



DATA SHEET
"RTA-ARXXX-3G" SMART DEFLECTOR™

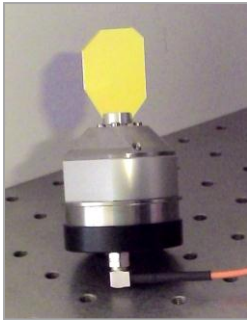
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1 SMART DEFLECTOR™

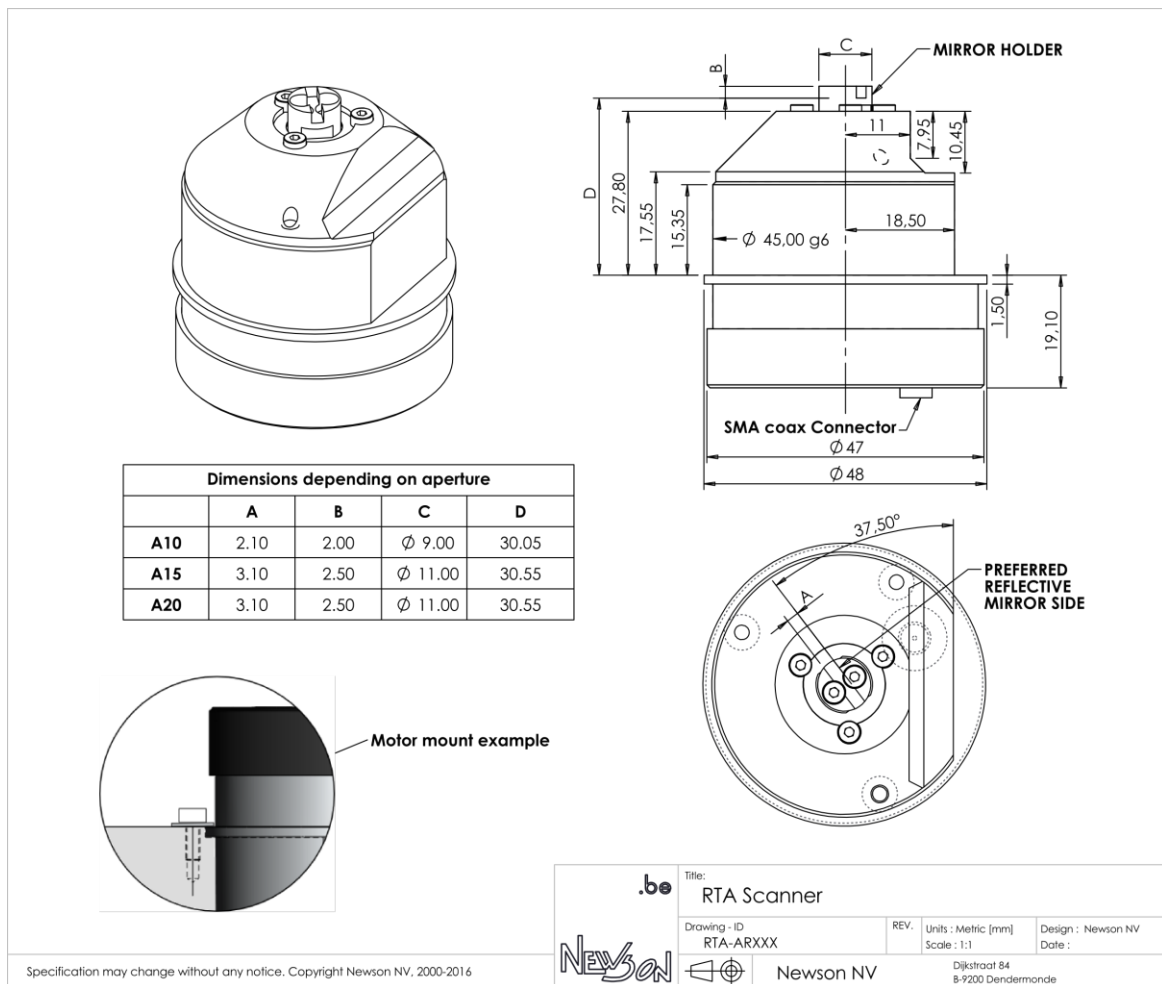
1.1. GENERAL DESCRIPTION



The Smart Deflector™ is a complete closed loop servo system. Regulator and amplifier are integrated into the mechanical device to obtain a complete self-operating system. Energy efficiency is maximized to avoid thermal heating.

