TEXAS DEPARTMENT OF TRANSPORTATION
SPECIAL SPECIFICATION TO-8248
UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM FOR SIGNAL CABINETS

1.0 SCOPE

This specification sets forth the minimum requirements for a traffic signal uninterruptible power supply (UPS) system. The UPS system is designed for intersections operating LED lenses with typical loads of 700 watts or less. The UPS system shall provide a cabinet meeting all the criteria of this specification. All system components of the UPS system shall be housed within the cabinet. The UPS system shall provide reliable emergency power to a traffic signal intersection (vehicle and pedestrian) in the event of utility power failure or interruption. The UPS system shall also act as a power conditioner and/or voltage regulation device.

The UPS system shall be capable of operating a signalized intersection (700 watt load) for 4 hours of full runtime when utility power is disabled and under ambient temperatures of 25˚C. The UPS system shall switch the intersection to flash mode of operation when approximately 40% of battery charge is remaining, via relay contact connection points on front panel of unit. The UPS system shall operate the intersection in the flash mode of operation (350 watt load) for an additional 2 hours. UPS system components shall be rated for a minimum 1,400 watt load capacity.

The UPS system shall be designed for outdoor applications in accordance with NEMA TS2 2003, or latest revision, Section 2. All components of the UPS system shall be rated to operate under temperature extremes of -34˚C to +74˚C.

2.0 DEFINITIONS

2.1 **Uninterruptible Power Supply System (UPS System)**. A device that provides battery backup when utility line voltage fails. A device that provides voltage regulation and/or power conditioning when utility line voltage drops below or above nominal operating voltages. The UPS system includes, but is not limited to a manual bypass switch, automatic/manual bypass switch, power transfer relay, an inverter/charger, batteries, battery monitoring device, wiring, external cabinet and all necessary hardware for system operation.

2.2 **UPS System Software.** All software associated with operation, programming and functional requirements of the UPS system.

2.3 **Battery Monitoring Device.** The device which monitors battery temperature and charge rate of the batteries used in the UPS system.

2.4 **Batteries.** Standard 12 Volt batteries wired in series to create a 48V DC to 96V DC voltage storage.

2.5 **Boost.** When enabled, the UPS inverter/charger shall automatically switch into this mode to raise the utility line voltage when it drops below a preset limit. The limit may be user defined or use manufacturer default settings (typical 100V AC).

2.6 **Buck.** When enabled, the unit shall automatically switch into this mode to reduce the utility line voltage when it rises above a preset limit. The limit may be user defined or use manufacturer defaults (typical 135V AC).

2.7 **Inverter/Charger**. The unit which converts the DC voltage input into 120V AC output for the traffic signal cabinet to operate. As a minimum the inverter/charger shall be rated for 1,400 watts.

2.8 **Inverter Line Voltage**. The power supplied from the UPS system to the traffic signal cabinet from the UPS system inverter.

2.9 **Manual Bypass Switch.** Manual switch that allows user to bypass UPS power to service system equipment. Manual bypass switch switches utility line power directly to cabinet.

2.10 **Power Transfer Relay**. A relay connected between the manual bypass switch and the inverter/charger that switches power from utility line voltage to UPS voltage. The power transfer relay may be internal to the inverter charger or combined with the manual bypass switch. In the event of battery voltage loss, the power transfer switch will automatically return to utility line power.

2.11 **Signal Operation Mode.** A signalized intersection generating a 700 watt load when running in normal operation.

2.12 **Signal Flash Mode.** A signalized intersection generating a 350 watt load when running in the flash mode of operation.

2.13 **Utility Line Voltage**. The 120V AC power supplied to the UPS system.

3.0 OPERATION

The UPS system shall operate using one or more of the following methods:

3.1 **Line Interactive (Buck and Boost) Method**

3.1.1 When the buck and boost functions are enabled they shall set the upper and lower control limit allowable for the utility line voltage. If the utility line voltage falls within the parameters set by buck and boost then the UPS system shall continue to operate the intersection under utility line power. If the utility line voltage fluctuates above or below the buck and boost values, the UPS system shall raise or lower the voltage by approximately 10%-15% of the utility line voltage in an attempt to bring the voltage back into the upper and lower control limits set by buck and boost. Buck and boost shall have preset manufacturer defaults.

