

APC's smart protocol

Credits

The APC UPS protocol was originally analyzed by Pavel Korensky with additions from Andre H. Hendrick beginning in 1995, and we want to give credit for good, hard work, where credit is due. After having said that, you will see that Steven Freed built much of the original **apcupsd** information file. [Comment inserted by Riccardo Facchetti]

The start of this chapter of the **apcupsd** manual in HTML format was pulled from the [Network UPS Tools \(NUT\)](#) site. It has been an invaluable tool in improving **apcupsd**, and I consider it the **Bible** of APC UPS programming. In the course of using it, I have added information gleaned from **apcupsd** and information graciously supplied by APC. Hopefully, the additions made herein can benefit the original author and his [programming project](#), and maybe some day, the **Apcupsd** project and the **NUT** project can join forces.

Description

Here's the information on the elusive APC smart signaling protocol used by their higher end units (Back-UPS Pro, Smart-UPS, Matrix-UPS, etc). What you see here has been collected from a variety of sources. Some people analyzed the chatter between PowerChute and their hardware. Others sent various characters to the UPS and figured out what the results meant.

RS-232 differences

Normal 9 pin serial connections have TxD on 3 and RxD on 2. APC's smart serial ports put TxD on pin 1 and RxD on pin 2. This means you go nowhere if you use a normal straight through serial cable. In fact, you might even power down the load if you plug one of those cables in. This is due to the odd routing of pins - DTR and RTS from the PC usually wind up driving the on/off line. So, when you open the port, they go high and *poof* your computer dies.

Originally this evil hack was used to connect the UPS to the PC when this page was first being built. As you can see, I cheated and neglected the ground (only 2 wires!) and it still worked. This method can be used for playing around, but for professional systems this is obviously not a viable option.

That hack didn't work out so well (damned cats), so it was retired quite awhile back. The most practical

solution was to go out and BUY the DOS/Win version of PowerChute just for the black (smart) cable. I recommend doing the same thing if you actually care about this thing working properly. Of course, if you have one of the newer packages that came with PowerChute, you already have the cable you need.

Diagram for cable hackers

If you are handy with cable creation tools, check out the [940-0024C clone diagram](#). That's the black "smart" cable normally provided with APC models sold after 1996. The loopback pins on that diagram are used to keep PowerChute happy by allowing cable detection. If you use the [NUT](#) apcsmart driver, those pins don't matter.

Many thanks to Steve Draper for providing this scan.

For additional information on cables, see the [cables section](#) of this manual.

The Smart Protocol

Despite the lack of official information from APC, this table has been constructed. It's standard RS-232 serial communications at 2400 bps/8N1. Don't rush the UPS while transmitting or it may stop talking to you. This isn't a problem with the normal single character queries, but it really does matter for multi-char things like "@000". Sprinkle a few calls to `usleep()` in your code and everything will work a lot better.

The following table describes the single character **Code** or command that you can send to the UPS, its meaning, and what sort of response the UPS will provide. Typically, the response shown below is followed by a newline (`\n` in C) and a carriage return (`\r` in C). If you send the UPS a command that it does not recognize or that is not available on your UPS, it will normally respond by "NA" for not available, otherwise the response is given in the "Typical results" column.

Code	Meaning	Typical results
^A	Model string	SMART-UPS 700
^N	Turn on UPS (send twice, with > 1.5s delay between chars) Only on 3rd gen SmartUPS and Black Back-UPS Pros	n/a
^Z	Permitted EEPROM Values	A large string (254 chars) that gives the EEPROM permitted values for your model. For details see below.

