Green Traffic Controller Cabinet

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Green Traffic Controller Cabinet

Final Report

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Notice

Disclaimer

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Abstract

The report details the work performed by the New York City Department of Transportation (NYCDOT) and TransCore ITS LLC. to design and deploy low power and low voltage traffic controller cabinets using 48 VDC technology. Theoretically, the 48VDC devices should offer a power savings at each signalized intersection, which extrapolated over the approximately 14,000 intersections in NYC should be quite significant. In addition, the low voltage field wiring should make the overall maintenance on the traffic signals safer for the technicians. The cabinet design would leverage 48 VDC devices defined in the Advanced Transportation Controller Cabinet standards (ATCC Standards: ITE-5301) with modifications to support the data rates used in the existing traffic controller. The original plan was to deploy these cabinets at ten locations in Long Island City, New York and perform a before after study on the overall power draw. Throughout the process of the cabinet shop testing, the team determined multiple design mismatches between the power draw of the 48VDC signal and pedestrian heads and the rated power outputs of the ATCC standard devices. These issues prevented the NYCDOT from certifying the cabinets as safe for field deployment at this time. NYCDOT created a simulated field environment in their shop to collect data on the cabinet power draw for the study. The NYCDOT is continuing to work with both the cabinet and signal head vendors to address the issues and be able to field install the cabinets at some point in the future.

Keywords

Low Voltage Low Power Cabinet (LPLVC), 48 VDC ITS Cabinet Standards.

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Acronyms and Abbreviations

ASTC	Advanced Solid State Traffic Controller
ATC	Advanced Transportation Controller
ATCC	Advanced Transportation Controller Cabinet
BIU	Bus Interface Unit
CALTRANS	California Department of Transportation
CMU	Cabinet Monitoring Unit
CV	Connected Vehicle
EVP	Emergency Vehicle Preemption
ft	feet
HDSP	High Density Switch Pack
ITS	Intelligent Transportation System
kWh	kilowatt hours
LED	light emitting diode
MWh	megawatt hours
NEMA	National Electrical Manufacturers Association
NYC	New York City
NYCDOT	New York City Department of Transportation
NYS	New York State
NYSDOT	New York State Department of Transportation
NYSERDA	New York State Energy Research and Development Authority
PED	Pedestrian
SIU	Serial Interface Unit
SPaT	Signal Phase and Timing
TSP	Transit Signal Priority
VAC	Alternating Current Voltage
VDC	Direct Current Voltage
W	watts

Summary

S.1 Project Overview

TransCore was awarded a contract in 2014 to develop a specification for a New York City Department of Transportation (NYCDOT) traffic controller cabinet using devices that support the use 48 VDC traffic signals. Under this contract, TransCore would also be responsible for letting the specification for bid, reviewing the proposals, procuring the cabinets, funding firmware updates to the existing traffic controller, providing support for shop testing and field installation, and performing a before/after study to determine the amount power savings accrued from switching to the low-voltage, low-power traffic signals. As a prerequisite of the contract, TransCore would enter into a teaming agreement with NYCDOT. NYCDOT would be responsible for procuring the 48 VDC traffic signals, provide labor for the shop testing, before/after study, and field installation, and provide communication modems and the cabinets shells.

The specification would leverage 48 VDC devices defined in the Advanced Transportation Controller Cabinet standards (ATCC Standards: ITE-5301) with modifications to support the data rates used in the existing traffic controller. The need for a smaller footprint for the traffic control cabinet in New York City precluded the use of the ATTC Standards cabinets. The vendors were required to design the cabinet, including the equipment rack and external termination points, i.e., field terminal blocks, ground bus bar, etc., to fit in the ASTC-6, which was the dominant cabinet size installed in New York City at the time.

S.2 Project Delays

The project encountered numerous external and technical challenges that delayed the schedule and ultimately prevented TransCore and NYCDOT from reaching the desired outcome of installation and testing of the cabinets at live intersections prior to the project end date of June 2023. NYCDOT is continuing to work with the vendor to overcome the obstacles that prevented them from certifying the cabinet as reliable for field installation. The following is a timeline of delays that prevented the full completion by the project end date, but it is important to note that the project has contributed to the development and updates to the standards needed for future deployment of the Low-Voltage Low-Power cabinets for both NYC and nationally:

- At the time the NYSERDA contract was awarded, the ATCC Cabinet Standards had not been finalized but the expectation was that it would be finalized by mid-2015. However, it did not get finalized until 2018 which delayed the specification and the letting of the bid until late 2018.

