SIDEREAL CLOCK SC110

HANDBOOK

AWR TECHNOLOGY

DUAL MODE SIDEREAL / UNIVERSAL TIME CLOCK

CONTENTS

These units comply with the European directives on Electro-Magnetic Compatibility for Domestic and Light Industrial equipment. (CE MARK). This unit may not be treated as household waste and should be disposed of at the appropriate collection point.

UNDER NO CIRCUMSTANCES REMOVE THE COVERS AS THERE COULD BE MAINS VOLTAGES PRESENT WHICH IS DANGEROUS.

SC110 Handbook 8003-96 Iss 3.0 February 2007 AWR Technology
The latest issue will be on our website www.awrtech.co.uk

FEATURES

* Dual mode display showing Sidereal Time or Universal Time. Two Independent time stores.

* 24 hour display of Hours, Minutes and Seconds.

* 0.8" high LCD digits with backlight switch for use in the dark.

* Microprocessor based with Quartz crystal accuracy.

* 12V DC Operation, PP3 battery back up.

* Ability to run off a 12V car battery.

* Time set (reasonably finger proof).

* Observatory style metronome ‘PIPS’.

Options include Mains operation, Increased accuracy, Electrical outputs.

INTRODUCTION

The Dual Mode Sidereal / Universal time Clock model SC110 from AWR Technology is designed for Astronomers to keep track of 'Star Time'. It runs faster than Greenwich Mean Time by about 3 minutes 56 seconds a day to complete an extra 24 hours in one year. This rate matches that of the Sidereal Heavens and so the time, once set, will show the Right Ascension of the object passing the observer's Meridian (due South).

This display of Sidereal Time is useful in knowing what is in the sky at any time by reference to star atlases; for setting drive systems in Equatorial telescopes; and for use in calculations, typically for converting coordinates of stars to horizon coordinates so that an Alt-Azimuth telescope can be pointed directly at an object. It is also very easy to predict rising times of objects and useful in locating planets in the daytime.

The clock is designed to be left running permanently and so will require very little re-setting. Over most of the UK mains interruptions are infrequent but battery back is included to keep the time running accurately. More useful is the ability to run the unit off a car battery and this is provided in the external terminals. A quartz crystal is used in preference to the mains as a reference frequency as the mains frequency wanders unacceptably through the day, dropping at periods of heavy load and speeding up at night.

OPERATING INSTRUCTIONS

Installation of SC110 with OPTION 4 – MAINS SUPPLY.

A mains plug top adapter is supplied to provide low voltage 12V DC at up to 400mA. If the unit is to be installed in an observatory then it is recommended that Circuit Breaker protection is provided for the mains supply to the whole observatory. If in doubt consult a qualified electrician.

Note the SC110 with OPT 4 does not require an EARTH wire as it is double insulated and tested in accordance with IEC 536 safety class II. A convenient plug top mains adapter is normally supplied for this option.

External Low Voltage Power Connection.

The 2.1mm power connector on the rear panel can be connected to a DC power pack, such as a car battery, with an output voltage in the range 12V to 16V at up to 20mA current drain. Connect the POSITIVE (+ve) lead to the centre pole and NEGATIVE (-ve) lead to the outside. The Clock and the Battery are protected if the wires are reversed.

Controls.

SET - FAST	Increments the hour display at one per second. The seconds display is also zeroed. (SET+FAST pressed together).
SET - SLOW	Increments the minute display at one per second with no hours rollover. The second display is zeroed at the instant of increment of the minute display. (SET+SLOW pressed together).
BACKLIGHT ( )	Toggles the backlight on or off to allow viewing the display at night time. Use sparingly if only the PP3 is powering the clock.
BUZZER ( )	Toggles the observatory style buzzer on or off to allow timing of events and durations.
MODE	Toggles the time display mode between Sidereal and Universal. Both times are maintained independently and are indicated as ':' for Universal and '.' for Sidereal.
FAST – SLOW	At power up (00:00:00) this fetches the times from LX200 compatible serial devices. (FAST+SLOW pressed together).
FAST – SLOW	When time stores are running, this sets Local Time to LX200 compatible serial devices. (FAST+SLOW pressed together).

Setting the Time.

The time display of the selected mode is set using the following procedure. Hold in the SET button and press either the FAST or the SLOW buttons. Pressing FAST advances the hour display at once per second. Pressing SLOW advances the minutes display at once per second. The seconds display is also zeroed at the instant the minutes count is incremented. Set up the hours first then the minutes. Accidental pressing of FAST or SLOW will not alter the time if SET is not pressed. The increment of the display takes place as soon as the button is pressed (FAST or SLOW). We suggest that the time is altered to read 1 minute before the required time then the minute is advanced using SLOW when 00 seconds are required.

