AG-TFS-00
August 30, 2004

TFS
Application Guide

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General

This document provides application highlights covering TFS fan-powered terminals.

Additional information may be found at the Titus website, www.titus-hvac.com.

Introduction

Titus has designed the new TFS series fan-powered terminal using a base box plus options concept borrowed from the automotive industry. The TFS base box is cost competitive with other manufacturers' non-quiet fan-powered terminals. The TFS can be upgraded to a TFS-F by adding the Fantom™ Intelligently Quiet™ (Fantom IQ™) acoustic upgrade package. The TFS-F Fantom IQ is the quietest fan box in the industry!

We are happy to announce the TFS and TFS-F Fantom IQ series fan-powered terminals.

Research and Development of the TFS and TFS-F

Extensive research was done to look at all areas of the box design. Titus investigated and tested technologies related to motor development, motor mounting, motor positioning, acoustic materials, cabinet design, blower technology, and alternate liner options. Many of these technologies have been incorporated into the TFS and TFS-F Fantom IQ design.

Features and Benefits

The following table lists features and benefits of TFS fan-powered terminals.

Table 1. TFS Fan-powered Terminals Features

Feature	Benefit
Access doors	• Easy top and bottom access to the motor and damper sections.
	• Improved flanged design means fewer screws and easier removal.
Center discharge	• Does not move between right and left hand units.
	• Better shipping protection of water coils.
Interchangeable motor / blower	• Easy field size changes when necessary.
Interchangeable inlets	• Easily change inlet sizes in the field.
Shaft down motor	• Reduces shaft loading and increases motor reliability.
	• Shaft down position eliminates the need for fan packing, which eliminates the possibility of the motor being started with fan packing in place.
	• Lower profile casing.
	• Shaft down positions provides vibro-acoustic benefits.
Easy to install motor / blower assembly	• Tabbed brackets allow motor / blower assembly to "hang" in place to allow for easy alignment of screw holes for easy field installation.

Table 2. Optional Upgrades

Upgrade	Benefit
FAST acoustic upgrade system	• Allows the base and quiet boxes to be mixed on a project.
	• Adding FAST attenuators make the TFS Fantom IQ the quietest fan box in the market.
TITAN™ programmed ECM motor	• Energy-efficient operation.
	• Pressure independent operation.
	• Uses Titus Iterative Test & Analysis Network.

Description

The TFS and TFS-F Fantom IQ series fan-powered terminals provide the flexibility to be cost competitive when sound is not an issue and be extremely quiet when sound is an issue. The TFS and TFS-F Fantom IQ can be mixed on projects to get the best combination of quiet units and cost effective units to meet the needs of the project.

The TFS and TFS Fantom IQ have two casing sizes to simplify design. The TFS small casing covers unit sizes B and C and the TFS large casing covers unit sizes D and E.

The TFS has a smaller footprint than the TQS, especially in the large casing, which is almost 10 inches narrower than the TQS large casing. (See Table 3.)

Table 3. TFS vs. TQS dimensions

		H	L	W
TFS	**B,C**	**16**	**42**	**27**
TQS	2,3,4	17	41	36.5
		(1.00)	1.00	0.50

		H	L	W
TFS	**D,E**	**20**	**46.75**	**39**
TQS	5,6,7	20	47	48.5
		0.00	(0.25)	(9.50)

TFS Base Box Features

The TFS has top and bottom access provided by four (4) access doors. The flanged access door design allows us to use fewer screws to secure the doors, which makes removing the access doors in the field easier. The four access door design allows the box to be built and shipped right side up. This will allow for quicker installation in the field since the unit will not have to be turned over prior to installation.

The discharge has been centered on the unit so the discharge location does not change between left and right hand units. Unlike the TQS, left hand and right hand units are not mirror images of each other, so the hand of the unit does not affect the discharge ductwork. The centered discharge also provides more protection for the water coils during shipping. (See Figure 2.)