3.1.2 If the utility line voltage falls above or below the functional capabilities of buck and boost then the UPS system shall transfer power from utility line voltage and the inverter/charger shall operate the intersection from battery power converting DC voltage to AC.

3.2 **Continuous Operating Mode, Double Conversion Method**

3.2.1 Using the continuous operating mode buck and boost functions are disabled and the UPS system operates continuously converting utility line voltage, 120V AC, to DC voltage then back to 120V AC supplying the cabinet with inverter line power. Should the utility line voltage fail, the UPS system will continue to supply inverter line power to the cabinet via the UPS system.

4.0 GENERAL OPERATING REQUIREMENTS

4.1 The UPS system shall be capable of providing 1,400 watts active output capacity, with a minimum of 80% inverter efficiency. The inverter/charger shall be rated for a minimum of 2,000V AC and capable of operating at 1,400 watts continuous load.

4.2 When batteries are fully charged, ensure the UPS system provides power to run a intersection and all peripherals for a minimum of 240 minutes (4 hours) of fully actuated runtime (700 watt load), then switch to flash mode for a minimum of 120 minutes (2 hours) of flash runtime(350 watt load).

4.3 When system is running on battery power, the UPS system shall allow the user to select a voltage (typical 46V) at which the transition from normal operating loads (700 watts) to flash mode of operation (350 watts) will occur via a set of relay contacts and connection points on the front panel of the inverter/charger.

4.4 The transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from batteries, shall be less than 65 milliseconds. The same allowable transfer time shall also apply when switching from inverter line voltage to utility line voltage.

4.5 The UPS system shall bypass utility line power whenever the utility line voltage is outside of the manufacturer's default or a user programmed voltage range ±2V AC.

4.6 When the utility line power has been restored to a normal operating voltage for more than 30 seconds, the UPS system shall transfer from battery back to utility line mode. The UPS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service.

4.7 The UPS system shall be compatible with TS1, TS2 and Model 170/2070 controllers and cabinet components for full run time operation.

4.8 The UPS system shall be shelf mounted in TS1 and TS2 cabinets. For Model 170/2070 332 cabinets shall be rack mounted. The manual bypass switch shall be able to be mounted on the shelf or side of cabinets. The interconnect cables shall be no less than 10 feet in length. Relay contact wiring for each set of normally open (NO) and normally closed (NC) relay contact closure terminals shall be no less than 6 feet long of #18 AWG wire. Wire size shall be sized accordingly to manufacturer recommendations for any cable lengths greater then 10 feet.

4.9 The UPS system shall have lightning surge protection compliant with IEEE/ANSI C.62.41, latest revision and meeting all current UL1449 standards. Lightening surge protection shall be provided to the utility line voltage coming into the inverter/charger. The surge protection device shall be easily accessible and mounted externally from the inverter/charger.

4.10 The UPS system and batteries shall be easily replaced and provided with all needed hardware. The UPS system shall not require any special tools for installation.

4.11 The UPS system shall operate with an automatic "fail safe" mode. Should a breaker trip on the inverter/charger and/or the power transfer relay, the unit will automatically default to utility line power and bypass the UPS system.

4.12 The UPS system unit shall be capable of logging up to 100 events. Events shall date and time stamp faults with AC line voltage and UPS battery voltages. At a minimum, the following conditions shall be recorded as an event:

4.12.2 The UPS system shall record utility line voltage occurrences whenever the line voltage falls above or below the upper and lower control limits or manufacturer preset defaults. When this condition occurs, it shall be recorded as an event.

4.12.3 Whenever the UPS system automatically switches to battery power this shall be recorded as an event.

4.12.4 Self monitoring, UPS system component failures shall be recorded as an event

5.0 DISPLAYS, CONTROLS, DIAGNOSTICS AND MAINTENANCE

5.1 The UPS system shall include a front panel display. All applicable programmable functions of the operational methods described in this specification shall be viewable through the front panel display.