The result is a part that can be used in nearly any optical layout. To maximize its ease of use, the electrical connection to the deflector is done over a coaxial connector. Both power supply and data are provided through this connection.

1.2. DIMENSIONS



2 SPECIFICATIONS

General

Principle	moving coil
Coil inductance	4 μ H
Coil resistance	300 mOhm
Regulator	digital 20 bit
Amplifier	class D
Position Sensor	Optical
Electrical connection	50 Ohm SMA coaxial connection (shared power and data)

Mechanical

Rotor inertia	2.6 g.cm ²
Maximum load	10 g.cm ²

Positioning (optical angles)

Motor Type	RTA-AR800	RTA-AR640	RTA-AR180
Rated angular excursion	800mrad (45.8°)	640mrad(36.7°)	180mrad(10.3°)
Resolution	1048576 steps	1048576 steps	1048576 steps
Drift measured over 8 hours	< 24 μ rad	< 20 μ rad	< 6 μ rad
Repeatability	< 12 μ rad	< 10 μ rad	< 3 μ rad

SMA coaxial connection

Description	Min	Type	Max	Units
Power supply	9	12	13	V (*)
Power RMS current		0.2	0.6	A
Power Peak current		3		A (**)
Serial modulation type		AC-UART		(***)
Serial baud rate		10		Mbit/sec
Serial number of data bits		8 + 1		bit
Serial number of stop bits		1.5		bit
SMA inner contact to SMA shield AC resistance		50		Ohm
SMA inner contact to SMA shield AC reactance		2.2		μ H
SMA shield to enclosure voltage	-5	0	5	V (****)
SMA shield to enclosure resistance		220		Ohm
SMA shield to enclosure reactance		1		μ F

Temperature

Operating ambient temperature	-10 to +50°C
Storage temperature	-10 to +60°C

(*) The deflector is not protected against reverse polarity. Reverse polarisation will damage the system.

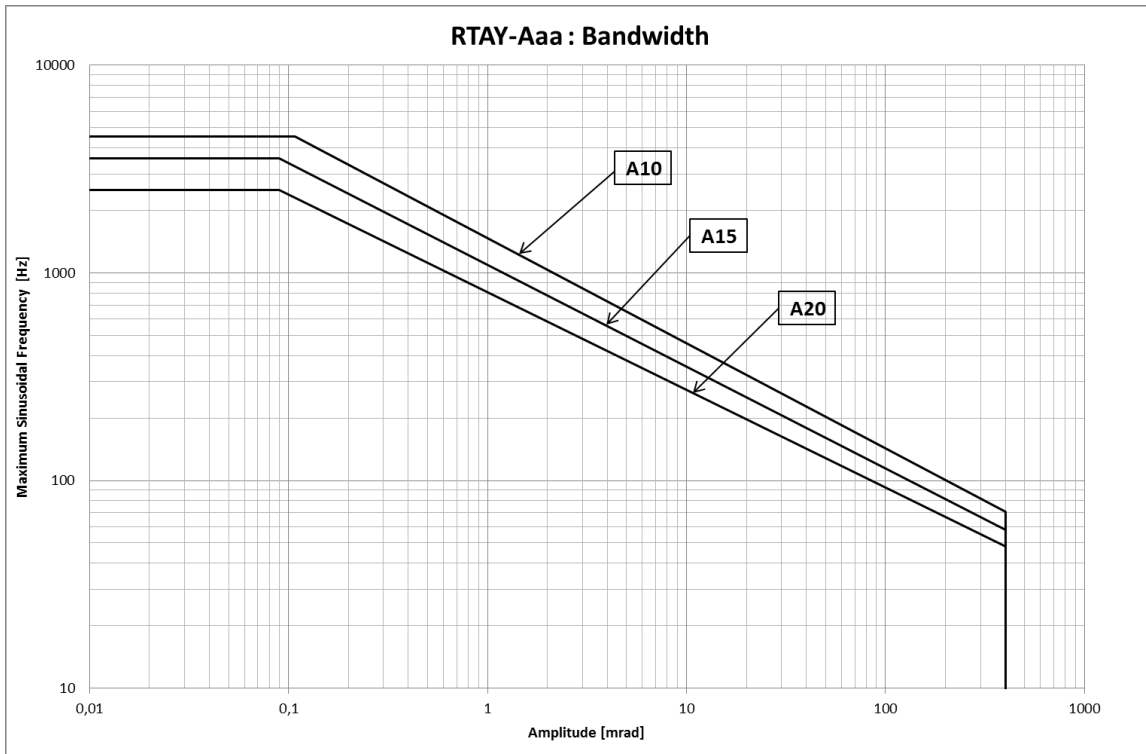
(**) Peak current level and frequency depend on deflector movements. Peak current duration is approx. 200 μ sec.