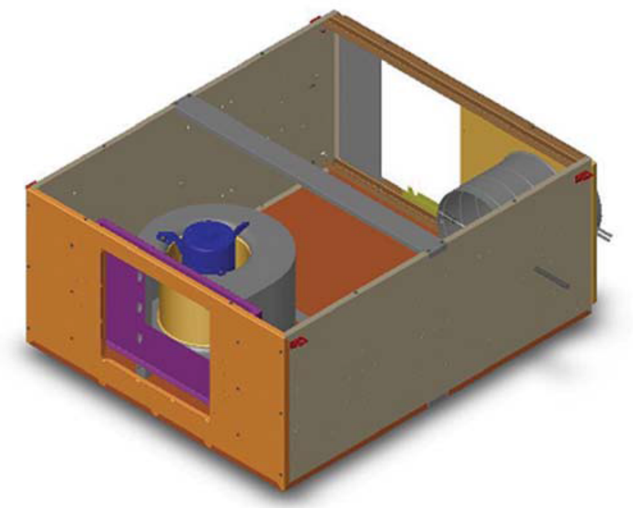

Figure 1. TFS Base Box

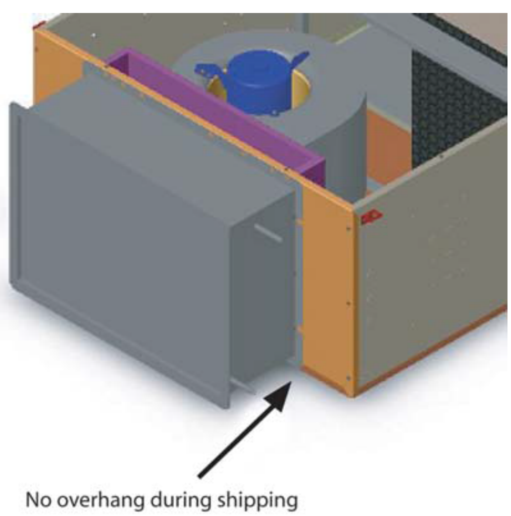

Figure 2. Centered Discharge Protects Water Coil During Shipping

The TFS has interchangeable motor / blowers assemblies and interchangeable inlets. This provides flexibility in stocking, as well as for quick size changes in the field.

Most sizes of the TFS will have top mounted motors. This motor arrangement provides better support of the motor weight during shipping and will allow the units to be shipped without fan packing. The elimination of fan packing will save time during installation since the units do not need to be opened for the packing to be removed. It also eliminates the chance of damaged motors and blowers due to the fan packing not being removed prior to starting the fan motor. The improved shipping support and elimination of the possibility of motors running with fan packing in the blower will improve motor reliability and lifetime.

Replacing a motor in the ceiling requires you to have access to both sides of the blower to tighten the setscrew. Misaligning the motor shaft or not tightening the setscrew will result in future motor or blower damage. Replacing a motor in the ceiling is not recommended for this reason.

The TFS motor / blower assembly has a tabbed bracket that mounts to the blower deck. This tabbed assembly allows for quick removal and installation of the motor / blower. As the blower bracket screws are removed, the tabs allow the assembly to "hang" in place so that you do not have to support the blower assembly while removing the screws. When the screws have been removed, the motor / blower assembly can be lifted to release the tabs and lowered to the floor to replace the motor. (See Figure 3.)

During motor / blower installation, the tabbed brackets once again allow the assembly to "hang" in place to allow for easy alignment of screw holes. (The tabs are not designed to support the weight of the motor / blower assembly for prolonged periods of time. The bracket screws must be replaced.)

TFS-F Fantom IQ Optional Acoustic Upgrade Package

The TFS-F Fantom IQ has all of the same features mentioned above as the TFS base box. The optional Fantom IQ acoustic upgrade package turns the TFS into the quietest fan box in the market.

The TFS-F Fantom IQ has internal and external attenuators that significantly reduce the sound of the TFS base box. The unique Full Acoustic Spectrum Turner™ (FAST™) attenuator system design (patent pending) means that the footprint of the TFS-F Fantom IQ only changes in the direction of the primary ductwork when compared to the TFS base box.

The FAST attenuator is shipped inside the TFS-F casing to protect it from shipping damage. Once at the jobsite, the attenuator is pulled out and snapped into place.