- During the proposal review, NYCDOT identified a need for a redundant power supply to prevent a “dark” intersection in the event of primary power supply failure. This required changes to the original cabinet layout that delayed the approved cabinet layout until late 2019 as follows:
    - Design of a new device, automated power supply switch (PSC), addition to the cabinet.
    - Resizing the power supply to a smaller form factor and reduced the max output current.
    - Review of alternative smaller form factor terminal blocks.
    - Multiple cabinet layout iterations to support the additional devices.
- Covid-19 had a dramatic effect on the project schedule, adding numerous delays.
    - Supply chain issues delayed the vendor from completing the buildout of the cabinets.
    - NYCDOT experienced issues in gaining funding approval for the procurement of the 48 VDC traffic signals due to overall financial uncertainty at the beginning of the pandemic.
    - Supply chain issues delayed the delivery of the 48 VDC traffic signals for shop testing.
    - Remote testing and troubleshooting under NYC COVID-19 protocols proved challenging and time consuming.
- During the initial shop testing, faulty components in the signal heads revealed a mismatch between the internal fusing of the traffic signal and the maximum output current of the high-density switch pack (HDSP). In the event of device failure, the traffic signal created a short circuit causing a flash event or worse a “dark” intersection in the event the defective signal head was illuminated during flashing operation. As a result, all signal/pedestrian heads were returned to the vendor for corrections and the cabinet vendor designed a fuse panel for the field circuits.
- After the repaired signal and pedestrian heads were returned to NYCDOT, we found an issue with the in-rush current from the pedestrian heads. The in-rush current of a single pedestrian head was measured to be roughly sixteen times higher than the power shown in the product specification. Measurements were confirmed with the signal vendor. The pedestrian heads require additional energy storage to display the countdown timer during the “off” state of flashing “DONT WALK” operation. When all eight pedestrian heads are started together during cabinet startup, the substantial in-rush current is more than the smaller form factor power supplies could accommodate. The power supply vendor was working to rectify this issue at the time of the report, although a high-power supply can support the required operation.

S.3 Modified Before/After Study

Since the current cabinet operation is not reliable, the NYCDOT could not install the cabinet at live intersections. To meet the project end date and collect data on the 48 VDC cabinet operation, the cabinets were run in the NYCDOT shop with the full complement of devices that are found at the field locations, including traffic/pedestrian signal heads and communication modem. To power the 48 VDC cabinets, a high-power supply was used but was mounted externally to the cabinet. In addition, we recollected the before data simultaneously, with the fans disabled because we could not recreate the ambient temperature of the field in the shop.

Based on the data collected from four field sites and equivalent shop cabinets, the field cabinet running at 120 VAC uses on average 4.1375 kWh daily and the 48 VDC cabinets use on average 3.7125 kWh daily. That is a per intersection reduction of approximately 10.27% of the power usage.

S.4 Conclusions and Future Steps

Although the project was not successful in fully quantifying the actual power savings in a field environment derived from converting a traffic cabinet and signals to 48 VDC, the technical issues highlight a need for a national standard for 48 VDC signal heads and the need for additions to the ATCC standard, such as redundant power supplies and PSCs. These issues will need to be addressed before any agency can safely deploy the 48 VDC cabinet and signal technology.

TransCore and NYCDOT continue to work with the power supply and cabinet vendors to find a viable modification to the power supply to support the in-rush current. Once this issue is resolved NYCDOT is committed to deploy these cabinets in the field and evaluate the overall suitability of 48 VDC devices for their next iteration of the traffic cabinet procurement specification.

1 Introduction

1.1 Project Background

New York City has been installing a wide variety of new, Intelligent Transportation Systems (ITS) technologies to tackle the problems of congestion, multimodal mobility, and operational inefficiency. In 2001, New York City Department of Transportation (NYCDOT) developed a specification for a replacement on their more than14,000 electromechanical controllers. The procurement specification was based on the evolving Advanced Transportation Controller (ATC) standards and leveraged the existing National Electrical Manufacturers Association (NEMA) specifications as well as both the New York State and California Department of Transportation (CALTRANS) standards. The result was the development of the Advanced Solid-State Traffic Controller (ASTC) and cabinet which is now operating at ~14,000 intersections throughout the NYC. The ASTC is a compact unit that employs standard components and subassemblies and is designed for maintenance by electrical contractors; the approach also adopted automated processes for the configuration and management of communications and traffic operation. The ASTC provided flexibility for efficient field wiring and supports interval-based control, adaptive control, actuated coordinated control, and additional features such as Transit Signal Priority (TSP), Emergency Vehicle Preemption (EVP), and Connected Vehicle (CV) messages (e.g., SPaT) where needed.

