DG14™ RTK

Supplement to DG14 Reference Manual

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1. General Information

About this Manual

This manual comes as a supplement to the DG14 Reference Manual PN630851. For any information about electrical and mechanical characteristics of the DG14 receiver, please refer to that manual.

All proprietary commands described in the DG14 Reference Manual also apply to the DG14 RTK. If some commands are changed or made invalid because of the DG14 RTK firmware, then corrections are provided in the present manual.

Conventions Used

The following conventions are used in this manual:

- The term “receiver” or “DG14 receiver” refers to any DG14 unit, whether a board or a sensor.
- In command descriptions, square brackets [ ] delimit optional parameters.

Introduction to DG14 RTK

DG14 RTK is a DG14 receiver with special firmware allowing it to benefit from Real-Time Kinematic (RTK) functionality. The RTK algorithm used in the DG14 RTK is the newly released Magellan Blade™ algorithm.

The DG14 RTK firmware offers the following features:

- Three different cases of RTK implementation:
  - *Standard RTK* (i.e. with static base)
  - *Moving Base*
  - *Heading*.

  See also *RTK Modes Available on page 2*.

- Two different solution types corresponding to two different levels of accuracy:
  - *Fixed solution*, offering real-time centimeter accuracy, i.e. the standard RTK solution where integer ambiguity is solved.
  - *Flying RTK™ solution*, offering real-time decimeter accuracy. Flying RTK is a Magellan trademarked algorithm, which can be described as an enhanced float solution (better convergence pattern and more robust solution).

- Two different types of data output rates:
  - *Time-tagged/Synchronized RTK*: Rover data output (up to 5 Hz) is synchronized with base data input.
  - *Fast RTK*: Rover data output takes place at a higher rate (up to 10 Hz) than base data input. This is made possible by extrapolating base data in the rover.

  The table below indicates which type of data output rate can be used with which RTK mode:

RTK Mode	Time Tagged	Fast RTK
Standard RTK	•	•
Moving Base	•	
Heading	•	

  Important! Fast RTK can only be used in standard RTK mode.

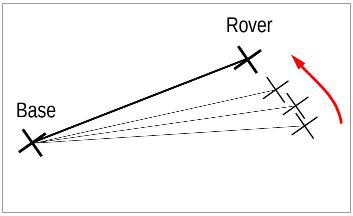
- Several data protocols for RTK implementation:
  Base:
  - RTCM 2.3 messages 3, 22,18 and 19.

  Rover:
  - RTCM 2.3 messages 3,22,18 and 19
  - RTCM 2.3 messages 3,22,20 and 21
  - RTCM 3.0 messages 1001-1006
  - Proprietary DBEN Ashtech protocol.

  NOTE: Rovers automatically recognize the input protocol after the $PASHS,CPD,MOD,ROV command has been run in the receiver.

RTK Modes Available

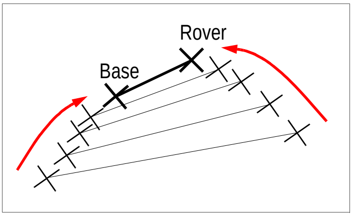
Standard RTK



The position of the base is accurately known. Only the rover causes the baseline to change in length and direction as it moves.

Standard RTK determines the real-time components of the baseline vector (orientation and length) from which it deduces the rover position. The real-time position of the rover directly benefits from the same accuracy as that of the baseline vector.

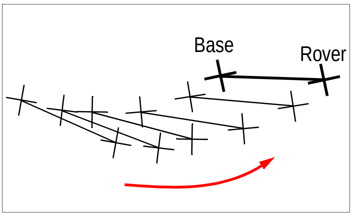
Moving Base



Both the rover and the base cause the baseline to change in length and direction.

Moving Base measures the real-time components of the baseline vector (orientation and length).

Heading



The baseline length is constant and accurately known because the base and the rover are both securely mounted on board the vehicle.

Only the orientation of the baseline changes as the vehicle moves.

Heading measures the vehicle's heading angle, provided the offset angle between the baseline and the vehicle centerline is known. In most cases, this offset angle will be set to 0° or 90°, thus making it possible to also determine the vehicle pitch or roll respectively. Using this mode requires prior calibration of the system.