5.2 All events described in Section 4.12 shall be viewable from the front panel display.

5.3 The UPS system software shall be programmable from the front panel of the inverter/charger by means of a keyboard or momentary buttons allowing user to step through menu driven software.

5.4 A 10/100 Ethernet port shall be provided on the front panel of the inverter/charger.

5.5 A RS232 port shall be provided on the front panel of the inverter/charger.

5.6 UPS system software shall be provided for the operational needs of the UPS system. The user/ operator shall be able to access all system software via the Ethernet port and RS232 port on the front panel of the inverter/charger. The user shall be able to read logged events and/or change programmable parameters from the keyboard, laptop or local area network via the Ethernet port.

5.7 System software shall be upgradeable via the RS232 port on the front panel of the inverter/ charger.

6.0 INVERTER/CHARGER

6.1 When utility line voltage is out of normal operating range (typical 100V AC to 135V AC), the inverter/charger shall provide voltage regulation and/or power conditioning to the inverter line voltage using one or more of the methods described in Section 3.0 of this specification. When utility line voltage is present it shall act as a charging device for the batteries.

6.2 Ensure a minimum of 6 sets of NO and NC single-pole double-throw dry contact relay closures shall be made available on the front face of the inverter/charger and labeled so as to identify each contact. The relay closures shall consist of:

6.2.2 A set of NO and NC contact closures shall be energized whenever the unit switches to battery power. Contact shall be labeled or marked as “On Battery” or equal.

6.2.3 A second set of NO and NC contact closures shall be energized whenever the battery approaches approximately 40% of remaining capacity. This limit will determine when the unit will switch from normal operation to flash. Contact shall be labeled or marked as “Low Battery” or equal.

6.3 Operating temperature range for both the inverter/charger unit and power transfer relay shall be -34°C to + 74°C.

6.4 When battery power is used, the UPS system output voltage shall be between 110V AC and 125V AC, pure sine wave output, ≤ 3% THD, 60Hz ± 3Hz.

6.5 As a minimum, the inverter charger shall be rated for 2,000V AC and a power factor of .7 allowing 1,400 watts of continuous power from the unit.

7.0 POWER TRANSFER SWITCH OR AUTOMATIC/MANUAL BYPASS

The UPS system shall operate using one of the following methods:

7.1 Power Transfer Switch and Manual Bypass Switch Method

7.1.1 The power transfer switch and a manual bypass switch shall be provided as a separate unit external to the inverter/charger unit. The power transfer switch shall be rated at a minimum of 240V AC/20 amp.

7.1.2 A manual bypass switch shall be provided in addition to the power transfer switch. The manual bypass shall be 2 position switch. The switch positions shall be labeled “Bypass” and “UPS”.

7.1.3 When the switch is in the “Bypass” position, the utility line voltage will feed power directly to the traffic signal cabinet service panel and power to the inverter/charger will be deactivated allowing the user to service UPS equipment and replace the automatic power transfer switch without interrupting power to the intersection.

7.1.4 When the switch is in the “UPS” position, utility line power will be fed through the contacts of the external power transfer relay/contactor and to the cabinet service panel. Should a utility line condition occur activating buck or boost or in the event of utility line loss, the power transfer relay/contactor will be energized and power from the output of the inverter/charger will be connected to the cabinet service panel. Utility line power will be disconnected when power transfer relay/contactor is energized.

7.2 Automatic/Remote Manual Bypass Switch Method

7.2.1 The automatic bypass switch shall be provided as a separate unit external to the inverter/charger unit. The automatic bypass switch shall be 2 position and rated at a minimum of 240V AC/20 amp. A UPS supply breaker rated at 240V AC/20 amps shall be provided for the 120V AC input to the inverter/charger.

7.2.2 When the automatic bypass switch is in the “on” position and the supply breaker is “on”, the UPS system is connected to utility line voltage and its output is connected to the cabinet service panel. If the utility line voltage is deactivated, the UPS system will automatically switch over to battery power.

7.2.3 When the automatic bypass switch is in the “off” position, and the supply breaker is “on”, utility line power is provided to the cabinet service panel and the inverter/charger allowing equipment to be tested without interrupting power to the traffic signal load.

