Object: **"NAVIGATOR-1"**
POSITION SENSORS AND ENCODER ON ASTRONOMICAL TELESCOPES

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processed: **Jan Grecner**

title: **Pictures of CONSTRUCTION**
OF POSITION SENSORS AND ENCODER ON TELESCOPE.

1. INTRODUCTION

front-page represents whole system strings wiring:

- Astronomical telescopes - refractor on polar (or azimuthal) mount in our case type GS-300,
- two incremental sensors fixed on mount for scanning a axe Ra and axe Dec declination,
- outcome of incremental sensors are fetched to the electronic modulus NAVIGATOR-1,
- outcome modulus NAVIGATOR-1 is connected to port COMX for serial data transmission to /from PC.

Let us look in detail on single string links starting with mount armament IRC sensor and electronics.

2. OPTOELECTRONIC – INCREMENTAL SENSORS

In arrangement NAVIGATOR-1 usage of **two various types** of incremental sensors is possible:

- ROTARY INCREMENTAL SENSOR OF POSITION - mark IRC 122 - classical type used e.g. . in NC machine. On axes IRC necessity lead over speed sensing axes by mechanical transmission. Sense organ IRC has several disadvantages: cost (the cheapest applicable costs. 2000,- Kcz/piece), weighs upon moderate, has long delivery times and is delicate on mechanical axes straining and on shaking.
- INCREMENTAL SENSOR FROM AN OPTICAL PC MOUSE - further denotation: IRC-M. Optical mouse for PC includes optical-electronic part, which works on the principle of rotary incremental sensor. It can be used for scan position of astronomical telescopes use without any compromise in quality. Benefits: IRC-M is much more resistant, does not contain a movable part (rotary) and does not require mechanical transmission. A plate is fixed On sensing axes, its perimeter designates number of pulses on sensor IRC-M. IRC-M transmit ray onto the plate surface . IRC-M receives and evaluates the reflected beam and then it is processed on the electronic modulus NAVIGATOR-1. Optical mice price is up to 600,- Kc (partly defective optical mouse is often regarded to be unreparable..).

2.1 INCREMENTAL ROTARY SENSOR - type IRC 122

Fixation and position of sensors IRC 122 and their (almost unbearable) size are evident from photos. The size of the sensors is apparently startling (they are cs. production from 1980s). But according to pragmatic thinking:: where a big sensor (which I have),can be placed a smaller one can be placed as well (when I have it).

Figure. 1. (jpg) general view of polar mount GS-300 with IRC 122

IRC from older cz production. IRC 122 (in this case type GS-300, but any mount can be concerned) are interfaced to axes Ra and De polar mount with the help of transmission 1:1 created by accurately turning work band-wheels and strap from ex-service floppy disc units. The radius was chosen as big as possible, to increase the angle of the strap around band-wheels and so prevent the danger of slipping. The band wheels were modified on needed longitude perimeter so, that with chamfer cut jumper and second glue were stuck together with the overlap cca. 10 mm at the place of conglutination.

Figure. 2. (jpg)
view of mechanical transmission of axes Ra and IRC 122

Figure. 3. (jpg)
close-up view of axes De on IRC strap transmission and IRC fixation to mount with the help of two lengthwise steel mouldings Al profile with IRC fixed directly on them.

Note: Design documentation concerning to fixation IRC and strap - transmission wasn't processed because

- used type of cz production. "IRC-122" are not perspective already and a new IRC for professional purposes is quite expensive,

- there are various suitable types of cz IRC from different foreign producer (HP, US-DIGITAL ..),

- for every atypical mount it is necessary to solve the fixation and transmission of IRC distributively.

2.2 INCREMENTAL SENSOR TYPE IRC-M (IRC-Mouse)

By observation practice I managed to check up and prove by measurement fitness of using **IRC-M** optoelectronics for ours purposes - results are surprisingly excellent. It is well known that , the mouse disturbances are mostly due to fast action switch - and these we don't need. Hence all partly defective optical mice going mostly to the groats, are worth salvages for our purposes. Prices of new optical mice are more than 800 Kc, but right in maintenance organization we can sometimes get partly functional optical mice cheaper .. Mice using IC of equivalent type H2000 from different producers will obviously be applicable (this type IC is used e.g. . in optical mice for PC Genius, Logitech and DEXXA). Everything else is clear from the series of photos:

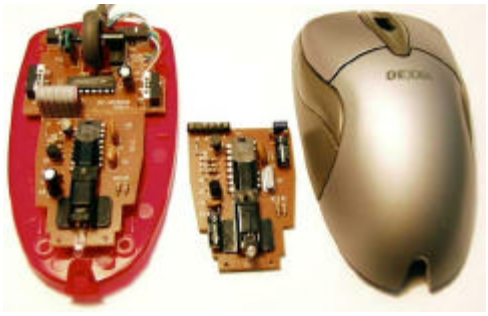


Figure. 4. a.