Supported Update Rates

The maximum update rates are listed below:

- RTCM generation update rate: maximum 5 Hz
- Time-tagged RTK update rate: maximum 5 Hz
- Fast RTK update rate: maximum 10 Hz
- Conventional (not RTK) position update rate: 10 Hz (20 Hz option forced to 10 Hz)
- Raw data update rate: 10 Hz (20 Hz option forced to 10 Hz).

NOTE: Because of potential throughput problems, it is not recommended to enable Fast RTK with 5 Hz RTK base.

Receiver Options

This section introduces the new receiver option required for RTK operation and lists those, already existing, that are affected by the installation of the DG14 RTK firmware. This section also lists the options that need to be validated for RTK operation.

[J] Option

The [J] option is the new option that enables RTK operation. If the option is disabled, the RTK enabling command is NAKed.

[W] Option

The [W] option is normally used to enable the 20-Hz update rate. When the DG14 RTK version is loaded to the receiver, the [W] option becomes equivalent to “T” (10 Hz) to avoid throughput problems (i.e. missing solutions) in Time-tagged and Fast RTK.

Option [W] is automatically re-enabled when you re-install the regular version of firmware.

[I] Option

The [I] option is normally used to enable RAIM operation. When the DG14 RTK version is loaded to the receiver, the RAIM option is automatically disabled.

Option [I] is automatically re-enabled when you re-install the regular version of firmware.

Required Options

Whether it is configured as a base or a rover, the receiver must be fitted with the following options to be able to operate in RTK.

Option	Designation
B	Differential RTCM Base
K	RTCM Type 18/19
J	Rover in RTK, Heading or Moving Base

RTK Performance Specifications

Fixed RTK (kinematic)

Sigma: 1 cm + 1 ppm [1] [2]

Flying RTK (kinematic)

CEP: 5 cm + 1 ppm [1] [3]

CEP: 20 cm + 1 ppm [1] [4]

Heading, Pitch/Roll

Heading (sigma): 0.2 degree for a 1-meter baseline [1] [5] [6]

Pitch/roll (sigma): 0.4 degree for a 1-meter baseline [1] [5] [6]

(1) Values correspond to open sky conditions. Performance may degrade with limited visibility, multipath, and high ionosphere activity.

(2) For baseline lengths <10 km.

(3) Steady state value for baselines <50 km after sufficient convergence time.

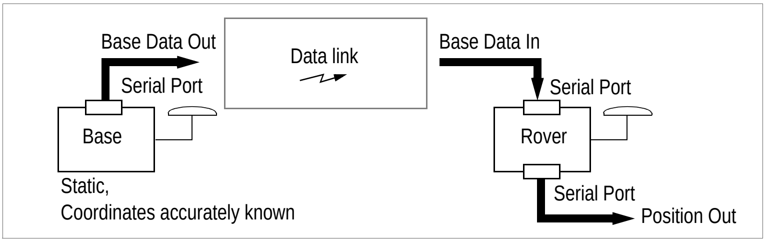
(4) Typical value after 3 minutes of convergence for baselines <50 km

(5) Typical value for properly installed antennas on vehicle body.

(6) Sigma values are in inverse proportion to the baseline length. For example, with a 2-meter baseline, heading (sigma) is 0.1 degree and pitch/roll (sigma) is 0.2 degree.

2. Standard RTK

Overview



Base Setup Procedure

The procedure to set up a receiver as a static RTK base is summarized in the table below:

#	Configuration Step	Relevant Commands	See (*)
1	Reset the receiver configuration for a safe start.	$PASHS,RST	Page 123 RM
2	Set the speed of the ports used.	$PASHS,SPD	Page 130 RM
3	Set the RTCM messages the base must generate, as well as their output rates.	$PASHS,RTC,TYP	Page 311 RM *Page 19 TM*
4	Set the receiver port used to output base corrections.	$PASHS,RTC,BAS	Page 300 RM *Page 18 TM*
5	Set the different elevation masks (for raw data and position).	$PASHS,ELM $PASHS,PEM	Page 164 RM Page 109 RM
6	Set the code smoothing interval.	$PASHS,SMI	Page 128 RM
7	Set the RTCM output rate.	$PASHS,RTC,SPD	Page 308 RM
8	Define the base position.	$PASHS,POS	Page 112 RM *Page 18 TM*
9	Set base station identification number.	$PASHS,RTC,STI	Page 310 RM
10	Save the base configuration.	$PASHS,SAV,Y	Page 123 RM

* Page numbers are followed by two letters identifying the manual to refer to:
RM: DG14 Reference Manual P/N630851.
TM: The Present Manual.

