

USER'S GUIDE
for
MIDDLETON SOLAR
APT-02
AUTOMATIC PASSIVE
SOLAR TRACKING SYSTEM

Version: 1.1



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1. GENERAL DESCRIPTION

The APT-02 Solar Tracker consists of a 2-axis Gearbox with integrated Single Board Computer and Global Positioning System (GPS). It is designed to automatically point a solar radiometer at the sun throughout the day.

The horizontal axis and the vertical axis are each rotated by a stepper motor and harmonic gearhead. The harmonic gearhead has zero-backlash so there is no motion hysteresis, and both axes have a rotary sensor to monitor absolute angular position.

The GPS signal is used to automatically configure the Tracker for the geographic location of the site and to set the computer to real local time. The APT-02 runs open-loop automatic tracking using GPS position information. The Tracker halts shortly after sunset, then at midnight (solar time) reverses to the dawn position ready to resume tracking shortly before sunrise.

The Tracker operates on 12VDC and has low power consumption so it is suitable for solar powered sites. The User interface consists of a single Status light to provide information about the normal operation of the Tracker and also indicate warning or error states.

Recommended options are:

- LP01 Levelling Plate;
- PM02 Pyrheliometer Mount.

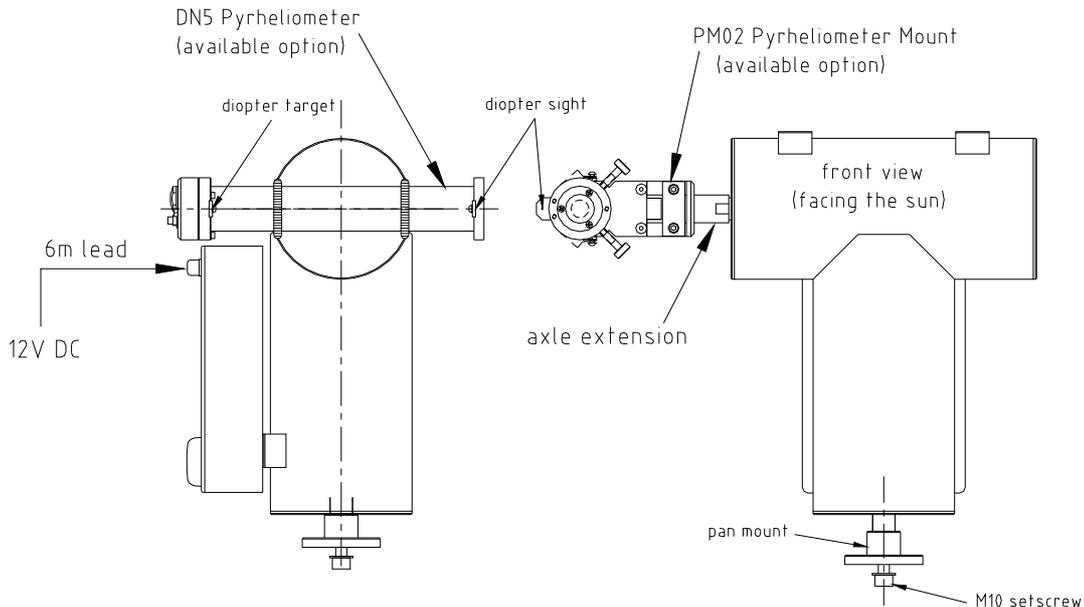
Other available options include:

- LS01 Levelling Stand;
- PM04 Dual Pyrheliometer Mount;
- Status Output Lead (see Appendix F).

Middleton Solar radiometers that are suitable for the APT-02 Tracker include:

- DN5/E Pyrheliometers;
- SP02/L Sunphotometers.

2. INSTALLATION & SETUP



Setup should be undertaken at or near solar noon, the sun must be clearly visible, and the GPS antenna must not be obscured. Setup must proceed in the sequence described.

A) Unpack the Tracker.

B) Place the Pan Mount on a level platform that has a 10mm hole¹.

The platform must be level to 0.1°.

Pass the M10 setscrew, with washer, up through the platform hole & Pan Mount. Place the vertical stub axle into the Pan Mount, and loosely secure it with the M10 setscrew.

A locating pin inside the Pan Mount must align with a hole in the stub axle. Do not fully tighten the setscrew until step (G) below.

C) Fit the supplied Axle Extension to the horizontal axle of the Tracker

Ensure the locating pin in is fully engaged before tightening.