View of optical mouse for PC performance DEXXA with five buttons with microswitch and scrollwheel. Microswitches are reputedly the very most frequent source of error and reason for imposition of such disabled mouse. Repaired mice, are sometimes offered in second-hand shops at half price below 600.- Kcz. **On the left** a mouse with dismantled canopy. **P.C. placed in the middle** of the picture is dismantled optical-electronic mice modified for the purposes IRC-M sensor.

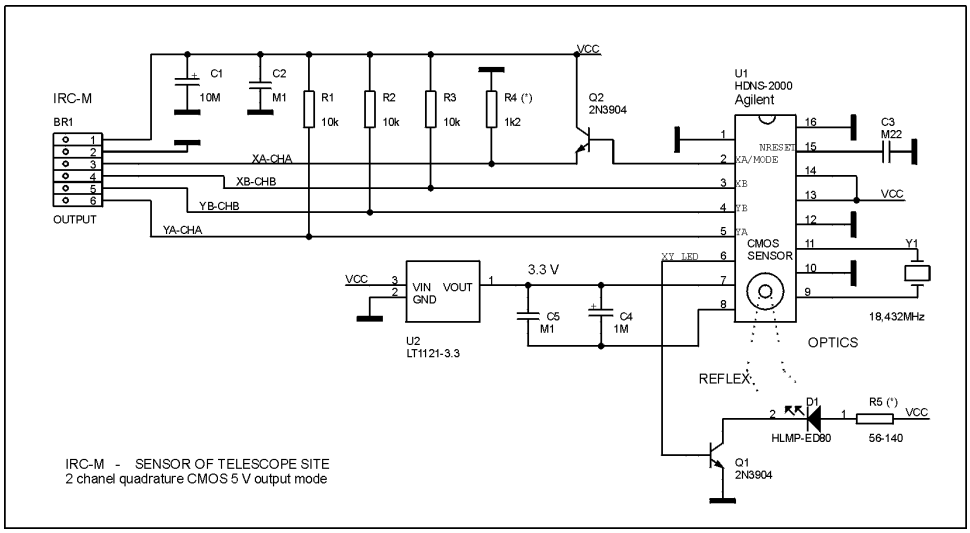


Figure. 4. b. You can look at the diagram using optical-electronic parts of the mice. You will be surprised at the simplicity - but the price? Is it a very attractive product .. in particular for producers /vendors and astronomer...

Figure. 5.
IRC-M was tested in laboratory conditions with arrangement NAVIGATOR-1 in protocol OURANOS. (By click to increase photo 4x)

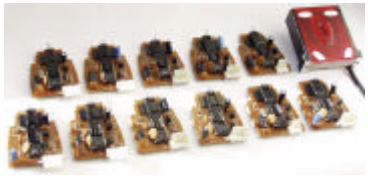
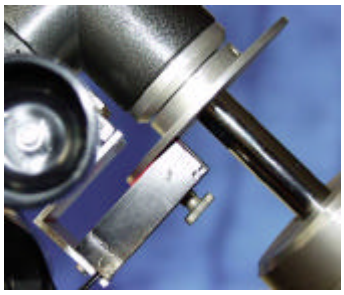
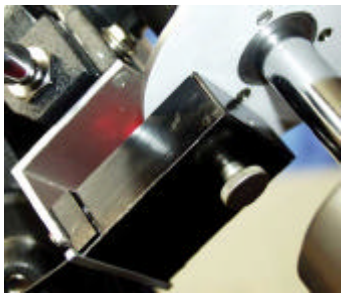


Fig.6.
IRC-M sensor components - lot of 12 sensors





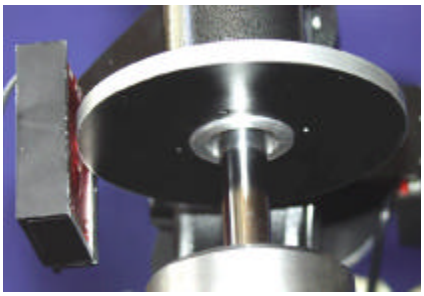


Figure. 7. a, b. Sensor, parts their placing and fixation on mount GS 300. On Al disc surface of 100 mm radius fixed on axes DE, white matt office impregnated paper is stuck , A Screw with denticulated head on back wall of sensor IRC-M adjusts position of the sensor to the disc, i. e.. radius size -of scan circle and its corresponding number pulse. Number of pulses/360° must be identical with arithmetic pulse defined in SW single-chip MCU-CITAC in modulus NAVIGATOR-1.