Rover Setup Procedure

The procedure to set up a receiver as an RTK rover is summarized in the table below:

#	Configuration Step	Relevant Commands	See (*)
1	Reset the receiver configuration for a safe start.	$PASHS,RST	Page 123 RM
2	Set the speed of the ports used.	$PASHS,SPD	Page 130 RM
3	Set the code smoothing interval.	$PASHS,SMI	Page 128 RM
4	Set the position elevation mask.	$PASHS,PEM	Page 109 RM
5	Allow the rover to output raw positions in absence of any more accurate position solution.	$PASHS,RTC,AUT	Page 299 RM
6	Set the confidence level for integer ambiguity resolution.	$PASHS,CPD,AFP	*Page 21 TM*
7	Set the maximum age of corrections.	$PASHS,CPD,MAX	*Page 20 TM*
8	Set the receiver as an RTK rover.	$PASHS,CPD,MOD	*Page 19 TM*
9	Set the position update mode.	$PASHS,CPD,FST	*Page 20 TM*
10	Tell the rover the base is static.	$PASHS,CPD,BAS	*Page 19 TM*
11	Set the receiver port used to output position solution messages	$PASHS,NME,GGA $PASHS,NME,POS	Page 211 RM Page 245 RM
12	Save the rover configuration.	$PASHS,SAV,Y	Page 123 RM

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Examples of Base and Rover Configurations for Static Base

Base Generating RTCM Corrections at 5 Hz Max. on Port B

Command	Action
$PASHS,RST	Resets receiver.
$PASHS,SPD,A,9	Sets port A baud rate to 115200 Bd.
$PASHS,SPD,B,5	Sets port B baud rate to 9600 Bd.
$PASHS,RTC,TYP,1,0	Sets RTCM Message Type 1 to OFF.
$PASHS,RTC,TYP,2,0	Sets RTCM Message Type 2 to OFF.
$PASHS,RTC,TYP,3,1	Sets RTCM Message Type 3 to ON; Output rate: 1 min.
$PASHS,RTC,TYP,22,1	Sets RTCM Message Type 22 to ON; Output rate: 1 min.
$PASHS,RTC,TYP,18,0.2	Sets RTCM Message Type 18 to ON; Output rate: 5 Hz.
$PASHS,RTC,TYP,19,0.2	Sets RTCM Message Type 22 to ON; Output rate: 5 Hz.
$PASHS,RTC,BAS,B	Asks generated corrections to be sent via port B.
$PASHS,ELM,0	Sets raw data elevation mask to 0°.
$PASHS,PEM,0	Sets position elevation mask to 0°.
$PASHS,SMI,600,2	Sets code smoothing interval to 600 seconds.
$PASHS,RTC,SPD,9	Sets RTCM in burst mode.
$PASHS,POS,...	Defines base position.
$PASHS,RTC,STI,0005	Assigns base station with “0005” as identification number.
$PASHS,SAV,Y	Saves base configuration in receiver.

Rover Delivering 10-Hz “Fixed” RTK Positions in Fast RTK

(The rover receives RTCM corrections at a rate of 1 or 5 Hz from the base.)

Command	Action
$PASHS,RST	Resets receiver.
$PASHS,SPD,A,9	Sets port A baud rate to 115200 Bd.
$PASHS,SPD,B,5	Sets port B baud rate to 9600 Bd.
$PASHS,SMI,600,2	Sets code smoothing interval to 600 seconds.
$PASHS,PEM,5	Sets position elevation mask to 5°.
$PASHS,RTC,AUT,Y	Allows the rover to output raw positions if no more accurate position solution is currently available.
$PASHS,CPD,AFP,99	Sets confidence level to 99% for integer ambiguity resolution.
$PASHS,CPD,MAX,60	Sets maximum age of corrections to 60 seconds.
$PASHS,CPD,MOD,ROV	Enables RTK rover operation in receiver.
$PASHS,CPD,FST,ON	Selects the Fast RTK update position mode.
$PASHS,CPD,BAS,0	Tells the rover that base data will come from a static base.
$PASHS,NME,GGA,A,ON,0.1	Enables GGA messages on port A at 10 Hz
$PASHS,SAV,Y	Saves rover configuration in receiver.

