[APPLICATION NOTE #177]

Software Interface for Switched Outlets and UPS Management in Smart-UPS™

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PROJECT AT A GLANCE

Project Type

Manage the behaviour of the Smart-UPS and its outlets through a custom application making use of standard Modbus communications and the command instructions presented here.

Products Supported

APC Smart-UPS that support Modbus protocol. See Application Note #176 for details on the supported products.

Additional Equipment Required

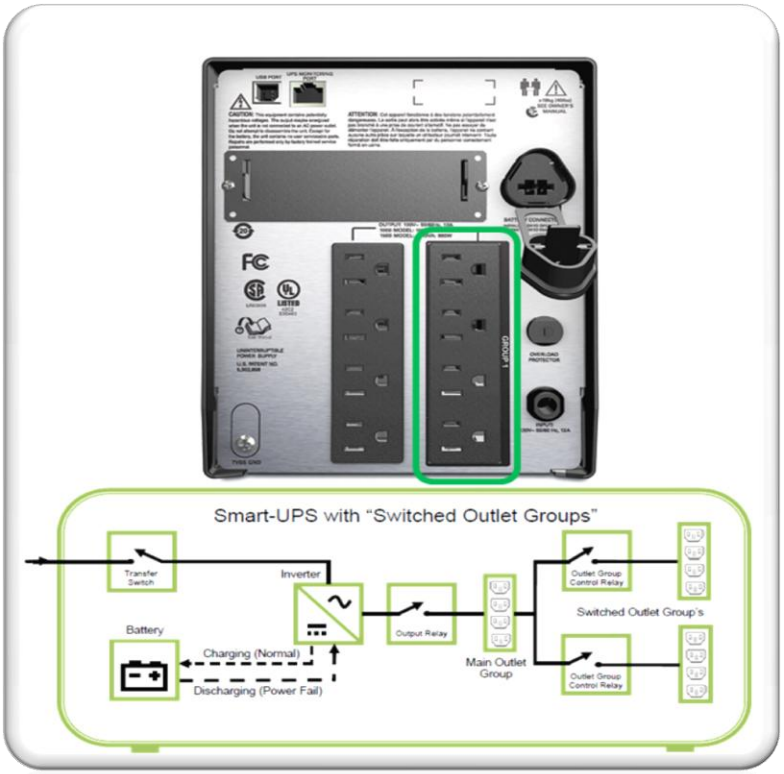
Application Note #176, Modbus Implementation in APC SMART-UPS.

Recommended References

Application Note #165, Switched Outlet Groups on SMT, SMX and SRT Smart-UPS

Modbus Application Protocol Specification V1.1b3 – Modbus Organization, 2012

Modbus over serial line specification and implementation guide V1.02 – Modbus Organization, 2006



Software Interface for Switched Outlet and IPS Management in SMART-UPS

The open software interface for Smart-UPS utilizes Modbus as a serial communications protocol; it is managed and made publicly available by the Modbus Organization (www.modbus.org). While it was developed for, and is heavily used in, industrial control environments, it is a well defined protocol suitable for machine to machine communications. A wide variety of readily available software and hardware devices exist today that support communications via Modbus.

Schneider Electric's APC Smart-UPS implement the Modbus protocol to provide access to controls and configuration parameters through user-defined applications. The data available via Modbus is the same data accessible through APC's software products.

This document outlines how to use the Modbus registers to control switched outlet groups and UPS behavior.

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Table of Contents

1 Introduction

Switched outlet groups are used in UPS to individually control loads, and to pre-program certain operations.

1.1 Definitions

1.1.1 Main Outlet Group (MOG)

The Main Outlet Group, or MOG, is the output of the UPS without any relays. This group is powered whenever the UPS output is on. The MOG must be powered for any Switched Outlet Group (SOG) to receive power. The main outlet group is not always physically present in a UPS.

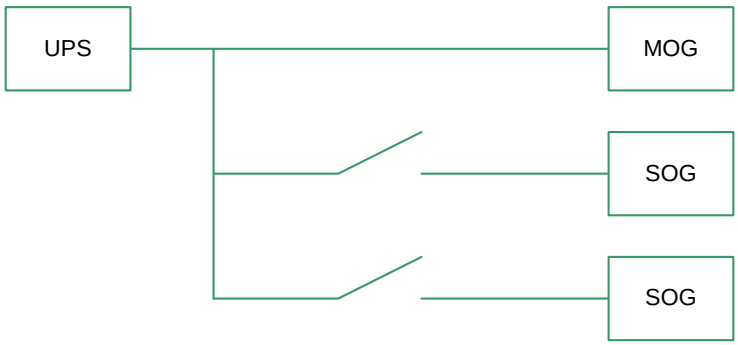

Figure 1 - MOG/SOG 1-Line Diagram

1.1.2 Switched Outlet Group (SOG)

A Switch Outlet Group (SOG) is the output of the UPS with a relay between the UPS and the output. For a SOG to be powered the UPS output (MOG) must also be powered and the SOG relay must be activated.