A	Front panel test	Light show + "OK" (and 2s beep)
B	Battery voltage	Ranges - typical "27.87"
C	Internal temperature (degrees C)	Ranges - typical "036.0"
D	Runtime calibration - runs until battery is below 25% (35% for Matrix) This updates the 'j' values - only works at 100% battery charge Can be aborted with a second "D"	! when on battery, \$ on line
E	Automatic self test intervals	Default = 336 (336 hours = 14 days) (336=14 days, 168=7 days, ON=power on, OFF=never)
F	Line frequency, Hz	60.00 (50.0 in Europe)
G	Cause of transfer	R = unacceptable utility voltage rate of change, H = high utility voltage, L = low utility voltage, T = line voltage notch or spike, O = no transfers yet (since turnon), S = transfer due to serial port U command or activation of UPS test from front panel, NA = transfer reason still not available (read again).
K--K	Shutdown with grace period (set with 'p') - need > 1.5s between first and second K	Matrix/3rd gen SmartUPS/Black Back-UPS Pros: "OK", all others: "**"
L	Input line voltage	Ranges - typical "118.3" or "228.8" in Europe
M	Maximum line voltage received since last M query	Ranges - typical "118.9" or "230.1" in Europe
N	Minimum line voltage received since last N query	Ranges - typical "118.9" or "226.2" in Europe
O	Output voltage	Ranges - typical "118.3" or "228.8" in Europe
P	Power load %	Ranges - typical "011.4" depends on what you have plugged in.

Q	Status flags	Bitmapped, see below
R	Turn dumb Only on 3rd gen SmartUPS, SmartUPS v/s, BackUPS Pro	"BYE"
S	Soft shutdown after 'p' delay, return online when power returns Only works when UPS is on battery	OK
U	Simulate power failure	!! when switching to battery, then \$ when back on line
V	Old firmware revision	"GWD" or "IWI" The last character indicates the locale (Domestic, International).
W	Self test (battery), results stored in "X"	"OK"
X	Results of last self test	"OK" - good battery, "BT" - failed due to insufficient capacity, "NG" - failed due to overload, "NO" - no results available (no test performed in last 5 minutes)
Y	Enter smart mode	"SM"
Z--Z	Shutdown immediately (no delay) - need > 1.5s between first and second Z	N/A
a	Show protocol version.alert messages.valid commands (delimited by periods)	"3.!\$%+?=#.^A^N^Z+- 789<@ABCDEFGHIJKLMNOPQRSTUVWXYZ'abcefghijklmnopqrsuvzy~^?" - Link-Level.alert-messages.commands
b	Firmware revision	"50.9.D" - 50 = SKU (variable length), 9 = firmware revision, D = country code (D=USA, I=International, A=Asia, J=Japan, M=Canada)
c	UPS local id	UPS_IDEN (you can program any 8 characters here)
e	Return threshold	% battery charge threshold for return (00=00%, 01=15%, 02=25%, 03=90%)

f	Battery level %	Ranges - typical "100.0" when fully charged as should normally be the case
g	Nominal battery voltage (not actual voltage - see B)	"012" or "024" or "048".
h	Measure-UPS: ambient humidity (%)	"nnn.n" - percentage
i	Measure-UPS: dry contacts	10 = contact 1, 20 = 2, 40 = 3, 80 = 4
j	Estimated runtime at current load (minutes)	"0112:" (note, it is terminated with a colon)
k	Alarm delay	0(zero) = 5 second delay after fail, T = 30 second delay, L = alarm at low battery only, N = no alarm
l	Low transfer voltage	Default "103" or "208" in Europe
m	Manufacturing date	Unique within groups of UPSes (production runs)
n	Serial number	Unique for each UPS
o	Nominal Output Voltage	The Nominal Output Voltage when running on batteries. Default "115" or "230" in Europe.
p	Shutdown grace delay, seconds	Default "020" (020/180/300/600)
q	Low battery warning, minutes	Default "02"
r	Wakeup delay (time) - seconds	Default "000" (000/060/180/300)
s	Sensitivity	"H" - highest, "M" - medium, "L" - lowest, "A" - autoadjust (Matrix only)
u	Upper transfer voltage	Default "132" or "253" in Europe
t	Measure-UPS: ambient temperature (degrees C)	"nn.nn"
x	Last battery change	Eight characters. Varies typically dd/mm/yy - 31/12/99
y	Copyright notice	"(C) APCC" - only works if firmware letter (from "V") is later than O