Attach the PM02 Mount (or equivalent) to this axle, lightly tighten the two M6 capscrews.

Tools required: 5mm AF hex key (for capscrew).

D) Attach a DN5 Pyrheliometer (or equivalent) to the PM02 Mount, using the two Mount springs.

The orientation of the DN5 is important, position it facing as illustrated.

E) Connect the power lead to a 12 volt DC; red core to +ve, blue to -ve.

The pan motor will operate to move the Tracker to a nominal North/South orientation, then the tilt motor will operate to move the DN5 to a nominal horizontal orientation. Pan & tilt movement will then pause while a search for the GPS signal is performed.

¹ alternatively use the available LS01 Stand, or the LP01 Plate.

The status indicator will loop <on 2 seconds, off 2 seconds> until the GPS signal is found.

The GPS signal search may take up to 15 minutes.

The typical GPS search time is 15 seconds to a few minutes.

If no GPS signal is available the setup can not proceed further.

In this case try again later as temporary atmospheric conditions may have attenuated the GPS signal.

F) When the GPS information has been obtained the Tracker will tilt then pan until it has moved to the local sun position.

Although the Tracker is not yet aligned, it will commence to move as if tracking the sun.

The status indicator will loop <on 3 seconds, off 1 second>.

G) Manually pan the Tracker & adjust the PM02 Mount, to aim the DN5 directly at the sun.

The Pan Mount & PM02 Mount fasteners must be slightly loose.

Do not force the Tracker axles to rotate.

The alignment is correct when the sun spot from the DN5 diopter sight is centered on the DN5 diopter target²

Tighten the two M6 capscrews of the PM02 Mount.

Tighten the the Pan Mount bolt.

Check that the diopter sight is centered on the diopter target.

The APT-02 pointing accuracy is wholly dependent on careful manual alignment.

H) Disconnect & re-connect the 12V power to check the alignment is correct.

The Tracker should go through the initial pan & tilt routine and then precisely point the DN5 Pyrheliometer at the sun.

I) Ensure the power lead can not restrict the movement of the Tracker. The Tracker can range up to 500° in pan.

² DN5 Pyrheliometer slope angle is 1°, so sun spot must remain within 4mm of target

3. OPERATION

The initial installation and setup is described in Section 2.

Once setup is completed the Tracker will operate continuously so long as the power is not disconnected.

Whenever a power-up occurs the Tracker will sequence through:

- pan to orient the Tracker to North/South;
- tilt to orient the Pyrheliometer to horizontal;
- pause and search for the GPS signal;
- tilt then pan to point the Pyrheliometer at the sun;
- commence tracking.

For Normal Operation the Status Indicator will display one of these conditions:

- loop <on 2 seconds, off 2 seconds> = start-up and search for GPS;
- loop <on 3 seconds, off 1 second> = automatic tracking.

The GPS information is updated daily at 12:15am. Tracking will pause up to 25 minutes during this update.

For Operation Warning the Status Indicator will display this condition:

- loop <on 3 seconds, flash x 5> = GPS signal not available;

The Tracker will continue to operate during the warning condition, but correct tracking alignment is not assured. The User should identify the cause of the warning and take corrective action if necessary.

For Operation Fault the Status Indicator will display this condition:

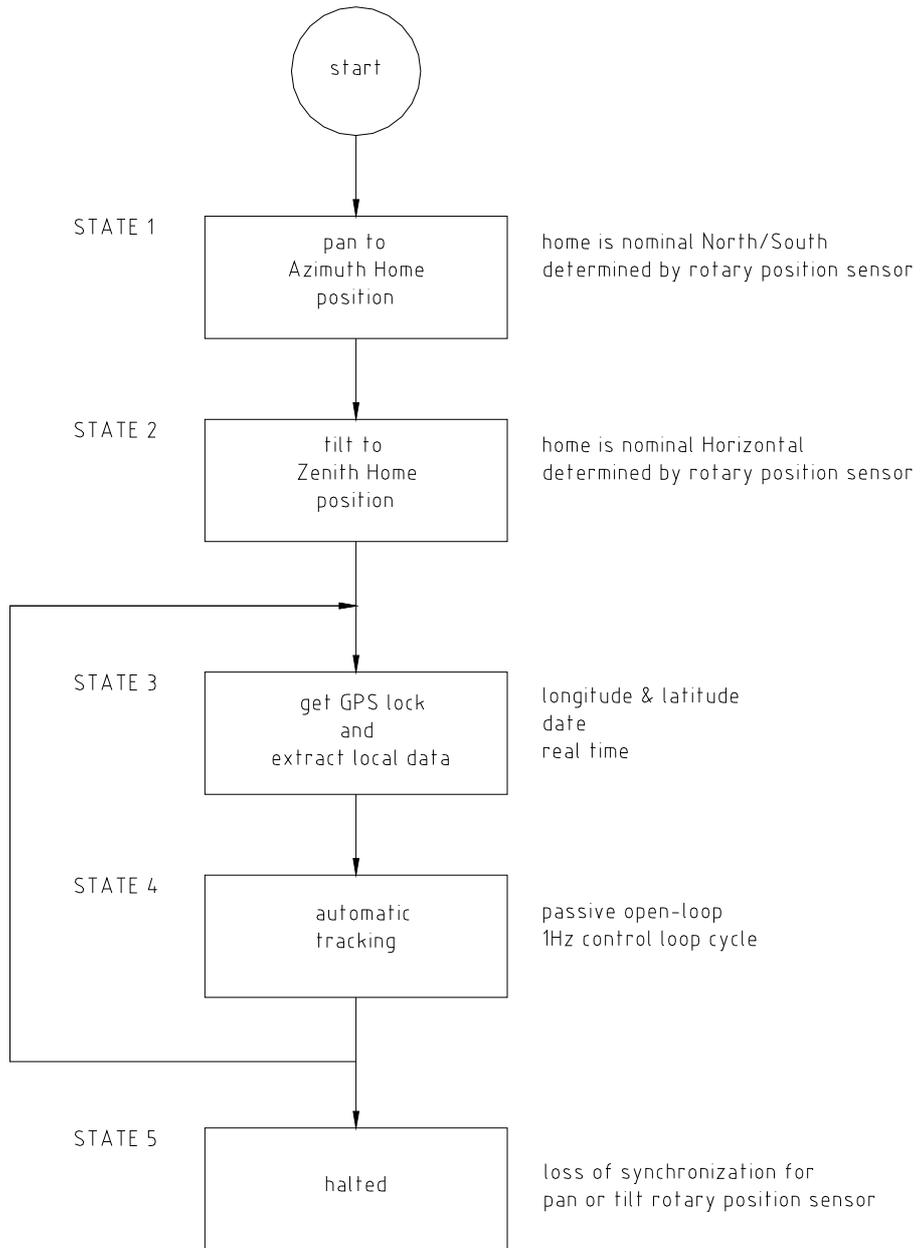
- loop <flash every 1 second> = hardware error, tracking halted.

The Tracker will stop operating if a fault condition occurs. In this case re-start the Tracker to determine if the fault condition persists. If the fault persists it is likely that a motor has failed, or a rotary position sensor has failed or is out-of-range³. The User should have the Tracker inspected and repaired. The most recent 20 minutes of Tracker operation is logged in internal memory to assist in fault diagnosis⁴.

³ An out-of-range position sensor will halt motor operation regardless of control commands. This feature is a fail-safe limit stop to prevent self-harm.

⁴ Contact Middleton Solar if you require access to the internal datalog file.

APPENDIX A. APT-02 Tracker Control States



APPENDIX B. APT-02 Status Indicator Table

#	Indicator	display priority	Status	Comment
-	off	-	power not connected	-
F1	on, flashing at 1Hz continuous	1	hardware error: tracking halted	Pan or Tilt position error > 8°; or out of range; or Motor fault
W2	on 3s, flash x 5, looping	2	GPS warning: automatic tracking continues	GPS fault, or Antenna obscured
N2	on 3s, off 1s, looping	3	automatic tracking, with GPS	normal operation
N1	on 2s, off 2s, looping	4	start-up & GPS search	may take 15 min.