7.2.4 When the automatic bypass switch is “off” and the supply breaker is “off”, the utility line voltage will feed power directly to the traffic signal cabinet service panel and power to the inverter/charger will be deactivated allowing the user to service UPS equipment.

7.2.5 A manual bypass switch shall be provided separately from the automatic bypass switch. The manual bypass switch shall be 2 position and allow the user to switch utility line power directly to the cabinet service panel. When the manual bypass switch is in this mode the user may replace the automatic bypass switch and/ or the inverter/charger without interrupting power to the intersection.

8.0 BATTERIES

8.1 Batteries shall be provided by the manufacturer/vendor providing the UPS system.

8.2 Individual batteries shall be 12V type, and shall be easily replaced and commercially available for purchase as common off the shelf equal.

8.3 Batteries shall be sized and rated to operate at 700 watt load for 4 hours (normal operation) followed by a 350 watt load for 2 hours (flash mode) for a total of 6 hours.

8.4 Battery configurations shall consist of 12V batteries arranged in one of the following arrangements of 48V, 60V, 72V, 84V or 96V.

8.5 Batteries shall be deep discharge sealed prismatic valve regulated lead acid (VRLA) AGM or Gel cell batteries.

8.6 Batteries shall operate over a temperature range of -34°C to +74°C.

8.7 Batteries shall indicate maximum recharge data and recharging cycles and manufacture defaults on the inverter shall not allow the recharging process to exceed the batteries maximum values.

8.8 Battery interconnect wiring shall connect to the inverter unit via modular harness with red and black cabling that terminates into a typical power pole style connector. Harness shall be equipped with mating power flag style connectors for batteries and a single insulated plug-in style connection to inverter/charging unit. Harness shall allow batteries to be quickly and easily connected in any order and shall be keyed to ensure proper polarity and circuit configuration.

8.9 Insulated covers shall be provided at the connection points (post) to prevent accidental shorting.

8.10 Battery cables provided to connect battery to battery harness main cable shall be a minimum of 24 inches. Battery harness shall be sized accordingly with system requirements.

8.11 Batteries weighing more than 50 pounds or more shall be provided with a handle or hand strap allowing the user to carry or move the battery without the use of other equipment.

9.0 BATTERY MONITORING SYSTEM

9.1 The UPS system shall use a temperature compensated battery charging system. The charging system shall compensate over a range of 2.5 to 4.0 mV/°C per cell.

9.2 The temperature sensor shall be used to monitor the temperature and regulate the charge rate of the batteries. Unless required otherwise by the plans the temperature sensor wire shall be as follows:

9.2.1 8 foot if external side mount cabinet is attached to existing controller cabinet

9.2.2 8 foot if batteries are housed in traffic signal base used for cabinet foundation and batteries are stored on shelf within base.

9.3 Should the temperature sensor fail, the inverter/charger shall not allow the UPS system to overcharge the batteries. The UPS system shall provide an alarm should the temperature sensor fail.

9.4 Recharge time for the batteries to 80% or more of full battery charge capacity shall not exceed 20 hours at 70°F.

9.5 Batteries shall not be charged when battery temperature exceeds 50°C ± 3°C.

9.6 The UPS system shall monitor battery strings within a system and set a fault indicator if battery voltage falls below normal operating voltages.

10.0 EXTERNAL UPS SYSTEM CABINET:

10.1 The external cabinet shall be NEMA type 3R all aluminum with stainless steel hardware, or equal, approved by TxDOT Traffic Signal Engineer. The external cabinet shall be sized to house all of the UPS system components including batteries and designed to mount to side of traffic signal pole, side of TS2 size 6 base mount cabinets or be capable of base mounting to its own foundation.

10.2 The external cabinet shall be equipped with proper ventilation, (1) electric fan, thermostat control for the fan, and metal permanent air filter in accordance with TS2 standards. The fans shall be a commercially available model with a capacity of at least 2.7 m^3/minimum. The thermostats shall be adjustable range of 20°C to 43°C. The fan shall be temperature controlled by an adjustable thermostat in the UPS cabinet or via software setting from the inverter/charger. The fan shall operate when utility line voltage is absent and the system is running on UPS power.