Examples of Output Messages

Below are samples of POS and GGA messages delivered by a rover operating in standard RTK mode. The content is different depending on whether the position solution is “fixed” or “flying” (see underlined, red characters in the samples).

Float Position Solution

$PASHR,POS,<u>2</u>,9,090200.00,4718.004466,N,00130.551812,W,00080.687,????,000.00,000.00,+000.00,01.6,01.1,01.2,00.8,DR08*19

$GPGGA,090200.00,4718.004466,N,00130.551812,W,<u>5</u>,09,1.1,31.211,M,49.48,M,1,0000*4A

Fixed Position Solution

$PASHR,POS,<u>3</u>,9,090201.00,4718.004804,N,00130.551738,W,00079.931,????,000.00,000.00,+000.00,01.6,01.1,01.2,00.8,DR08*12

$GPGGA,090201.00,4718.004804,N,00130.551738,W,<u>4</u>,09,1.1,30.455,M,49.48,M,1,0000*42

Position Type Flagging

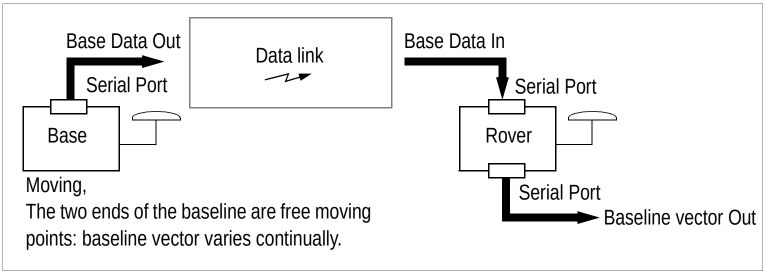
In the GGA message, the flag that qualifies the position solution is as defined in NMEA V.3.0.

In the POS message, this flag may take one of the following values:

0-Standalone mode
1-RTCM or SBAS differential mode
2-Flying RTK mode
3-Fixed RTK mode.

3. Moving Base

Overview



Base Setup Procedure

The procedure to set up a receiver as a moving RTK base is summarized in the table below:

#	Configuration Step	Relevant Commands	See (*)
1	Reset the receiver configuration for a safe start.	$PASHS,RST	Page 123 RM
2	Set the speed of the ports used.	$PASHS,SPD	Page 130 RM
3	Set the RTCM messages the base must generate, as well as their output rates.	$PASHS,RTC,TYP	Page 311 RM *Page 19 TM*
4	Sets the receiver as a moving base.	$PASHS,POS,MOV	*Page 18 TM*
5	Set the receiver port used to output base corrections.	$PASHS,RTC,BAS	Page 300 RM *Page 18 TM*
6	Set the different elevation masks (for raw data and position).	$PASHS,ELM $PASHS,PEM	Page 164 RM Page 109 RM
7	Set the code smoothing interval.	$PASHS,SMI	Page 128 RM
8	Set the RTCM output rate.	$PASHS,RTC,SPD	Page 308 RM
9	Set base station identification number.	$PASHS,RTC,STI	Page 310 RM
10	Save the base configuration.	$PASHS,SAV,Y	Page 123 RM

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Rover Setup Procedure

The procedure to set up a receiver as an RTK rover is summarized in the table below:

#	Configuration Step	Relevant Commands	See (*)
1	Reset the receiver configuration for a safe start.	$PASHS,RST	Page 123 RM
2	Set the speed of the ports used.	$PASHS,SPD	Page 130 RM
3	Set the code smoothing interval.	$PASHS,SMI	Page 128 RM
4	Set the position elevation mask.	$PASHS,PEM	Page 109 RM
5	Allow the rover to output raw positions in absence of any more accurate position solution.	$PASHS,RTC,AUT	Page 299 RM
6	Set the confidence level for integer ambiguity resolution.	$PASHS,CPD,AFP	*Page 21 TM*
7	Set the maximum age of corrections.	$PASHS,CPD,MAX	*Page 20 TM*
8	Set the receiver as an RTK rover.	$PASHS,CPD,MOD	*Page 19 TM*
9	Set the position update mode to “Time-Tagged”.	$PASHS,CPD,FST,OFF	*Page 20 TM*
10	Tell the rover the base is moving.	$PASHS,CPD,BAS	*Page 19 TM*
11	Set the receiver port used to output baseline length messages	$PASHS,NME,VEC	*Page 28 TM*
12	Save the rover configuration.	$PASHS,SAV,Y	Page 123 RM