1.1.3 Load Shedding

This is a condition monitored by the UPS which causes a SOG (or MOG) to switch off based on some operating conditions.

1.1.4 Outlet Process

Many outlet commands are combinations of sequences, for example: a shutdown is a delay followed by an *OFF*, and a subsequent *ON* sequence when AC returns; a reboot is an *OFF* sequence, followed by a time to stay off, and an *ON* sequence. The grouping of these sequences is called a process.

2 Data Interface

There are several data usages that are important to understand when attempting to control or interpret with the state of MOG and SOG.

2.1 Status Timers

There are several counters that represent the time until a specified action will occur. The following diagram shows the 3 different counters and the time that they measure. It is important to note that at the beginning of a sequence all timers are loaded, and stay at their loaded values until the step that they are part of executes. For example if a reboot sequence is active, the TurnOff may be 90 seconds, StayOff =4, and

TurnOn = 0. In this case as soon as the turn off sequence has started the stay off and turn on counters will remain at the initial value 4 until the turn off counter has reached 0.

Figure 2 - Outlet Timers

2.1.1 TurnOff Counter

Displayed in TurnOffCountdown_EN it indicates the amount of time in seconds until an outlet turns off. A value of -1 indicates that the counter is not active. There is a setting TurnOffCountdownSetting which is loaded when a delayed off is commanded to an outlet.

2.1.2 StayOff Counter

Displayed in StayOffCountdown_EN, it indicates the amount of time in seconds until an outlet will be able to start its turn on sequence. There is a setting StayOffCountdownSetting which controls this duration and it is used during shutdown and reboot to guarantee that an outlet stays off for the specified duration. This counter is loaded with a value while the outlet is on, and holds this value until the outlet is off when it will start counting down. A value of -1 indicates that this timer is not active.

2.1.3 TurnOn Counter

Displayed in TurnOnCountdown_EN, it indicates the amount of time in seconds until an outlet will turn on. There is a setting TurnOnCountdownSetting which controls this duration and it is used during turn on sequences as well as shutdown and reboot to guarantee the startup delays between outlets. This counter is loaded with a value while the outlet is on or off, and holds this value until the outlet is off (and StayOffCountdown has completed) when it will start counting down. A value of -1 indicates that this timer is not active.

2.2 OutletStatus_BF

This usage indicates the current status of an outlet. There are several groups of bits within this usage.

	Status	Description
0	StateOn	State - indicates the outlet is powered. Mutually exclusive with other state bits.
1	StateOff	State - Indicates the outlet is not powered. Mutually exclusive with other state bits.
2	ProcessReboot	Modifier - indicates that a reboot command was issued and is still in progress. A reboot command can be issued by writing to the command bitfield or by writing timers. Mutually exclusive with other process bits.

	Status	Description
3	ProcessShutdown	Modifier - indicates that shutdown command was issued and is still in progress. A shutdown command can be issued by writing to the command bitfield or by writing timers. Mutually exclusive with other process bits.
4	ProcessSleep	Modifier - indicates that a sleep command was issued and is still in progress. A sleep command can be issued by writing to the command bitfield or by writing timers. A master should indicate sleep rather than reboot if the StayOffCountdown_EN_4B timer is initially loaded with a value greater than 300 seconds. Mutually exclusive with other process bits.
7	PendingLoadShed	Modifier - indicates that one or more condition exists that potentially could turn the outlet off.
8	PendingOnDelay	Modifier - indicates the outlet has an active process that requires an on delay when switching an outlet from off to on.
9	PendingOffDelay	Modifier - indicates the outlet has an active process that requires an off delay when switching an outlet from on to off.
10	PendingOnACPresence	Modifier - indicates the outlet will not turn on unless AC input power is available.
11	PendingOnMinRuntime	Modifier - indicates the outlet will not turn on unless sufficient runtime is available.
12	MemberGroupProcess1	Modifier - indicates the outlet is participating in the 1st "group process command".
13	MemberGroupProcess2	Modifier - indicates the outlet is participating in the 2nd "group process command".
14	LowRuntime	Modifier - indicates the run time is below the setting for the outlet group.

