch and verify that it is operating properly. Running without bearing air will damage the turbine.
Air Flow	Verify that airflow rate and pressure is sufficient to drive the turbine to the desired speed.
Microphone	Check adjustment of the microphone input. Depending on the system, a microphone may pick up harmonics and report false speed information to the TSC-400.
Counts per Turn	Verify that this setting matches the counts/turn output of the turbine speed sensor.
PID Gain Settings	The default settings may not be correct for the system. Reduce the gain settings and use the PID Control Monitor to assess how well the control loop is able to manage the turbine speed. See section 4.10.12 for more information on PID Control settings.

6 Specifications

6.1 Electrical Specifications

Power Requirements	115/230 VAC +/- 10%, 50/60 Hz., Single Phase
Power Consumption	22 VA Maximum AC
Main Power Fuse	2 AG 2 Ampere Slow Acting
Analog Control Input Voltage (optional)	0 to 5 VDC, Z=20k Ohms 0 VDC Input = 00.0 kRPM 5 VDC Input = Maximum Speed (see section 4.10.6)
Current	0 to 20 mA, Z = 250 Ohms 0 or 4 mA = 00.0 kRPM 20 mA = Maximum Speed (up to 99.9 kRPM)
Relay Contacts Relay 1	4A, 250VAC, Isolated
Relay 2	4A, 250VAC, Isolated

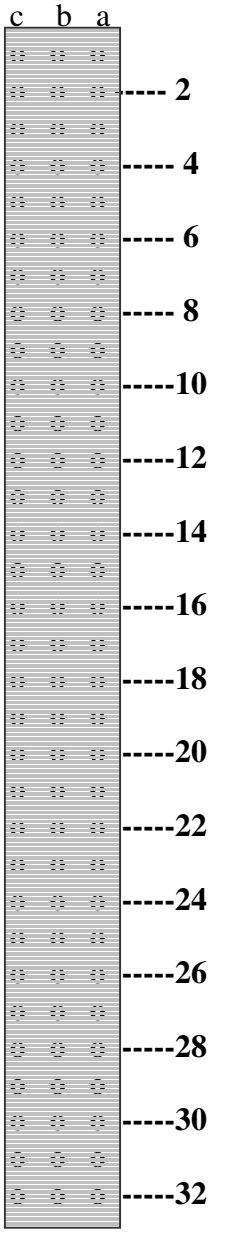
6.2 Mechanical Specifications

Height	10.3in., 267mm, 6U
Width	2.8in., 71mm, 14HP
Depth	7.7in., 173mm
Weight	4.5lbs, 2.0kg
Connectors Rear	A - AMP-650473-5 B - EPT-117-40064-2
Front	DB9-S - AMP 745781-4

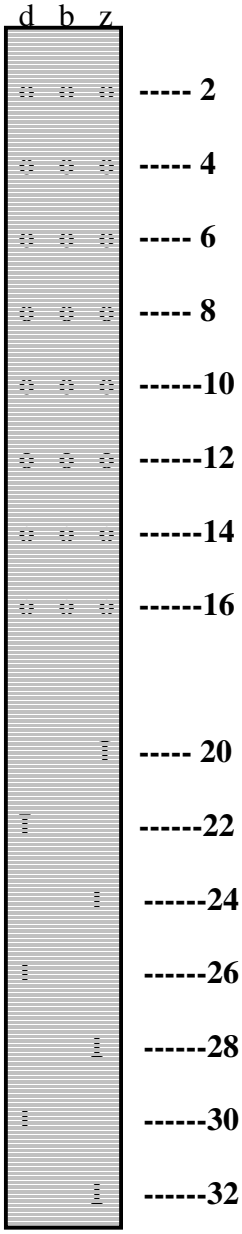
7 Appendices

7.1 Back Plane Connectors

The rear panel consists of two connectors. These are referred to as A and B. Connector A is above connector B when the TSC-400 is installed. The following sections outline the pin-out of these connectors.



