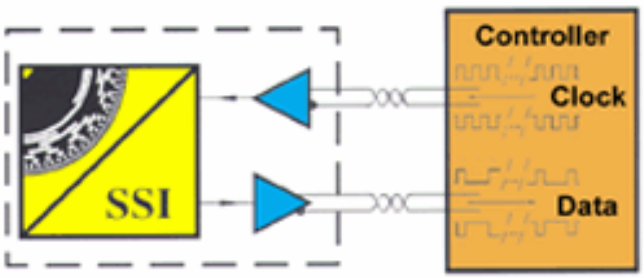
WHT AZ/ALT absolute encoders replacement:

Introduction:

The absolute encoding of the WHT Azimuth and Altitude is done with an assembly of two encoders and two synchro's mounted in one enclosure. This assembly is situated at the azimuth main gear and drive, accessible through the small tunnel from the bull ring.
Both encoders are manufactured by BEI. The coarse is an 8-bit type: 5V219 BGL, and the fine is a 16-bit type: 5V682 TBG. The whole absolute encoder / synchro assembly was build by: The Reliance Gear Co. in 1982.
The Azimuth fine encoder has been out of action for some years now, due to an accident, which made the encoder unserviceable, and has been replaced by a solid shaft. Replacement of the encoder has been looked into in the past, but replacement by BEI was considered too expensive. The coarse encoder has been electrically disconnected, but is still in place in the assembly. Initial position finding of the telescope was always done at startup of the TCS, copying the value of the absolute encoders to the incremental register. Telescope tracking is always done with the incremental encoders. Due to this failure of the absolute encoder, initial position finding is done zero setting the telescope by a target at a well defined position.

Replacement encoders:
For the 16 bit fine encoder, I´ve selected the AWG102/EAS57 absolute encoder from **INDUcoder.** This is a single turn robust encoder with through shaft, SSI data output. SSI stands for Synchronous Serial Interface and was designed for use with absolute encoders. A number of manufacturers of PLC's and intelligent controllers provide for SSI which is now an industry standard.



Picture 1: Principle operations of a SSI encoder:

The data-sheet can be dowloaded here:

Data sheet 16-bit ABS encoder AWG102

For the 8-bit course encoder, I've selected the EAS57 SSI absolute encoder also from **INDUcoder.** This encoder is also a single turn encoder with SSI data output. The minimum resolution of this encoder is 12-bit, therefore it has to be scaled down with a programmable parameter in the display module MOD 14-3.

Data sheet 8-bit ABS encoder EA57

Because of the SSI-output an additional interface module is needed, to convert from SSI serial to parallel binary data, needed for CAMAC. This is done with the SSI display module MOD 14-3.

Data sheet MOD14 display unit

To use the SSI serial standard has several advantages:

1. The signals form the encoder are already RS485 standard, so no additional line drivers are needed.
2. Irrespective of the encoder resolution, only 4 wires per encoder are needed to send the signals to the control room.
3. Easy electrical isolation between encoder and controller.
4. The display modules in the control room provide an extra diagnostic tool on the behavior of the encoders in respect to telescope movement.

