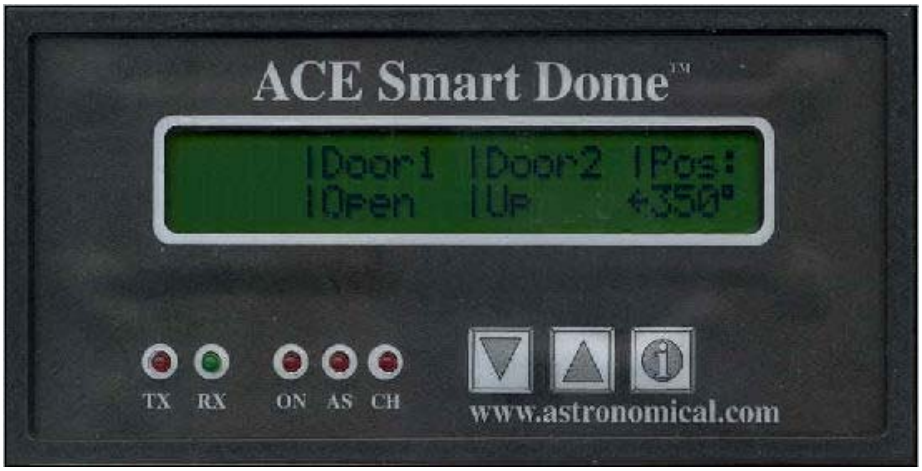
ACE SmartDome™

User Manual

Version 1.0, March 2006



Astronomical Consultants & Equipment, Inc.

2901 W Sahuaro Drive
Tucson, AZ 85742
USA

Tel: 520-219-8722
Fax: 520-219-7989
Web: www.astronomical.com

Introduction

Thank you for purchasing the ACE SmartDome™ Variable Speed Radio Control System from Astronomical Consultants & Equipment, Inc. A standard system comes with the following components:

Components

Two Control Boxes (Upper and Lower)
Variable Speed Azimuth Motor(s)
Rotary Optical Encoders
Home Sensor and Limit Switches
ACE SmartDome™ Application Software

The Lower Control Box, the main SmartDome™ module, communicates with a computer using an RS232 serial communications port. The main module also communicates to the Upper Control Box using radio signals. This permits full control and feedback of the shutter doors operating with only four power slip rings. Thus the dome can be opened and closed in any position. At observatories where radio quiet is necessary, the dome is fitted with partial rings and contactor pads. The main SmartDome™ (Lower) control box is mounted on a fixed wall, typically below one of the rotation motors. This module operates on 220 volts.

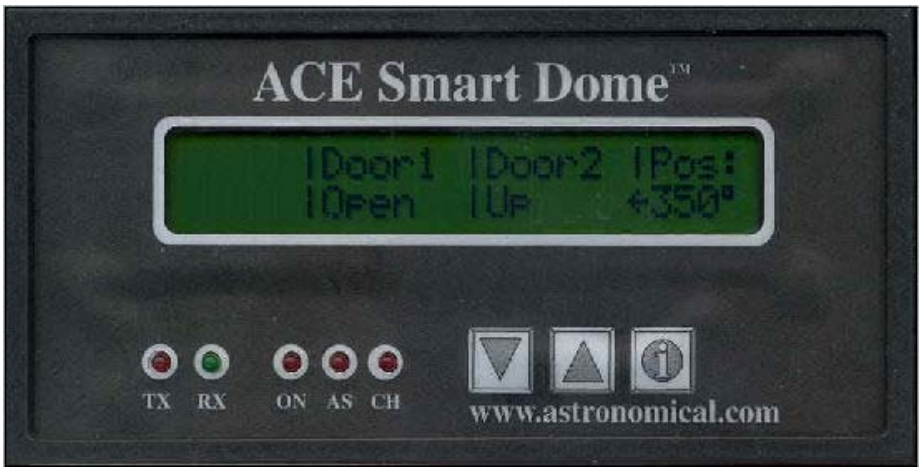
Features

Ramp-up Ramp-down variable speed UL listed frequency drive controller
Control for up to 2 doors or a single door plus a windscreen
Move dome to HOME azimuth position
Move dome to a specified azimuth in degrees
Move dome LEFT or RIGHT from current position
Control main dome shutter
Automatic calibration of dome encoder
Complete status report of shutters, home position, azimuth and setup parameters
Automatic dome closure due to a loss of communications or other external trigger.

(ACE Real-Time Rain/Snow Sensor). This assures an orderly dome closure and shutdown in the event of a computer crash. The feature is ideally suited for robotic and remotely operated telescopes.

Efficient and precise observations can be taken using the ACE Robotic Control System™. It is a complete telescope, dome and instrument software control package for interactive, remote and robotic observing-- including full control of ACE SmartDome™. ACE SmartDome™ can also be configured to control roll-off roof style observatories. Please inquire about the full line of ACE software.

Smart Dome Hardware Interface



ACE SmartDome™ is an embedded microprocessor used to control the dome. All of the input-output lines are optically isolated. This is a sophisticated controller that has a wealth of commands yet is easy to program. It talks over a standard RS232 serial port. It gives real-time status of the dome doors and dome azimuth . Opening this box will void the warranty .

Once the ACE SmartDome™ module is turned on it will display a start-up message including the copyright, and version number and date. Thereafter the display reads the status of the shutter doors and encoder position.

No Encoder or Limit Status Lines attached

With no encoder or shutter door limit status lines attached, the display will read:

Door 1	Door 2	Pos:
UKN	*UKN*	—> 000°

Door 1 is the main shutter door and Door 2, if installed, is either the lower dropout shutter or the windscreen. The message *UKN* means the status limit lines are unknown. the encoder position is the azimuth in degrees, measured from North through East, and reads Pos:. If the home sensor is active, the unit will instead display this special position as Home. The arrow in the position field indicates the direction of the last dome movement; —> for RIGHT and <— for LEFT. (Note, some units may read "AJAR" instead of *UKN*).

WatchDog Counter

The far left of the LCD display has space reserved for watchdog time failures. After the maximum number of failures is reached the dome will automatically close if the Auto Shutdown feature is ON.