Connector A (Top)
Rear View
Type C



Connector B (Bottom)
Rear View
Mate: EFC 60-1A70

7.2 Connector A Pin out

This connector interfaces the TSC-400 to the rest of the painting system.

Connector A				
	Row	C	B	A
TURBINE A	1	Relay 1 NC (normally closed)	Relay 1 COM (common)	Relay 1 NO (normally open)
	2	Analog Input 1 +	Analog Feedback +	Analog Proportional Valve Control +
	3	Analog Input 1 -	Analog Feedback -	Analog Proportional Valve Control -
	4	Counter Input –	Counter Input +	Power Supply +24V
	5	Relay 2 NC	Relay 2 COM	Relay 2 NO
	6	Input 1&2 Common Ground	Input 2 +	Input 1 (0 - 5 to 24V)
	7	Analog Input 2 +	RS422 RX +	24V+
	8	Analog Input 2 -	RS422 RX -	Ground
TURBINE B	9	Relay 1 NC (normally closed)	Relay 1 COM (common)	Relay 1 NO (normally open)
	10	Analog Input 1 +	Analog Feedback +	Analog Proportional Valve Control +
	11	Analog Input 1 -	Analog Feedback -	Analog Proportional Valve Control -
	12	Counter Input –	Counter Input +	Power Supply +24V
	13	Relay 2 NC	Relay 2 COM	Relay 2 NO
	14	Input 1&2 Common Ground	Input 2 +	Input 1 (0 - 5 to 24V)
	15	Analog Input 2 +	RS422 RX +	24V+
	16	Analog Input 2 -	RS422 RX -	Ground
TURBINE C	17	Relay 1 NC (normally closed)	Relay 1 COM (common)	Relay 1 NO (normally open)
	18	Analog Input 1 +	Analog Feedback +	Analog Proportional Valve Control +
	19	Analog Input 1 -	Analog Feedback -	Analog Proportional Valve Control -
	20	Counter Input –	Counter Input +	Power Supply +24V
	21	Relay 2 NC	Relay 2 COM	Relay 2 NO
	22	Input 1&2 Common Ground	Input 2 +	Input 1 (0 - 5 to 24V)
	23	Analog Input 2 +	RS422 RX +	24V+
	24	Analog Input 2 -	RS422 RX -	Ground
TURBINE D	25	Relay 1 NC (normally closed)	Relay 1 COM (common)	Relay 1 NO (normally open)
	26	Analog Input 1 +	Analog Feedback +	Analog Proportional Valve Control +
	27	Analog Input 1 -	Analog Feedback -	Analog Proportional Valve Control -
	28	Counter Input –	Counter Input +	Power Supply +24V
	29	Relay 2 NC	Relay 2 COM	Relay 2 NO
	30	Input 1&2 Common Ground	Input 2 +	Input 1 (0 - 5 to 24V)
	31	Analog Input 2 +	RS422 RX +	24V+
	32	Analog Input 2 -	RS422 RX -	Ground

7.3 Connector B Pin out

This connector is used exclusively for AC power.

Connector B			
Row	**D**	**B**	**Z**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
20			AC1
21			
22			
23			
24			
25			
26	AC2		
27			
28			
29			
30			
31			
32			Ground

7.4 Communications Cable

Local Data Port (Front Panel)

To PC		TSC-400-100
DB9-S		DB9-P
1		1
2	----------	2
3	----------	3
4		4
5	----------	5
6		6
7		7
8		8
9		9

7.5 RS232 Communication Parameters

Emulation:	VT100
Speed:	9600
Stop Bits:	1
Data Bits:	8
Parity:	None
Flow Control:	Xon, Xoff

7.6 Save Configuration using HyperTerminal

The following table offers step-by-step instructions for dumping the TSC-400's configuration and saving it into a file.

