

**Goals:**

The goal of this project is to provide you with an opportunity to apply your knowledge to solve an open-ended problem. The task is to design and build a machine that can autonomously navigate around the country and woo voters to your party and away from your opponent's party.

**Purpose:**

The underlying purpose of this project is to give you some experience in integrating all that you have learned in ME218 as well as your prior courses. The avenue through which you will gain this experience is the design and implementation of an autonomous mobile robot that can compete in a game of speed, skill and strategy against machines constructed by other teams from the class.

**The Game:**

Your machines were successful in abating the California drought and so your candidate has decided to take the campaign National. Unfortunately the other candidates are also claiming success and have launched campaigns. The only way to settle this is an old-fashioned, no-holds-barred, mud-slinging, winner-take-all battle for the Presidency. Your candidate, being pleased with your DAM, has requested that you build a Vehicle for Obtaining the Trust of the Electorate (VOTE) so that they can roll up to campaign stops in style. Your campaign manager has identified several key cities in swing states where voters are easily swayed and will support the last candidate who shook their hand.

**Specifications**

**The Political Landscape:**

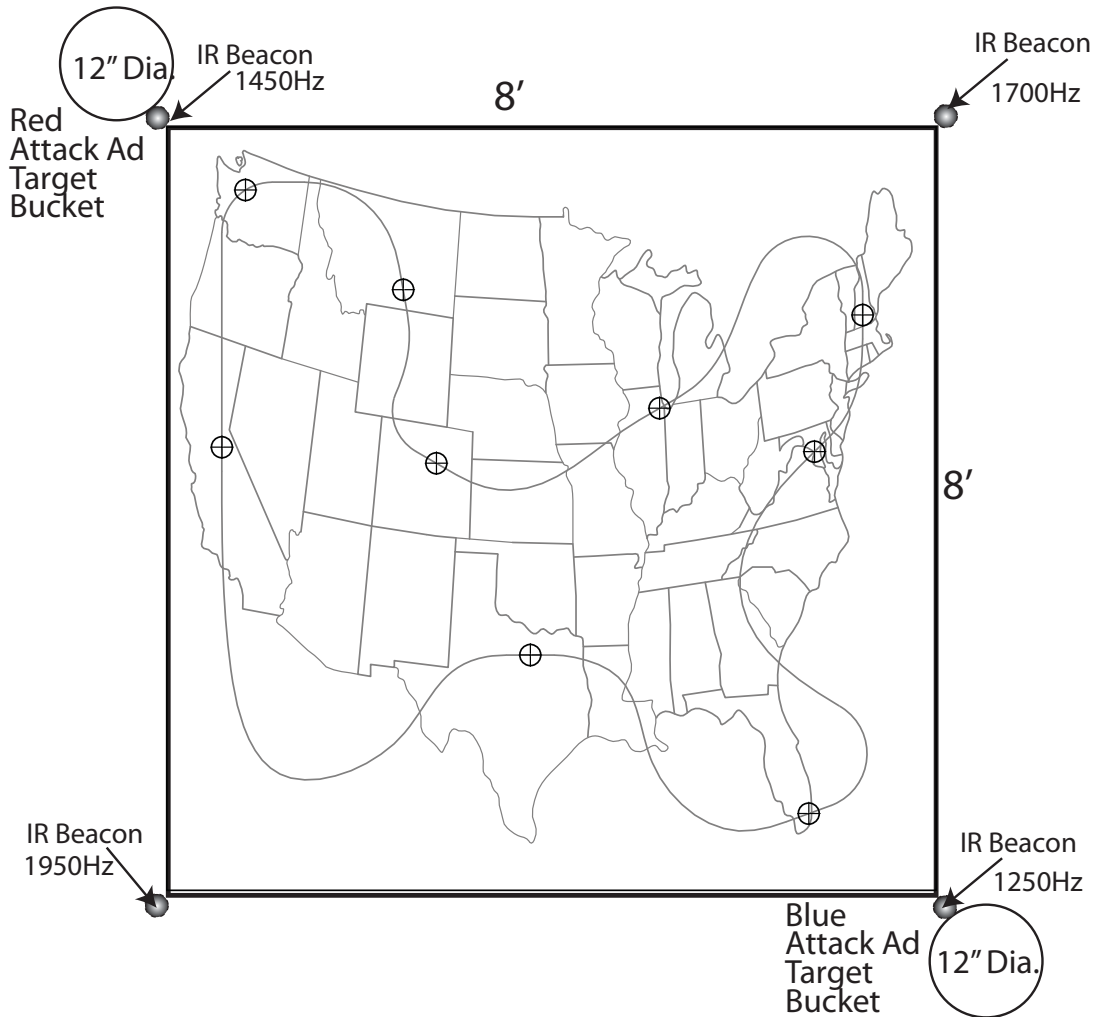


Fig. 1 The Campaign Trail

<input type="checkbox"/> Polling Station	Location
Seattle	39.0" W, 40.5" N
Sacramento	42.0" W, 7.8" N
Billings	18.9" W, 27.8" N
Denver	14.7" W, 5.8" N
Dallas	2.7" W, 18.6" S
Chicago	13.8" E, 12.8" N
Miami	32.8" E, 38.8" S
Washington, DC	33.5" E, 7.2" N
Concord	39.6" E, 24.6" N

- Polling station locations are given in inches from the center of the field  
The campaign trail is 31 feet in length.  
Minimum distance to the walls is 7".  
Minimum radius is 6".  
All polling stations except Seattle are on a local straight segment of at least 6" in length.
- The Political Landscape (playing field) is an approximately 8'x8' area with exterior walls 3.5" tall.
- Each of the regions to be captured will be marked, at the polling stations, by a magnetic field modulated at differing frequencies as the campaign progresses.
- Your candidate will need to be able to sense the frequency of the magnetic field in order to win over the voters in that region.
- The capture procedure is documented in the Communications Protocol document that is an appendix to this project description.
- In each of the corners of the Political Landscape will be mounted a modulated IR beacon, as shown in Fig. 1. The emitters of these beacons will be placed 12" above the surface of the landscape.