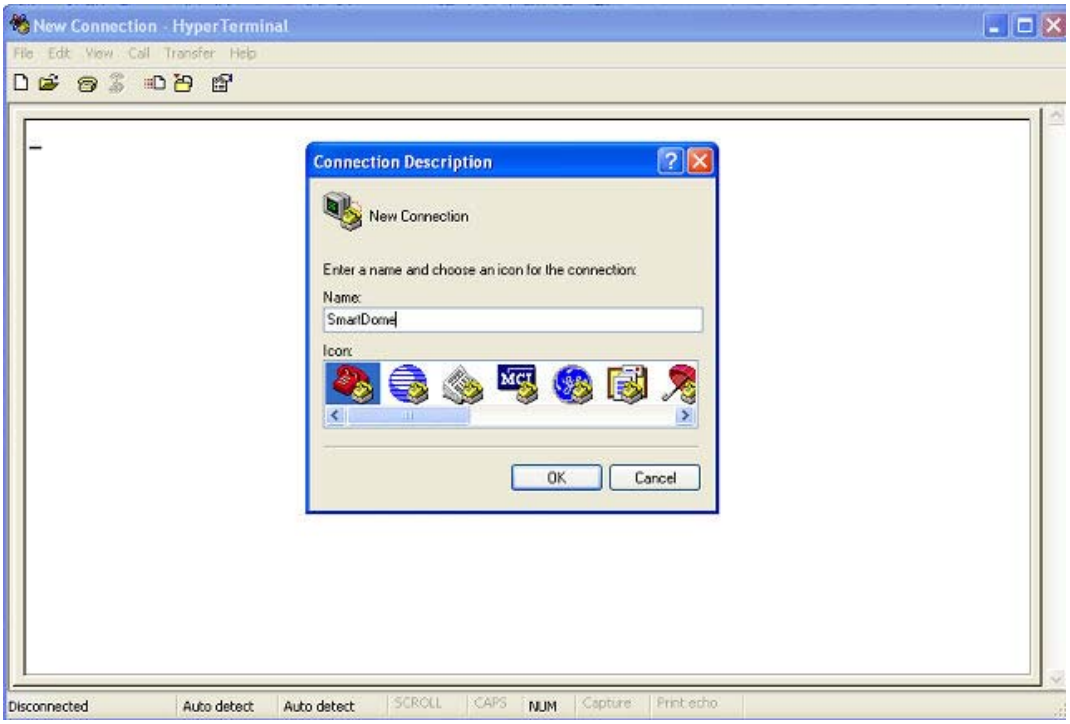
Front Panel LED's

There are five LED's on the front of the ACE SmartDome™ module:

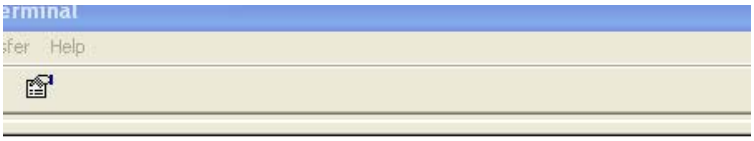
LED	Purpose
TX	RS-232 transmitting
RX	RS-232 receiving
ON	Lit when Auto Shutdown is ON (enabled)
AS	Lit when Auto Shutdown is in progress
CH	Lit when dome is Closed and at Home

Communicating with SmartDome (Serial)

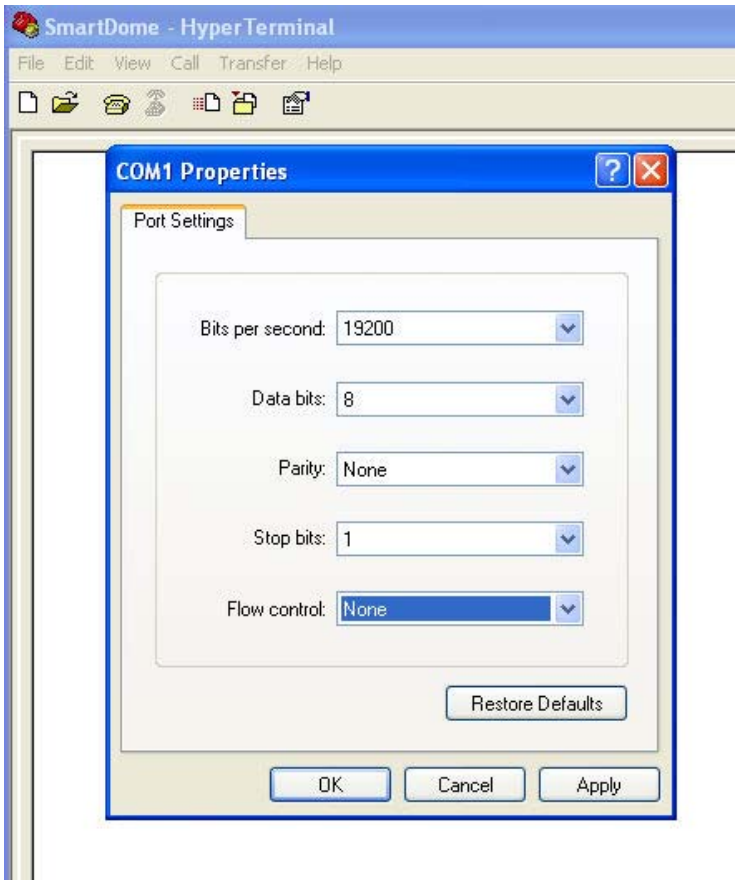
ACE SmartDome™ is connected to a computer through an available serial port. Communication with the module is possible through the Hyper-Terminal in Windows. Choose a name for the connection:



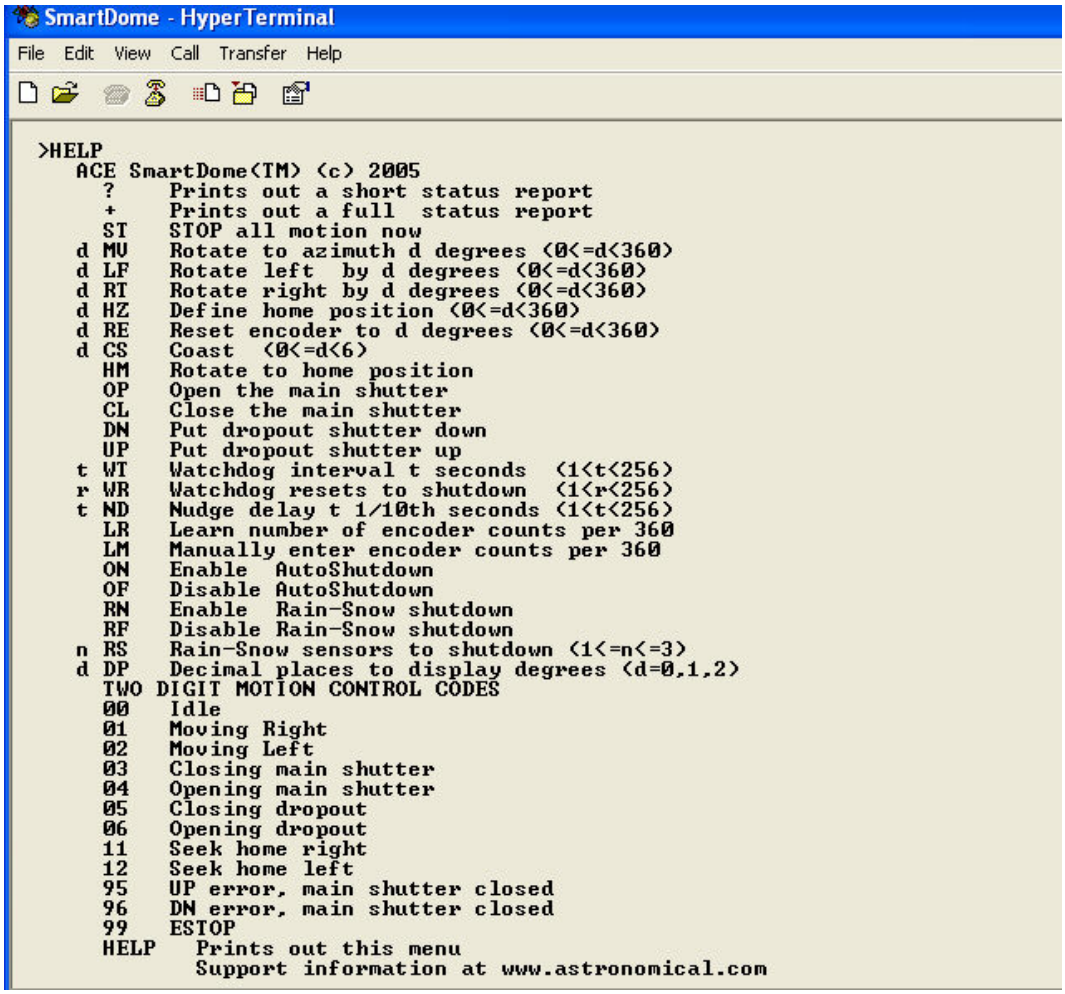
Then communicate through the serial port:



Finally setup the port settings as shown below:



Press <ENTER> to initiate communications. A prompt (">") will appear and allow other commands to be entered.
For example, entering "HELP" yields:



ACE SmartDome™ Commands

Command	Purpose and Range
HELP	Prints out this table (ACE SmartDome(TM) (c) 2005)
?	Print out a short status – use this for feedback control to see changes.
+	Print out a full status report – use this for engineering setup
ST	Stops all motion.
n MV	Rotate to azimuth n degrees (0<=n<360)
nLF	Rotate left by n degrees (0<=n<360)
nRT	Rotate right by n degrees (0<=n<360)
nHZ	Define home position (0<=n<360)
n RE	Reset encoder to n degrees (0<=n<360)
n CS	Coast (dome freewheel overshoot) (0<=n<6)
HM	Rotate to home position
OP	Open the main shutter
CL	Close the main shutter
DN	Put dropout shutter down
UP	Put dropout shutter up
tWT	Watchdog interval t seconds (1<t<256)
nWR	Watchdog resets to shutdown (1<n<256)

t ND	Nudge delay t 1/100th seconds (1<t<256)
LR	Learn number of encoder counts per 360
nLM	Manually enter encoder counts per 360 (1000<n<65535)
ON	Enable AutoShutdown
OF	Disable AutoShutdown
RN	Enable Rain-Snow shutdown
RF	Diasble Rain-Snow shutdown
nRS	Rain-Snow sensors to shutdown (1,2,3)
dDP	Decimal places to format output of degrees (d=0,1,2)
TWO Character MOTION REPORT CODES	
00	Idle
01	Moving Right
02	Moving Left
03	Closing Main Shutter
04	Opening Main Shutter
05	Closing Dropout
06	Opening Dropout
11	Seek Home Right
12	Seek Home Left
95	UP error, main shutter closed
96	DOWN error, main shutter closed
99	Emergency Stop
RR	Last Dome Rotation was to the Right
RL	Last Dome Rotation was to the Left

Commands are not case sensitive (they are converted to upper case). Note that if a typing error is made, it will be necessary to press the enter key and re-type the command.

Status Commands (Examples)

There are two status reports available:

? Displays a short status report (lines 1 through 5)

\+ Displays a full status report

Sending either ? or + resets the watchdog timer and tells SmartDome™ that the host computer is still active. Thus if AutoShutdown is ON (enabled) this will reset the watchdog timer (to zero).

Output for the ? command	Line	Comments
Posn 145.89	1	Posn or Home plus DDD degrees
[OFF] Rain	2	Auto-Shutdown [ON] or [OFF]
RR 99 ESTOP	3	See code table
D1 Shut	4	Door 1 (options are: Open Ajar Shut ????)
D2 Shut	5	Door 2 (options are: Open Ajar Shut ????)
>	6	prompt

Notes:
1) The number of decimal places for the degrees is set using the DP command.
2) If rain shutdown if off (RF) then the display will read Rain disabled.
3) Options on line 3 are RR (rotate right) or RL (rotate left) as the last commanded move.
4) The ESTOP message occurs on line 3 only if the emergency stop button is activated.
5) Lines are separated by line feed and carriage return.