Table 1 - Outlet Status Bit Field

2.2.1 Process Bits

These are all the possible processes that an outlet can be under. An outlet is only allowed to be operating under one process at a time.

2.2.1.1 Reboot

The outlet is in the process of turning off, staying off, and restarting. This comprises a delay until off. (TurnOffCountdown), a time to stay off (StayOffCountdown), and a delay to turn on (TurnOnDelay). Both the turn on and turn off may be set to 0 seconds. For a process to be considered reboot the stay off time must be less than 5 minutes.

2.2.1.2 Shutdown

The outlet is in the process of turning off, staying off until AC input power is valid, and restarting. This comprises a delay until off. (TurnOffCountdown), a time to stay off (StayOffCountdown), and a delay to turn on (TurnOnDelay). Both the turn on and turn off may be set to 0 seconds. This is the typical process that a server would initiate when shutting off due to an on battery event.

2.2.1.3 Sleep

The outlet is in the process of turning off, staying off, and restarting. This comprises a delay until off,

(TurnOffCountdown), a time to stay off (StayOffCountdown), and a delay to turn on (TurnOnDelay). Both the turn on and turn off may be set to 0 seconds. For a process to be considered sleep the stay off time must be greater than 5 minutes.

2.2.2 PendingBits

These bits indicate what is going to happen to the outlet in the future.

2.2.2.1 LoadShed

The outlet is in a condition where load shedding may occur. When the load shed event has occurred one of the process bits will be set (likely shutdown).

2.2.2.2 PendingOffDelay

The outlet is running an off-delay counter.

2.2.2.3 PendingOnDelay

A command has been loaded which will cause the outlet to turn on. There is either an on-delay timer running or one will run before the outlet turns back on.

2.2.2.4 PendingOnACPresence

A command has been loaded which will cause the outlet to turn on and AC is required to be present. This is asserted when any process is in progress which contains an “ON SEQUENCE” (shutdown, reboot, sleep, or on) and requires AC present for output to turn (cold boot allowed NOT set). The bit turns off when the outlet is on.

2.2.2.5 PendingOnMinRuntime

A command has been loaded which will cause the outlet to turn on only when there is sufficient battery capacity to meet runtime criteria.

2.3 Outlet Commands

	Command	Description
0	Cancel	Cancels pending actions to the targets selected. No modifiers are allowed.
1	OutputOn	Command the output to turn on. The only valid modifiers (in any combination) are UseOnDelay and ColdBootAllowed.
2	OutputOff	Command the output to turn off (and not come back on automatically). The only valid modifier is UseOffDelay.
3	OutputShutdown	Command the output to turn off and then back on automatically when AC input power is restored. The only valid modifiers (in any combination) are UseOffDelay and UseOnDelay. MinimumReturnRuntimeSetting is enforced when turning on. The outlet will obey the TurnOffCountdownSetting, StayOffCountdownSetting, and TurnOnCountdownSetting with this command.

	Command	Description
4	OutputReboot	Command the output to turn off and then back on automatically. The only valid modifiers (in any combination) are UseOffDelay, UseOnDelay and ColdBootAllowed. MinimumReturnRuntimeSetting is not enforced when turning on. A Reboot command is interpretted as a sleep command when the stayofftime countdown is greater than 300 seconds. The outlet will obey the TurnOffCountdownSetting, StayOffCountdownSetting, and TurnOnCountdownSetting with this command.
5	ColdBootAllowed	Modifier - allow the output to turn on without AC input power conditions met.
6	UseOnDelay	Modifier - use the on delay settings for the applied command
7	UseOffDelay	Modifier - use the off delay settings for the applied command
8	UnswitchedOutletGroup	Target - command applies to the unswitched outlet group
9	SwitchedOutletGroup0	Target - command applies to switched outlet group 0
10	SwitchedOutletGroup1	Target - command applies to switched outlet group 1
11	SwitchedOutletGroup2	Target - command applies to switched outlet group 2
12	USBPort	Source - Command came from a device connected to the USB port
13	LocalUser	Source - Command came from a local user interface.
14	RJ45Port	Source - Command came from a device connected to the Computer Interface port (Typically RJ45), This includes software over the serial RJ45 and simple signal via RJ45
15	SmartSlot1	Source - Command came from a device in SmartSlot 1.
16	SmartSlot2	Source - Command came from a device in SmartSlot 2.
17	InternalNetwork1	Source - Command came from the internal network card #1.
18	InternalNetwork2	Source - Command came from the internal network card #2.
19	SwitchedOutletGroup3	Target - command applies to switched outlet group 3