- The Red Attack Ad target is a 5 gal Home Depot paint bucket located just outside the Northwest corner of the country immediately behind a beacon emitting IR modulated at 1250Hz.
- The Blue Attack Ad target is a 5 gal Home Depot paint bucket located just outside the Southeast corner of the country immediately behind a beacon emitting IR modulated at 1450Hz.
- The campaign trail will be marked by a 1" black tape loop, as shown in Fig. 1. Beneath the black tape will be a wire carrying a 100mA current modulated at 20kHz.

### **The Vehicle for Obtaining the Trust of the Electorate (VOTE):**

- Your VOTE must be a stand-alone entity, capable of meeting all specifications described in this document. Only NiCd battery power is allowed. No more than two 7.2V batteries may be used to drive the motors that transfer force to the ground.
- Each VOTE must have a mechanism to designate the VOTE as RED or BLUE.
- Each VOTE must include a means to clearly indicate to the audience its RED/BLUE status.
- VOTES must be autonomous and un-tethered.
- The only parts of the VOTE that may ever touch the playing field surface are wheels, ball transfers, or slippery supports used to balance the VOTE.
- There must be a bumper surrounding the perimeter of your VOTE extending for 2" vertically with its bottom edge exactly 1" ( $\pm 1/16$ ") from the floor.

- Your VOTE must be fully contained within a 1' cube at the beginning of the campaign and never expand beyond the perimeter defined at the beginning of the campaign.
- Each VOTE may carry a maximum of 5 Attack Administering Devices (AttackADs) (foam balls) at any time. Each VOTE will start a round loaded with up to 5 ADs, as desired by your team.
- When deployed, the ADS must exit your VOTE with an above-horizontal trajectory, land no more than 12 feet from the VOTE and reach a peak height of no more than 8' above the floor of the playing field.
- Each VOTE must carry an easily accessible switch. The purpose of the switch will be to cut power to the VOTE in case of a software or hardware malfunction.
- Each VOTE must be constructed as part of ME218b. It may not be based on a commercial or otherwise pre-existing platform.
- Any exterior corners on the VOTE must have a radius of at least 1/4".
- To comply with campaign finance laws, you are limited to an expenditure of **\$200.00/ team** for all materials and parts used in the construction of your project. Materials from the lab kit or the Cabinet Of Freedom do not count against the limit, all other items count at their Fair Market Value.
- Each VOTE must provide a clearly visible indicator when it thinks that the campaign is in progress. This indicator should be activated when the VOTE determines that a campaign has started and be deactivated when the campaign status indicates the end of the campaign.
- Only the supplied motors may be used to drive anything that transfers force to the ground.