Output for the + command	Line	Comments
Posn 64.5	1	Posn or Home
[OFF] Rain	2	Auto-Shutdown [On] or [OFF]
RL 01 ESTOP	3	See code table
D1 Shut	4	Door 1 (options are: Open Ajar Shut ????)
D2 Shut	5	Door 2 (options are: Open Ajar Shut ????)
	6	blank line
Emergency Stop active: 1	7	
Home azimuth (degrees): 40.50	8	Stored to 2 decimal places
Coast (degrees): 1.00	9	Stored to 2 decimal places
Home Nudge Delay (ms): 1000	10	For precise home seek
Encoder counts/rev: 57285	11	<65536
Encoder counts: 10276	12	<65536
Last Az_GoTo: 78.56	13	
Time between resets: 60	14	60 seconds between resets
Resets to Autoshutdown : 5	15	5 resets to Autoshutdown
Doors 2	16	Number of doors
Dome Control Style: 1	17	Factory set- Do not alter
Power slip rings : 1	18	TRUE or FALSE (factory set)
Rain-Snow enabled: 1	19	TRUE or FALSE
Rain Sensors to Close	20	Number of Sensors
24-Oct-05 Copyright (c) A.C.E.Inc	21	Firmware version
www.astronomical.com	22	Website
>	23	prompt

Calibrating The Encoder

When first installing SmartDome™ it is necessary to calibrate the encoder. Manually move the dome to the left of the home position. Enter the command LR (learn). The dome will rotate to the right passing HOME and then going one full revolution and stop when it re-finds the home switch. The accuracy of the system depends upon the total number of pulses per revolution. It should ideally be between 12,000 and 65,536 counts. Make sure that the encoder is counting up (not down) during a learn. If it is counting down swap pins 2 and 3 on the encoder to reverse the counting direction. After the encoder is calibrated, define the home position using the low level HZ command or through the ACE SmartDome™ software interface.

AutoShutdown

Automatic closure of an observatory is triggered by either the final failure to communicate with the SmartDome™ module (dictated by the watchdog timer) or the detection of precipitation by a rain/snow sensor. The module will close the lower and upper shutters of the observatory and remain in this state until the watchdog timer is reset. These actions will only take place if Autoshutdown is enabled and the "ON" LED is lighted on the module. The module will report either the final watchdog timer failure or rain/snow on its display in the case of automatic closure and the "AS " LED will be illuminated during the shutdown pro chess.

Watchdog Timer

To use SmartDome™ in a robotic observatory as a fail-safe device the command ON must be issued. ACE recommends issuing ON at the same time the dome is opened. The red LED will be lit on the front of the SmartDome™ module and the status report will also indicate that the unit is ON.

When ON the watchdog timer is enabled.

There are two loops in the watchdog timer. Use the command tWT to set the main loop where t is the number of seconds. This should be several seconds longer than the poll update time from the main computer. If the computer has not sent a command to SmartDome™ within WT seconds then a watchdog flag (WDOG) will be set. The second loop is the number of fails before AutoShutdown takes place. Set this with the command tWR (where t is again the number of seconds). Typical settings are 60 WT and 5 WR giving a total of 5 minutes of non-communication to initiate an AutoShutdown.

When AutoShutdown is in progress the AS (AutoShutdown) LED will be lit and the status of the doors are not updated on the front of the module.

Sending any command (suggest ? for monitoring the dome status) resets the watchdog timer. This should be sent at a frequency greater than tWT . Every 1 to 10 seconds is suggested.

ACE also recommends turning AutoShutdown OFF (command OF) as soon as the doors have closed.

IMPORTANT

WARNING

In order to prevent unexpected dome motion the ACE SmartDome™ should be programmed to OFF when the dome is closed and at home (not observing).

This will prevent SmartDome™ from attempting to home and close the dome if it is manually moved and the control computer software application is not running.

Always unplug ACE SmartDome™ before attempting dome repairs or operating overhead cranes, ladders, etc.

For general repairs activate the Emergency Stop button on the ACE Dome Control Unit to eliminate unexpected dome movement.

Pinouts and Technical Information

The SmartDome™ control module is the small black extruded plastic box which houses the microprocessor and display. Opening this box will void the warranty. Information on this page is supplied for reference by the ACE Applications Engineer during installation.

The standard encoder has 256 counts per revolution giving a resolution of better than 0.1 degree with Ash Manufacturing Co. and similar domes. (See also Calibrating the Encoder)

Connector details for the mating plugs are as follows:

RS-232

Pin	Function
1	No connection
2	Transmit (TX)
3	Receive (RX)
4	No Connection
5	Ground
6-9	No Connection

ENCODER: Circular Plastic Connector AMP 206060-1

Pin	Function
1	+5 VDC
2	A+
3	B+
4	Ground

SmartDome™: Circular Plastic Connector AMP 206037-1

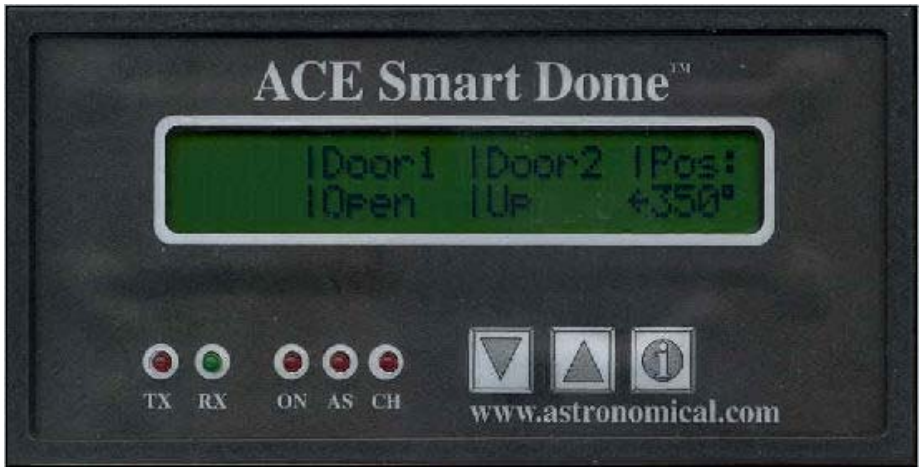
Pin	Function	Direction	Color
1	Rotate RIGHT	OUTPUT	BLK
2	Rotate LEFT	OUTPUT	RED
3	CLOSE main shutter	OUTPUT	WHT
4	OPEN main shutter	OUTPUT	ORG
5	Raise drop-out door UP	OUTPUT	YLW
6	Lower drop-out door DOWN	OUTPUT	BRN
7	HOME sensor input	INPUT	BLU
8	Main Shutter CLOSED input	INPUT	WHT
9	Main Shutter OPENED input	INPUT	ORG
10	Dropout shutter CLOSED input	INPUT	YLW
11	Dropout shutter OPENED input	INPUT	BRN
12	RAIN/SNOW	INPUT	VLT
13	Emergency STOP	INPUT	RED
14	No Connection		
15	No Connection		
16	Ground		GRN