* Page numbers are followed by two letters identifying the manual to refer to:
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Examples of Base and Rover Configurations for Moving Base

Base Generating RTCM Corrections at 5 Hz Max. on Port B

Command	Action
$PASHS,RST	Resets receiver.
$PASHS,SPD,A,9	Sets port A baud rate to 115200 Bd.
$PASHS,SPD,B,5	Sets port B baud rate to 9600 Bd.
$PASHS,RTC,TYP,1,0	Sets RTCM Message Type 1 to OFF.
$PASHS,RTC,TYP,2,0	Sets RTCM Message Type 2 to OFF.
$PASHS,RTC,TYP,3,0.002	Sets RTCM Message Type 3 to ON; Output rate: 5 Hz
$PASHS,RTC,TYP,22,0.002	Sets RTCM Message Type 22 to ON; Output rate: 5 Hz
$PASHS,RTC,TYP,18,0.2	Sets RTCM Message Type 18 to ON; Output rate: 5 Hz.
$PASHS,RTC,TYP,19,0.2	Sets RTCM Message Type 22 to ON; Output rate: 5 Hz.
$PASHS,POS,MOV	Sets receiver as moving base.
$PASHS,RTC,BAS,B	Asks generated corrections to be sent via port B.
$PASHS,ELM,0	Sets raw data elevation mask to 0°.
$PASHS,PEM,0	Sets position elevation mask to 0°.
$PASHS,SMI,600,2	Sets code smoothing interval to 600 seconds.
$PASHS,RTC,SPD,9	Sets RTCM in burst mode.
$PASHS,RTC,STI,0005	Assigns base station with “0005” as identification number.
$PASHS,SAV,Y	Saves base configuration in receiver.

Rover Receiving 1- to 5-Hz Corrections on Port B

Command	Action
$PASHS,RST	Resets receiver.
$PASHS,SPD,A,9	Sets port A baud rate to 115200 Bd.
$PASHS,SPD,B,5	Sets port B baud rate to 9600 Bd.
$PASHS,SMI,600,2	Sets code smoothing interval to 600 seconds.
$PASHS,PEM,5	Sets position elevation mask to 5°.
$PASHS,RTC,AUT,Y	Allows the rover to output raw positions if no more accurate position solution is currently available.
$PASHS,CPD,AFP,99	Sets confidence level to 99% for integer ambiguity resolution.
$PASHS,CPD,MAX,60	Sets maximum age of corrections to 60 seconds.
$PASHS,CPD,MOD,ROV	Enables RTK rover operation in receiver.
$PASHS,CPD,FST,OFF	Selects the time-tagged RTK update position mode.
$PASHS,CPD,BAS,1	Tells the rover that base data will come from a moving base.
$PASHS,NME,VEC,A,ON,0.1	Enables VEC messages on port A at 10 Hz
$PASHS,SAV,Y	Saves rover configuration in receiver.

Example of Output Message

In the Moving Base mode, baseline measurements can be found in the VEC message (see also $PASHR,VEC on page 29) generated by the rover.

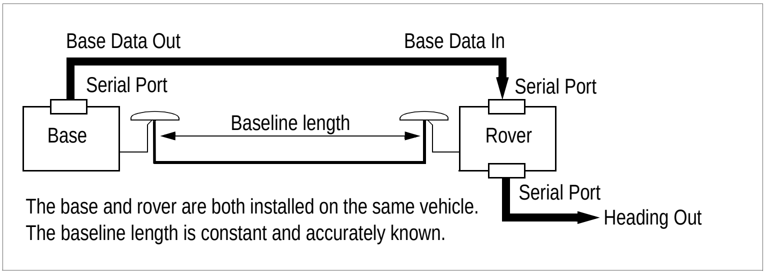
Below is a sample of VEC message delivered by a rover operating with a moving base.