### **The Presidential Administrative Communicator:**

- The Presidential Administrative Communicator (PAC) will provide information to the VOTE about the status of the campaign and provide for communications with the SuperPAC (field infrastructure) to win over the voters in a region.
- The PAC will communicate with your robot over a 4-wire SPI bus.
- The PAC will be recognized by and communicate wirelessly with the SuperPAC, so it should be mounted where it will have good radio reception.
- A complete description of the Presidential Administrative Communicator, from both an electrical and protocol standpoint, is included in an appendix that accompanies this project description.

### **The Campaign:**

- The campaign is a head-to-head contest among two VOTES as they navigate around the country stopping in the various regions in order to win over voters to their party.
- Each campaign will last for 2:18 (Min:Sec).
- At the end of 2:18, the VOTE with the greatest number of regions captured is the winner.
- VOTES will start a campaign based on a seeding determined by when they complete the grading requirements. The highest seeded team chooses whether to place their VOTE first or second. After the first team places their VOTE, the remaining team must place their VOTE no closer than 2' from the first VOTE.
- The campaign will begin when a query to the PAC indicates that the game state has changed from "waiting for start" to "Campaigning".
- A VOTE may, at any time, deploy (shoot) an ADS into an Attack Ad Bucket. If a successful attack ad is mounted (the ball goes into the bucket and remains there) the VOTE associated with that bucket will be prevented from capturing any regions for 10 seconds. The Red Attack Bucket affects the Red VOTE.
- The attack ad effect time will start, or re-start, every time an AD enters and is recognized by the bucket.

- A VOTE that is stationary or obviously jammed for more than 10 seconds will be removed from the political landscape.

**Rules:**

- No solder-less breadboards (proto-boards) are permitted in the final project.
- Light contact is permitted, but intentional interference with the operation of another VOTE is prohibited.
- Each VOTE must start and remain in one piece during the round. Any locomotion of the VOTE should cause all parts of the VOTE to move.
- Your VOTE may not **IN ANY WAY** alter the condition (e.g. mar the walls or the floor) of the playing field or the foam balls. Before you choose your wheel material and again before you place your VOTE on the field for the first time, borrow a material sample from the TAs and test to be sure that your wheels will not mar the floor material.
- Intentional jamming of your opponent's senses or violation of the communications protocol is prohibited.

**Safety:**

- The VOTE should be safe, both to the user and the spectators. The teaching staff reserves the right to disqualify any VOTE considered unsafe. This also applies during testing, so keep the VOTE velocity and shooting velocity low enough so as not to cause problems.
- VOTES must be stable in the presence of a 30MPH wind.
- No part of the machine may become ballistic. The foam balls are not actually part of your machines.
- All liquids, gels and aerosols must be in three-ounce or smaller containers. All liquids, gels and aerosols must be placed in a single, quart-size, zip-top, clear plastic bag. Each VOTE can use only one, quart-size, zip-top, clear plastic bag.
- Red, Green, and Blue shells are prohibited. Any Banana peels must stay within the confines of your VOTE at all times.
- VOTES may alter the Space-Time continuum only during the public presentations.

**Check-Points****Design Review:**

During the day on **02/09/16** we will conduct design reviews. A few teams at a time will meet with the teaching staff to present their ideas and get feedback on their proposals. Each group should prepare a **few** sheets of paper showing your idea(s). The focus should be on the overall design and how you are tackling what you think are the critical subsystems. These should be scanned into a no-frills PowerPoint file for projection. You will have 10 minutes to walk us through your ideas. The members of the other teams, the teaching staff, and coaches will be on hand to hear about your ideas and provide feedback and advice. ***I have decided to launch an exploratory committee to examine whether I should run for president in 2016 (Jim Webb).***

**First Check-Point:**

On **02/12/16**, you will turn in a set of Protel schematics, textual descriptions and software design documentation (including refined state chart) that describes the state of the design *at that point in time*. The designs need not be tested at this point, but must include designs to address all of the major subsystems. It must be turned in as soft copy. Only one team member needs to submit your checkpoint. ***Each individual who is a candidate for federal office must file an FEC Form 2 within 15 days of becoming a candidate. (Federal Election Commission)***