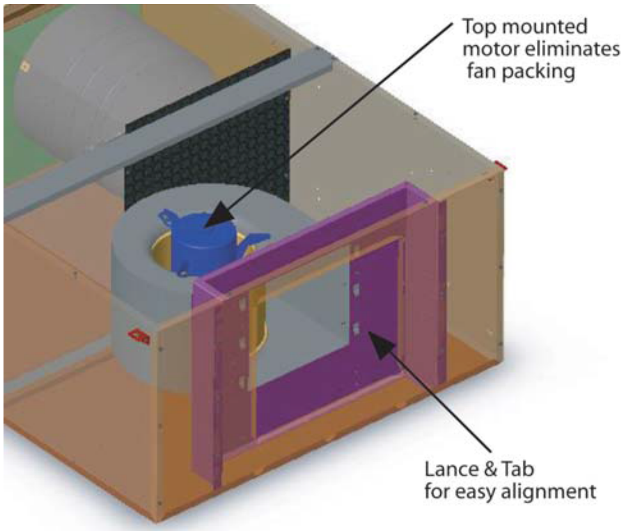

Figure 3. Motor / Blower Assembly

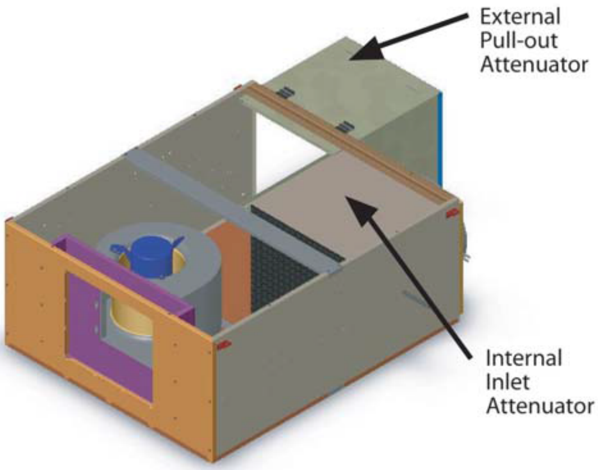

Figure 4. TFS-F Fantom IQ

The FAST attenuator has four clips that hold it in place inside the unit casing during shipping. (See Figure 5.) Once at the jobsite, the contractor simply pulls the attenuator out until the clips snap in place. (See Figure 6.) Once snapped in place, the clips support and secure the attenuator in its operation position. (The attenuator must be pulled out of the shipping position for operation. Failure to do so may cause the motor to operate under excessive pressure conditions.)