Prior to the controller and cabinet deployment, the NYC completed a program to replace the incandescent traffic signals and pedestrian (PED) signals with low-power light emitting diode (LED) technology. However, all these changes have continued to utilize the NEMA and CALTRANS/NYS cabinet specifications based on high-power load switches (~1200 watts), 120 Volt signal operation, and high-voltage cabinet and intersection wiring (120 VAC). Unfortunately, the high-power cabinet design has limited the savings possible and tends to compromise the operation of the cabinet monitoring system requiring dummy loads or leading to false tripping to flashing operation. These circuits also require more space and higher capacity wiring than is needed for the latest energy saving technology.

The high-density urban environment needs to be outfitted with a new cabinet type that incorporates higher density switching, lower operating voltages, current monitoring, and lower power operation, which would allow longer battery operation when needed and safer maintenance. In addition, with low-voltage operation, the field wiring would present a lower threat of personal injury in the event of a knock-down or damage (open cabinet). Newer technology coming into the marketplace can reduce the power required for the signal heads, reduce the power consumed by the electronics, incorporate battery backup, improve the accuracy and reliability of the monitoring system, and reduce the voltages to those considered "intrinsically" safer, making the service safer for field personnel. This can also reduce the overall size of the cabinets, increase the number of circuits that can be supported, and improve overall reliability.

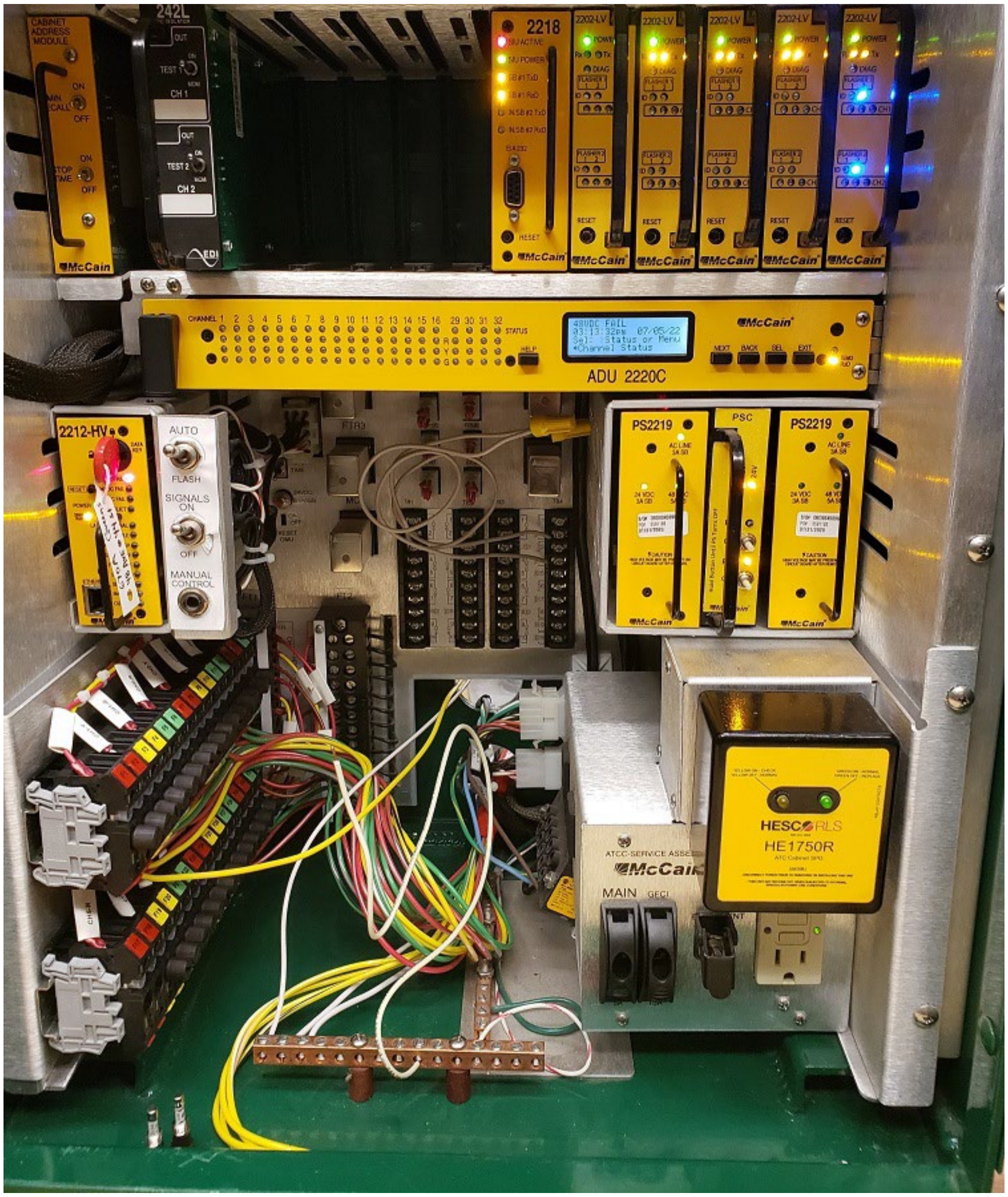
In 2014, TransCore ITS, LLC was awarded a task order from the New York State Energy Research and Development Authority (NYSERDA) to develop, procure, and perform a before/after study on traffic controller cabinets, using 48VDC devices and signal heads based on the evolving Advanced Transportation Controller (ATC). As a prerequisite of the NYSERDA contract, a separate teaming agreement between TransCore and NYCDOT was initiated. The agreement stipulated NYCDOT would provide the staff for shop testing and field installation of the cabinets as well as procuring the 48VDC signal and pedestrian heads in exchange for receiving ownership of the 48VDC cabinets.