Lower Control Box

The Lower Control Box is the main controller because it contains the ACE SmartDome™ module The photograph shows a controller for use with a main shutter door and lower dropout door. Rotation is activated by pressing the white LEFT/RIGHT buttons. A twist-lock emergency stop button is provided for enhanced user safety .

The Lower Control Box is typically located below one of the dome rotation motors. It requires a 220 VAC power supply (which is readily available in almost every building). The Lower Control Box can either be installed into a circuit disconnect box or into a NEMA L14-20R twist-lock receptacle. The dome controller should be wired to its own dedicated 2-pole 20A circuit breaker.

ACE SmartDome™ module



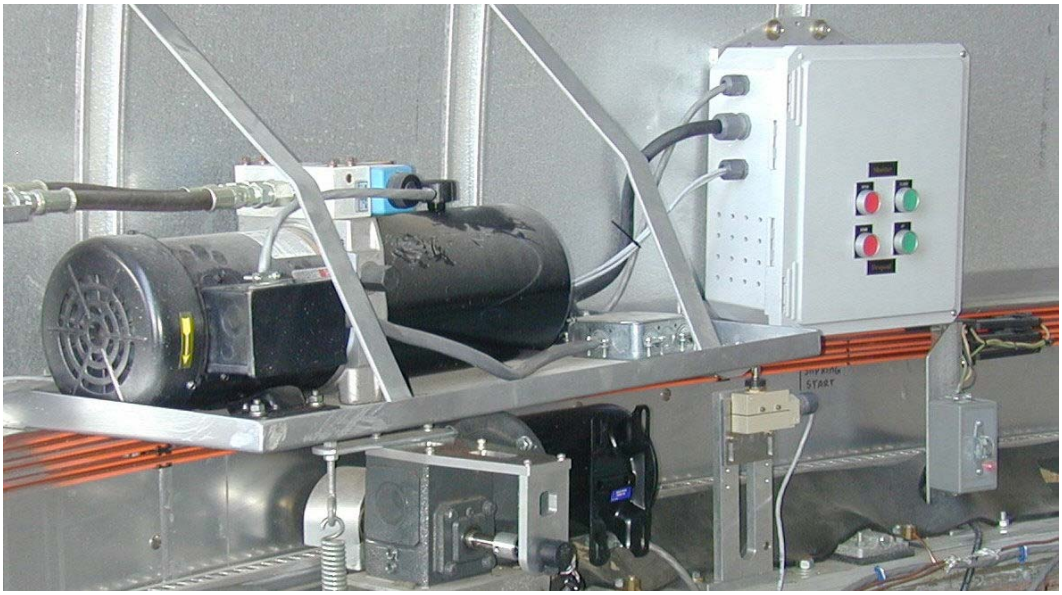
ACE SmartDome™ is an embedded microprocessor used to control the dome. All of the input output lines are optically isolated. This is a sophisticated controller that has a wealth of commands yet is easy to program. It talks over a standard RS232 serial port. It gives real-time status of the dome doors and dome azimuth . It can automatically close the dome in the event of rain or in the event of a communications failure with the host (telescope control) computer. Opening this box will void the warranty

The Buttons at the bottom right of the unit are not currently implemented. However, you are welcome to press them if you desire.

Upper Control Box

The upper control box communicates with the ACE SmartDome™ main module (Lower box) by radio. The upper control box has push button controls for both doors in the event of a radio failure. Real-time status of the dome doors is always available. However, if there is a loss radio contact both the Upper and Lower control box will sound an audible, rapid beeping.

Slip Rings



The photograph shows a typical control for a hydraulic dropout and three slip rings. The number of slip rings necessary (3 or 4) depends on the configuration of the observatory. We can retrofit slip-rings for pre-existing domes. Contact ACE for more information.

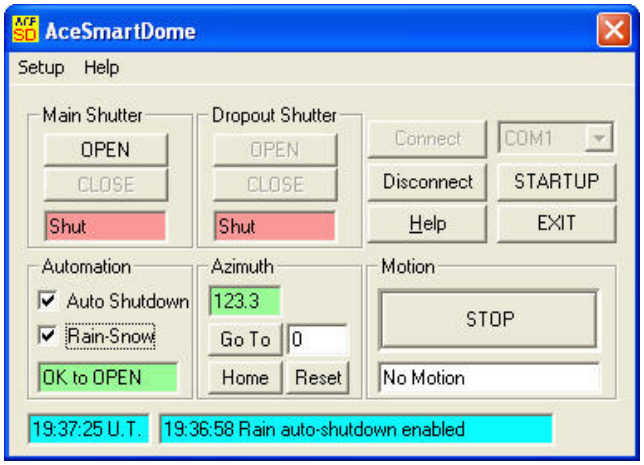
Rain/Snow Sensors

ACE can supply rain/snow sensors for your observatory. These sensors give the security necessary to conduct remote observations. Detection of water droplets will trigger an AutoShutdown sequence and protect a telescope and electronics from damage.

Contactor Boxes

For observatories where radio quietness must be maintained or where slip rings are not available we have an alternative solution.
The ACE Dome Contactor Box is a series of seven or fourteen partial slip rings. When the dome is sent to a "home" position the upper and lower boxes mate together and provide up to 14 slip rings. This allows full control of the doors and/or windscreen and full feedback of the limits (open - ajar - close). The dome can only be opened or closed when at the home position. A safety interlock prevents power from reaching the slip rings unless the dome is home and the control buttons are being pressed. ACE Dome Contactor Boxes can be found at observatories around the world.