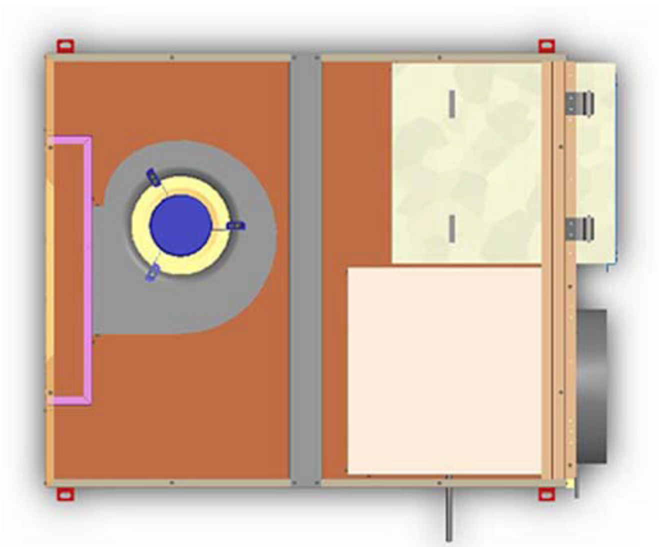

Figure 5. Attenuator Shipping Position

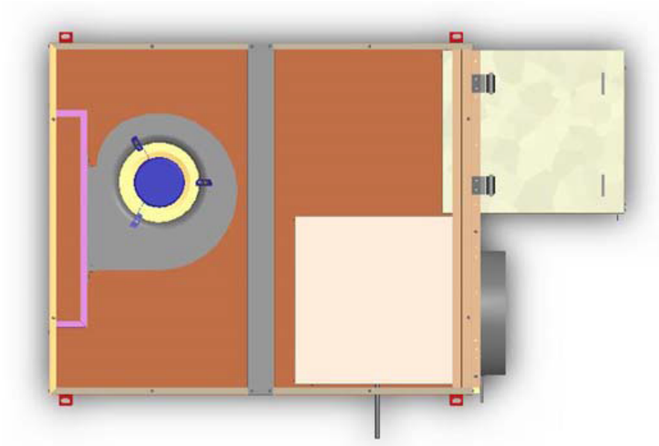

Figure 6. Attenuator Operating Position

TITAN ECM Programming Process

The TFS and TFS-F Fantom IQ are available with the optional ultra high-efficiency GE ECM motor. Any manufacturer can purchase the ECM motor. The difference is in the development and programming to the ECM motor to operate effectively and efficiency within the specific fan-powered terminal's design and configuration. The ECM motor only offers a benefit, if it is developed and programmed correctly within the specific fan box.

Titus uses the Titus Iterative Test & Analysis Network™ (TITAN™) ECM Programming Process in the Titus ISO 9001:2000 certified lab, the Harold Straub Aero-Acoustics & Vibration Research & Training Center. The TITAN process ensures the performance of the ECM motor in all of the Titus fan-powered terminals.

History of ECM Motors in Commercial HVAC

Titus has been programming ECM motors for almost a decade. In early 1995, GE and Titus brought motors into the commercial HVAC market.

Understanding that the ECM motor was a significant price increase over standard PSC motors, Titus retrofitted one floor of the Oryx Energy Tower in Dallas, TX with ECM motors and compared the energy usage of that floor against a floor with PSC motors over an eighteen month period to prove the energy savings would provide an acceptable payback of three years or less.

Titus shipped the first ECM fan-powered terminal to a school district in Houston in 1997. Titus has been shipping ECM motors ever since. This extensive history and commitment to the development of the ECM motor for commercial applications, makes Titus an expert in ECM development. This expertise is the basis of the TITAN ECM Programming Process.

Process Summary

The TITAN ECM Programming Process is an iterative process of developing constants for the ECM motor to operate at the optimum efficiency and provide pressure independent airflow. Up to a dozen test runs are preformed using the GE ECM motor programming interface equipment to ensure the correct motor constants. Developing the correct motor constants allows optimal control of the speed and torque of the motor in the particular fan box design.

The minimum and maximum fan curves are determined based on minimum and maximum rpm of the ECM motor (300 rpm and 1200 rpm respectively). The GE interface unit plots rpm vs. torque of the motor and determines the difference between measured venturi CFM and the ECM calculated CFM. This test is repeated until the difference in venturi CFM and the ECM calculated CFM equals zero. Once the CFM difference is zero, or as close to zero as possible, the ECM constants are saved for that unit's airflow characteristics.

All Titus fan-powered terminals with ECM motors are provides with a factory installed PWM controller. The PWM voltage signal is calibrated to provide 100% fan at full voltage (10.0V) and minimum fan at minimum voltage (1.0V). The calibrated PWM allows the ECM motor to operated as programmed by Titus regardless of what manufacturer's DDC controller provides the voltage signal to the PWM controller. This ensures the pressure independent operation of the motor with any DDC controller. The PWM signal can also be controlled manually using a dial pot much like a SCR on a standard PSC motor. The Titus PWM has RPM feedback. LED readout on the manual PWM, displays the motor rpm when the PWM screwdriver adjustment is not activated. When the screwdriver adjustment is turned, the LED displays the flow index. The flow index is a number from 0 to 100, which correlates to a CFM through the PWM calibration.

The TITAN ECM Programming Process extends from the lab to the ISO 9001:2000 certified factories where individual ECM motors are programmed with the appropriate ECM program for each order.