1.2 Project Approach

1.2.1 Cabinet Specification

The cabinet specification was developed using the devices defined in the Advanced Transportation Controller Cabinet standards (ATCC Standards: ITE-5301) that support 48VDC operation, including high-density switch pack (HDSP), and advanced cabinet monitoring unit (CMU), Serial Interface Unit (SIU), and 48 VDC power supplies. Due to the need for a smaller overall footprint for traffic control cabinets in New York City's urban environment, the ATCC standard cabinet had to be modified to meet the needs of this project. The approach was to utilize the ATCC standard devices but package them into a compact and efficient cabinet that minimizes the footprint at the street corner. The final cabinet rack configuration is shown in Figure 1.

Figure 1. 48 VDC Cabinet Rack Layout



In addition to the above, NYCDOT was anxious to evaluate the increased servicing and efficiency benefits of the ATCC cabinet constructs and subassemblies. With the existing controllers approaching 20 years of field operation, the NYSERDA project provided the opportunity to evaluate the potential benefits of adopting the ATCC specifications and lower power signal heads with potential savings in operating costs and maintenance as well as increasing safety operational features possible at the signalized intersections.

By way of example, the High-Density Switch Packs (HDSP) shown in Figure 2 supports the equivalent of 8 traditional load switches, standby flasher, and Serial Interface Unity (SIU) in roughly a third of the space required in the existing cabinets. The CMU shown in Figure 3 takes about half the space of the monitor unit in the existing cabinets and includes current and voltage monitoring that allows the TMC to alert maintenance personnel in the event of signal head failure such that proactive maintenance can be undertaken to avoid the failsafe flashing operation.

Figure 2. High-Density Switch Packs and Serial Interface Unit

Figure 3. Cabinet Monitoring Unit

Based on the available standards, the 48VDC cabinet Low-Voltage/Low-Power specification was developed using the following criteria:

- The cabinet would use the existing NYCDOT traffic controllers.
- The controller firmware would be updated, under a separate contract from the cabinet vendor, to support the ATCC device messages: however, the controller would continue to operate the serial bus data transfer rate of 153,600 bits per second (NEMA TS2 Type 1 Standard).
- The SIU and CMU devices typically operate at a data rate of 614,400 bits per second; however, to maintain compatibility with the existing traffic controller unit, the specification called for the data rates of these devices to be downgraded to the NEMA standard.
- To support the requirement for a smaller cabinet footprint, the cabinet rack was required to fit in the existing NYCDOT ASTC-6 Cabinet shell. (Note that this was the dominant cabinet and supported six load switches—18 circuits).

1.2.2 Procurement

The original project goal was to award two separate vendors contracts for five 48 VDC cabinets each. NYC would install these cabinets and evaluate their performance as well as the power savings versus the original cabinets. However, based on the proposals we received from the vendors and the original estimated budget, only one vendor was awarded a contract to supply all 10 cabinets. TransCore attempted negotiating with the second bidder; however, a suitable price could not be agreed upon.

1.2.3 Evaluation Process

NYC chose 10 existing traffic signal sites, with three approaches, six red, amber, and green signal heads and eight pedestrian heads per site, to use for the evaluation. Each site was confirmed to have no additional devices installed, other than the communication modem, that would affect the power consumption. Power meters, measuring the kilowatt hours, would be installed at each site to determine the daily average power usage before and after the installation of the 48VDC cabinets and signal heads at each of the intersections.

1.2.4 Project Implementation

The project was subject to numerous delays, from both the external environment and technological hurdles that needed to be overcome, throughout the course of the schedule, that required extensions as well as modifications to the evaluation process. The following sections will describe the technical and external issues that were overcome during this project. In essence, there were challenges/issues with the design of the signal heads, cabinet power management, and the standards that had to be overcome.

