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DUAL Azimuth control protocol,

An evolution of rotor control protocols to address hardware and station automation requirements.

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1 Introduction:

For many years the evolution of the rotor control protocols has been almost none existent, there as been some interesting evolutions in early 2000 with expanded DCU-1 AZ protocols to address very basic needs, but most Azimuth interfaces use mostly the dated (late 1980's) DCU-1 which is a very basic protocols that offers very little control and no feedback from the rotor.

Commands added to the original DCU-1 helped, but this being an already limited approach these were very limited and just brought this approach to a barely acceptable level. And some of the protocol design decisions in DCU-1 itself were none standard and even somewhat bizarre!

GS232A and GS232B introduced by Yaesu/Kempro for there rotor controllers in the 1990's were very well designed and much more powerful then DCU-1, it can control either single axis (Azimuth only rotors mostly but also Elevation only rotors) or dual axis rotors (Azimuth/Elevation Satellite setup only). And because of the very high cost of the Yaesu/Kempro GS232A and GS232B hardware, there are very little implementation of the GS232 protocols other then in satellite tracking applications. Logging and contesting softwares likes Logger 32, N1MM, Wintest and HRD with its introduction of HRD Rotator did address both Single (HF) axis and dual (Satellite) axis operations and integrated very well the GS232A and GS232B protocols (HRD Rotator) along with many others.

But all DUAL Axis controllers until now were always satellite oriented controllers, ***even tough technically an elevation rotor is nothing but an Azimuth rotor turned on it side***, as more and more hams are automating there HF stations using logging softwares likes HRD Rotator or Logger32 and contest softwares like N1MM or WINTEST, many of these stations have more then one azimuth rotors turning HF antennas or HF and VHF antennas, thus why not offer the possibility in a new design rotor interface like the DF9GR's ERC-M to use the interface as a single Azimuth, an Azimuth/Elevation or ***Dual Azimuth interface***.

In this document we will look at the details of the GS232 protocols (AZ and AZ/EL), the possible evolution of the GS232B-AZ and GS232B-AZ/EL protocols and how this advanced rotor control protocol could take an evolution change to add ***dual Azimuth*** control called ***GS232B-AZ/AZ***. Finaly we will look at how this could also be implemented in GS232**A**-AZ/AZ

2 History:

Automated rotor control was introduced in the late 1980s by satellite ham radio operators (AMSAT). At first these were very expensive Ham and commercial products, the evolution of low cost personal computers and the requirement to track at all time of a fast moving satellites on dual axis with very short communication windows, meant this was a badly needed accessory.

Hy-gain introduced a control box replacement with the DCU-1 protocol in the late 1980's that was a very limited control only protocol, in early 2000 some ham products in control box replacement or addon pcbs expanded protocol versions of DCU-1 (with added position request and feedback commands), but little more then that.

Early interfaces were very expensive and not very flexible; in the late 1990 we saw with XQ2FOD's Fodtrack and soon after DL7AOT AOTTracker some great low cost approaches making these affordable for all. These were soon followed in early 2000 by Mark WA8SME's Sat688 and Howard G6LVB's LVB Trackers that were two very large advancements to the evolution of rotor control interfaces, especially Howard's LVB Tracker made large steps in offering rotor position feedback and using a better integration of the GS232A-AZ/EL protocols.

But all of these evolutions were mostly oriented for sat based AZ/EL operations, until the advancement of better station automation/logging like Logger32 and Ham Radio Deluxe (HRD) with the introduction of the HRD Rotator application, the complete station integration of the Azimuth only rotor was very slow coming.

in 2009 Rene DF9GR introduce a product line called the Easy Rotor Control (Known as ERC) that was a single axis rotor interface used for either Azimuth or Elevation. The ERC hardware and supporting software design made for an incredible evolution that added both hardware and protocol compatibility and flexibility. This was followed in late 2009 with the ERC-3D that took the strength of the ERC design and added dual axis, LCD display, control, etc... And in mid 2010, with the very small plug ready based dual axis USB ERC-R... and in june 2011 the new modular design of the ERC-M that also supports DUAL-Azimuth (GS232A-AZ/AZ and GS232B-AZ/AZ).