Software Overview



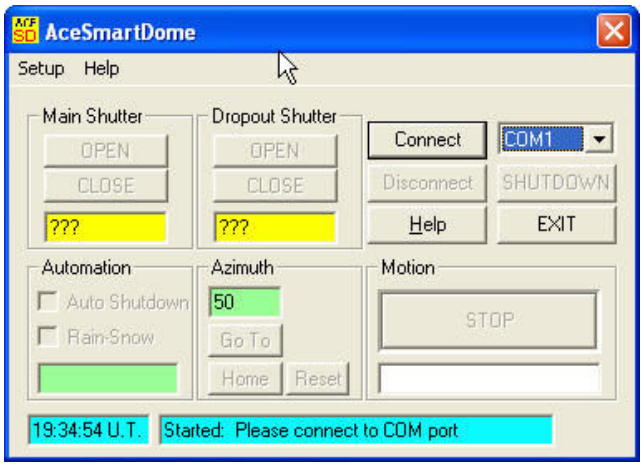
ACE SmartDome™ software is a stand-alone program that communicates with and controls the system hardware through a computer. This user-friendly interface is one of three ways of talking with the hardware- the other two methods include:

Low Level Commands (See Communicating with SmartDome™ (Serial)) (Hyperterminal)
Write your own software that sends these low-level commands.

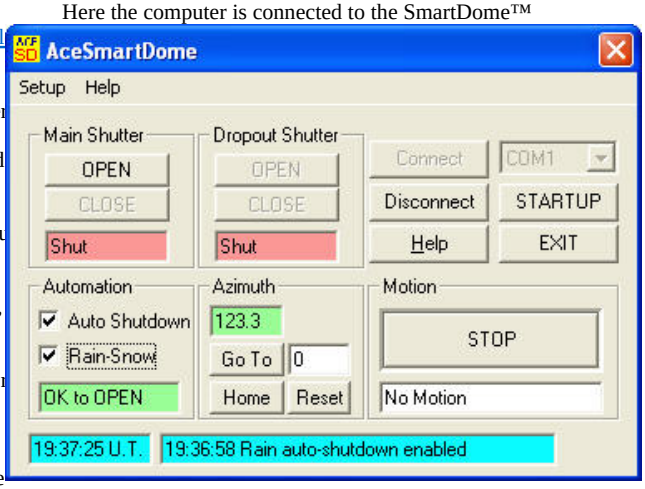
Basic Opening

The following screens will demonstrate some of the salient details of the program.

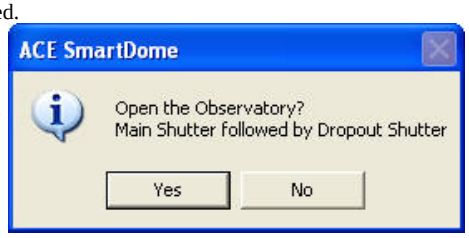
This screen shows what the program looks like initially when not connected. The state of the Main and Dropout shutters are undetermined. The last azimuth the program recorded when connected was "50" degrees. And finally the bottom dialogue kindly suggests the user to connect to the SmartDome™ module.



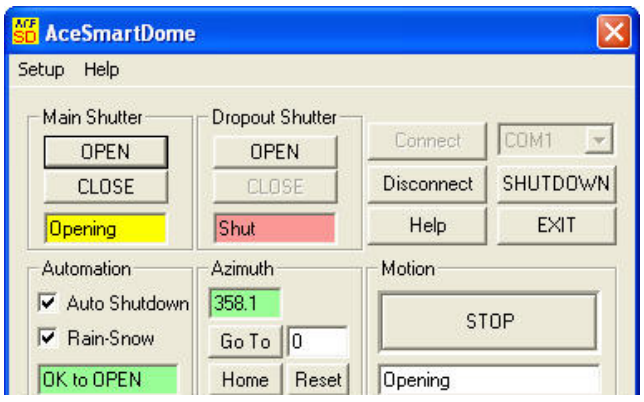
Here the computer is connected to the SmartDome™ module. Each of the shutters are closed. In this particular type of dome, the main shutter needs to open before the dropout portion can be lowered. Pressing these buttons individually will open each. Alternatively pressing the "STARTUP" button will sequentially open both automatically. Before opening a remotely operated enclosure, check the status of the Rain/Snow Sensors in the bottom left field. In this case it is "OK to OPEN." The Auto Shutdown and Rain-Snow shutdown features are both active (checked). This means that if either communication with the SmartDome™ module is lost or Rain/Snow is detected, the observatory will close automatically. Note that in this screen capture the azimuth now reads "123.3" compared with the above screen that read 50. This means that a person manually rotated the dome while the software was not connected; and once connected the new position is displayed.



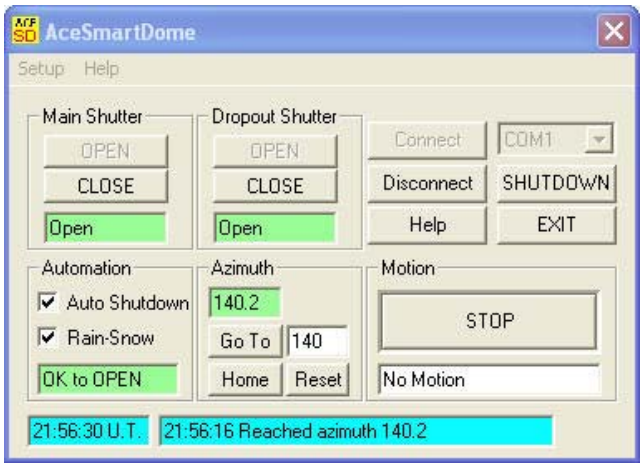
A dialogue box asks for confirmation to open the shutter. Since the STARTUP button was activated, the program will open the main shutter followed by the dropout shutter. This software is configured to understand that the observatory is completely open when BOTH the Main Shutter and Dropout Shutter are open. (See ASCOM support to disable the Dropout shutter)



The main information field in the bottom left reports that the request to open the main shutter was received. While the shutter(s) opens, both the Main Shutter status section and the motion status section indicate the dome activity. In this case, it reads 'Opening." The Dropout shutter will report "Opening" once the Main shutter is completely open.