Repeat this procedure for the other time mode.

Alternatively, if connected to LX200 compatible equipment that is running these times, press both FAST and SLOW together and the times will be fetched. The local time, sidereal time and GMT offset are required to get the correct UT display.

Power Interruptions.

On power up both time modes will show zero (00:00:00) and stay zero until the time set procedure is started. A reset to this will happen whenever the power source has been interrupted and the internal PP3 battery is not good. Both time modes will have to be set to completely set up the clock. The PP3 should be changed periodically to keep the clock running.

Buzzer.

The observatory style buzzer is a 'PIP' every second plus a longer 'PEEP' at the minute marker where the start of the sound is the seconds update. The seconds update of the mode selected is used to provide the buzzer update signal. The buzzer can be disabled or enabled by pressing the BUZZER ( ) switch. Accurate 1s GMT pips are present which ever time mode is selected.

EXT lamp.

Illuminates when external power is being used ie mains or 12V input. It goes out if battery alone is powering the clock. Use the backlight sparingly if the battery is powering the clock.

SERIAL Connection

A standard serial cable from an AWR or Meade LX200 style intelligent telescope (or compatible) connects to the 9 pin D connector on the rear. It can be connected and disconnected whilst powered with no damage to the clock. The unit operates RS232 at 9600,N,8,1 with no handshake although RTS is asserted to indicate it is present.

OPTIONS (IF FITTED)

OPT 1: Internal rechargeable NiMH battery instead if PP3 battery to allow for continuous availability of power. Useful if the clock relies on the PP3 power source frequently. Especially during transportation to remote observing sites. Will power the clock for at least 25 hours, or 10 hours if the oven is fitted.

OPT 2: Electrical output of the 1 Hz metronome control signal from the U.T. time store. This output is on opto-coupled signal and can be connected to other equipment safely without interference. The opto-switch starts to conduct at the beginning of the second and lasts for 0.16 seconds or 0.49 seconds at the minute pulse. Connection is via a

3.5mm Jack Socket on the rear panel.

OPT 3: Variable brightness backlight to allow setting according to the users conditions. Variable Control on the rear panel.

OPT 4: An external 'battery Eliminator' is supplied which plugs into the 12V DC input.

OPT 5: Improved temperature performance with a 5ppm crystal over the temperature range 0 deg C to 35 deg C. Reduces errors caused by fluctuating ambient temperature by approx 4 times.

OPT 6: Tape recorder output of the metronome signal. 800Hz signal of the pulse envelope, long or short, present all the time, always in synchronism with the UT clock. Connection is via 3.5mm Jack Socket on the rear panel.

OPT 7: Crystal OVEN oscillator to maintain absolute accuracy less than 5 seconds drift over 6 months. It can be operated over –5 deg C to +35 deg C with a temperature coefficient of 0.005ppm per degree C. The major sources of error are calibration and ageing of the crystal itself (approx 0.1ppm per month). Calibrated to +/- 0.05ppm. Recalibration is required to maintain accuracy. The crystals are selected to have a very low T.C at the oven temperature (about 40 deg C). This option requires a maximum of 130mA supply from 12V DC. OPTION 1 is advised if power interruptions are not to upset the crystal oven.

OPT 8: Output of user set FREQUENCY in the range 10.000 to 99.99 Hz. The set function is obtained by a third mode on the MODE key. When in this mode it will display the default frequency or the last set value. Adjust in the same way you adjust the time stores.

ACCURACY AND RECALIBRATION OF CLOCKS

The main accuracy errors are rate error and setting error. [N.B. ppm = parts per million]. Note that there are 86,400 seconds in a day so a 1 ppm setting rate error will give 1 second error over 12 days.

Setting Error

The user sets the clock according to reference. It is possible with practise to achieve setting of the AWR Clocks to another clock to within 0.2 seconds. If the other clock is from the radio or the British Telecom speaking clock (for U.T.) then it is tied very closely to internationally held time reference sources.

Sidereal Time setting has to be calculated and elsewhere in this Handbook there are details of this with various methods to achieve various accuracies.

Rate Error – SHORT TERM

Temperature fluctuations. The quartz crystal has a temperature coefficient and at 20 deg C this is approx -0.5ppm per degree C for a standard crystal with a total error of not more than +/-30ppm over the full temperature range. A much better crystal is available with a temperature coefficient at 20 deg C of -0.2ppm (OPTION 5) and with an overall error within +/- 5ppm over the range 0 to 35 degrees C.