z	Reset the EEPROM to factory settings (but not ident or batt replacement date) Not on SmartUPS v/s or BackUPS Pro	"CLEAR"
+	Capability cycle	Cycle forward through possible values (" " from UPS afterward to confirm change). Do not use this unless you know how to program your UPS EEPROM or you may damage your UPS.
-	Capability cycle	Cycle backward through possible values (" " from UPS afterward to confirm change)Do not use this unless you know how to program your UPS EEPROM or you may damage your UPS.
@nnn	Shutdown (after delay 'p') with delayed wakeup of nnn tenths of an hour (after 'r' time)	Matrix/3rd gen UPS: "OK", others "*"
0x7f (DEL key)	Abort shutdown - use to abort @, S, K--K	"OK"
~	Register #1	See below
'	Register #2	See below
7	Dip switch positions (if applicable)	See below
8	Register #3	See below
9	Line quality	"FF" acceptable, "00" unacceptable
>	Number of external battery packs attached	SmartCell models: "nnn" where nnn is how many external packs are connected Non-SmartCell units: whatever has been set with >+ and >- by the user
Matrix UPS (and possibly Symmetra) specific commands		
^	Run in bypass mode	If online, "BYP" is received as bypass mode starts If already in bypass, "INV" is received and UPS goes online "ERR" received if UPS is unable to transfer
<	Number of bad battery packs	"nnn" - count of bad packs connected to the UPS
/	Load current	"nn.nn" - true RMS load current drawn by UPS
\	Apparent load power	"nnn.nn" - output load as percentage of full rated load in VA.

^V	Output voltage selection (editable)	"A" - automatic according to input tap, "M" - 208 VAC, "I" - 240 VAC
^L	Front panel language	"E" - English, "F" - French, "G" - German, "S" - Spanish, "1" "2" "3" "4" - ?
w	Run time conservation	"NO" (disabled) or "02" "05" "08" - minutes of runtime to leave in battery (UPS shuts down "early")

Dip switch info

Bit	Switch	Option when bit=1
0	4	Low battery alarm changed from 2 to 5 mins. Autostartup disabled on SU370ci and 400
1	3	Audible alarm delayed 30 seconds
2	2	Output transfer set to 115 VAC (from 120 VAC) or to 240 VAC (from 230 VAC)
3	1	UPS desensitized - input voltage range expanded
4-7	-	Unused at this time

Status bits

This is probably the most important register of the UPS, which indicates the overall UPS status. Some common things you'll see:

- 08 = On line, battery OK
- 10 = On battery, battery OK
- 50 = On battery, battery low
- SM = Status bit is still not available (retry reading)

Bit	Hex Bit	Meaning
0	0x01	1 = Runtime calibration occurring Not reported by Smart UPS v/s and BackUPS Pro

1	0x02	1 = SmartTrim Not reported by 1st and 2nd generation SmartUPS models
2	0x04	1 = SmartBoost
3	0x08	1 = On line (this is the normal condition)
4	0x10	1 = On battery
5	0x20	1 = Overloaded output
6	0x40	1 = Battery low
7	0x80	1 = Replace battery

Alert messages

These single character messages are sent by the UPS any time there is an Alert condition. All other responses indicated above are sent by the UPS only in response to a query or action command.

Character	Description
!	Line Fail - sent when the UPS goes on-battery, repeated every 30 seconds until low battery condition reached. Sometimes occurs more than once in the first 30 seconds.
\$	Return from line fail - UPS back on line power, only sent if a ! has been sent.
%	Low battery - Sent to indicate low battery, but not on SmartUPS v/s or BackUPS Pro models
+	Return from low battery - Sent when the battery has been recharged to some level only if a % has been sent previously
?	Abnormal condition - sent for conditions such as "shutdown due to overload" or "shutdown due to low battery capacity". Also occurs within 10 minutes of turnon.
=	Return from abnormal condition - Sent when the UPS returns from an abnormal condition where ? was sent, but not a turn-on. Not implemented on SmartUPS v/s or BackUPS Pro models.
*	About to turn off - Sent when the UPS is about to switch off the load. No commands are processed after this character is sent. Not implemented on SmartUPS v/s, BackUPS Pro, or 3rd generation SmartUPS models.