Figure. 7. c. Sensors to circumference of Al discs

Figure. 7. d. General view of mount

Adjustment in electronic parts using mice performance DEXXA, are minimum: Addition of two filter capacitors in circuit voltage +5V and addition of bleeder in emitter check out of transistor are needed. Functionality and accuracy of IRC-M in our application was thoroughly verified , sensor IRC-M of the number of 4600 graduation /360° was installed on axes Dec on telescope and replaced type IRC 122.

For completeness it is necessary to remark, that **in electronic modulus NAVIGATOR-1 there are no changes of SW in MCU nor in HW by virtue of using IRC-M instead of rotary IRC.**

Figure. 8. a,b (jpg)
INCREMENTAL SENSOR item IRC-M **from OPTICAL MICE PC** (66x24x47 mm)

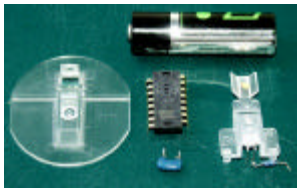


Figure. 9. a, b, c.
INCREMENTAL SENSOR on the basis of IC HDNS-2000 of Agilent Tec
a: printed circuit, **b**: optic parts **c:** encoder assembled
IC chip HDNS-2000 and the optic parts remove from the mouse faulty of manufacturer LOGITECH or GENIUS in an emergency of mouse DEXXA

3. MODULUS ELECTRONICS ENCODER: NAVIGATOR-1

Now we can proceed to the next string single: to modulus NAVIGATOR-1 containing electronics.
View on the diagram of modulus electronics NAVIGATOR-1

Placement of semiconductor parts counterclockwise copies data stream:
- on the right lateral panel are placed two connectors for interface IRC and connector +12V
- separating and forming IC 74HCT14 is placed behind connector
- MCU AT90S1200 fulfills functions of detection and signal processing from sensor
- MCU AT89C2051 functions as quantification of impulse and prepares data for serial transmission
- IO MAX232 are set near front P.C. , ensures data transmission for serial port COMX
- on left lateral panel is placed 9-the pi-new connector type CANON for COMX
- in the left bottom corner P.C. green light diode LED indicates +12V, red one data transmission to the PC

Modulus electronics NAVIGATOR-1 is from economic reasons engineered on unilateral printed circuit (PC) proportion 100x60 mm with minimize number (two) connections on the upper side parts.

Figure. 10. (jpg)
Unilateral P.C. 100x60 mm for modulus NAVIGATOR-1

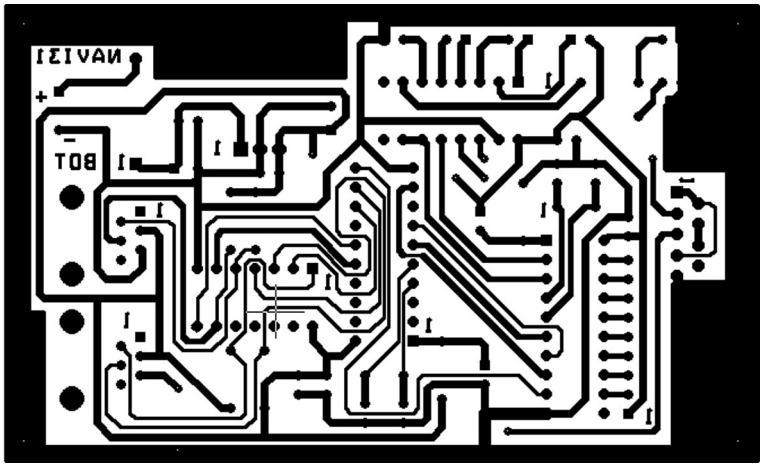


Figure. 11.
Mask P.C. on tracing paper.

Transmission ground on portfolio PC was fulfilled by application and exposition of photo-sensitive layer, its developing and subsequent etching of PC. Chemical products for prototype (home made) production P.C. were purchased in vender electronic.