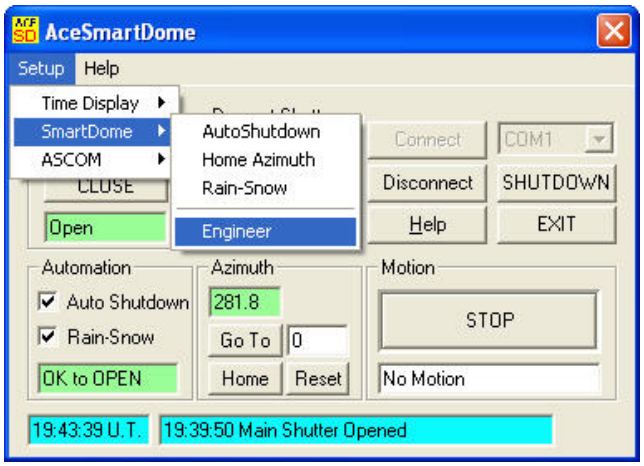


Finally the observatory is open and the dome has been moved to a new azimuth position of 140 degrees.



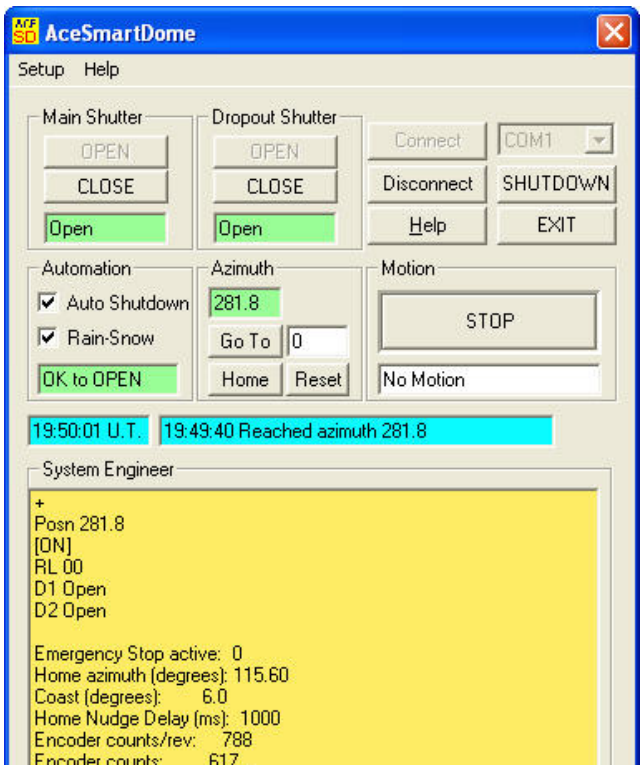
Engineering Mode

An engineering mode (interface) is available under Setup—>SmartDome—>Engineer.



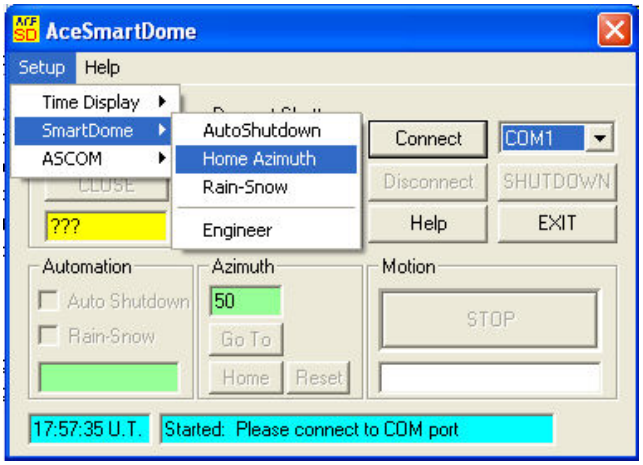
The engineering mode lets the user communicate with the SmartDome™ module and see the state of the dome through low level hardware commands. The complete listing of commands and report codes are listed in the section called Communicating with the Smartdome.

Send commands from the bottom field. For example, to drive the dome to an azimuth of 150 degrees input: 150 MV



Define HOME Azimuth (ACE SmartDome™ Software)

To set the azimuthal position of the HOME sensor, navigate to Setup—>SmartDome—>Home Azimuth .

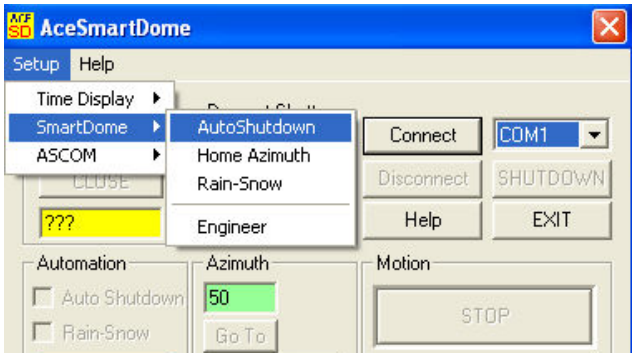


Input the value you have measured from inside of your dome. A precision of 0.1 degrees is usually more than adequate.

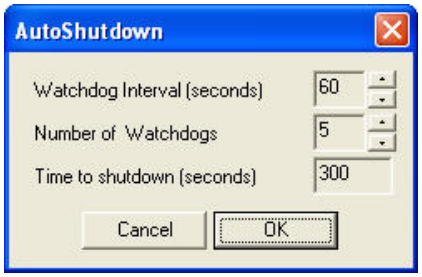
This setting is identical to the low level HZ command.

AutoShutdown (ACE SmartDome™ Software)

The settings for AutoShutdown can be accessed by navigating to Setup—>SmartDome—>AutoShutdown.