#	Replace battery - Sent when the UPS detects that the battery needs to be replaced. Sent every 5 hours until a new battery test is run or the UPS is shut off. Not implemented on SmartUPS v/s or BackUPS Pro models.
&	Check alarm register for fault (Measure-UPS) - sent to signal that temp or humidity out of set limits. Also sent when one of the contact closures changes states. Sent every 2 minutes, stops when the alarm conditions are reset. Only sent for alarms enabled with I. Cause of alarm may be determined with J. Not on SmartUPS v/s or BackUPS Pro.
	Variable change in EEPROM - Sent whenever any EEPROM variable is changed. Only supported on Matrix UPS and 3rd generation SmartUPS models.

Register 1

All bits are valid on the Matrix UPS. SmartUPS models only support bits 6 and 7. Other models do not respond.

Bit	Hex Bit	Meaning
0	0x01	In wakeup mode (typically lasts < 2s)
1	0x02	In bypass mode due to internal fault - see register 2 or 3
2	0x04	Going to bypass mode due to command
3	0x08	In bypass mode due to command
4	0x10	Returning from bypass mode
5	0x20	In bypass mode due to manual bypass control
6	0x40	Ready to power load on user command
7	0x80	Ready to power load on user command or return of line power

Register 2

Matrix UPS models report bits 0-5. SmartUPS models only support bits 4 and 6. SmartUPS v/s and BackUPS Pro report bits 4, 6, 7. Unused bits are set to 0. Other models do not respond.

Bit	Meaning
0	Fan failure in electronics, UPS in bypass
1	Fan failure in isolation unit
2	Bypass supply failure
3	Output voltage select failure, UPS in bypass
4	DC imbalance, UPS in bypass
5	Command sent to stop bypass with no battery connected - UPS still in bypass
6	Relay fault in SmartTrim or SmartBoost
7	Bad output voltage

Register 3

All bits are valid on the Matrix UPS and 3rd generation SmartUPS models. SmartUPS v/s and BackUPS Pro models report bits 0-5. All others report 0-4. State change of bits 1,2,5,6,7 are reported asynchronously with ? and = messages.

Bit	Meaning
0	Output unpowered due to shutdown by low battery
1	Unable to transfer to battery due to overload
2	Main relay malfunction - UPS turned off
3	In sleep mode from @ (maybe others)
4	In shutdown mode from S
5	Battery charger failure
6	Bypass relay malfunction
7	Normal operating temperature exceeded

Interpretation of the Old Firmware Revision

The Old Firmware Revision is obtained with the "V" command, which gives a typical response such as "GWD" or "IWI", and can be interpreted as follows:

Old Firmware revision and model ID String for SmartUPS & MatrixUPS

This is a three character string XYZ

where X == Smart-UPS or Matrix-UPS ID Code.

range 0-9 and A-P

1 == unknown

0 == Matrix 3000

5 == Matrix 5000

the rest are Smart-UPS and Smart-UPS-XL

2 == 250

3 == 400

4 == 400

6 == 600

7 == 900

8 == 1250

9 == 2000

A == 1400

B == 1000

C == 650

D == 420

E == 280

F == 450

G == 700

H == 700XL

I == 1000

J == 1000XL

K == 1400

L == 1400XL

M == 2200

N == 2200XL

O == 3000

P == 5000

where Y == Possible Level of Smart Features, unknown???

G == Stand Alone

T == Stand Alone

V == ???

W == Rack Mount

where Z == National Model Use Only Codes

D == Domestic

115 Volts

I == International

230 Volts

A == Asia ??

100 Volts

J == Japan ??

100 Volts

Interpretation of the New Firmware Revision

The New Firmware Revision is obtained with the "b" command, which give a typical response such as "50.9.D" or "60.11.I", and can be interpreted as follows:

New Firmware revision and model ID String in NN.M.L is the format

where NN == UPS ID Code.

12 == Back-UPS Pro 650
 13 == Back-UPS Pro 1000
 52 == Smart-UPS 700
 60 == SmartUPS 1000
 72 == Smart-UPS 1400

where NN now Nn has possible meanings.