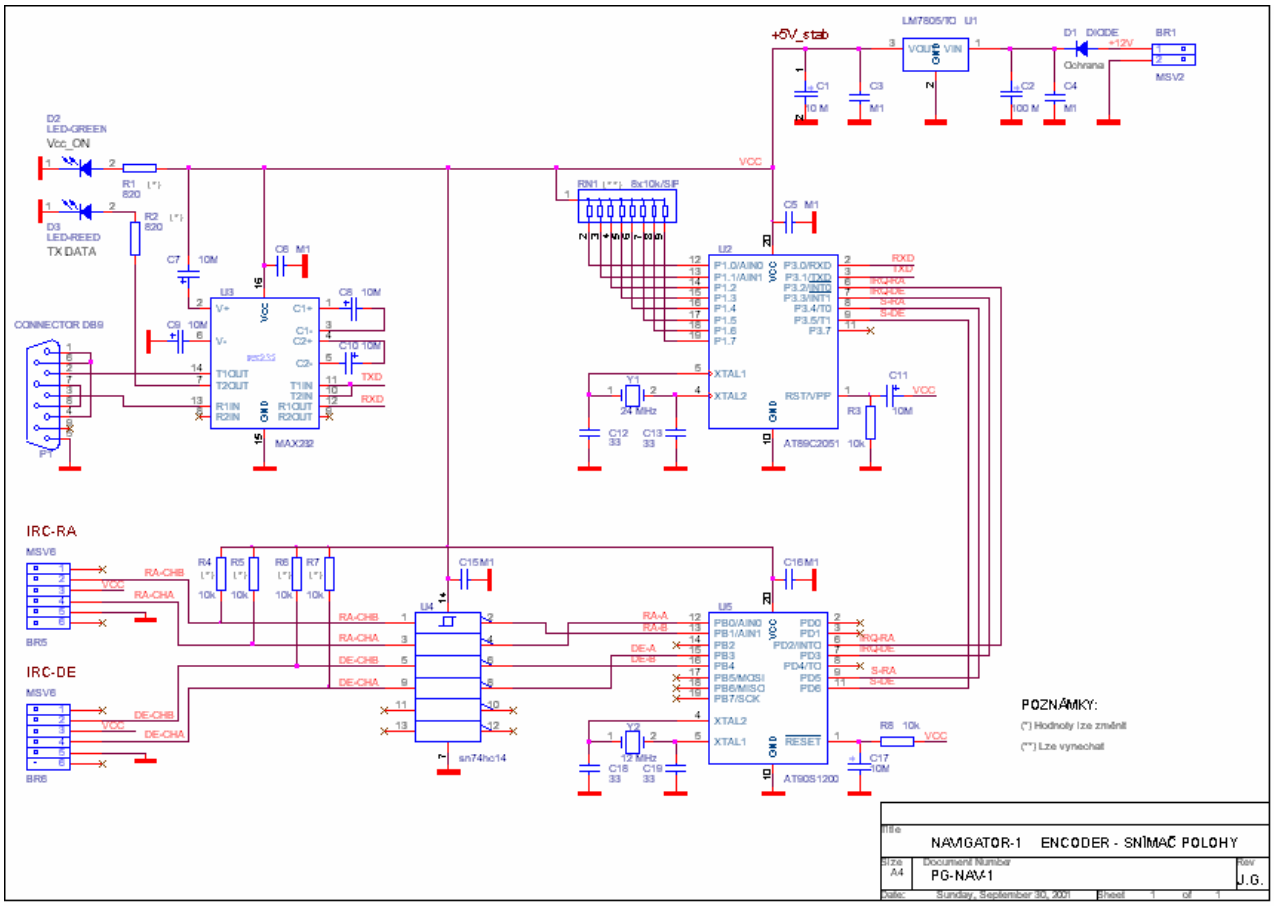


Figure. 12 (169 kB pcx) – Circuit diagram of the NAVIGATOR-1 – for forward use diagram.zip

Figure. 13. (jpg)
Prototype P.C. board two-sided P.C. 100x30 mm is universal and is used for testing and competitive examinations SW for arrangement with single-chip "small" MCU type AT90S1200 and AT89C2051.

However, the way to pilot led through functional design, on which both the structural design, and software of both single-chip microcomputers was check.

Figure. 14. (jpg) **NAVIGATOR-1**
To complete the picture, this time perpendicular views of modulus NAVIGATOR-1. P.C. was designed on minimum number wire-bound connection. Cables from IRC (or IRC-M) will be connected to the drawers input 6 (ev. 4) polar "phone" connectors.