10.3 A power panel with surge protection and breaker shall be provided within the external UPS system cabinet. The surge protection shall meet the requirements specified in Section 11170.6.K.3 of DMS Specification 11170 effective November 2008, or latest revision. The breaker shall be 30 amps and provide protection for the UPS system components. The breakers shall be Square "D" QUO 150 Series, or approved equal. A neutral buss and equipment ground bus shall be provided on the power panel. The utility line service shall terminate to a 3 circuit termination block sized for #6 AWG wire.

10.4 System components such as: manual bypass switch, automatic bypass switch, and power transfer relay shall be mounted in the cabinet or on the power panel and designed for easy access and replacement. A shelf shall be designated for the inverter/charger unit.

10.5 The cabinet shall be provided with one door in front that will provide access to the cabinet. The door shall be provided with three hinges with non-removable stainless steel pins, or a full-length piano hinge with stainless steel pins spot welded at the top of the hinge. The hinges shall be mounted so that it is not possible to remove them from the door or cabinet without first opening the door.

10.6 The cabinet door shall be fitted with a Number 2 Corbin lock and a cast aluminum or chrome plated steel handle with a 16 mm (minimum) diameter shaft (or equivalent cross-sectional area for a square shaft) and a three point latch. The lock and latch design shall be such that the handle cannot be released until the lock is released. One key shall be provided for each cabinet. A gasket shall be provided to act as a permanent dust and weather resistant seal at the cabinet door facing. The gasket material shall be of a nonabsorbent material and shall maintain its resiliency after long term exposure to the outdoor environment. The gasket shall have a minimum thickness of 6.25 mm. The gasket shall be located in a channel provided on the cabinet or on the door(s). An "L" bracket is acceptable in lieu of this channel if the gasket is fitted snugly against the bracket to insure a uniform dust and weather resistant seal around the entire door facing. Any other method is subject to written purchaser approval during inspection of an order.

10.7 The intake for the vent system shall be on the lower section of the cabinet front door and filtered with a permanent metal air filter. The filter shall be securely mounted so that any air entering the cabinet must pass through the filter. The cabinet opening for intake of air shall be large enough to use the entire filter. The air intake and exhaust vent shall be screened to prevent entry of insects. The screen shall have opening no larger than 8.1 mm^2. The total free air opening of the exhaust vent shall be large enough to prevent excessive back-pressure on the fan.

11.0 DOCUMENTATION

11.1 Operation and maintenance manuals shall be provided. The operation manual shall include a block diagram schematic of all system hardware components. The manual shall include instructions for programming and viewing software features. The manual shall include all uploading/ downloading (communication protocol) requirements via RS232 port or Ethernet port.

11.2 Board level schematics shall be provided when requested.

11.3 Battery documentation and replacement information shall be provided.

12.0 TESTING

12.1 TxDOT reserves the right to do testing on UPS systems to ensure quality assurance before installations and random sampling of units being provided to the State. UPS systems that fail will be removed from the Prequalified Products List (QPL).

12.2 TxDOT QPL testing procedures will include the following:

12.2.1 UPS system shall comply with all the criteria of this specification.

12.2.2 Event logging for fault/alarm conditions.

12.2.3 System will demonstrate one or more of the operation methods described in Section 3.0.

12.2.4 UPS system will operate at 700 watt load (minimum 4 hours), system will transfer to flash mode and operate at 350 watt load (minimum 2 hours) under battery power and at ambient temperatures +25°C, total length of test 6 hours.

12.2.5 All components of the system shall be tested in environmental chamber (temperature ranges from -30°C to +74°C) following NEMA TS2 2003 standards, or latest revision, Section 2.

13.0 WARRANTY, MAINTANANCE AND SUPPORT

13.1 The manufacturer shall provide a 5 year full replacement warranty on all components of the UPS system.

13.2 Batteries shall be warranted for full replacement for 5 years. Batteries shall be defined as bad, if they are not able to deliver 80% of battery rating.