Suggested Specification

1. Furnish and install TITUS Model (P)(A)(D)TFS series flow fan-powered terminals of the sizes and capacities shown on the plans. Space limitations shall be reviewed carefully to ensure that all terminals will fit the available space.
2. Terminals should be certified in an ISO9001:2000 certified lab under the ARI Standard 880 Certification Program and carry the ARI Seal. Non-certified terminals may be submitted after testing at an independent testing laboratory under conditions selected by the engineer in full compliance with ARI Standard 880. These tests must be witnessed by the engineering consultant and with all costs to be borne by the terminal manufacturer. Testing does not ensure acceptance.
3. The terminal shall be designed, built, and tested as a single unit including motor and fan assembly, primary air damper assembly, water or electric heating coils, and accessories as shipped. Unit shall ship as a complete assembly requiring no field assembly (including accessories). All electrical components shall be UL listed and installed in accordance with the UL Standard 1995. Electrical connection shall be single point. All electrical components, including low voltage controls, shall be mounted in sheet metal control enclosures. The entire terminal shall be ETL listed as a complete assembly.
4. The terminal casing shall be minimum 20-gauge galvanized steel, internally lined with ½-inch matte faced, natural fiber insulation that complies with UL 181 and NFPA 90A. The liner shall comply with ASTM G21 and G22 for fungi and bacterial resistance. The casing shall be designed for hanging by sheet metal brackets. The terminal shall have a round duct collar for the primary air connection and a centered rectangular discharge suitable for flanged duct connection.
5. The terminal casing shall have a top and bottom access panels, which allows removal of fan assembly and servicing of terminal without disturbing duct connections.

6. The fan shall be constructed of steel and have a forward curved, dynamically balanced wheel with direct drive motor. The motor shall be suitable for 120, 208, 240, or 277 volt, 60 cycle, single-phase power. The motor shall be of energy efficient design, permanent split capacitor type, with integral thermal overload protection and permanently lubricated bearings, and be specifically designed for use with an SCR for fan speed adjustment. Fan assembly shall include a tuned spring steel suspension and isolation between motor and fan housing.
7. The terminals shall utilize a manual SCR, which allows continuously adjustable fan speed from maximum to minimum, as a means of setting fan airflow. Setting fan airflow with any device that raises the pressure across the fan to reduce airflow is not acceptable. The speed control shall incorporate a minimum voltage stop to ensure that the motor cannot operate in a stall mode.
8. The primary air damper assembly shall be heavy gauge steel with shaft rotating in Delrin self-lubricating bearings. Nylon bearings are not acceptable. Shaft shall be clearly marked on the end to indicate damper position. Stickers or other removable markings are not acceptable. The damper shall incorporate a mechanical stop to prevent overstroking, and a synthetic seal to limit close-off leakage to the maximum values shown in the following table. Provide an AeroCross™ four point, center-averaging differential pressure airflow sensor. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. Balancing taps and airflow calibration charts shall be provided for field airflow measurements.
9. The sound levels shall not exceed the octave band sound power levels indicated in the table below. Sound performance shall be ARI certified. If NC is provided instead of octave band sound power data, the radiated and discharge path attenuation function for the specified NC shall be based upon factors found in ARI Standard 885-98, Appendix E. No additional attenuation factors shall be deducted from the sound power.

Table 8. Maximum Radiated Sound Power Level

Radiated	Octave Band					
	2	3	4	5	6	7
NC 35	70	61	54	53	52	51
NC 40	74	68	61	59	58	57

Table 9. Maximum Discharge Sound Power Level

Discharge	Octave Band					
	2	3	4	5	6	7
NC 35	80	77	69	73	74	73
NC 40	84	80	72	75	75	74

TFS-F Fantom IQ

(Substitute paragraphs 1and 5 below for paragraphs 1, and 5 in the TFS Basic Unit Specification.)

1. Furnish and install TITUS Model (P)(A)(D)TFS-F Fantom IQ series flow fan-powered terminals of the sizes and capacities shown on the plans. Space limitations shall be reviewed carefully to ensure that all terminals will fit the available space.
5. The terminal casing shall have a two top and two bottom access panels, which allows removal of fan assembly and servicing of terminal without disturbing duct connections. The terminal shall have internal and external attenuators factory installed. The external attenuator shall be shipped internal to the unit to protect it from shipping damage. The external attenuator shall be slid into the operation position and secured without the need for additional screws. Factory provided attenuators that require field installation are not acceptable.

ECM Motor

(Substitute paragraphs 6 and 7 below for paragraphs 6 and 7 in the TFS Basic Unit Specification)

6. Fan motor assembly shall be forward curved centrifugal fan with a direct drive motor. Motors shall be General Electric ECM variable-speed dc brushless motors specifically designed for use with single phase, 277 volt, and 60 hertz electrical input.