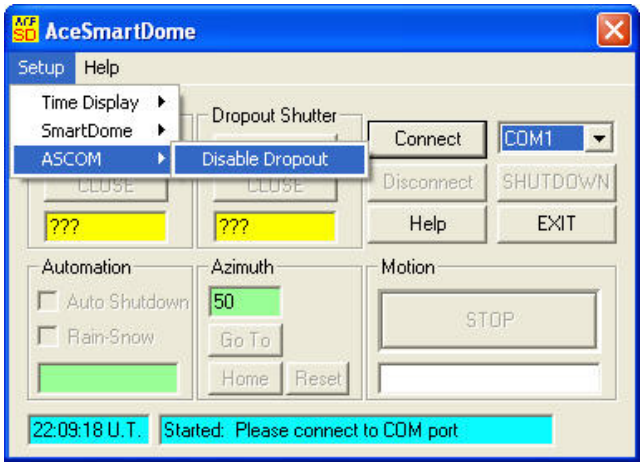
Automatic shut down will commence if the ACE SmartDome™ module fails to hear from the computer a number of times set by the watchdog parameter. Here, this value is set to 5. After a 5th failure to communicate ACE SmartDome™ will close the dome. The watchdog interval determines the length of time between communication attempts. Thus, the total time is the number of watchdogs times the interval in seconds. In this case 5x60 seconds equals 300 seconds (5 minutes).



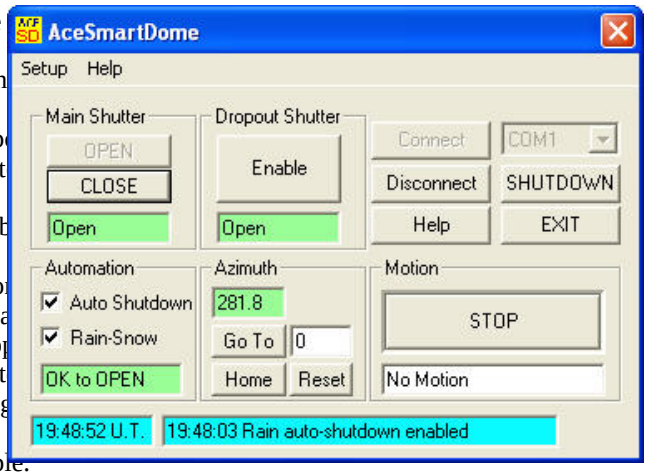
In the low level command language the watchdog interval is synonymous with WT and the number of watchdogs is WR.

ASCOM Dropout Shutter Support

It is sometimes desired to have the SmartDome software disable the lower Dropout shutter. Some ASCOM compliant programs will continue to report the dome as completely "OPEN" even though only the main shutter has been opened. In this way, the observatory can be partially open but operated as normal.

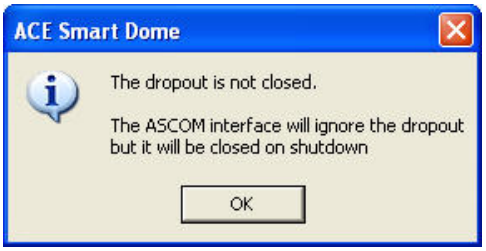


Note that when the Drop Shutt is Disab - the butto benea "Drop Shutt chang to Enable.



This is the indication that this mode is in affect.

Generally the dropout shutter will be disabled before opening the dome. As was shown above, it is useful to have the dropout closed and still have the ASCOM program report a fully opened dome. However, it is possible to accidentally (or otherwise) disable the dropout AFTER having already opened it. While this may not be a useful state, the software informs the user as such and states it will ignore the dropout except during shutdown (or Auto-shutdown) procedures. (a very good safety feature)



Service

The ACE Radio Control System and ACE SmartDome™ do not require routine servicing. We recommend powering it through a surge suppressor or an uninteruptible power supply.

If equipment needs service please call ACE for technical support. Breaking the seals on the radio controller or the SmartDome™ module will void the warranty.

If you need to access (open) either of the control boxes turn the power off first! They both contain high voltage

.

Warranty

WARRANTY
Astronomical Consultants & Equipment, Inc., (ACE) warrants the ACE SmartDome™ Control System to be free from defects in material and workmanship for a period of one (1) year from the date of original installation.

This warranty is subject to the following conditions and limitations:

1) This warranty does covers use under normal operating conditions. It does not cover damage caused by lightning or other electrical surges. It is the responsibility of the end user to ensure adequate surge protection, usually by employing an uninterruptable power supply.

2) The installation must be performed by an ACE certified technician.

3) In the event of equipment failure the user must contact ACE for technical support. Unauthorized attempts at repairs will void the warranty. (email: support@astronomical.com).

4) In the event of equipment failure during the warranty period ACE will, at its discretion, repair or replace parts found defective. Repaired or replaced parts are warranted for the longer of thirty (30) days or the remainder of the warranty period. The end user will be responsible for minor part replacement. For major malfunctions requiring more than a simple part replacement ACE will provide on-site service.

5) All equipment returns must have an RMA (Return Merchandise Authorization) number supplied by ACE and shipped using a common carrier (FedEx, UPS) with tracking numbers. ACE will pay for the return shipment to the end user.

6) ACE DISCLAIMS ANY WARRANTIES, EXPRESS OR IMPLIED, EXCEPT AS EXPRESSLY SET FORTH HEREIN. THE SOLE OBLIGATION OF ACE UNDER THIS LIMITED WARRANTY SHALL BE TO REPAIR OR REPLACE THE COVERED PRODUCT, IN ACCORDANCE WITH THE TERMS SET FORTH HEREIN. ACE EXPRESSLY

DISCLAIMS ANY LOST PROFITS, GENERAL, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES WHICH MAY RESULT FROM BREACH OF ANY WARRANTY, OR ARISING OUT OF THE USE OR INABILITY TO USE THE PRODUCT. IN NO EVENT SHALL ACE BE LIABLE FOR MORE THAN THE ORIGINAL PURCHASE PRICE OF THE PRODUCT

Safety Warning

WARNING

In order to prevent unexpected dome motion the ACE SmartDome™ should be programmed to OFF when the dome is closed and at home (not observing).

This will prevent SmartDome™ from attempting to home and close the dome if it is manually moved and the control computer software application is not running.

Always unplug ACE SmartDome™ before attempting dome repairs or operating overhead cranes, ladders, etc.

For general repairs activate the Emergency Stop button on the ACE Dome Control Unit to eliminate unexpected dome movement.