The flexibility of the ERC designs raised some questions as to why not use a dual axis device like the LVB, ERC-3D or ERC-R with TWO AZIMUTH rotors? Technically there is no difference, lets face it an Elevation rotor is nothing but an azimuth designed to operate while sitting on its side and limited to 180 degrees instead of 360 or 450...

And with the growing ham radio station automation requirements, more and more hams are using Azimuth only HF operations with applications like logger32, HRD 5 Rotator, N1MM and WinTest that will let you pick a station from you DX Cluster, push it to you log entry screen, tune your radio and change your rotor bearing to make your contact within one or two clicks of your mouse! With the evolution of SO2R, this is even more important in contest operations, where you don't have time to decide if your rotors are positioned correctly or not... or even worse if you just turned the correct rotor...

3 Goals:

In this document we itend to set a new dual Azimuth rotor control command set standard:

- New protocol name will be GS232B-AZ/AZ
- New Protocol will be based on thhe GS232B-AZ and GS232B-AZ/EL protocol standards.
- Integrate the new dual Azimuth command set to control a second Azimuth rotor keeping changes to a minimum.
- Keep GS232B-AZ and GS232B-AZ/EL compatibility.
- Keep response feedback format.
- Plan advanced for future operations like Dual Rotor commands, where both azimuth rotors can be made to be synched and controlled at the same time with or without an offset between the two rotors.
- Address the GS232A requirements based on the same rules used to adress the GS232B requirements.

4 The problems:

The main problem is simple; there is presently no standard dual Azimuth protocol. Thus I intend in this reference to explain how we can take the evolution of the GS232B protocols, originally introduced by the Kempro/Yaesu group for there Azimuth and Azimuth/Elevation rotor product family, and add to it the GS232B-AZ/AZ command set.

There are other issues that may need to be addressed to help GS232B-AZ/AZ product introduction;

1 Most application will not be GS232B-AZ/AZ compatible immediately. This will be adress with application evolution adding support of GS232B-AZ/AZ and rotator interfacing applications like Codrut's PSTRotator.

2 Application accessing one or both of the Azimuths may not be GS232B-AZ compatible (gs232a-az, idiompress DCU-1 or DCU-1 modified). This will be address with application evolution adding support of GS232B-AZ/AZ and rotator interfacing applications like Codrut's PSTRotator.

3 User may want have two distinct applications addressing each rotor. This will be address with application applications like Codrut's PSTRotator.

4 Keeping firmware and application integration of the new protocol as simple as possible. Proper firmware integration of command sets by interface suppliers like Rene DF9GR would address this issue.

5 The generic S command used in GS232B-AZ and GS232B-AZ/EL (Stop Azimuth or stop Azimuth and Elevation Movement) would be a problem in GS232B-AZ/AZ mode since it would apply to both Azimuth and in most cases this would not be the intend… This will be adress with application evolution adding support of GS232B-AZ/AZ and rotator interfacing applications like Codrut's PSTRotator.

5 Why GS232 based evolution:

First we need to look at what is available to us and there strength, the goal being to add the functionnality to an existing standard and make it fit without affecting the existing protocol and have a simple logic to the evolution.

5.1 Easycom I and II:

Easycom I is a very basic protocol that did not adress the basic minimum control requirements of a rotor interface protocol (AZ, EL, L, R, U and D) and did not offer rotor position feedback.

Easycom II was a major evolution from Easycom I, adding more rotor and also radio control commands, but both Easycom version always had one MAJOR drawback they can not give rotor position feedback. There are also some confusion around protocol standards since it is not well documented, finally the Easycom II was designed as a complete station control protocol controlling not only the rotor but also the radio, this last issue adds complexity that would make adapting it to Dual AZ operation somewhat more complex.