Motor shall be complete and operated by a single phase integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator. All motors shall be designed for synchronous rotation. Rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in soft start and soft speed change ramps. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motor shall be directly coupled to the blower. Motor shall maintain a minimum of 70 percent efficiency over its entire operating range. Provide a motor that is designed to overcome reverse rotation and not affect life expectancy.

7. The terminal unit manufacturer shall provide a factory installed PWM controller for either manual or DDC controlled fan CFM adjustment. The manual PWM controller shall be field adjustable with a standard screwdriver. The remote PWM controller shall be capable of receiving a 0-10 Vdc signal from the DDC controller (provided by the controls contractor) to control the fan CFM. When the manual PWM controller is used, the factory shall preset the fan CFMs as shown on the schedule. Manual PWM shall have an LED display of motor rpm and remote PWM shall have rpm output that can be wired to the DDC analog input to read motor rpm.

Steri-Loc Liner

(Substitute paragraph 4 below for paragraph 4 in the TFS Basic Unit Specification.)

4. The terminal casing shall be minimum 20-gauge galvanized steel, internally lined with non-porous, sealed liner, which complies with UL 181 and NFPA 90A. Insulation shall be 4-pound density. All cut edges must be sealed from the airstream using barrier strips. Liners made of Tedlar, Silane, or woven fiberglass cloth are not acceptable. Insulation shall be equivalent to Titus Steri-Loc. Double wall lining is acceptable. The terminal shall have a round duct connection and a rectangular discharge suitable for flanged duct connection. The casing shall be designed for hanging by sheet metal straps.

Fibre-Free Liner

(Substitute paragraph 4 below for paragraph 4 in the TFS Basic Unit Specification.)

4. The terminal casing shall be minimum 20-gauge galvanized steel, internally lined with engineered polymer foam insulation, which complies to UL181 and NFPA 90A. Insulation shall be 1 1/2 pound density, closed cell foam. Exposed fiberglass is not acceptable. The insulation shall be mechanically fastened to the unit casing. The casing shall be designed for hanging by sheet metal brackets.

Hot Water Heating Coils

4. Hot water heating coils shall be enclosed in a minimum 20-gauge galvanized steel casing, with flanged construction for attachment to metal ductwork. Coils shall be factory installed on the terminal. Fins shall be rippled and corrugated heavy gauge aluminum, mechanically bonded to tubes. Tubes shall be copper with minimum wall thickness of 0.016 inch, with male solder header connections. Coils shall be leak tested to 300 psi, with minimum burst pressure of 1800 psi at ambient temperature. Number of coil rows and circuits shall be selected to provide performance as required per the plans. Coil performance data shall be based on tests run in accordance with ARI Standard 410.

Electric Heating Coils

1. Electric coils shall be supplied and installed on the terminal by the terminal manufacturer. Coil shall be integral with the terminal. Elements shall be 80/20 nickel chrome, supported by ceramic isolators a maximum of 3.5 inches apart, staggered for maximum thermal transfer and element life, and balanced to ensure equal output per step. The integral control panel shall be housed in a NEMA 1 enclosure, with hinged access door for access to all controls and safety devices.
2. Electric coils shall contain a primary automatic reset thermal cutout, a secondary replaceable heat limiter per element, differential pressure airflow switch for proof of flow, and line terminal block. Coil shall include an integral door interlock type

disconnect switch, which will not allow the access door to be opened while power is on. Non-interlocking type disconnects are not acceptable. All individual components shall be UL listed or recognized.

3. (Optional) Electric coils shall include (manual reset secondary thermal cutouts), (line fusing), (mercury contactors) mounted and wired within the control enclosure.

Abbreviations

The following table lists abbreviations used within this document.

Abbrev.	Term
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
CFM	cubic feet per minute
DC	Direct Current
DDC	Direct digital control
ECM	Electronically Commutated Motor
GE	General Electric
hp	horsepower
HVAC	Heating Ventilation and Air Conditioning
IEEC	International Energy Conservation Code
ISO	International Standards Organization
LEED	Leadership Energy and Environmental Design
NEMA	National Electrical Manufacturers Association
PSC	Permanent Split Capacitor
PWM	Pulse Width Modulator
rpm	revolutions per minute
TITAN	Titus Iterative Test & Analysis Network
USGBC	United States Green Building Council
V	Volt
Vdc	Volt direct current