1.3 External Delays

1.3.1 ATCC Standards

The 48VDC cabinet specification was being developed using HDSPs, CMUs, SIUs, and power supplies specified in the ATCC Standards [ITE-5301]. At the time of the contract award, the ATCC standard had not been finalized but the assumption was it would be completed in mid to late 2015. This turned out to be too optimistic and the standards development program continued making modifications to the standard, such that it was not finalized until 2018, which delayed the release of bid documents for the project.

1.3.2 Covid-19 Impact

Overall, the Covid-19 pandemic delayed the project by approximately two years. From manufacturing delays to funding approvals, to the challenges of remote testing and troubleshooting, the pandemic greatly affected the project schedule:

- During the cabinet manufacturing and assembly phase of the project, Covid-19 started to impact the world market. The cabinet vendor was delayed by product supply chain issues, preventing the timely completion of the cabinet assembly.
- Due to the financial instability at the beginning of the pandemic, NYCDOT had some delays in receiving funding approval for the procurement of traffic and pedestrian signal heads. Once funding approval was obtained, the signal head vendor had delivery delays due to ongoing product supply chain issues as well.
- After the cabinets and traffic signals were received, periodic shutdowns due to exposures and the limited access to perform in-person testing proved challenging and slowed the process of troubleshooting the technical issues that arose.

1.4 Technological Challenges

Throughout the course of this project numerous unanticipated technical issues surfaced that needed to be addressed before attempting to field deploy the 48VDC cabinets. Ultimately these technical issues forced the evaluation process to be modified since the 48VDC cabinet and low-voltage signal heads were determined to not be reliable enough for field deployment by the project end date. Note that NYC is continuing to test the cabinets and signal heads in order to evaluate their suitability for future procurements.

1.4.1 Power Supply Redundancy

During the cabinet design review phase of the project, NYCDOT identified that in the event of a 48VDC power supply failure, the intersection would be dark. This was deemed unsafe, and a redundant power supply was added to the design with an automatic switching unit. The original power supply rating included in the cabinet design was for 12 amps (@48 VDC). To support two redundant power supplies and an automated switch (PSC), the power supply rating needed to be reduced to support a smaller form factor power supply. See Figure 4 below. It was determined that for this project the power supplies would only be sized to support the total number of signal and pedestrian heads at the test intersections based on the documented power ratings of the signal heads. The vendor determined a 3-amp power supply should support the required load. This would have unanticipated complications in the future that we were unaware of at the time.

Figure 4. Redundant Power Supplies and Automated Switch

1.4.2 Signal Head Failures

The first issue identified during shop testing was that certain failures in the signal head electronics would cause a short circuit condition instead of the expected open circuit condition, that is the standard when a 120 VAC signal head fails. The short circuit would pull down the voltage on the power supplies causing a 48 VDC failure triggering a flash event. However, if the failed signal head was on the circuit that would be involved in the flashing operation (red or yellow signal head), the power supply switcher would cause the power supplies to toggle back and forth due to the constant presence of a short circuit, resulting in all the outputs becoming dark.