5.2 DCU-1:

DCU-1 was introduced by Hy-Gain for there rotor controller replacement box, the nemonics used are somewhat off the wall not using any simple easy to understand commands memonics. It is also a protocol that does not offer rotor position feedback information even dougth this and other lacking commands were added by some Ham product suppliers to there version of DCU-1, it is still a very limitating protocol and being that it was not originaly design to support dual axis (AZ only and no AZ/EL versions...) it is somewhat more complicated to adapt...

5.3 GS232A and B:

GS232A protocol was first introduced in early 1990's by Yaesu/Kempro for there external rotor controller interface. it is a full set complete and well design protocol set to control bot Azimuth only and Azimut/Elevation controllers thanks to both command sets.

GS232B was an evolution of the GS232A, mainly changing the response feedback format from a +0nnn+0nnn format to a more simple and easier to understand AZ=nnn and EL=nnn format.

The GS232B is well designed for the evolution to add a DUAL Azimuth command set being that it is already based on two distinct command sets;

Command Set 1 : Azimuth Only Commands

Command Set 2 : AZ/EL commands

Thus it is a natural fit for Command Set 3 that would be an evolution of the first two based largely on how command set 2 was implemented to add Dual Azimuth based commands oriented mainly into controlling mostly the second Azimuth.

6 Principals of operations of Dual Azimuth rotor interface:

A dual azimuth interface is mainly a dual axis controller similar if not identical to an AZ/EL controller as far as hardware is concerned. Except, the second axis can be used to control an Elevation rotor or a second Azimuth rotor. This is done either via a single application like logger32 or HRD 5 Rotator where both Axis rotor are then configured to specific portions of the applications, thus offering the possibility to the user to operate two HF antennas distinctively for two HF operations or an HF and a VHF/UHF Stack. Or like Logger32 did configure the Rotor Axis selection based on, band, frequency and mode selection, as you operate the application switches rotors to cover your needs as per your configuration...

There maybe other situations where two very different applications or a singles application that do not support dual Azimuth rotor interfaces may require to control two Azimuth rotor via a GS232B-AZ/AZ protocol, in this situation a third party interface application like PSTRotator maybe required to offer these applications two separate virtual GS232B-AZ or why not DCU-1 com ports thus making the GS232B-AZ/AZ transition a responsibility of this application. This would have the added advantage of offering the advantages of the GS232B-AZ/AZ interfaces to any application and even running two different applications each driving a different Azimuth rotor via the same interface.

Later with the evolution of controllers we are hoping to introduce the possibility to link both Azimuth axis together to synchronize both antennas for specific operations with or without any offset, this would be nice in contesting or large antenna farm setup where you want to use multiple antennas on different rotors for the same goal.

7 GS232B Command sets:

The GS232B command sets are separated in two very distinct groups;

7.1 Command set 1 GS232B-AZ:

Used mainly to control single axis azimuth only rotors it is made up of these commands;

(In yellow and RED commands with very low importance)

7.1.1 GS-232B protocol Command set 1

7.1.1.1 High Usage commands

Command list	Description	Comments
A	Azimuth Direction Rotation Stop	Stop azimuth rotation
C	Antenna Direction Value	Return current azimuth angle in the form " AZ=nnn" degrees
L	Counter Clockwise Rotation A CW/CCW Rotation Stop	Start turning the rotator to the left
Mxxx	Antenna Direction Setting.	Turn to xxx degrees azimuth, where xxx is three digits between 000. Rotation starts.
R	Clockwise Rotation	Start turning the rotator to the right
S	All Stop	Cancel current command before completion.
Xn	Select azimuth rotator turning speed, where n= 1 (slowest) to 4 (fastest).	This command can be issued during rotation, and takes effect immediately. There is no equivalent for elevation
X1	Rotation Speed I	(Horizontal)Low
X2	Rotation Speed 2	(Horizontal)Middle 1
X3	Rotation Speed 3	(Horizontal)Middle 2
X4	Rotation Speed 4	(Horizontal)High