**Second Check-Point:**

On **02/17/16**, you must demonstrate your un-tethered, motorized platform moving under autonomous software control. Your platform must be able to drive across the country and back under software control. ***It's tough campaigning, kissing hands and shaking babies (Pat Paulsen)***

**Third Check-Point:**

On **02/20/16**, you must demonstrate the integration of the PAC with your mobile platform and your robot's ability to communicate with the PAC to exercise all of the PAC's capabilities. Evidence of achieving this functionality will be demonstrated by driving to and capturing a region starting from an arbitrary starting location upon initiation of an "Inauguration 2013" status from the PAC. *Corporations are people, my friend (Mitt Romney).*

**Fourth Check-Point:**

On **02/24/16**, you must demonstrate your robot's ability to 1) orient to the Attack AD Bucket and shoot an AttackAD at the bucket, 2) navigate to a specific Polling Station and capture it. *Some politicians have become convinced that negative campaigning pays off in elections (George McGovern)*

**Project Preview:**

At the Project Preview on **02/28/16**, each VOTE must demonstrate (in an integrated form) 1) the ability to move around the political landscape under software control and 2) the ability to communicate with the PAC and 3) the ability to orient and shoot at the goal. This will be tested by communicating an "Inauguration 2013" status followed by the VOTE proceeding to at least 2 Polling Stations and capturing them. *I knew that my staying up would not change the election result if I were defeated, while if elected I had a hard day ahead of me. So I thought a night's rest was best in any event. (Benjamin Harrison)*

**Grading Session:**

During the **Grading Session on 03/01/16** each VOTE will be required to demonstrate a complete campaign. If your VOTE fails at its first attempt to demonstrate its ability, it must then demonstrate the ability two times in succession at its next attempt. These increases continue after repeated failed attempts to a maximum of 4 required successive demonstrations. This evaluation will take place with only a single VOTE on the course. Evaluation for grading purposes will occur only during these sessions. At the time of the grading session, you must submit a copy of your Keil Project folder that you run during the grading session to your Reports folder for archiving. *The people who cast the votes don't decide an election, the people who count the votes do. (Joseph Stalin)*

**Public Presentation:**

Will take place on **03/02/16** starting at 7pm in the Peterson Atrium. *Every citizen of this country should be guaranteed that their vote matters, that their vote is counted, and that in the voting booth their vote has as much weight as any CEO. (Barbara Boxer)*

**Report:**

Draft due on **03/07/16** at 4:00pm. Final version with revisions due by 5:00pm on **03/11/16**. *One who does not vote has no right to complain. (Louis L'Amour)*

**Evaluation****Performance Testing Procedures:**

One or more of the team members will operate the VOTES during the performance evaluation. A competition among the class's VOTES will take place after the performance evaluation.

**Performance Evaluation:**

Performance evaluation will take place twice during the project duration, at the Project Preview and at the Grading Session. Everyone will participate at this level.

**The Competition:**

On the night of the public presentations, a tournament will be held. **Performance during the tournament has no impact on your grade.**

**Grading Criteria:**

- Concept (10%)** This will be based on the technical merit of the design and coding for the machine. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware, software and use of physical principles in the solution.