N == Class of UPS
 1n == Back-UPS Pro
 5n == Smart-UPS
 7n == Smart-UPS NET

n == Level of intelligence
 N1 == Simple Signal, if detectable WAG(*)
 N2 == Full Set of Smart Signals
 N3 == Micro Subset of Smart Signals

where M == Possible Level of Smart Features, unknown???

1 == Stand Alone
 8 == Rack Mount
 9 == Rack Mount

where L == National Model Use Only Codes

D == Domestic 115 Volts
 I == International 230 Volts
 A == Asia ?? 100 Volts
 J == Japan ?? 100 Volts
 M == North America 208 Volts (Servers)

EEPROM Values

Upon sending a ^Z, your UPS will probably spit back approximately 254 characters something like the following (truncated here for the example):

```
#uD43132135138129uM43229234239224uA43110112114108 ....
```

It looks bizarre and ugly, but is easily parsed. The # is some kind of marker/ident character. Skip it. The rest fits this form:

- Command character - use this to select the value

- Locale - use 'b' to find out what yours is (the last character), '4' applies to all
- Number of choices - '4' means there are 4 possibilities coming up
- Choice length - '3' means they are all 3 chars long

Then it's followed by the choices, and it starts over.

Matrix-UPS models have ## between each grouping for some reason.

Here is an example broken out to be more readable:

CMD	DFO	RSP	FSZ	FVL				
u	D	4	3	127	130	133	136	
u	M	4	3	229	234	239	224	
u	A	4	3	108	110	112	114	
u	I	4	3	253	257	261	265	
l	D	4	3	106	103	100	097	
l	M	4	3	177	172	168	182	
l	A	4	3	092	090	088	086	
l	I	4	3	208	204	200	196	
e	4	4	2	00	15	50	90	
o	D	1	3	115				
o	J	1	3	100				
o	I	1	3	230	240	220	225	
o	M	1	3	208				
s	4	4	1		H	M	L	L
q	4	4	2	02	05	07	10	
p	4	4	3	020	180	300	600	
k	4	4	1	0	T	L	N	
r	4	4	3	000	060	180	300	
E	4	4	3	336	168	ON	OFF	

CMD == UPSlink Command.

u = upper transfer voltage
 l = lower transfer voltage
 e = return threshold
 o = output voltage
 s = sensitivity
 p = shutdown grace delay
 q = low battery warning
 k = alarm delay
 r = wakeup delay
 E = self test interval

DFO == (4)-all-countries (D)omestic (I)nternational (A)sia (J)apan
(M) North America - servers.

RSP == Total number possible answers returned by a given CMD.

FSZ == Max. number of field positions to be filled.

FVL == Values that are returned and legal.

Programming the UPS EEPROM

There are at this time a maximum of 12 different values that can be programmed into the UPS EEPROM. They are:

Item	Command	Meaning
1.	c	The UPS Id or name
2.	x	The last date the batteries were replaced
3.	u	The Upper Transfer Voltage
4.	l	The Lower Transfer Voltage
5.	e	The Return Battery Charge Percentage
6.	o	The Output Voltage when on Batteries
7.	s	The Sensitivity to Line Quality
8.	p	The Shutdown Grace Delay
9.	q	The Low Battery Warning Delay
10.	k	The Alarm Delay
11.	r	The Wakeup Delay
12.	E	The Automatic Self Test Interval

The first two cases (Ident and Batt date) are somewhat special in that you tell the UPS you want to change the value, then you supply 8 characters that are saved in the EEPROM. The last ten item are programmed by telling the UPS that you want it to cycle to the next permitted value.

In each case, you indicate to the UPS that you want to change the EEPROM by first sending the appropriate query command (e.g. "c" for the UPS ID or "u" for the Upper Transfer voltage. This command is then immediately followed by the cycle EEPROM command or "-". In the case of the UPS Id or the battery date, you follow the cycle command by the eight characters that you want to put in the EEPROM. In the case of the other ten items, there is nothing more to enter.

The UPS will respond by "OK" and approximately 5 seconds later by a vertical bar (|) to indicate that the EEPROM was changed.

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