(***) The deflector uses 5V supply for modulation/demodulation electronics (ref. chapter Modulation Electronics).

(****) This range limits the potential difference between ground and the deflector's power supply return.

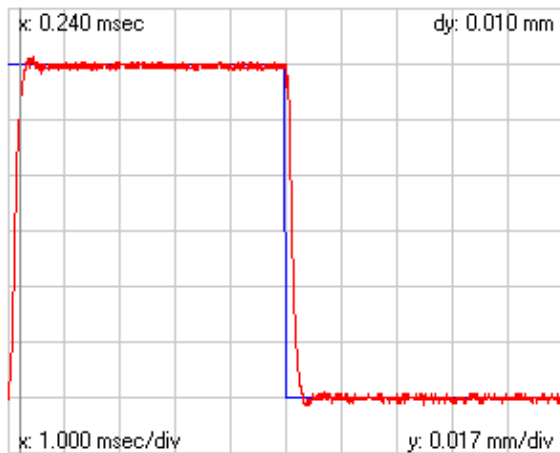
3 TYPICAL CHARACTERISTICS

3.1 BANDWIDTH

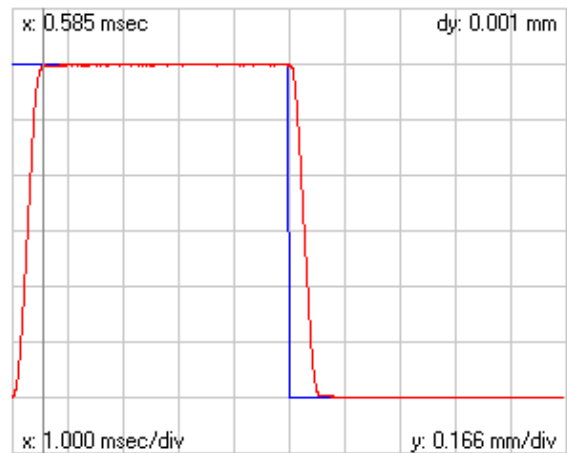


3.2 TYPICAL STEP RESPONSES

Aperture 15mm, Y-mirror, SiC



100µm jump, Field size 46mm, Jump Speed 3m/sec

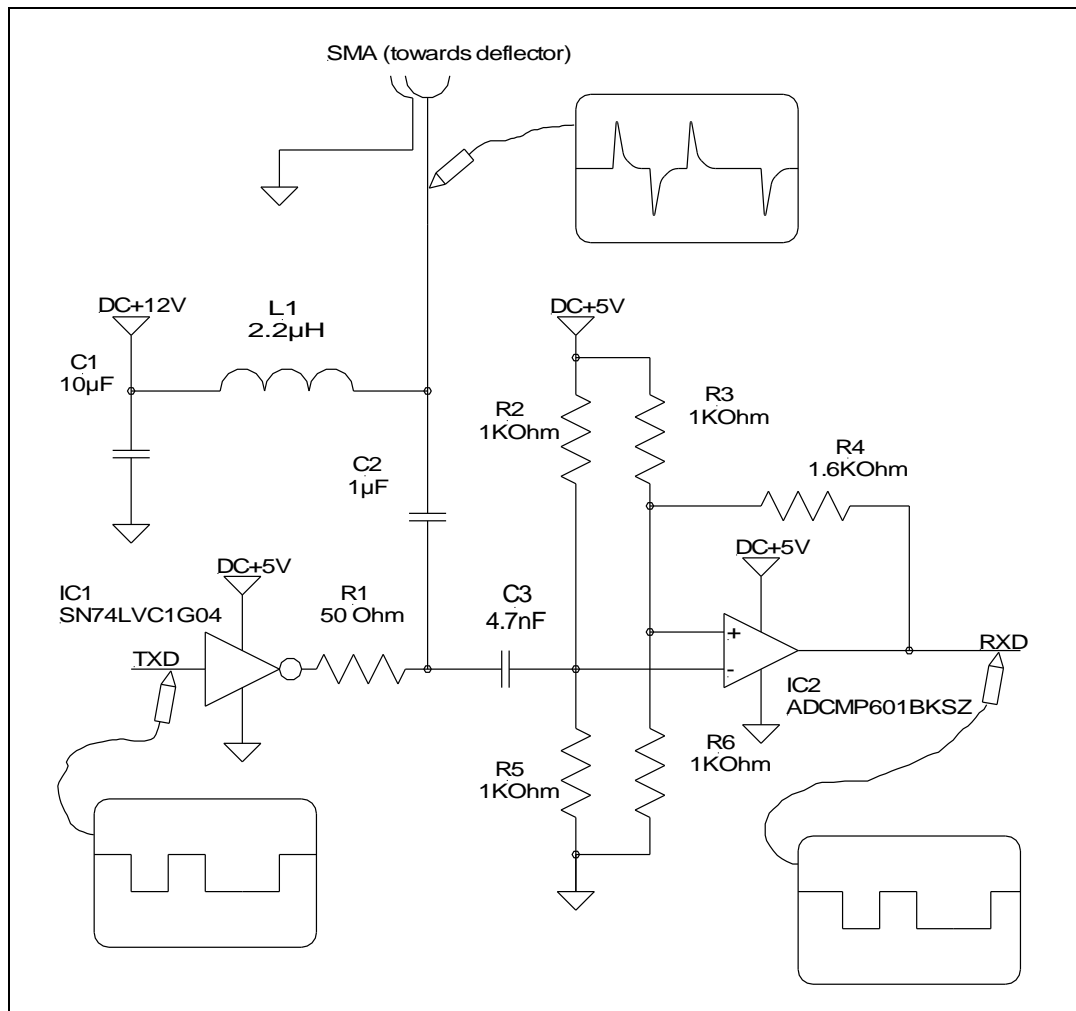


1mm jump, Field size 46mm, Jump Speed 3m/sec

4 COMMUNICATION WITH THE SMART DEFLECTOR™

4.1 MODULATION ELECTRONICS

The smart deflector is powered by a single 12V power supply applied by means of a coaxial connection. Serial data communication (exchanging set point and actual position) is modulated hereon. As a result the SMA connector provides the deflector with both data and power supply. Following schematic shows the modulation electronics. Because data traffic and power supply needs to be isolated on both sides of the coaxial connection, the deflector comprises a similar schematic.