The crystal oven option substantially reduces the temperature effect by keeping the crystal temperature fairly constant in spite of large changes in ambient temperature.

EXPECTED VARIATIONS WHEN TEMPERATURE CHANGES by 20 deg C

Standard Clock	1 second per day
OPTION 5	1 second in 4 days
OPTION 7	1 second in 120 days

- Voltage fluctuations. The oscillator circuit runs from a stabilised supply but if the external voltage drops below 9.5 Volts then the crystal will start slowing down. Above this value it is not affected. The battery also requires to be above 8.5 Volts.

Rate Error – LONG TERM

- The settability of the adjustment circuit at calibration. This is currently about 0.05ppm. It is possible that this setting will not be held due to vibration, drop or shock.

- Calibration error due to the accuracy of the calibration standard. The accuracy of the standard from AWR is about 0.05ppm. The resolution of the AWR standard is 0.02ppm. This is a Crystal Oven clock and runs as a transfer standard from the Telecom speaking clock to check on the frequency meter.

- Calibration error – the temperature at calibration. When the temperature at calibration is not 20 degrees C, compensation for the temperature error is performed. It is checked by heating up / cooling down the crystal.

- Ageing of the crystal – an inherent property, which can be measured. Low cost crystals age at about 1ppm in the first year. Very expensive crystals can age at better than 0.05ppm per year. The crystals in the oven option have reduced ageing rates.

The uncertainties add. Running the clocks for at least two days will check gross errors provided the ambient temperature does not fluctuate by more than 5 degrees.

RE-CALIBRATION PROCEDURE

Make sure that mains power is removed and the recalibration procedure is done with 12V DC supplied, as the lid has to be taken off. The following procedure applies to the standard clock or with option 5 fitted. Option 7 requires more accuracy and is best done by working out the error rate and compensating by adjustment accordingly.

The frequency counter timer should have a resolution of at least 0.5ppm. (1 digit in 2,000,000) The absolute accuracy of this instrument is not important if you know the clock error over a certain number of days. Measure the frequency and then adjust it by the error. If the clock is running fast then slow down the frequency. Short-term stability of 1 digit over 10 minutes is required.

The measurement point is the 200Hz signal on point ‘BP’ and the ground (the strap across the crystal). The variable capacitor adjusts the frequency. The total adjustment range is about 6ppm. As it leaves the factory the adjustment capacitor should be in the middle of the working range. If the absolute accuracy of the frequency meter is good then at this point can be adjusted to 200.00000Hz (or 5.0000000ms) when the crystal is at 20 deg C. 20 (50) digits correspond to 1ppm. Alternatively if it is known that the working temperature over the long term is something else then calibrate to this value at the working temperature.

DETERMINING SIDEREAL TIME

Setting up of Sidereal Time can be done by several different methods but the end result is the same. All tables and calculation methods tell the Sidereal Time at Greenwich (Longitude 0 degrees) i.e. Greenwich Sidereal Time (G.S.T.). The time should be set to Local Sidereal Time which is unique to the position of your observatory. Thus it is important to obtain the longitude of your observatory as it is used in several of these methods.

L.S.T. = G.S.T. - L

Where L is the longitude measured positively westwards from Greenwich. Convert degrees to angle expressed in hours, minutes and seconds. (15 degrees = 1 hour).

The accuracy required depends on what purpose the Sidereal Time is to be used for. If it is for locating objects within a medium power telescopic field then about 1/8th degree in angle is required, corresponding to a 30 second accuracy on Sidereal time.

Look up Table.

The table below gives the sidereal time throughout any year but it is accurate to +/- 3 minutes only. It has been compiled from a mean table from the Astronomical Ephemeris.

GREENWICH SIDEREAL TIME AT 00.00HRS

DAY	JAN	FEB	MAR	APR	MAY	JUN
1	6 41	8 44	10 34	12 36	14 35	16 37
6	7 01	9 03	10 54	12 56	14 54	16 57
11	7 21	9 23	11 14	13 16	15 14	17 16
16	7 41	9 43	11 33	13 36	15 34	17 36
21	8 00	10 03	11 53	13 55	15 53	17 56
26	8 20	10 22	12 13	14 15	16 13	18 15

DAY	JLY	AUG	SEP	OCT	NOV	DEC
1	18 35	20 37	22 40	0 38	2 40	4 38
6	18 55	20 57	22 59	0 58	3 00	4 58
11	19 15	21 17	23 19	1 17	3 20	5 18
16	19 34	21 36	23 39	1 37	3 39	5 37
21	19 54	21 56	23 58	1 57	3 59	5 57
26	20 14	22 16	0 18	2 16	4 19	6 17

Standard Stars.