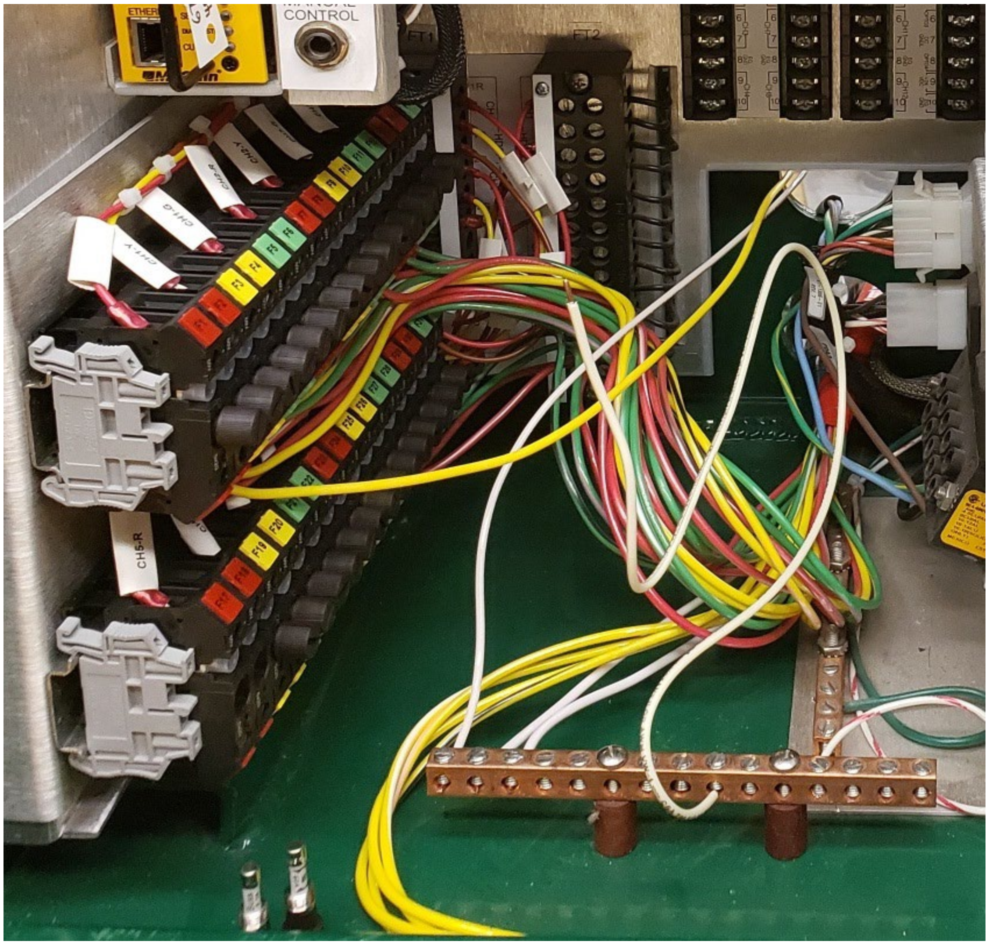
After reviewing the signal head design with the manufacturer, it was determined that in addition to faulty capacitors, there was a mismatch in fuse sizing between the signal heads and the maximum output current of the HDSPs. The vendor's design in the event of LED illumination failure was to cause a short circuit, which would blow the fuse on the input line, thus presenting an open circuit. However, in the event of a short circuit condition on the signal heads, the HDSP output current was not sufficient to blow the internal fuse. The vendor's design was apparently designed for high-voltage and high-current switching systems (120 VAC 10 Amp Circuits) and was not suitable for the low-voltage/low-power ATCC design.

The signal head manufacturer installed new higher quality capacitors in the signal heads, to minimize their chance of failure in the future, but they were not in a position at this time to redesign the signal head fusing to match the maximum current supplied by cabinet. All the traffic and pedestrian signal heads needed to be shipped back to the manufacturer to complete the upgrade, adding further delays.

To prevent a failed signal head from causing a "dark" intersection, an external fuse panel was supplied by the cabinet manufacturer to fuse the wiring between the signal heads and the HDSP outputs. See Figure 5 below. The fusing was sized to support two signal heads per circuit. The circuit was then tested by wiring in the failed signal heads and confirming the fuse would blow and disconnect the failed signal head from the cabinet.

The ATCC standards committee was notified of this issue. The United States Department of Transportation (USDOT) is currently investigating the need to support the development of a national standard for LED signal for low-voltage operation.