The data towards the deflector (TXD) is high pass filtered while the power supply (DC+12V) is low pass filtered. The high pass filtering is achieved through inductor L1 and resistor R1. Capacitor C2 only serves as a DC level shifter between output amplifier (IC1) and the deflector's power supply. The time constant of the high pass filter equals 44 nsec ($2.2\mu\text{H}/50\text{Ohm}$). The saturation current of inductor L1 should be high enough to handle the deflector's peak currents.

The (DC) potential between inner wire and shield of the coaxial connection equals 12V. When the control card sends a data, every TXD bit transition will induce a glitch. Due to inversion by IC1, low going flanks induce positive glitches while high going flanks induce negative glitches. The height of the glitches is about 2.5 V (IC1 powered by 5V). This is the result of the divide by 2 network constituted by the deflector's input impedance and the modulation electronics output impedance (R1). The glitch duration is set by the time constant of the high pass filter.

The returned data is obtained by demodulation using a Schmitt trigger. A positive glitch will reset while a negative glitch will set the Schmitt trigger's output (RXD). The hysteresis is set by the resistor values R3, R4 and R6. When RXD is high, the voltage on the non-inverting input equals 3.1V (IC2 powered by 5V). The voltage on the inverting input is set by the resistors R2 and R5 to 2.5V. A hereon applied positive glitch with amplitude larger than 0.6V will bring the potential above the non-inverting one. The comparator's output becomes low setting the voltage on the non-inverting input to 1.9V. A low going glitch is now needed to set the output back to high.

When 5V power lines are not available, the modulation circuit can also be powered by a 3.3V power supply. Because the glitches will have less energy, the maximal length of the coaxial connection between deflector and control card is reduced from 25 to 5 meter. The resistor value R4 should be decreased to 1 KOhm in order to have a similar hysteresis voltage.

4.2 INSTRUCTION SET

The 3G deflector uses a 20 bit two's complement presentation for both set point and actual position. During operation the set point needs to be controlled by the application. Some applications also need to verify actual deflector positions. For ease of use the deflectors have both a 20 bit and a 16 bit interface to exchange these values. The latter disregards the 4 least significant bits and only accesses the 16 most significant bits.

The instructions and their replies are exchanged with deflector through a half-duplex UART connection. Transmitting a single byte takes 1.1 µsec. Depending on the instruction type the control card sends one or three bytes to the deflector. After reception the deflector will process it and start his reply within 1.5 µsec. To avoid data collision, the time between different instructions must be at least 5 µsec for single byte and 10 µsec for multiple byte instructions.

Instruction overview

Control	Resolution	Size instruction	Size reply	Execution time
20 bit absolute set point	1048576 bits	3 bytes	3 bytes	10 µsec
16 bit relative set point	65536 bits	1 byte	1 byte	5 µsec

UART byte format:

Serial data	START, B0, B1, B2, B3, B4, B5, B6, B7, LATCH, STOP
START	Start bit, low
B0..B7	data byte (B0 least significant bit, B7 most significant bit)
LATCH	instruction latch (*)
STOP	Stop bit, high

(*) The instruction set of a deflector comprises single and multiple byte instructions. When the LATCH bit is true, the received instruction is interpreted. Single byte instructions must have their LATCH bit set. On multiple byte instructions only the last byte must have the LATCH bit set. All other bytes must be send with LATCH bit cleared. All replies from the deflector are done with LATCH bit cleared.

4.2.1 20 bit absolute set point control

With a three byte instruction a 20 bit target position is sent to the deflector. Actual position and error bits are replied. When the distance between target and set point is too far, the target position is clipped following a maximum speed principle. The maximum speed whereby the set point is allowed to change, is set at 105 Mbit/sec. When clipping occurred, it is signalled by the error bit ERR_POS. When this bit is cleared, no clipping was done and the set point is loaded with the target position. When this bit is set, the control card should repeat the instruction in 10 µsec intervals until acknowledged.