- Implementation (15%)** This will be based on the prototype displayed at the evaluation session. Included in this grade will be evaluation of the physical appearance of the prototype and quality of construction. We will not presume to judge true aesthetics, but will concentrate on craftsmanship and finished appearance.
- Check-Point Performance (10%) Based on demonstrating the required functionality at the checkpoints.**
- Preliminary Performance (10%)** Based on the results of the performance testing during the **Project Preview**.
- Performance (20%)** Based on the results of the performance testing during the **Grading Session**.
- Coaches Evaluation (5%)** Evaluation by your coach: did you make use of their input before the design review and during the course of the project.
- Report (20%)** This will be based on an evaluation of the written report. It will be judged on clarity of explanations, completeness and appropriateness of the documentation. The report should be in the form of a web site and must include schematics, pseudo-code, header & code listings, dimensioned sketches/drawings showing relative scale, a complete Bill-of-Materials (BOM) for the project as well as a 1 page description of function and a “Gems of Wisdom for future generations of 218ers” page. The web-site must be submitted as a single **Zip** file (The zipping software (7-zip) is installed on all the workstations in the lab). The only file types in your final report should be HTML (including style sheets if you choose), JPEG or other viewable image files and PDF files. Schematics should be PDF files, **not** bitmaps (PNG, JPEG, GIF, etc.). A reasonable resolution bitmap place-holder with a link to a PDF is the best solution to readability. Do not simply place a link to the PDF of the schematic without a viewable preview on the web page. Do not include .doc, .docx, .xls, .xlsx or other files that require opening a separate application outside of the browser. **Do not embed video files** directly into your site. If you want to include video, link to a You-Tube or other video sharing site. In addition, if your web-site is hosted, you should include a text file with the URL to your site. It is critical that your report be in the Reports folder on time so that the peer reviewing team will have an adequate opportunity to review it before class the following day. Final versions of the reports, incorporating the review comments are due (also in the form of a single zip file) by 5:00pm on 03/11/16. The front page of your project description must be in a file called `index.html` at the root folder of the web site. Test your zip-file by unzipping it into an empty folder. Once un-zipped, you should be able to view the entire site starting from the `index.html` file. Make sure to test all of your links before submitting. If we can't simply unzip it and read it on our machines, then we can't grade it.
- Report Review (10%)** These points will be awarded based on the thoroughness of your review of your partner team's report. Read the explanations, do they make sense? Review the circuits, do they look like they should work?
- Housekeeping** Based on the timely return of SPDL components, cleanliness of group workstations as well as the overall cleanliness of the lab. No grades will be recorded for teams who have not returned or paid replacement costs for the items borrowed from the SPDL, including but not limited to Tiva, power supplies, logic analyzer, tools....

## Team Organization

---

While it may be tempting (as more efficient) to organize your teams around specialists who handle, for example, communications, sensing, motion, etc. I believe that in the long run this will be a mistake. I have heard from many 218 alumni who did this and reported that they were sad that they had because they didn't get, for example, communications experience. I would like to encourage you to remember that, first and foremost, the purpose of the project is to enhance your learning of the material. An organization that deeply involves all of the team members in the details of the design, implementation and debugging of all subsystems will not only provide a better learning experience, it will also prevent you from getting hung up during the integration and testing phase because the “expert” on that subsystem is not available.

**Purpose:**

The primary purpose of the Presidential Administrative Communicator (PAC) is to act as a gateway to the field infrastructure to allow your VOTE to request information about the state of the campaign and to woo the voters at a polling station to your candidate.


**Interface Connection**

**Connector:**

The connector of the PAC is a 6-pin keyed Molex connector.

**Pinout:**

Pin	Name/Function
1	+3.3V (@ 100mA) / Power to the PAC ( $V_{dd}$ )
2	SDI / Serial Data Into the PAC
3	SDO / Serial Data Out of the PAC
4	SCK / Serial Clock
5	SS / active low select line for the PAC with on-board pull-up to +3.3V
6	GND / Ground reference for the PAC