If the telescope can be accurately set to run on the meridian, ie due North through the Zenith to due South, then when a standard star of known position transits in the telescope the clock should be adjusted to this value. This gives Local Sidereal Time directly.

Star	RA (1988.5)	DEC	Mag	1 yr PREC. (RA)
	h m s	o '		s
Alpha And (Alpheratz)	00:07:47	+29 02	2.06	+3.07
Beta Cet (Diphda)	00:43:01	-18 03	2.04	+2.94
Beta Per (Algol)	03:07:25	+40 55	2.12v	+3.84
Delta Ori (Mintaka)	05:31:25	-00 18	2.23	+3.07
Alpha CMi (Procyon)	07:38:42	+05 15	0.34	+3.07
Alpha Hya (Alphard)	09:27:01	-08 36	1.98	+2.88
Beta Leo (Denebola)	11:48:28	+14 38	2.14	+3.15
Alpha Vir (Spica)	13:24:35	-11 06	0.97	+3.15
Alpha Sco (Antares)	16:28:42	-26 24	0.96	+3.66
Alpha Oph (Rasalhague)	17:34:24	+12 34	2.08	+2.76
Alpha Aql (Altair)	19:50:13	+08 50	0.77	+2.88
Alpha Cyg (Deneb)	20:41:02	+45 14	1.25	+2.04

This method is not without its drawbacks as the position of a star changes with the passing of years and a correction must be added for Precession to maintain the accuracy. See Norton's Star Atlas & Reference Handbook. Use the value in the table above and multiply by the number of years since 1988.5

Annual Handbook.

In a publication such as the British Astronomical Association Handbook produced annually, there is a tabulation of Sidereal Time at Greenwich (0 degrees longitude) for 00:00hr every fifth day. There is also an interpolation table for days and parts of days. This will give an accuracy of +/- 3 seconds, sufficient for most uses.

Calculation Method 1.

Using a formula involving the number of days from January 0 and a table of constants (Sidereal Time at Jan 0.0) it can be computed to an accuracy of +/- 0.2 seconds. A correction must then be applied for the longitude.

G.S.T. = K + (n * d) / 3600

Where K is tabulated
n = 236.55536 seconds
d = number of days (including decimal parts of) since January 0.0

Year	K	Year	K	Year	K	Year	K
2007	6.618804	2010	6.636770	2013	6.654735	2016	6.606990
2008	6.602890	2011	6.620855	2014	6.638820	2017	6.656785
2009	6.652684	2012	6.604940	2015	6.622905	2018	6.640870

Note. The longitude correction must be better than 0.1 seconds accuracy corresponding to knowing where your observatory is to the nearest 33 yards (at latitude 50 degrees).

Calculation Method 2.

This method involves calculation like method 1 but the constant is computed first. Again it must be corrected for longitude. See Practical Astronomy with your Calculator for the details.

References.

1) Norton's Star Atlas & Reference Handbook.
General Sidereal time look up table Setting up a telescope Precession Background information
2) Practical Astronomy with your Calculator - P Duffett-Smith
Calculation methods 1, 2 and Coordinate conversion
3) British Astronomical Association Handbook (Annual)
Annual positions of bright stars Sidereal time every fifth day

USING SIDEREAL TIME

Visibility of objects.

For any given latitude any object will be above the horizon for a given time. The time from horizon to culmination on the meridian is called the Semi-Diurnal Arc and is tabulated opposite for various declinations and latitudes. Pick out the nearest that matches the object/your latitude and this will tell you the range of Right Ascensions that are visible when added/subtracted from the Sidereal Time shown. A realistic horizon of +5 degrees in altitude is used. This table works for northern and southern latitudes.