The amount of energy consumed by a deflector increases with applied target position variations. The deflector has dual stage protection to avoid thermal overloading. When the power consumed by the deflector is above maximum load, error bit ERR_OVLD (overload) becomes high. The control card should respond by reducing the set point speed. When the power level rises above twice the maximum load the second stage protection switches off amplifier and regulator. The deflector stops tracking and sets error bit ERR_TRACK. After 4 seconds the deflector reboots. During normal operation the error bits should be cleared.

Serial bit sequence (*):

Instruction Byte 1	START,0,0,0,0,S0,S1,S2,S3,0,STOP
Instruction Byte 2	START,S4,S5,S6,S7,S8,S9,S10,S11,0,STOP
Instruction Byte 3	START,S12,S13,S14,S15,S16,S17,S18,S19,1,STOP
Reply Byte 1	START,ERR_POS,ERR_TRACK,ERR_OVLD,0,A0,A1,A2,A3,0,STOP
Reply Byte2	START,A4,A5,A6,A7,A8,A9,A10,A11,0,STOP
Reply Byte 3	START,A12,A13,A14,A15,A16,A17,A18,A19,0,STOP

(*)

S0...S19: new set point (20 bit two's complement, S0 least significant bit, S19 most significant bit)

A0...A19: actual position (20 bit two's complement, A0 least significant bit, A19 most significant bit)

ERR_POS: logic low when new set point is accepted (no speed clipping)

ERR_TRACK: logic high when deflector has stopped tracking

ERR_OVLD: logic high when deflector is overloading

4.2.2 16 bit relative set point control

A complete instruction set is available to control and query the 16 most significant bits of both set point and actual position using byte sized instructions. This control mode makes the deflector's full angular range accessible using 16 bit values. As a result the physical angle change pro bit is 16 times larger when compared with 20 bit control. The relative set point control mode is compatible with previous deflector versions.

Controlling the set point is achieved by using μ step move instructions. When the deflector receives such an instruction, its value is added to the set point (16 bit presentation). The valid instruction range is limited from -111 to 111. All values outside this range are interpreted by the deflector as a system instruction, not as a μ step move instruction. Based on a selectable reply mode, a μ step move instruction will be replied with delta actual (mode 1) or echoing (mode 2).

The system instruction set comprises instructions to select reply mode and to query positions. At power up, the deflector switches to reply mode 1. In this mode any μ step move instruction will be replied with delta actual. When echoing is desired, the system instruction 126 must be used to change the reply mode to 2. In reply mode 1 it is possible to keep track of the actual position while reply mode 2 allows error control on the communication link.

The maximal speed whereby the set point can be changed using relative control, equals:

$$\text{max speed} = \text{max } \mu\text{step} * \text{max instruction frequency} = 111 * 200 \text{ KHz} = 22 \text{ Mbit/sec}$$

The deflector's maximal angular speed is more than three times faster than the speed achievable using 20 bit absolute set point control because (angular wise) every bit is 16 times larger.

Single byte instructions

Instruction (*)	Description	Reply
-111... 111	μ step move instruction (8 bit two's complement)	Delta actual (when in reply mode 1) Echo μ step (when in reply mode 2)
112	fetch actual position	most significant byte actual position
115	fetch set point position	most significant byte set point
113	fetch least significant byte	least significant byte previous fetch
117	switch off deflector	0
125	switch on deflector, set reply mode 1	125
126	switch on deflector, set reply mode 2	126

(*) Undeclared instruction values are used by the rhothor™ tuning and configuration software. Do not use these values.

Serial bit sequence (*):

Instruction Byte 1	START,C0,C1,C2,C3,C4,C5,C6,C7,1,STOP
Reply Byte 1	START,R0,R1,R2,R3,R4,R5,R6,R7,0,STOP

(*)

C0...C7: 8 bit instruction (C0 least significant bit, C7 most significant bit)

R0...R7: 8 bit reply (R0 least significant bit, R7 most significant bit)

The relative targeting reduces the communication bandwidth. Only variations of the set point are communicated. A new target can't be send directly to the deflector but needs to be translated and communicated as a chain of μ steps. This chain has to be compiled based on target position, deflector's set point and desired speed. To avoid querying the deflector's set point before every move, the control card should keep a local copy of it. After power up, this copy should be initialised by fetching the deflector's set point (boot cycle reply mode 1 and 2).