VEC Message

$PASHR,VEC,140746.00,2,1,0,1,,,05,,,0,1,-68.467,-26.867,5.428,0.011,0.010,0.020,
0.003 ,0.390,0.000,*25

4. Heading

Overview



Base Setup Procedure

The procedure to set up a base in Heading mode is summarized in the table below. Note that the configuration is similar to the one required for the base in moving base RTK.

#	Configuration Step	Relevant Commands	See (*)
1	Reset the receiver configuration for a safe start.	$PASHS,RST	Page 123 RM
2	Set the speed of the ports used.	$PASHS,SPD	Page 130 RM
3	Set the RTCM messages the base must generate, as well as their output rates.	$PASHS,RTC,TYP	Page 311 RM *Page 19 TM*
4	Sets the receiver as a moving base.	$PASHS,POS,MOV	*Page 18 TM*
5	Set the receiver port used to output base corrections.	$PASHS,RTC,BAS	Page 300 RM *Page 18 TM*
6	Set the different elevation masks (for raw data and position).	$PASHS,ELM $PASHS,PEM	Page 164 RM Page 109 RM
7	Set the code smoothing interval.	$PASHS,SMI	Page 128 RM
9	Set the RTCM output rate.	$PASHS,RTC,SPD	Page 308 RM
10	Set base station identification number.	$PASHS,RTC,STI	Page 310 RM
11	Save the base configuration.	$PASHS,SAV,Y	Page 123 RM

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Rover Setup Procedure

The procedure to set up the rover in Heading is summarized in the table below:

#	Configuration Step	Relevant Commands	See (*)
1	Reset the receiver configuration for a safe start.	$PASHS,RST	Page 123 RM
2	Set the speed of the ports used.	$PASHS,SPD	Page 130 RM
3	Set the code smoothing interval.	$PASHS,SMI	Page 128 RM
4	Set the position elevation mask.	$PASHS,PEM	Page 109 RM
5	Allow the rover to output raw positions in absence of any more accurate position solution.	$PASHS,RTC,AUT	Page 299 RM
6	Set the confidence level for integer ambiguity resolution.	$PASHS,CPD,AFP	*Page 21 TM*
7	Set the maximum age of corrections.	$PASHS,CPD,MAX	*Page 20 TM*
8	Set the receiver as an RTK rover.	$PASHS,CPD,MOD	*Page 19 TM*
9	Set the position update mode to “Time-Tagged”.	$PASHS,CPD,FST,OFF	*Page 20 TM*
10	Set the receiver port used to output heading messages	$PASHS,NME,ATT	*Page 25 TM*
11	Tell the rover the base is moving.	$PASHS,CPD,BAS	*Page 19 TM*
12	Enable heading RTK in the rover	$PASHS,CPD,ARR,MOD	*Page 22 TM*
13	Start the baseline calibration mode	$PASHS,CPD,ARR,LEN	*Page 23 TM*
14	Save the rover configuration.	$PASHS,SAV,Y	Page 123 RM

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Examples of Base and Rover Configurations for Heading

Base Generating RTCM Corrections at 5 Hz Max. on Port B

Command	Action
$PASHS,RST	Resets receiver.
$PASHS,SPD,A,9	Sets port A baud rate to 115200 Bd.
$PASHS,SPD,B,5	Sets port B baud rate to 9600 Bd.
$PASHS,RTC,TYP,1,0	Sets RTCM Message Type 1 to OFF.
$PASHS,RTC,TYP,2,0	Sets RTCM Message Type 2 to OFF.
$PASHS,RTC,TYP,3,0.002	Sets RTCM Message Type 3 to ON; Output rate: 5 Hz
$PASHS,RTC,TYP,22,0.002	Sets RTCM Message Type 22 to ON; Output rate: 5 Hz
$PASHS,RTC,TYP,18,0.2	Sets RTCM Message Type 18 to ON; Output rate: 5 Hz.
$PASHS,RTC,TYP,19,0.2	Sets RTCM Message Type 22 to ON; Output rate: 5 Hz.
$PASHS,POS,MOV	Sets receiver as moving base.
$PASHS,RTC,BAS,B	Asks generated corrections to be sent via port B.
$PASHS,ELM,0	Sets raw data elevation mask to 0°.
$PASHS,PEM,0	Sets position elevation mask to 0°.
$PASHS,SMI,600,2	Sets code smoothing interval to 600 seconds.
$PASHS,RTC,SPD,9	Sets RTCM in burst mode.
$PASHS,RTC,STI,0005	Assigns base station with “0005” as identification number.
$PASHS,SAV,Y	Saves base configuration in receiver.