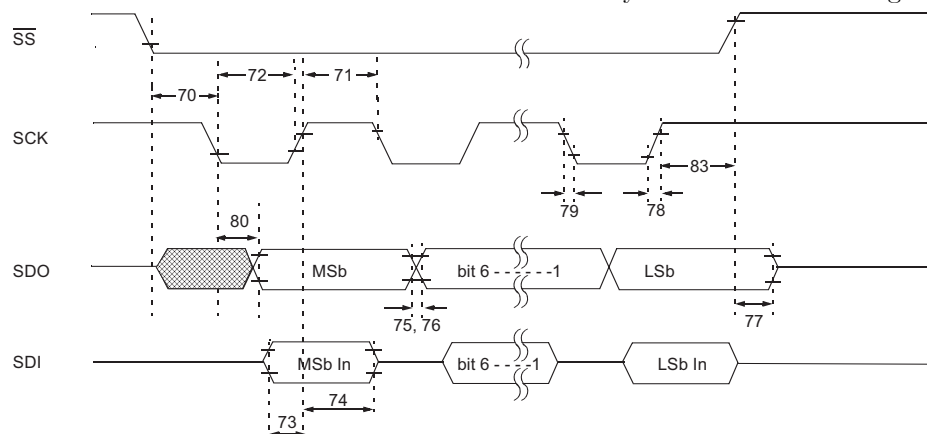
**Electrical Specifications**

Parameter	Min.	Max	Units
$V_{iH}$	$V_{dd} * 0.65$		V
$V_{oH}$	$V_{dd} - 0.4$		V
$V_{iL}$		$V_{dd} * 0.35$	V
$V_{oL}$		0.4	V
$I_{iH}, I_{iL}$		$\pm 1$	$\mu A$
$I_{oH}$	-20		$\mu A$
$I_{oL}$	20		$\mu A$
All Specifications at $V_{dd} = 3.3V$			

**Byte Transfer Specification**

The Presidential Administrative Communicator uses a synchronous serial signaling method to transfer data into and out of the PAC. The signaling method is compatible with SPI communications, with the PAC operating as a slave device on an SPI network. The  $\overline{SS}$  line must be lowered (asserted) to begin an 5-byte (40 bit) transfer and raised at the completion of the 5-byte transfer. The  $\overline{SS}$  line must remain de-asserted for a minimum of 2ms between transfers. The SDO line represents the serial data out of the PAC, while the SDI line represents serial data into the PAC.

The relationships between the four lines involved in the transfer of a byte are shown in the figure & table below:



Param No.	Symbol	Characteristic	Min	Typ	Max	Units	Conditions
70*	TssL2scH, TssL2scL	$\overline{SS}$ ↓ to SCK↓ or SCK↑ input	T <sub>CY</sub> <sup>a</sup>	—	—	ns	
71*	Tsch	SCK input high time (Slave mode)	T <sub>CY</sub> + 20	—	—	ns	
72*	TscL	SCK input low time (Slave mode)	T <sub>CY</sub> + 20	—	—	ns	
73*	TdIV2scH, TdIV2scL	Setup time of SDI data input to SCK edge	100	—	—	ns	
74*	Tsch2dIL, TscL2dIL	Hold time of SDI data input to SCK edge	100	—	—	ns	
75*	TdoR	SDO data output rise time	3.0-5.5V	—	10	25	ns
			2.0-5.5V	—	25	50	ns
76*	TdoF	SDO data output fall time	—	10	25	ns	
77*	TssH2doZ	$\overline{SS}$ ↑ to SDO output high-impedance	10	—	50	ns	
78*	TscR	SCK output rise time (Master mode)	3.0-5.5V	—	10	25	ns
			2.0-5.5V	—	25	50	ns
79*	TscF	SCK output fall time (Master mode)	—	10	25	ns	
80*	Tsch2doV, TscL2doV	SDO data output valid after SCK edge	3.0-5.5V	—	—	50	ns
			2.0-5.5V	—	—	145	ns
83*	Tsch2ssH, TscL2ssH	$\overline{SS}$ ↑ after SCK edge	1.5T <sub>CY</sub> + 40	—	—	ns	

\* These parameters are characterized but not tested. <sup>a</sup>T<sub>CY</sub> = 33μS

## Byte Level Protocol Specification

### Common Byte Format:

Exchanges between the Presidential Administrative Communicator (PAC) and your VOTE take place with five successive bytes being exchanged. The first byte from the VOTE to the PAC is the actual command. The value returned from the PAC during this transfer will be 0x00, but has no meaning. The values sent to the PAC as the second through fifth bytes of the sequence should always be 0x00. The meanings of the values returned by the second through fifth byte transfers will be the results from the command byte.

### VOTE to Presidential Administrative Communicator Bytes:

The meaningful values for the command bytes from the VOTE to the Presidential Administrative Communicator are shown in the following table:

Command	Meaning
0b1100 0000	Return the <b>Status</b> of the campaign.
0b10MR iiii	<b>Request</b> a change in polling station state.
0b0111 0000	<b>Query</b> for new response ready.

In the above message, M = My Color, R = requested Color (for both, 0=RED, 1=BLUE), iiii = 4bit number identifying the current frequency measured at the polling station (See **Codes for Frequency of the Magnetic Field at a Polling Station**, below). Making a **Request** to change a polling station's state may take significant time (up to hundreds of ms) to complete.