Figure 5. Cabinet Auxiliary Fuse Panel

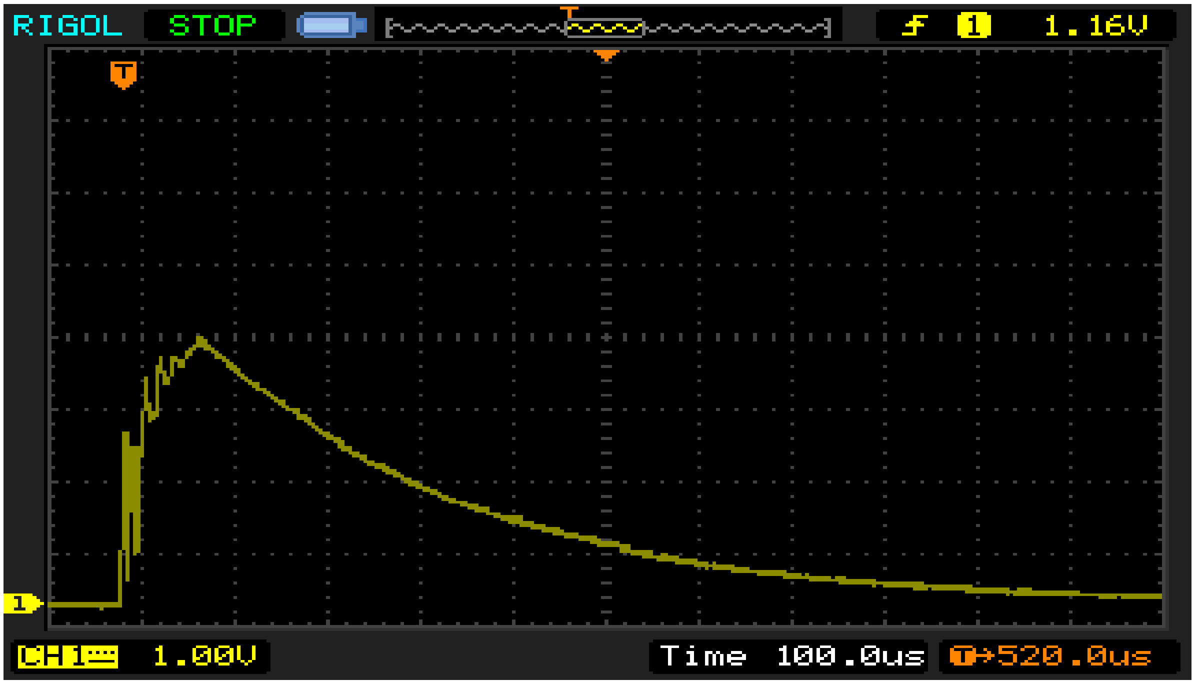


1.4.3 Pedestrian Signal—Countdown Timers

After the manufacturer modified all the signal head hardware, NYCDOT began testing the cabinets with a full complement of signal and pedestrian heads attached to the 48VDC cabinet. During the testing, the technicians noted that when all 8 pedestrian heads were connected to the cabinet, the cabinet would not come out of flashing operation and the CMU indicated a 48VDC failure.

The issue was reported to the cabinet manufacture for review. The power supply manufacture performed extensive testing on the pedestrian heads and determined the in-rush current for a single pedestrian head was approximately four amps as shown in the oscilloscope output in Figure 6. (The scope trace was across a 1 Ohm resistor in series, and hence 1 volt is equivalent to 1 amp of current.) During power turn-on with 8 pedestrian heads connected, the in-rush current would be approximately 32 amps. The manufacturer determined the power supply is being overloaded by the excessive current demand, causing the output voltage to drop.

Figure 6. Pedestrian In-Rush Current Measurement



These findings were reported to the pedestrian signal manufacturer, who confirmed the results. The substantial in-rush current arises from the need of the pedestrian signal heads to store energy required to display a countdown timer during the "off" state of the flashing "DON'T WALK" signal.

At this point, the power supply system is still undergoing modifications and testing to optimize the design to address the initial in-rush current and in-rush current that occurs when the flashing "DON'T WALK" and countdown timer are displayed.

1.5 Modified Evaluation Process

The power supplies were designed to meet the steady state current ratings of the signal heads. Due to the substantially higher in-rush current, the power supplies could not recover from power failures in the field without manual intervention. The pedestrian signal heads would need to be disconnected and then reconnected after the controller was operational. NYCDOT determined this was not a satisfactory operation for field installation until the reliability could be improved.

To meet the project end date, the evaluation process was modified as follows:

- The 48VDC cabinets would be installed in NYCDOT shop with power meters.
  - The cabinet vendor supplied 12-amp power supplies with extension adaptors that could be connected to the cabinet power supply card slot. The power supplies were mounted externally to the cabinet.
  - The NYCDOT shop could support running two cabinets simultaneously.
  - The cabinets would run a separate intersection programming database that matched the corresponding database running in the field.
  - Each intersection database would be run for two weeks, with power meter readings taken at weekly intervals.
  - A total of four intersection databases would be used for data collection.
- The corresponding field intersections, running 120 VAC components, would have their power meter readings recorded concurrently for comparison.
- In both the field and shop cabinets, the fan was disabled since the fan operation is based on the ambient temperature of the cabinet.
- This arrangement duplicates the street configuration in the lab as both are running with the same complement of signal heads (vehicle and pedestrian) and the same timing pattern, thus simulating comparable operation.

2 Results

The tables below show the weekly readings and the daily average kilowatt-hours usage of both the 48VDC cabinets in the shop and 120VAC cabinets in the field.

Table 1. Kilowatt-hour Meter Readings

Field(120VAC)/ Shop(48VDC)	Intersection	Initial Reading	First Week Meter Reading	Second Week Meter Reading
Field	48 Avenue @ 37 Street	6284.47	6314.24	6344.00
Shop		7021.15	7048.45	7075.69
Field	48 Avenue @ 40 Street	5879.81	5908.61	5937.40
Shop		5796.67	5821.36	5846.00
Field	47 Avenue @ 36 Street	6331.36	6361.18	6390.97
Shop		6941.34	6968.66	6995.97
Field	47 Avenue @ 38 Street	5999.49	6026.99	6054.48
Shop		5733.26	5758.00	5782.74