Rover Receiving 1- to 5-Hz Corrections on Port B

Command	Action
$PASHS,RST	Resets receiver.
$PASHS,SPD,A,9	Sets port A baud rate to 115200 Bd.
$PASHS,SPD,B,5	Sets port B baud rate to 9600 Bd.
$PASHS,SMI,600,2	Sets code smoothing interval to 600 seconds.
$PASHS,PEM,5	Sets position elevation mask to 5°.
$PASHS,RTC,AUT,Y	Allows the rover to output raw positions if no more accurate position solution is currently available.
$PASHS,CPD,AFP,99	Sets confidence level to 99% for integer ambiguity resolution.
$PASHS,CPD,MAX,60	Sets maximum age of corrections to 60 seconds.
$PASHS,CPD,MOD,ROV	Enables RTK rover operation in receiver.
$PASHS,CPD,FST,OFF	Selects the time-tagged RTK update position mode.
$PASHS,NME,ATT,A,ON,0.2	Enables ATT messages on port A at 5 Hz
$PASHS,CPD,BAS,1	Tells the rover that base data will come from a moving base.
$PASHS,CPD,ARR,MOD,ON	Enables Heading RTK in receiver
$PASHS,CPD,ARR,LEN,0.0	Starts the baseline calibration.
$PASHS,SAV,Y	Saves rover configuration in receiver.

Calibration

When the rover is told that the baseline length is fixed but unknown (through the $PASHS,CPD,ARR,LEN,0 command), then self-calibration starts.

Once the calibration process is finished, the calibrated baseline length is then saved in the receiver battery backup unit (BBU). The RTK engine is reset once again and the receiver can start operating in heading RTK, taking advantage of a baseline length now known to within a centimeter.

Roll and Pitch

If the baseline is aligned with the vehicle's centerline, the Heading RTK mode will be able to determine the angle describing the vehicle's pitch, in addition to the vehicle's heading.

In another installation configuration where the baseline is made perpendicular to the vehicle's centerline, it is the vehicle's roll, instead of the pitch, that will be computed in addition to the vehicle's heading.

Example of Output Message

In Heading mode, heading measurements can be found in the ATT message (see also *$PASHR,ATT on page 26*).

Below is a sample of ATT message as delivered by a rover:

```
$PASHR,ATT,310080.0,248.57,+04.22,,0.0027,0.0000,0*2B
```

5. Proprietary Commands

This chapter describes all the proprietary commands involved in RTK modes. For the already existing commands, references to the DG14 Reference Manual are provided below. For each new command introduced, a detailed description of the syntax is provided.

Reminder: parameters between square brackets are optional.

New Commands for Base

$PASHS,POS

For general syntax, see page 112 in the DG14 Reference Manual. A new parameter (MOV) has been introduced for this command in the DG14 RTK firmware to set the base as a static or moving base.

- To set a receiver as a static base, use the $PASHS,POS command to define the accurate position of the static base. The example below gives the location of a base station in Moscow:

  $PASHS,POS,5539.145,N,03729.890,E,250

  The base position will then be periodically sent to the rover through RTCM message types 3 and 22.
- To set a receiver as a moving base, use the $PASHS,POS command with the MOV parameter:

  $PASHS,POS,MOV

  The raw position computed for the base at each epoch (corresponding to the PBN message, see page 182 in DG14 Reference Manual) will be sent to the rover through RTCM message types 3 and 22.

$PASHS,RTC,BAS

This command is used to set the port through which corrections are sent out. For general syntax, see page 300 in the DG14 Reference Manual.

$PASHS,RTC,TYP

This command is used to set the output rates of the different data types sent by the base to the rover for RTK operation. For general syntax, see page 311 in the DG14 Reference Manual.

New message types (18, 19, 22) are processed with the DG14 RTK firmware. The table below summarizes the possible output rates for each new data type. Message type 3 is also listed in this table as a reminder.