Table 2 - Outlet Command Bit Field

2.3.1 Outlet Command Conflicts

An outlet command will not be accepted by the UPS if a command is already pending on any of the targeted outlets. One must cancel any pending commands for a new command to be successful. A common conflict with outlet commands is load shedding. Generally an outlet that is configured for load shedding would not be controlled by outlet command also. If a load shed is pending (typically when operating on battery) an off command to the outlet is not possible until the load shed is canceled with an outlet command.

2.3.2 Issuing an Outlet Command

An outlet command is comprised of several parts, a command, options, targets, and source.

2.3.2.1 Required Portions

2.3.2.2 Command

One and only one outlet command can be issued at a time. Cancel, OutletOn, OutletOff, Shutdown or Reboot. Issuing more than one command in a single write will result in the write not being accepted. Commands that are issued are only allowed if they can be done without requiring another outlet to change states. For example, a SOG may not be turned on until the MOG has already been turned on. The MOG cannot be turned off until all the SOGs have been turned off.

2.3.2.3 Command Targets

Multiple outlets may be targeted with a single command. For example ALL outlets may be targeted to turn everything ON or everything OFF. Note: Although a MOG cannot be turned off before the SOG has been turned off, a MOG and a SOG may be turned off in the same command by targeting both.

2.3.2.4 Command Sources

For the logging of commands to occur properly a source bit must be set when commanding Outlets. For Modbus commands one should select the appropriate interface. Failure to set the source bit may result in the command not being accepted.

2.3.2.5 Command Options

Some Outlet commands have options such as UseOffDelay, UseOnDelay, or ColdBootAllowed (start without AC), If an outlet command supports these options they may be used with the outlet command.

2.4 Simple Signal Command

This command is used by Modbus clients to cause overall UPS actions regardless of present outlet state. For example RemoteOff will turn off all outputs immediately. The following table shows the individual bits of the command and their meaning.

	Command	Description
0	RequestShutdown	If there is no "shutdown" action in process this bit indicates a command to shutdown the UPS. When this command is received the UPS will load the appropriate TurnOffCountdownSetting(s) into the corresponding TurnOffCountdown_EN(s). The UPS will accept this command regardless of the UPS State (Online or On Battery). It is the responsibility of the issuer of the command to guarantee that the unit is on battery when it is issued.
1	RemoteOff	This is the equivalent of pressing and holding the On/Off button while the unit is is on. This will execute an immediate off function of all outlets that are on and the UPS output.
2	RemoteOn	This is the equivalent of pressing the On/Off button when the unit is off. This will execute a sequenced on.

Table 3 - Simple Signal Command Bit Field

2.5 Simple Signal Status

	Command	Description
0	PowerFailure	Indicates that the input power has failed. Signal will be driven

	Command	Description
		with output on or off. Complement of InputStatus.Acceptable.
1	ShutdownImminent	Indicates that the UPS is committed to disconnecting power from its output(s). The bit is set when UPSStatus_BF.PendingOutputOff is set AND RunTimeRemaining is less than or equal to LowRunTimeWarningSetting OR any of the following depending upon the UPS configuration. * For UPS with an unswitched outlet group - when the UPSSystem.UnswitchedOutletGroup.TurnOffCountdown_EN is greater than -1 * For UPS with no unswitched outlet group and with switched outlet group(s) - when the "last commanded" UPSSystem.SwitchedOutletGroup[x].TurnOffCountdown_EN is greater than -1. * For UPS with no unswitched outlet group and with no switched outlet groups - when the UPSSystem.OutputSystem.TurnOffCountdown_EN is greater than -1. In response to this bit becoming set, the device using the simple signaling interface should drive request to shutdown if it hasn't already done so (this ensures that TurnOffCountdown_EN timer will be set to at least the minimum time needed by the simple signaling host).

Table 4 - Simple Signal Status Bit Field

3 Operating the UPS

Since the SOG commands were designed to only accept commands that have no ambiguity in them it means that many commands can be rejected by the UPS as not fully specified. (eg. You cannot turn on a SOG without first turning on the MOG). To avoid these conflicts there are commands that allow for operating the UPS to “Force” the desired effect on the unit without conflict. The following section describes the recommended way to guarantee some common operation.