Table 2. Average Kilowatt-hour and Percentage Savings

Field(120VAC)/ Shop(48VDC)	Intersection	First Week Daily Average (kWh)	Second Week Daily Average (kWh)	Overall Daily Average (kWh)	Percentage Difference
Field	48 Avenue @ 37 Street	4.25	4.25	4.25	
Shop		3.90	3.89	3.90	8.38%
Field	48 Avenue @ 40 Street	4.11	4.11	4.11	
Shop		3.53	3.52	3.52	14.34%
Field	47 Avenue @ 36 Street	4.26	4.26	4.26	
Shop		3.90	3.90	3.90	8.35%
Field	47 Avenue @ 38 Street	3.93	3.93	3.93	
Shop		3.53	3.53	3.53	10.02%

2.1 Extrapolation of Results

Based on the results above the 120 VAC cabinets use on average 4.1375 kWh daily and the daily percentage savings is 10.27%. This would provide savings of .4138 kWh per intersection. Extrapolated over the 14,000 intersections in the NYCDOT jurisdictions, this would be an approximate savings of 5.8 MWh daily. This is a conservative estimate since the majority of NYCDOT intersections will have additional signal heads such as bike lanes, turn arrows, and additional approaches that will increase the per intersection power savings.

3 Next Steps

NYCDOT is committed to installing and testing the 48 VDC cabinets in the field if the issues with the power supplies can be resolved to their satisfaction. To this end, two potential solutions have been identified and will require further testing.

The first solution is to modify the existing power supply electronics to handle the in-rush current. The manufacturer is currently testing alternate designs. Once the alternate design is finalized, the power supply will be shipped to NYCDOT for testing and verification.

The second solution is to use the 12-amp power supply originally included in the design. The 12-amp power supply has additional capacitance built into its larger form factor that can support the short duration, larger in-rush current. This power supply has already been tested by NYCDOT and confirmed to handle the additional in-rush current from the pedestrian signal head. Unfortunately, this power supply does not fit in with the current cabinet layout. The cabinet rack would need to be modified to fit in NYCDOT ASTC-8 cabinet with an additional shelf installed to house the power supply.

Once the power supply issue is resolved the cabinet will need to go through intermittent power failure testing. The cabinet should automatically recover from power interruptions of varying durations as per the original cabinet testing profile. This testing will also identify any timing issues and race conditions with the automated switching process for the redundant supply.

4 Conclusions and Future Considerations

Due to the numerous delays encountered throughout the project, the cabinet design was not brought to a level that was considered safe for field deployment in the project timeframe. The technical issues did, however, highlight a need for a national standard for 48VDC signal heads and the need for additions to the ATCC standard before any agency can safely deploy the 48VDC technology.

4.1 Future Power Supply Considerations

The guiding principle during the design and testing was that the cabinet should at a minimum operate as safely as the current 120 VAC cabinet by not adding any additional points of failure that can cause an intersection to go into flashing operation or "dark."

Identifying the 48VDC power supply as an additional point of failure in the ATCC standard cabinet that currently doesn't exist in the 120VAC cabinet was an important observation. The design team tried to address this with a fully redundant cold power supply and an automated switch which was successful to an extent. However, due to the in-rush current issue, the cabinet could not be tested for short duration power outages to confirm the cabinet recovered properly. There are potential timing issues and race conditions that could arise during future testing. This points to the need for a standard, developed for the automated switch that defines the precise timing of the switching mechanism. The power supply power-on timing requirements may need to be defined as well.

An alternative method to mitigate a power supply failure, if acceptable to the agencies, is a backup power supply that only supplies power to the flasher HDSP. In the event of a power supply failure, the cabinet would transfer to flashing operation. This can be accomplished by either having a cold power supply and an automatic switch, similar to this project's cabinet design. The primary difference is the backup power supply would only be sized to support fail-safe flashing operation which does not include the pedestrian signals. The other option is to have the flasher HDSP be powered by its own source, therefore the primary power supply failure would not affect flashing operation. This secondary power supply would need to be monitored by the CMU to alert maintenance staff in the event of a failure.

4.2 Low-Voltage Traffic Signal: Future Considerations

The identification of the short circuit failure state of the signal/pedestrian heads and the undocumented in-rush current of the ped heads points to the need for a national standard for the low-voltage signals. The standard needs to consider the ATCC standards hardware specifications to eliminate any potential mismatches between power requirements. In addition, the maximum in-rush current and duration needs to be specified so power supplies can be designed to compensate for this current properly.

4.3 Further Improvement in Results

The results showed approximately 10% improvement in power consumption at the test intersections. There is the potential in future designs to improve these numbers by designing the traffic controller and the cabinet fan to be powered directly from 48 VDC power supply. 48VDC signal head design improvements could further improve the power savings—some vendors are reporting signal heads available that draw only 1 or 2 watts. Another potential area of research is to calculate whether smaller gauge field wiring could be used for the low-voltage signals to reduce the cost of signal construction.

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