7.1.1.2 Low Usage commands

Command list	Description	Comments
02	Offset Calibration	NA
F	Full Scale Calibration	after calibration push reset switch
F2	Full Scale Calibration	NA
M	M Time interval Direction	Setting. MTTT XXX XXX XXX (TTT=Step value XXX=Horizontal Angle)
N	Total number of setting angle in 'M' mode and traced number of all data	setting angles
P45	Set the rotor in 450 mode	NA
P36	Set the rotor in 360 mode	NA
T	Start automatic stepping routine (both azimuth and elevation)	Turn rotator to next sequentially memorized azimuth (or az-el pair, for the W command), wait sss seconds, and turn to next angle (or pair), etc. This command works only if a long-form M or W has been issued since power-up or the last reset.
Z	Toggles Between North or South Center	

7.1.1.3 Very Low Usage commands

Command list	Description	Comments
H	List Help 1 page	NA
H2	List Help 2 page	NA
H3	List Help 3 page	NA

7.2 Command set 2 GS232B-AZ/EL:

Expansion of GS232B-AZ to cover the dual axis satellite operations;

7.2.1.1 GS-232B-AZ/EL protocol Command set 2 (includes all command set 1)

7.2.1.2 High Usage commands

Command list	Description	Comments
B	Elevation Antenna Direction Value	Return current elevation angle in the form " EL=nnn" degrees
C2	Antenna Direction Value	Return azimuth and elevation ("AZ=aaa EL=eee", where eee = elevation, aaa = azimuth).
D	DOWN Direction Rotation	Start turning the rotator down
E	UP/DOWN Direction Rotation Stop	Stop elevation
S	All Stop	Cancel current command before completion.
U	UP Direction Rotation	Start turning the rotator UP
W	Antenna Direction Setting.	WXXX YYY

7.2.1.3 Very Low Usage commands

Command list	Description	Comments
W	Time Interval Direction Setting.	WTTT XXX YYY XXX YYY

7.3 Command set 3 GS232B-AZ/AZ:

Evolution of the GS232B-AZ and GS232B-AZ/EL to cover the dual azimuth operations;

(In yellow commands with very low importance

7.3.1 GS-232B-AZ/AZ protocol Command set 3 for Azimuth 2 (includes all command set 1 and 2)

7.3.1.1 High Usage commands

Command list	Description	Comments
B	Azimuth 2 Antenna Direction Value	Return current elevation angle in the form " EL=nnn" degrees
C2	Azimuth 2 Antenna Direction Value	Return current azimuth angle in the form " AZ=nnnEL=nnn " degrees where the first AZ=nnn applies to Azimuth 1 and the EL=nnn applies to Azimuth 2.
E	Azimuth 2 Direction Rotation Stop	Stop Azimuth 2
D	Counter Clockwise Rotation A CW/CCW Rotation Stop	Start turning the rotator to the left (CCW)
MBxxx	Azimuth 2 Antenna Direction Setting.	Turn to xxx degrees azimuth, where xxx is three digits between 000 and 360. Rotation starts.
U **S**	Clockwise Rotation All Stop both Azimuth	Start turning the rotator to the right Cancel all current commands before completion.
W	Azimuth 1 and 2 Antenna Direction Setting.	WXXX YYY, where XXX is for Azimuth 1 and YYY is for Azimuth 2
XBn	Select Azimuth 2 rotator turning speed, where n= 1 (slowest) to 4 (fastest).	This command can be issued during rotation, and takes effect immediately. There is no equivalent for elevation
XB1	Rotation Speed 1	(Horizontal)Low
XB2	Rotation Speed 2	(Horizontal)Middle 1
XB3	Rotation Speed 3	(Horizontal)Middle 2
XB4	Rotation Speed 4	(Horizontal)High