TABLE OF SEMI DIURNAL ARCS

Dec	NORTHERN LATITUDES				HORIZON = +5 DEGREES			
	35	45	50	52	54	56	58	60
50	8:47	11:59	0:00	0:00	0:00	0:00	0:00	0:00
45	8:13	9:42	11:59	0:00	0:00	0:00	0:00	0:00
40	7:46	8:50	9:41	10:11	10:56	0:00	0:00	0:00
35	7:24	8:13	8:47	9:05	9:26	9:51	10:27	11:59
30	7:05	7:43	8:08	8:20	8:34	8:50	9:08	9:32
25	6:48	7:17	7:35	7:44	7:54	8:05	8:17	8:31
20	6:32	6:53	7:07	7:13	7:20	7:27	7:36	7:45
15	6:17	6:32	6:41	6:45	6:49	6:54	6:59	7:05
10	6:03	6:11	6:16	6:18	6:21	6:23	6:26	6:29
5	5:49	5:51	5:52	5:53	5:53	5:53	5:54	5:54
0	5:35	5:31	5:28	5:27	5:25	5:24	5:22	5:19
-5	5:21	5:11	5:04	5:01	4:57	4:53	4:48	4:43
-10	5:06	4:49	4:38	4:33	4:27	4:20	4:13	4:04
-15	4:50	4:26	4:10	4:02	3:54	3:44	3:32	3:19
-20	4:33	4:01	3:38	3:27	3:15	3:00	2:43	2:21
-25	4:14	3:31	3:00	2:44	2:25	2:01	1:27	0:00
-30	3:52	2:55	2:09	1:42	1:00	0:00	0:00	0:00
-35	3:26	2:06	0:00	0:00	0:00	0:00	0:00	0:00
-40	2:53	0:00	0:00	0:00	0:00	0:00	0:00	0:00

For SOUTHERN LATITUDES reverse the Declination sign

Rising Time.

For a particular declination look up the semi-diurnal arc. Subtract this from the object's Right Ascension to obtain the sidereal time at which the object will be rising. A glance at the clock will show how much longer to wait.

Use with an Alt-Azimuth telescope mounting.

Using an application of spherical triangles to transform coordinate systems you can adjust the Right Ascension, Declination of an object to horizon coordinates of Altitude and Azimuth using the value of Sidereal time. This makes it easy to set up an Alt-Azimuth telescope when fitted with fixed setting circles for altitude and azimuth.

For an object of Right Ascension R, Declination d, azimuth A, Altitude a with the observer at latitude lat:

1) Hour Angle H = L.S.T. - R
2) Convert to degrees H = H * 15
3) Altitude sin a = sin d sin lat + cos d cos lat cos H
4) Azimuth cos A' = (sin d - sin lat sin a)/(cos lat cos a)

If the value of sin H is positive the true azimuth is 360 - A'
else true azimuth = A'

Use with equatorially mounted telescopes.

For setting up equatorial telescopes with setting circles two methods can be used for driven and non-driven polar axes:

1) For driven polar axis set the central meridian on the Sidereal circle to the time shown on the Sidereal Clock, then switch on the drive.

2) For non-driven polar axis use a fixed setting circle on this axis calibrated in hours and minutes and fix 00:00hr on the central meridian ie due south. To find the position of an object it is necessary to calculate the hour angle of the object by reference to its catalogued position and the Sidereal Time shown. The telescope can then be set at this hour angle.

SPECIFICATION: MODEL SC110 (Mk 3)

Calibration accuracy	+/- 0.05ppm at 20 deg C
Temperature stability	+/- 30ppm over range -10 to 60 deg C
	+/- 5ppm over range 10 to 30 deg C

Deviation between Sidereal and Universal time . . . . 1.89s per year
DC Input: 12V to 16V at 20mA.
Typical current draw with no lamps illuminated 7mA at 12V DC
Battery back-up: PP3 alkaline type recommended. It is only in operation when no other power source connected. If used infrequently then replace about every 3 years. This can be done with mains or 12V power supplied so the clock will not have a power cut when the battery is changed.
Power consumption 1 Watt.
Size: 205 x 80 x 140mm
Weight: 0.5kg

UNDER NO CIRCUMSTANCES REMOVE THE COVERS AS THERE COULD BE MAINS VOLTAGES PRESENT WHICH IS DANGEROUS.

GUARANTEE & SERVICE

The SC110 SIDEREAL CLOCK is guaranteed for 1 year from date of purchase against faulty workmanship and materials only. CAUTION: There are no user serviceable parts within the clock. If the seals are broken then the guarantee is invalidated. Service can be obtained from AWR Technology, The Old Bakehouse, Albert Road, DEAL, Kent CT14 9RD. Tel 01304-365918. Please ring before returning goods.

DATE OF PURCHASE . . . .

SERIAL NUMBER . . . .

Designed and manufactured in the UK by AWR Technology.
SC110 Handbook Issue 8003-96 Iss 3.0 February 2007 copyright AWR Technology