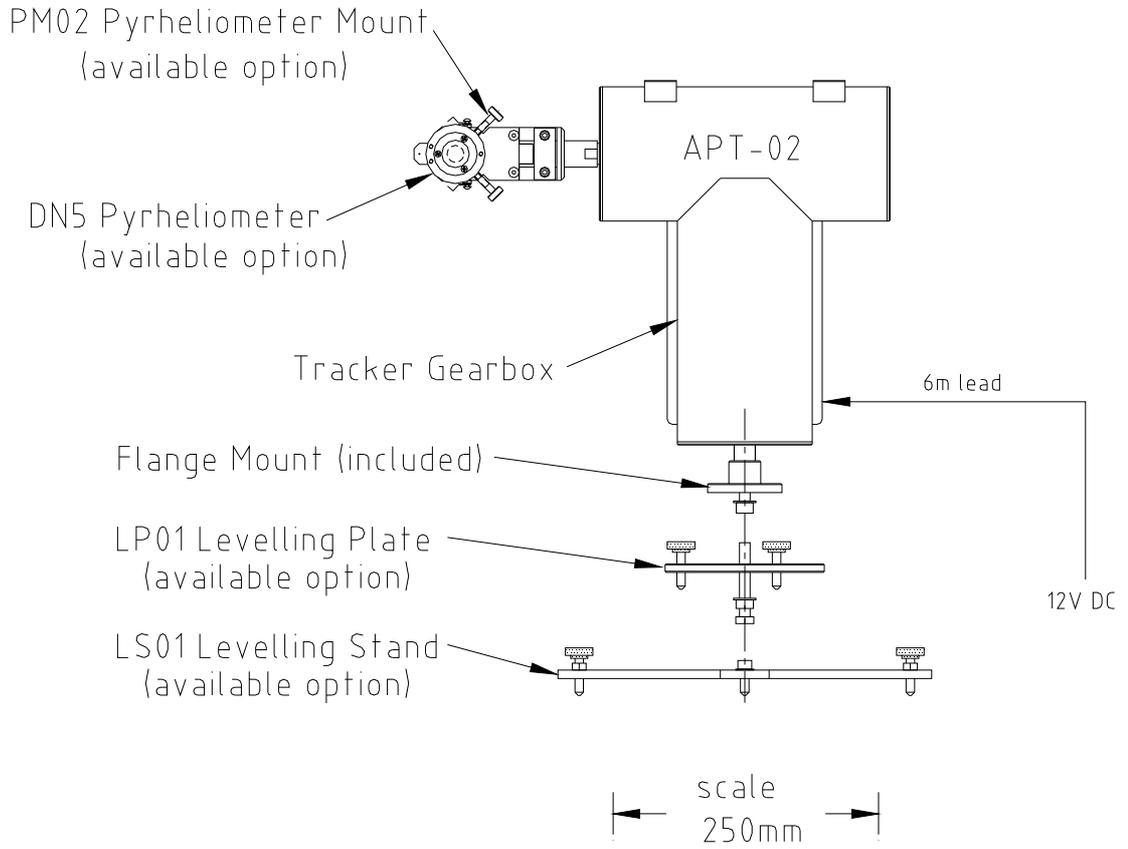
Normal conditions are N1, N2.

Warning condition is W2.

Fault condition is F1.

A higher priority display status will usually override a prior lower priority status.

APPENDIX C. Instrument & Accessory Installation Example



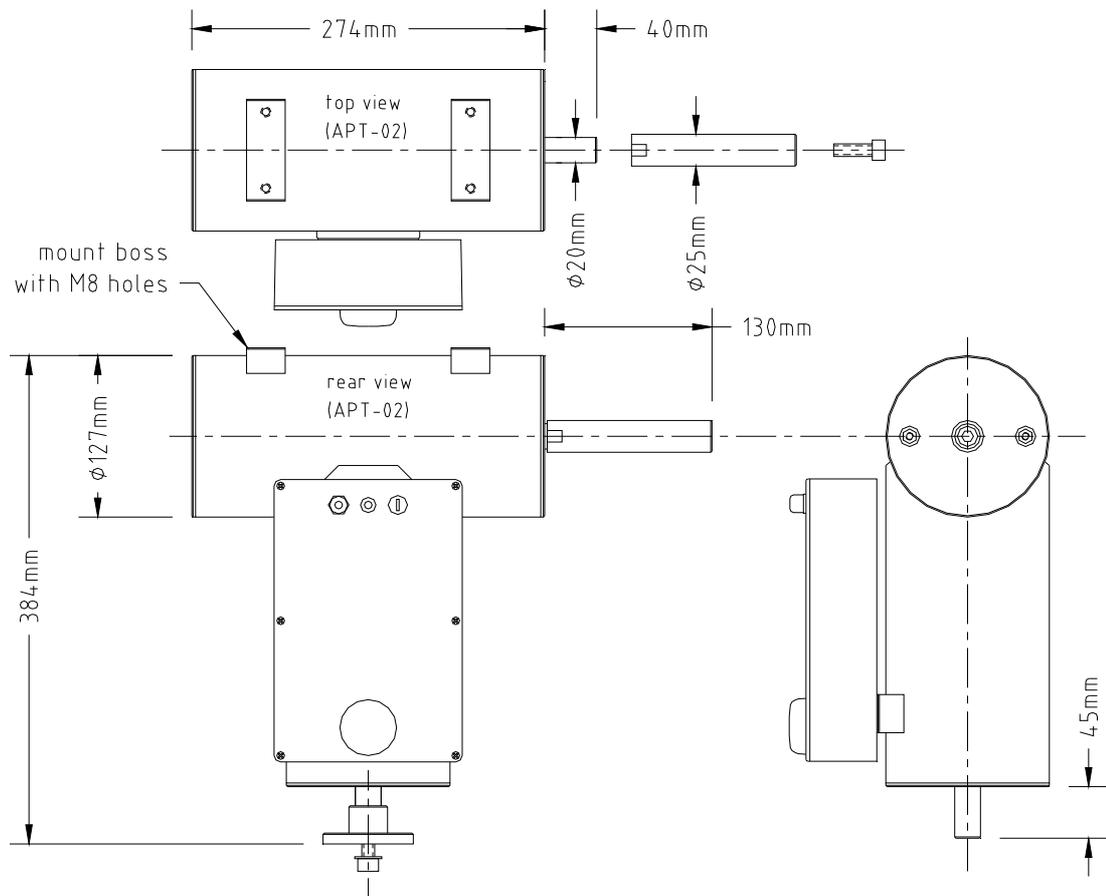
APPENDIX D. APT-02 General Specification