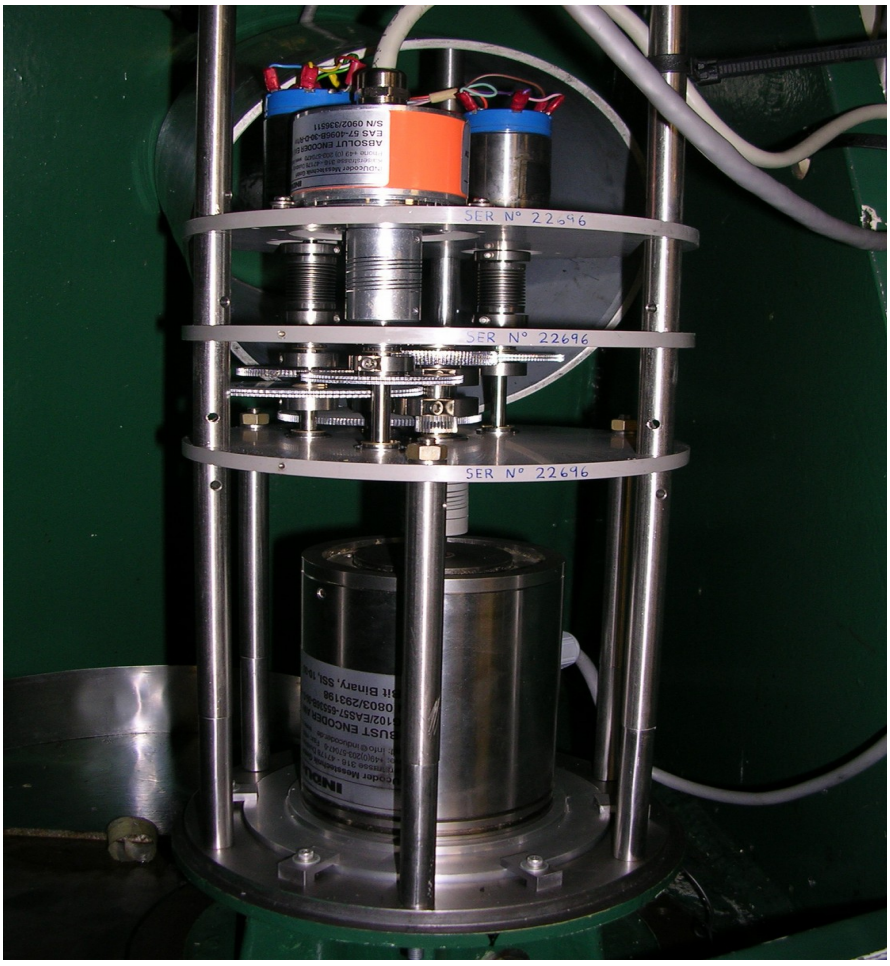
Mechanical work:
To fit the 16 bit fine encoder the assembly rods had to be extended, as the new encoder was slightly longer. An adapter flange was needed for the course encoder.

8-bit course encoder

flexible couplings

gear wheels

16-bit fine encoder



Picture 2: Assembly of the Az absolute encoders + synchros

Afbeelding 3: Absolute encoder display boxes in control room

Programming of Parameters of the MOD 14-3 display unit:

You can enable this mode by pressing and holding the **+1** button and press the ← button 5 times followed by pressing the **P** button.
Each of the parameter can be chosen by pressing the **+1** or the → button.
In order to edit a parameter, you must press the ← button, after that a digit will flash, the value of this digit can then be changed pressing the **+1** button. By pressing the the ← you can choose the next digit. The input of the digit can be confirmed pressing the → button. By simultaneous pressing the ← and → button the value will not be stored.
By pushing the **P** button you will return to the selection of parameters.
By pushing the **P** button again you will return to standard operation mode.

Most of the parameters are default, the only ones which are different are: PAR 03, 04 and 28

The multiplier factor, PAR 03 for the coarse encoder has been calculated, to allow a 12 bit encoder and only use 8 bits. The factor therefore is 255 : 4095 = 0.062271.

For more information on programming, the complete MOD14 manual can be downloaded here

Parameter:	Short description:	Coarse Encoder display:	Fine Encoder display:
PAR 01	Zero offset	0	0
PAR 02	SSI interface	1.0.0	1.0.0
PAR 03	Multiplier	0.062271	1.000000
PAR 04	Number of relevant bits	12.00	12.04
PAR 05	Control inputs STORE	0	1
PAR 06	Decimal point	0	0
PAR 07	Adjustment value	0	0
PAR 08	Control inputs	0.1	0.1
PAR 09	Outputs 1 … 4	1.1.1.1	1.1.1.1
PAR 10	Hysteresis	0	0
PAR 11	Pulse length	0.00	0.00
PAR 12	Adjustment mode	0	0
PAR 13	SSI-ERROR	1	1
PAR 14	RS485 parameters	0.6.0.0	0.6.0.0
PAR 15	Assignment of preset values	00.00.00.00	00.00.00.00
PAR 16	Umin Voltage output	- 10.000	- 10.000
PAR 17	Umax Voltage output	10.000	10.000
PAR 18	Position Umin	- 10000	- 10000
PAR 19	Position Umax	10000	10000
PAR 20	Imin Current output	- 20.000	- 20.000
PAR 21	Imax Current output	20.000	20.000
PAR 22	Position Imin	- 20000	- 20000
PAR 23	Position Imax	20000	20000
PAR 24	Display Multiplier	0	0
PAR 25	Ind. of data on RS485	0	0
PAR 26	Data format parallel input	0.0.0.0.00	0.0.0.0.00
PAR 27	Activation ext. preset	0.0.0.0.0.0.0.0	0.0.0.0.0.0.0.0
PAR 28	Data format parallel output	1.0.0.0	1.0.0.0
PAR 29	Time out RS485 int.	0.0	0.0