Example :

Assume that the deflector is at position 1000 and that ramping towards position 2200 at a speed of 1.2 Mbit/sec is needed.

<i>position (local copy of deflector's set point)</i>	<i>1000 bit</i>
<i>target (new position)</i>	<i>2200 bit</i>
<i>Speed</i>	<i>1200000 bit/sec</i>
<i>Distance</i>	<i>target-set point = 2200-1000 = 1200 bit</i>
<i>Duration</i>	<i>distance/speed = 1200/1200000 = 1 msec.</i>
<i>#μsteps (number of μsteps when sending at 5μsec interval)</i>	<i>duration/0.005 = 200</i>
<i>μstep</i>	<i>distance/#μsteps = 1200/200 = 6</i>

After sending 200 times the value 6, the deflector's set point will be increased with 1200. Sending those values at 5 μ sec interval will result in an 1 msec. execution time for the ramp.

The deflector has a build in security against thermal overloading. When over steered above twice the thermal rating, it stops tracking. The amplifier and regulator are switched off and the deflector stops replying μ step move instructions. The control card can respond by sending command 125 (reply mode 1) or 126 (reply mode 2) to restart the deflector. Without response within 4 seconds the deflector will reset and a full boot cycle will be needed to restore operation.

4.2.2.1 Boot cycle reply mode 1 (actual position tracking)

step 1	send instruction 125	setup to reply μ step move commands with delta actual
step 2	send instruction 115	the deflector replies with most significant byte set point
step 3	send instruction 113	the deflector replies with least significant byte set point
step 4	send instruction 112	the deflector replies with most significant byte actual position
step 5	send instruction 113	the deflector replies with least significant byte actual position

After executing step 5, the control card has a 16 bit copy of the deflector's set point and the actual position. Changing the set point is done by sending μ step move instructions. The deflector will reply them with delta actual values. By integrating these replies, a live copy of the deflector's actual position can be obtained.

4.2.2.2 Boot cycle reply mode 2 (error control on data link)

step 1	send instruction 126	setup to echo received μ step move commands
step 2	send instruction 115	the deflector replies with most significant byte set point
step 3	send instruction 113	the deflector replies with least significant byte set point
step 4	send instruction 115	the deflector replies with most significant byte set point
step 5	send instruction 113	the deflector replies with least significant byte set point

Step 4 and 5 are optional. However they give the advantage of a double read of the set point. The reply of step 2/3 and step 4/5 should be the same. If not you should fetch the set point again. Changing the set point is done by sending μ step move instructions. By verifying the replied echo's the integrity of the instruction flow can be verified. If an echo is different from its instruction, the set point should be fetched again (restart at step 2).

4.3 POWER UP SEQUENCE

During normal operation the deflector only replies on received instructions. All communication needs to be initiated by the control card. The only exception is at power up. 100 msec after power up the deflector sends character 204. This is done to set the Schmitt triggers in the modulation electronics.

When the deflector and the control card are powered by the same power supply, the latter should wait for 1 second after power up before sending data to the deflector. During this time, the deflector boots and initialises all communication electronics. Control card should initialise its TXD output within 100 msec after power up. When the control card's booting process takes longer and said time limit can't be guaranteed different power supplies should be used.

When powered using different power supplies the following power up sequence is advised:

step 1	power up and boot control card
step 2	power up deflector, control card polls serial link (RXD) for activity

100 msec after receiving the power up byte (204) from the deflector, the control card may send instructions. The control card can use the power up byte to initialise its communication electronics (Schmitt triggers). When the absolute set point control will be used, the control card can start sending the 3 byte sized instructions. When relative set point control will be used, the control card needs to set reply mode and fetch the current position(s) of the deflector prior to sending μ step move instructions.