3.1 Turn on UPS with ALL SOGs

Issue the RemoteOn command in the SimpleSignalCommand_BF to force the unit to turn on and execute all On Delay sequences (the same as if the On/Off button has been pressed). This will issue an on command to every SOG (and MOG). Each outlet will obey its corresponding TurnOnCountdownSetting. Any outlets that are already on will remain in their ON state.

3.2 Turn off UPS with ALL SOGs

Issue the RemoteOff command in the SimpleSignalCommand_BF to force the unit to turn off immediately (the same as if the OFF button has been pressed). This will issue an off command to every SOG (and MOG) to turn off immediately. Any outlets that are already off will remain in their OFF state.

3.3 Turn off ALL SOGs using Off Delays

To force the unit to turn off with Off delays (the same as if a server is asking the output to turn off) issue the

Shutdown command in the SimpleSignalCommand_BF. This will issue an on command to every SOG (and MOG) to turn off using its specified OffDelay program. Note that when AC is present the outlets that were on prior to issuing this command will be turned on automatically. So if this command is issued with AC present it will result in a reboot of all outlets. Also note that any outlets that are already off before issuing this command will remain in their OFF state afterwards.

3.4 Turning on the MOG (UPS)

This command should only be attempted when the UPS is actually off with no commands pending. To determine if the UPS is off one should read the MOG.OutletStatus_BF and determine whether it is in the OFF state with no pending commands. If there are any pending commands one should first Force the Unit off (See section 3.1.2). Once turned off, simply issue an outlet command to turn the MOG on, selecting the following bits– OutletOn, UseOnDelay (optional), ColdBootallowed(optional), UnswitchedOutletGroup, and RJ45 port (or USB port) depending on the interface being used.

3.5 Turning on a SOG

This command should only be attempted when the UPS is actually on with no commands pending. To determine if the UPS is on one should read the MOG.OutletStatus_BF and determine whether it is in the ON state with no pending off commands. If there are any pending commands one should first issue a CANCEL command to the MOG before attempting to control the SOGs. Then issue an outlet command to turn the SOG on, selecting the following bits– OutletOn, UseOnDelay (optional), ColdBootallowed(optional), SwitchedOutletGroup, and RJ45 port (or USB port) depending on the interface being used.

4 Outlet Configuration Settings

4.1 Turn On Delay

The delay used for sequencing outlets. Default is set to 0 seconds (immediate on), can be set to sequence outlets when a normal on sequence is issued.

4.2 Turn Off Delay

This is the shutdown delay or delay that is applied for off commands that use delay. The default value for a MOG is typically 0 (when SOGs exist), and a SOG is typically 90 seconds.

4.3 Stay Off Delay

This is the amount of time that an outlet will be guaranteed to remain off in an off-then-on sequence. The default value is typically 8 seconds.

4.4 Minimum Return Runtime

This is the amount of run time required in the battery before an outlet may turn on. This is not used for immediate on commands. The default value is 0 (always turn on regardless of battery state of charge).

4.5 LoadShed Configuration

	Command	Description
0	UseOffDelay	Modifier - When set, the load shed conditions that have this as a valid modifier will use the TurnOffCountdownSetting to shut the outlet off.

	Command	Description
1	ManualRestartRequired	Modifier - When set, the load shed conditions that have this as a valid modifer will use a turn off command instead of shutdown. This results in a manual intervention to restart the outlet.
2	Reserved	
3	TimeOnBattery	The outlet group will shed based on the LoadShedTimeOnBatterySetting usage. When operating on battery greater than this time the outlet (output) will turn off. The modifier bits UseOffDelay and ManualRestartRequried are valid with this bit.
4	RunTimeRemaining	The outlet group will shed based on the LoadShedRunTimeRemainingSetting usage. When operating on battery and the runtime remaining is less than or equal to this value the outlet (output) will turn off. The modifier bits UseOffDelay and ManualRestartRequried are valid with this bit.
5	UPSOverload	When set the outlet will turn off immediately (no off delay possible) when the UPS is in overload. The outlet will require a manual command to restart.

Table 5 - Load Shed Configuraton Setting Bit Field

4.5.1 LoadShedTimeOnBatterySetting

The time on battery when after which an off command will be issued to the outlet. This condition is enabled and configured with the LoadShedConfigSetting_BF

4.5.2 LoadShedRunTimeRemainingSetting

When the Runtime remaining is less than or equal to this value, the outlet will turn off. This condition is enabled and configured with the LoadShedConfigSetting_BF Note: The default of this usage should be 0.