Step	Action
1	Connect serial cable to front panel of TSC-400. This cable must have pin 9 disconnected. See section 7.4 for the correct pin-out.
2	Connect 9-pin cable to the appropriate COM port on the PC. This is usually COM1, but not always.
3	Start HyperTerminal. This program is usually stored in Program Files > Accessories > HyperTerminal.
2	Connect 9-pin cable to COM1 port on the PC
3	Start HyperTerminal
4	In HyperTerminal, go to the menu bar and pull down the File, and choose Properties. In the properties dialog, click on the Settings tab and press the ASCII Setup button. Verify that: All boxes are unchecked Line delay = 2 milliseconds Character delay = 0 milliseconds
5	On the HyperTerminal menu bar, pull down the File menu and choose Properties. On the properties dialog, click on the Configure button. Verify that: Bits per seconds = 9600 Data bits = 8 Parity = None Stop bits = 1 Flow control = Xon / Xoff

6	Press the *Esc* key. You should see text scroll by. Press *Esc* until the top-level menu is displayed.
	
	`TSC-400 Monitor Menu - V2.xx`
	
	`A - Turbine A`
	`B - Turbine B`
	`C - Turbine C`
	`D - Turbine D`
	`E - System Control`
	
	`Select [A..E]:`

7	Press *E* to go to the System Control menu
	
	`TSC-400 System Control - V2.xx`
	
	`A - Turbine A`
	`B - Turbine B`
	`C - Turbine C`
	`D - Turbine D`
	`E - Display Event Log`
	`F - Default Configuration`
	`G - Dump Configuration`
	`H - Load Configuration`
	`I - Save Configuration`
	`J - Copy Configuration`
	`K - System Restart`
	`X - Exit`
	
	`Select [A..K,X]:`

8	Press *G* to dump the configuration
	
	`Prepare PC/HyperTerminal to receive configuration file.`
	
	`Press any key to continue:`

9	On HyperTerminal menu bar, pull down Transfer and select Capture Text. In the dialog box, enter the name of the file you want to create to contain the configuration dump. A name like "Tsc400_setup.txt" is recommended; as it identifies this file as belonging to a TSC-400. The .txt extension tells HyperTerminal that this is a plain text file.
10	After the file name is in place, press the Start button
11	Press the Enter key to start the dump. The text will scroll by quickly.
12	When the text stops – move the mouse up to the HyperTerminal menu bar, pull down Transfer, move the cursor down to Capture Text, then slide over and click on Stop. This will close the captured text file and write it to disk on the PC.
13	Press Enter on the keyboard. The System Control menu will scroll up.

7.7 Recovering Configuration using HyperTerminal

The following table contains step-by-step instructions for loading a saved configuration file into an TSC-400. Please see the previous section for details on how to save a configuration file.

Step	Action
1	Connect serial cable to front panel of TSC-400. This cable must have pin 9 disconnected. See section 7.4 for the correct pin-out.
2	Connect 9-pin cable to the appropriate COM port on the PC. This is usually COM1, but not always.
3	Start HyperTerminal. This program is usually stored in Program Files > Accessories > HyperTerminal.
4	In HyperTerminal, go to the menu bar and pull down the File, and choose Properties. In the properties dialog, click on the Settings tab and press the ASCII Setup button. Verify that: All boxes are unchecked Line delay = 2 milliseconds Character delay = 0 milliseconds
5	In HyperTerminal, go to the top and pull down the File menu, choose Properties. On the properties dialog, click on the Configure button. Verify that: Bits per seconds = 9600 Data bits = 8 Parity = None Stop bits = 1 Flow control = Xon / Xoff

6	Press the *Esc* key. You should see text scroll up. Press *Esc* until the top-level menu is displayed.
	
	`TSC-400 Monitor Menu - V2.xx`
	
	`A - Turbine A`
	`B - Turbine B`
	`C - Turbine C`
	`D - Turbine D`
	`E - System Control`
	
	`Select [A..E]:`

7	Press *E* to goto the System Control menu
	
	`TSC-400 System Control - V2.xx`
	
	`A - Turbine A`
	`B - Turbine B`
	`C - Turbine C`
	`D - Turbine D`
	`E - Display Event Log`
	`F - Default Configuration`
	`G - Dump Configuration`
	`H - Load Configuration`
	`I - Save Configuration`
	`J - Copy Configuration`
	`K - System Restart`
	`X - Exit`
	
	`Select [A..K,X]:`

8	Press *H* to load the configuration. The TSC-400 will display: `Ready to receive configuration file`
9	On HyperTerminal menu bar, pull down **Transfer** and select **Send Text File**. In the dialog box, left click on the file that contains the TSC-400 configuration that you want to recover. Press Open to start sending the file to the TSC-400.