7.3.1.2 Very Low Usage commands

Command list	Description	Comments
02B	Offset Calibration	NA
FB	Full Scale Calibration	after calibration push reset switch
FB2	Full Scale Calibration	NA
MB	M Time interval Direction	Setting. MTTT XXX XXX XXX (TTT=Step value XXX=Horizontal Angle)
NB	Total number of setting angle in 'M' mode and traced number of all data	setting angles
P36B	Set the rotor in 360 mode	NA
P45B	Set the rotor in 450 mode	NA
TB	Start automatic stepping routine (both azimuth and elevation)	Turn rotator to next sequentially memorized azimuth (or az-el pair, for the W command), wait sss seconds, and turn to next angle (or pair), etc. This command works only if a long-form M or W has been issued since power-up or the last reset.
W	Time Interval Direction Setting.	WTTT XXX YYY XXX YYY
Y	Syncronize Azimuth 1 and Azimuth 2 to the same bearing.	From this point on all GS232B-AZ commands will be used on both Azimuth rotors.
Ynnn	Syncronize Azimuth 1 and Azimuth 2 with a nnn (0 to 360) degree offset applied to Azimuth 2 in reference to the real time position of Azimuth 1.	From this point on all GS232B-AZ commands will be used on both Azimuth rotors. Except the Azimuth 2 will always be nnn degrees offset from Azimuth 1.
Y999	Cancel Azimuth Synchronisation.	From this point on all GS232B-AZ commands will be used on Azimuth rotor1 and all command set 3 commands will be used on Azimuth rotors 2.
ZB	Toggles Between North or South Center	

Note : even if barely used the commands in YELLOW are still adapted to GS232B-AZ/AZ changes to keep compatibility.

7.4 Command set 3 GS232B-AZ/AZ design principales:

You will note that in the proposed Command set 3 most of the GS232B-AZ/AZ commands stayed the same or very similar to GS232B-AZ/EL, these are commands that would be used in the same way as in AZ/EL operations and thus do not require changes helping compatibility, we are hoping by not replacing these commands we will be able to make the GS232B-AZ/AZ integration in existing application easier.

Thus Azimuth 1 commands for Azimuth 2 like L is now D, R is U, A is now E and C is now B. You should have noticed that these were all used previously in GS232B-AZ/EL to control the Elevation portion of the interface thus the second Axis, since Azimuth 2 is also the second axis of the GS232B-AZ/AZ interface we are keeping these same commands and keeping the firmware and application changes to a minimum.

Where Command set 2 (GS232B-AZ/EL) Commands can not be used and the required command is already used in Command set 1, then change is made by adding the letter B at the end of the command before the variable value if there is one, such as MBnnn, XBn and ZB these are basically the same as Mnnn, Xn and Z except the command set 3 commands will be applied to the Azimuth 2 rotor.

7.5 Command set 3 GS232B-AZ/AZ command definition:

Lets take a closer look at each commands;

B = The B command is used in the same way as the B command in the GS232B-AZ/EL command set 2, upon reception of the command, the interface will return the present position of Azimuth 2 in the EL=nnn format.

C2 = is used in Dual Azimuth operation to interrogate both axis present bearing, the interface will return AZ=nnnEL=nnn, where AZ=nnn is the present bearing of the Azimuth 1 rotor and EL=nnn is the present bearing of the Azimuth 2 rotor.

D = is used to initiate an immediate CCW move command to the Azimuth 2 rotor, once initiated this will not stop until reception of one of the following; D, E, MBnnn, U, TB, S, Wxxx yyy, Y, Ynnn or Y999 or when rotor reaches end of range.

E = Is used in the same way as the A command in GS232B command set 1, the E command is used to stop all operation on the second Axis thus Azimuth 2.