pointing resolution	0.02°
pointing accuracy ⁵	0.15°
angular velocity	9°/sec. (max.)
rotation	vertical/pan/azimuth axis = ±250° (0° = true North/South) horizontal/tilt/zenith axis = +100°, -15° (0° = horiz, 90° = vert)
torque (at 12VDC) ⁶	10Nm
payload	8kg balanced
drive mechanism	direct harmonic gearing, zero backlash
motor	stepping motor
horizontal axle	Ø25 x 130mm
axis position sensing	absolute, by rotation sensor
operating temperature	-20 to +50°C
power requirement	12V DC nominal (11-16VDC) <9W continuous
power lead	2-core, 6m
control method	in-built computer controller with GPS
user interface	status indicator LED internal USB port and RS232 port
calendar clock	automatic by GPS
Sealing	IP 65, all-weather
construction	aluminium & stainless steel
weight	10Kg
shipping size & weight	47 x 43 x 28cm; 12kg
standard configuration	Tracker Gearbox & Control Box, with single horizontal axle (Ø25mm)
recommended options	LP01 Levelling Plate (with spirit level) PM02 Pyrheliometer Mount
available options	LS01 Levelling Stand (with spirit level) PM04 Dual Pyrheliometer Mount Status Output Lead (see Appendix F)

⁵ valid for sun elevation > 5°, and for Tracker pan axis set vertical

⁶ at 11VDC the torque is reduced by 5%

APPENDIX E. APT-02 Dimensions



APPENDIX F. Status Output Lead, TTL or RS232

An optional Status Output lead is available in TTL type or RS232 type. This lead is factory fitted during manufacture.

The Status Output Lead is identified with a *yellow* marker sleeve.
 The 12VDC Power Lead has a black (or none) marker sleeve.

TTL Type Status Output Lead

This lead provides three TTL outputs which, in combination, show the same states as the Status Indicator light that is on the Tracker (see Appendix B). In the case of an unattended Tracker the TTL Status Outputs facilitate remote monitoring of Tracker behaviour.

Status priority	#	output 0	output 1	output 2	Status
0	-	Lo	Lo	Lo	no power
1	F1	Hi	Hi	Hi	hardware fault
2	W2	Lo	Hi	Hi	GPS warning
3	N2	Lo	Hi	Lo	automatic tracking
4	N1	Lo	Lo	Hi	start-up & GPS search

Lo = TTL output low (0V)
 Hi = TTL output high (5V)

The wire cores of the TTL Status Output Lead are:

- Black wire = status output 0
- White wire = status output 1
- Yellow wire = status output 2
- Green Wire = status output common

RS232 Type Status Output Lead

This lead provides access to a continuous RS232 stream of 26 internal Tracker control parameters, in CSV format, updated every second. This status output is not intended for the typical User; please contact Middleton Solar if you require further information.