10	After the configuration is sent, the TSC-400 will display its top-level menu:
	
	`TSC-400 Monitor Menu - V2.xx`
	
	`A - Turbine A`
	`B - Turbine B`
	`C - Turbine C`
	`D - Turbine D`
	`E - System Control`
	
	`Select [A..E]:`

7.8 Upgrading Software using HyperTerminal

The following table contains step-by-step instructions for downloading new software into a TSC-400. Prior to starting, copy the download file (usually named like tsc2xx.txt) into the PC's fixed disk. If using HyperTerminal, it is recommended to copy the file into the Program Files > Accessories > HyperTerminal directory.

Step	Action
1	Connect serial cable to front panel of TSC-400. This cable must have pin 9 disconnected. See section 7.4 for the correct pin-out.
2	Connect serial cable to the appropriate COM port on the PC. This is usually COM1, but not always.
3	Start HyperTerminal. This program is usually stored in Program Files > Accessories > HyperTerminal.
4	In HyperTerminal, go to the menu bar and pull down the **File**, and choose **Properties**. In the properties dialog, click on the **Settings** tab and press the **ASCII Setup** button. Verify that: All boxes are unchecked Line delay = 2 milliseconds Character delay = 0 milliseconds
5	In HyperTerminal, go to the top and pull down the **File** menu, choose **Properties**. On the properties dialog, click on the **Configure** button. Verify that: Bits per seconds = 9600 Data bits = 8 Parity = None Stop bits = 1 Flow control = Xon / Xoff
6	On the keyboard, press the *Esc* key. You should see text scroll up. Press *Esc* until the top-level menu is displayed. TSC-400 Monitor Menu - V2.xx A - Turbine A B - Turbine B C - Turbine C D - Turbine D **E - System Control** Select [A..E]:

7	Press *E* to go to the System Control menu
	
	`TSC-400 System Control - V2.xx`
	`A - Turbine A`
	`B - Turbine B`
	`C - Turbine C`
	`D - Turbine D`
	`E - Display Event Log`
	`F - Default Configuration`
	`G - Dump Configuration`
	`H - Load Configuration`
	`I - Save Configuration`
	`J - Copy Configuration`
	`K - System Restart`
	`X - Exit`
	`Select [A..K,X]:`

8	Press *K* to perform a system restart. The TSC-400 will reset and run its boot monitor software. Inside the TSC-400, this software is kept separate from the operational software and is used for downloading new software. The monitor menu looks like:
	
	`System Monitor- V2.xx`
	
	`A - Download Program`
	`B - Set Factory Configuration`
	
	`Select [A..B]:`
	
	Option A to prepares the TSC-400 to receive the new software. Option B is intended as a means to work around the possibility of a damaged configuration that causes the system to reset.

9	Press *A* to prepare the TSC-400 to receive the new software file. The TSC-400 will reply that it is ready to receive the file. The file is a text file, which contains the program image in the form of Motorola S-Records. `Start sending S-record file, press [Esc] to abort…`
10	On HyperTerminal menu bar, pull down **Transfer** and select **Send Text File**. In the dialog box, left click on the file that contains the program file that you want to download into the TSC-400. Press the **Open** button to start sending the file to the TSC-400. When the file is transferring, you will see dots displayed on the screen. Each dot represents a line of the S-record file.
11	After the download completes successfully, the TSC-400 will write the program into its flash memory for permanent storage. When complete, it is recommended to restart the system (power cycle) and verify that the card comes up and the front panel displays the correct version number of the new software.