Specification card containing updated parts prices (in Kcz) is in the last chapter

4. EXECUTIVE SUPERVISORY PROGRAM IN PC

At the end of the string there is PC, which in circumscribed system holding office:

- accepts and displays data from IRC (IRC-M) couple and data-preprocessing from modulus NAVIGATOR-1
- transmits instructions to modulus NAVIGATOR-1 to its activities, and accepts backward report
- exploits and processes data of celestial objects concentrated in PC data bank
- controls motor drive of telescope by protocol MEADE LX200 (198 kB *. htm) or LX200.zip
- allows exact polar and alto-azimuthal mount adjustment and astronomical laying of telescope on two objects in below displayed window Digital encoders

NAVIGATOR-1 has been tested and work under software **free SKY CHARTS version 2.74.**

The brief presentation of the main functions doesn't mention all possibilities of executive supervisory program **SKY CHARTS version 2.74** (original title in French is **CARTES DU CIEL from Patrick CHEVALLEY**), Czech version is available. The program has other functions, for activity sensor position of astronomical telescope, for drive steerage of Astronomical telescope and for object identification, yet very well worked out, interesting and useful. You will be persuaded about it on the basis of your own experience .

Good news directly from the source is, **beta version 2.74** of the presented program is the last trial version – till end of the year- final version should be released, for which manual is being created at present.

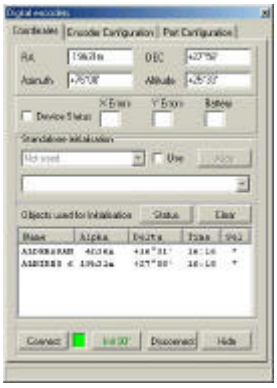


Figure. 15.
Window Digital encoders for initialization of Astronomical telescopes sensor position.

5. PRICES OF PARTS FOR NAVIGATOR-1 (1 EUR = cca 30 KCz)

MATERIÁLOVÝ LIST PRO MODUL			**NAVIGATOR-1**	\A-RS-CE2		DATUM	05.10.01
ř.	Počet	Value	Ref	Název	Cena jedn.	Cena celk.	Katal GES
1	1	BR1	MSV2 12 V	konekt HEBL21	18,30	18,30	
2	2	BR5,BR6	MVS6	konekt IRC R-D	24,50	49,00	
3	1	P1	DB9	COM1 female	28,30	28,30	
4	7	C1,C7,C8,C9,C10,C11,C17	10 M	Elyt-rad-63V	1,00	7,00	
5	1	C2	100 M	Elyt-rad-63V	4,00	4,00	
6	6	C3,C4,C5,C6,C15,C16	M1	Ker-63V	2,00	12,00	
7	4	C12,C13,C18,C19	33	Ker-500V	1,00	4,00	
8	2	R1,R2	820	Rez.min 0,4W	1,00	2,00	
9	1	D1	Dioda	Ochrana	1,00	1,00	
10	2	D2,D3	LED	Indikace	2,00	4,00	
11	1	RN1	8x10k/SIP	Rez.síť 8x5k6	3,50	3,50	
12	6	R1	10k	Rez.min 0,4W	1,00	6,00	
13	1	U1	LM7805/TO	Stab. +5V	12,00	12,00	
14	1	U4	74HCT14	Log.obvody	7,25	7,25	
15	1	U2	AT89C2051	MCU čitač	85,00	85,00	
16	1	U5	AT90S1200	MCU snímač	94,20	94,20	
17	1	Y1	24 MHz	krystal	15,90	15,90	
18	1	Y2	12 MHz	krystal	13,40	13,40	
19	1	U3	MAX232	Port COM	70,00	70,00	
						0,00	
	41	Cena součástek VC		Kč		436,85	
	41	Cena součástek vč. DPH 22%		Kč		532,96	
	1	Plošný spoj jednostranný bez / včetně DPH 22%		Kč	40,00	48,80	
		MATERIÁLOVÉ NÁKLADY MODULU	**NAVIGATOR-1**	Kč		581,76	celkem

Specification card of modulus NAVIGATOR-01 parts with presentation of individual and total prices.
Note: INCREMENTAL SENSOR items (IRC resp. IRC-M) are not stated in the specification

6. DOWNLOAD

Packet of SW for MCU in NAVIGATOR-1: **irc-sw-web.zip** contains the programs available

CITAC-26.hex
SNIM-31.hex for the case 1:1 of mechanical drive (encodeur on axis)

A lot of success in your construction work - let the circumscribed arrangement bring you savings of time and much use at sighting.

Jan Grecner Dipl.Ing.
Prague, October 21 2001 /Juin 20 2002

RETURN