PAR 30	Reset time out error RS485	0	0

Cable 181 (Azimuth)

Connector	Signal name:	Wire colour	Connector
SK 3 Enc. Box E Cable TEJ2			
A	Data + Fine encoder	GN	Sk1-N
B	Data – Fine encoder	YE	Sk1-O
C	Clock + Fine encoder	OR	Sk1-P
D	Clock – Fine encoder	BN	Sk1-Q
E	Data + Coarse encoder	RD	Sk4-N
F	Data – Coarse encoder	BL	Sk4-O
G	Clock + Coarse encoder	VT	Sk4-P
H	Clock – Coarse encoder	WH	Sk4-Q
J			
K			
L			
M			
N			

Cable 172 (Altitude)

Connector	Signal name:	Wire colour	Connector
SK 3 Enc. Box E Cable TDJ2			
A	Data + Fine encoder	GN	Sk1-N
B	Data – Fine encoder	YE	Sk1-O
C	Clock + Fine encoder	OR	Sk1-P
D	Clock – Fine encoder	BN	Sk1-Q
E	Data + Coarse encoder	RD	Sk4-N
F	Data – Coarse encoder	BL	Sk4-O
G	Clock + Coarse encoder	VT	Sk4-P
H	Clock – Coarse encoder	WH	Sk4-Q
J			
K			
L			
M			
N			

AZ/ALT display rack to CAMAC PR2403 input module

Connector	Signal name:	Connector
Hughes WSS0058 P08 BN 527 WK 33 83		37W D-connector Male
2	Bit 1	1
4	Bit 2	2
6	Bit 3	3
8	Bit 4	4
10	Bit 5	5
12	Bit 6	6
14	Bit 7	7
16	Bit 8	8
18	Bit 9	9
20	Bit 10	10
22	Bit 11	11
24	Bit 12	12
26	Bit 13	13
28	Bit 14	14
30	Bit 15	15
32	Bit 16	16
34	Bit 17	17
36	Bit 18	18
38	Bit 19	19
40	Bit 20	20
42	Bit 21	21
44	Bit 22	22
46	Bit 23	23
48	Bit 24	24
	nc	25
All Odd pins	Ground	26
50	Strobe	35

Gear ratio and resolution:

Some background information of the absolute encoder system.
See drawning nr: 1017A1 from Reliance Gear Co. in the grey AD folder of the WHT documentation.
The primary gear on both Azimuth and Altitude has 896 teeth, the gear wheel on the encoder assembly has 22 teeth, so the gear ratio is 896/22 = **40.727** . This means the that the fine encoder turns 40.727 times on one turn of 360 degrees of the telescope.
So the resolution of the fine encoder is:

(360 x 3600) / (40.727 x 2^16) = **0.486 arc sec/bit**

The telescope gear ratio and the ratio of the encoder assemblies internal gears are matched:

T/S gear		1st Enc. Gear		2nd Enc. Gear
896/22	x	33/180	x	15/112 = **1**

The ratio matching gives thus one revolution of the telescope axis to be equal to coarse encoder and the coarse synchro range providing 360° encoding of the axis.
Therefore the resolution of the coarse encoder is:

360 / 2^8 = **1.40625 degrees/bit**

The coarse encoder LSB will therefore increment on fractions of complete turns of the fine encoder, ie. 40.727 turns of the fine encoder will equal 2^8 counts of the coarse encoder, so:

1 LSB (Coarse encoder) = 40.727 / 2^8
= 0.15909 turns of the fine encoder
or 0.15909 x 2^16 = **10420.12 bits**

also **Count range** = 40.727 * 2 ^16
= **2669084.67 bits** (ie < 2^22)

Therefore, although the data is transmitted in 24 bit format to CAMAC ie. 2^16 + 2^8, its actual range is less then 2^22 bits.

Renee J. Pit, 15/11/2010

Updated: 20/02/2015, changed hyperlinks refering to data sheets to local.