### Presidential Administrative Communicator to VOTE Bytes:

The values and meanings of the response bytes returned by the Presidential Administrative Communicator are shown in the following table:

Command	Response Bytes	Description of meaning
0b1100 0000 (0xC0)	0xFF, SS1, SS2, SS3	SS1 = Station Status Byte 1, SS2 = Station Status Byte 2, SS3 = Station Status Byte 3
0b10MR iiii	0xFF, 0x00, 0x00, 0x00	The <b>Request</b> to change a polling station's state takes time to complete. After issuing this Request, you should issue repeated <b>Query</b> commands until the PAC returns a Response Ready status. Subsequent requests, without an intervening successful <b>Query</b> response will be ignored and not result in further Requests being forwarded to the SuperPAC.
0b0111 0000	0xFF, RR, RS, 0x00	RR = Response Ready Byte, RS = Request Status Byte



**Station Status Byte 1**

7	6	5	4	3	2	1	0
PS11	PS10	PS21	PS20	PS31	PS30	PS41	PS40

Field Name	Description
Polling Station #1 Status (PS11, PS10)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used
Polling Station #2 Status (PS21, PS20)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used
Polling Station #3 Status (PS31, PS30)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used
Polling Station #4 Status (PS41, PS40)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used

**Station Status Byte 2**

7	6	5	4	3	2	1	0
PS51	PS50	PS61	PS60	PS71	PS70	PS81	PS80

Field Name	Description
Polling Station #5 Status (PS51, PS50)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used
Polling Station #6 Status (PS61, PS60)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used
Polling Station #7 Status (PS71, PS70)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used
Polling Station #8 Status (PS81, PS80)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used

**Station Status Byte 3**

7	6	5	4	3	2	1	0
PS91	PS90	0	0	0	ASR	ASB	GS

Field Name	Description
Polling Station #9 Status (PS91, PS90)	0,0 = Unclaimed                      01 = BLUE 1,0 = RED                                11 = undefined, not used
Attack Ad Status for RED (ASR)	1 = Under Attack
Attack Ad Status for BLUE (ASB)	1 = Under Attack
Game Status (GS)	0 = Waiting 1 = Campaigning

**Response Ready Byte**

7	6	5	4	3	2	1	0
Response Ready Status							

Field Name	Description
Response Ready Status	0x00 = Response not ready 0xAA = Response ready Response Ready only returned once per <b>Request</b> If a response is not ready, then the Request Status Byte will be 0x00

**Request Status Byte**

7	6	5	4	3	2	1	0
ACK1	ACK0	RBN1	RBN0	LOC3	LOC2	LOC1	LOC0

Field Name	Description
Acknowledge (ACK1, ACK0)	0,0 = NACK 0,1 = ACK 1,0 = Blocked 1,1 = Busy
Red/Blue/None (RBN1, RBN0)	0,0 = Unclaimed 0,1 = BLUE 1,0 = RED 1,1 = undefined, not used
Location (LOC3-LOC0)	4-bit number indicating the location of the polling station. For the number to location correspondence, see Codes for Locations of the Polling Stations, below.

In response to a **Request** for a change in the polling station state, a reply of

ACK	Will only occur in response to a <b>Request</b> if the reported frequency is currently active at a polling station <b>and</b> that station is not currently in a state change transaction <b>and</b> the requestor is not currently under attack.
NACK	Will occur in response to a <b>Request</b> if the reported frequency is not currently active at a polling station. In this case, the R/B/N status will be 1,1 and the location bits will be 0000
Busy	Will occur if the requested polling station is currently in a transaction.
Blocked	Will occur if the requesting VOTE is currently under the influence of an Attack Ad.

**Query the Status of the Game:**

To query the game status, send a byte of 0xC0 to the PAC followed by 4 bytes of 0x00. The PAC will process the query and during the four 0x00 bytes of the exchange will return 0xFF, followed by the three status bytes as described above.

**Changing the state of a Polling Station:**

To successfully change the state of a polling station a VOTE must prove that they actually occupy that polling station. That proof is demonstrated by successfully executing two correctly formatted **Request** commands with no intervening unsuccessful **Request** commands. After the first **Request**, the SuperPAC will mark the polling station as being in a transaction sequence and change the frequency of the requested polling station, but not its RED/BLUE state. To complete the state change, the VOTE must issue a second **Request** with the new frequency. After this, second, successful request, the SuperPAC will change the state of the polling station and close transaction sequence, making the polling station available for a later state change request.