MBxxx = Used to send a bearing request to the Azimuth 2 rotor, where the xxx is the requested bearing, upon reception of the MBxxx the interface will initiate stop on Azimuth 2 and will initiate movement toward bearing xxx using the shortest possible direction. If the rotor was already turning in the proper direction the immediate stop command can be bypassed and the rotor simply changes the destination to the new bearing. Once initiated this will stop upon reception of one of the following; E, MBnnn, U, S, TB, Wxxx yyy, Y, Ynnn or Y999 or when rotor reaches destination.

S = This command is used to initiate an immediate STOP on both Azimuth attached to the interface.

Note: many application use the S command instead of the A or E commands to stop a GS232B-AZ or EL operations, when using the S command in a GS232B-AZ/AZ environment, this could initiate unwanted Azimuth 1 or 2 stops, we need to address this issue!

One way of doing this is to have the interface decide in its configuration where the S is applied (Azimuth 1 only, Azimuth 2 only or both Azimuth?)

When using an external application interface, then S commands going to Azimuth 1 could be converted to A commands. And the S commands going to Azimuth 2 should be converted to an E command.

Application implementation of GS232B-AZ/AZ should always be done using A or E commands, application designers should NOT use S command unless it is to STOP BOTH AZIMUTH.

U = is used to initiate a immediate CW move command to the Azimuth 2 rotor, once initiated this will not stop until reception of one of the following; D, E, MBnnn, U, S, TB, Wxxx yyy, Y, Ynnn or Y999 or when rotor reaches end of range.

Wxxx yyy = This command is used to send dual axis azimuth values where xxx is used to set a new bearing for Azimuth 1 and yyy is used to set a new bearing for Azimuth 2, upon reception both azimuth will initiate immediate stop and start movement in direction of the new bearing. If the rotor was already turning in the proper direction the immediate stop command can be bypassed and the rotor simply changes the destination to the new bearing. Once initiated this will stop upon reception of one of the following; D, E, MBnnn, U, S, TB, Wxxx yyy, Y, Ynnn or Y999 or when rotor reaches destination.

XBn = Same as GS232B-AZ X command, this is a speed control command where n = the required speed. N is a value from 1 to 4 where 1 is always full speed and 4 is always full speed, 2 and 3 can be set to initiate variation in high speed ramping up and down delays. The XBn setting should be kept until the next XBn command is received, power is recycled or until the user manually changes the speed control to manual mode in the interface, when the interface speed is set in manual mode the XBn commands will all be ignored.

Y, Ynnn and Y999 = The Y commands are used to synchronised both azimuth 1 and 2 together, a Y command by itself, initiates full control of Azimuth 2 at same bearing and speed as Azimuth 1. A Ynnn command is the same as a Y command except an offset value of nnn is added to the Azimuth 1 bearing and set as the required Azimuth 2 bearing, thus is a Y090 is received and my Azimuth 1 bearing is 060 then my Azimuth 2 bearing will be 060 + 090 = 150 thus Azimuth 2 bearing should be 150… In the same example if a Y330 is received then 330 + 060 = 390 and then this should be translated to a 030 bearing. The Y999 is used to cancel the Y or Ynnn command and return the Azimuth 2 rotor to individual control. This command will be cancelled upon reception of the Y999 command or a powerup reset of the interface. Once Y or Ynnn is initiated all other Command set 3 (Azimuth 2 commands) will be ignored.

7.6 Implementation of GS232A-AZ/AZ Dual Azimuth operations:

GS232A-AZ/AZ implementation is fairly simple, the exact same commands and principles used in GS232B-AZ/AZ can be applied to GS232A-AZ/AZ the only difference have to do with the responses from the interface to the application.

In GS232B operations these responses were AZ=xxx and EL=xxx, in GS232A these are +0nnn+0nnn or simply +0nnn when for a single Azimuth, this bring up a warning software developpers MUST be carefull to properly time there request and the interfaces reply since both axis in GS232A mode respond the same way to a single axis position request +0nnn... This was not an issue in GS232B since the response included an axis specific portion AZ= for the first axis and EL= for the second one...