**Codes for Frequency of the Magnetic Field at a Polling Station :**

Code	0000	0001	0010	0011	0100	0101	0110	0111
Period (μs)	1000	947	893	840	787	733	680	627
Code	1000	1001	1010	1011	1100	1101	1110	1111
Period (μs)	573	520	467	413	360	307	253	200

**Codes for Locations of the Polling Stations :**

Code	0001	0010	0011
Location	Sacramento	Seattle	Billings
Code	0100	0101	0110
Location	Denver	Dallas	Chicago
Code	0111	1000	1001
Location	Miami	Washington, DC	Concord

**Power on and reset behavior:**

Initially, after power on or a reset, the Presidential Administrative Communicator will return 0xFF from any query until such time as the Presidential Administrative Communicator is internally initialized.

**Command Timing:**

The interval between two successive transfers from VOTE to Presidential Administrative Communicator should be at least 2ms. The  $\overline{SS}$  line must remain high for a minimum of 2ms between successive transfers.

**Invalid Command Bytes:**

If the Presidential Administrative Communicator receives a command byte not listed in the table, it will respond to the invalid command byte by queuing a series of 0xFF bytes to be returned to the VOTE.

**Sample Byte Sequences:**

In the communication sequence diagrams shown below, there are 3 columns. The left column represent your VOTE. The Middle column represents the PAC and the right column represents the SuperPAC. The Diagrams are read top to bottom to follow a conversation between the VOTE and the PAC and between the PAC and the SuperPAC.

VOTE		PAC		SuperPAC
Normal Capture				
Measures freq. at polling station				
<b>Request</b> w/ Valid Freq.	→ ←	Returns Request response to VOTE, asks SuperPAC to change the state of the polling station	→	Check Freq, Check Attack status, Check transaction status if all OK, then Starts Transaction, changes freq of polling station
<b>Query</b>	→ ←	Returns Response Not Ready (may be repeated 0 or more times until the SuperPAC replies)		
			←	Replies that new freq is in place
<b>Query</b>	→ ←	Returns Response Ready, ACK		
Measures new Freq.				
<b>Request</b> w/ Valid Freq.	→ ←	Returns Request response to VOTE, asks SuperPAC to change the state of the polling station	→	Closes transactions, changes state of polling station
<b>Query</b>	→ ←	Returns Response Not Ready (may be repeated 0 or more times until the SuperPAC replies)		

			←	Replies that state has been changed.
<b>Query</b>	→ ←	Returns Response Ready, ACK		
<b>Bad Frequency</b>				
<b>Request w/ InValid Freq.</b>	→ ←	Returns Request response to VOTE	→	Check Frequency against list of active frequencies
<b>Query</b>	→ ←	Returns Response Not Ready (may be repeated 0 or more times until the SuperPAC replies)		
			←	Replies that frequency is invalid
<b>Query</b>	→ ←	Returns NACK		
<b>Game Status Request</b>				
<b>Status request</b>	→ ←	Returns Campaign status		
<b>While under attack</b>				
Measures freq. at polling station				Check Freq, Check Attack status, Check transaction status
<b>Request w/ Valid Freq.</b>	→ ←	Returns Request response to VOTE, asks SuperPAC to change the state of the polling station	→	
<b>Query</b>	→ ←	Returns Response Not Ready (may be repeated 0 or more times until the SuperPAC replies)		
			←	Replies that VOTE is under attack
<b>Query</b>	→ ←	Returns Response Ready, Blocked		
<b>If station is amid a capture</b>				
Measures freq. at polling station				
<b>Request w/ Valid Freq.</b>	→ ←	Returns Request response to VOTE, asks SuperPAC to change the state of the polling station	→	Check Freq, Check Attack status, Check transaction status
<b>Query</b>	→ ←	Returns Response Not Ready (may be repeated 0 or more times until the SuperPAC replies)		
			←	Replies that station is in a transaction
<b>Query</b>	→ ←	Returns Response Ready, Busy		

## Physical Specifications

### Dimensions:

The Presidential Administrative Communicator dimensions are 2" x 3" x 1".