Command line	Sets the Output Rate of:	Possible Output Rate Values
$PASHS,RTC,TYP,18,x<CR><LF>	Carrier data	0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60 seconds
$PASHS,RTC,TYP,19,x<CR><LF>	Code data	0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60 seconds
$PASHS,RTC,TYP,22,x<CR><LF>	Refined position corrections	x=m.ssd where m: minutes, ss: seconds, d: fraction of a second

$PASHS,RTC,TYP,3,x<CR><LF>	Position data	x=m.ssd where m: minutes, ss: seconds, d: fraction of a second

$PASHQ,RTC

This command is used to list the current settings of the RTK base. For general syntax, see page 304 in the DG14 Reference Manual.

New Commands for Rover

$PASHS,CPD,BAS

Function: This command is used to tell the rover that the base data will come from either a static or moving base.

Format: $PASHS,CPD,BAS,x<CR><LF>

Parameter	Action
x=0	Tells the rover that data will come from a static base (default).
x=1	Tells the rover that data will come from a moving base.

$PASHS,CPD,MOD

Function: This command is used to enable/disable RTK rover operation in the receiver.

Format: $PASHS,CPD,MOD,s<CR><LF>

Parameter	Action
s=OFF	Disables RTK rover operation in the receiver.
s=ROV	Enables RTK rover operation in the receiver. In this case, the receiver can: • Expect RTK corrections of any supported type from any of its ports • Output either RTK or standalone position. Standalone position will be output while in RTK differential mode only if the $PASHS,RTC,AUT,Y command has been set beforehand.

$PASHS,CPD,FST

Function: This command is used to select either the Fast RTK or Time-Tagged RTK data output rate.

Format: $PASHS,CPD,FST,s<CR><LF>

Parameter	Action
s=OFF	Selects Time-Tagged RTK. RTK output will be computed only when the receiver has RTK corrections available. Maximum update rate: 5 Hz
s=ON	Selects Fast RTK (default). RTK position will be computed for the current time, provided RTK corrections are still valid. Maximum update rate: 10 Hz

$PASHS,CPD,MAX

Function: This command is used to set the maximum age of RTK corrections. Older corrections will be rejected by the rover.

Format: $PASHS,CPD,MAX,d<CR><LF>

Parameter	Definition
d	Maximum age of RTK corrections. Default is 60 seconds.

$PASHS,CPD,RST

Function: This command is used to reset the rover's RTK engine.

Format: $PASHS,CPD,RST<CR><LF>

Parameters: None.

Comment: Note that resetting the RTK engine is different from resetting the receiver. When you reset the RTK engine, you do not reset the receiver at the same time. Resetting the receiver requires a different command.

$PASHS,CPD,AFP

Function: This command is used to set the desired level of confidence on how the integer ambiguity is fixed in the rover.

Format: $PASHS,CPD,AFP,x<CR><LF>

Parameter	Consequence
x=0	Integers will never be fixed (flying RTK solution) (default setting)
x= 99	Integers will be fixed with a confidence level of 99% (fixed RTK solution).

$PASHQ,CPD

Function: This command queries the rover's current RTK settings.

Format: $PASHQ,CPD[,c]<CR><LF>

Parameter	Definition
c	Receiver port ID routing the response (A, B or C). If c is omitted, the response is routed to the port that forwarded the command to the receiver.

Response Examples:

1)Moving Base RTK:

```
STATUS:
        TIME:414842400 FIXED:Y
SETUP:
        MODE:ON PEM:05 DYN:7 AFP:99.00 MTP:3 FLY:ON
        FST:OFF MAXAGE:60
        MOVING BASE OPERATION
ARROW:
        MODE:OFF  OFS HEAD:000.00 ELEV:00.00  PAR MAXEL:15 MAXER:0.010
        LEN:18.624
```

2)Heading, Baseline Known and Manually Entered:

STATUS:

TIME:325866600 FIXED:N

SETUP:

MODE:ON PEM:05 DYN:7 AFP:99.00 MTP:3

FST:OFF MAXAGE:60

ARROW:

MODE:ON OFS HEAD:000.00 ELEV:00.00 PAR MAXEL:45 MAXER:0.010

LEN:18.625

3)Heading, Baseline Unknown, Calibration Running:

STATUS:

TIME:325866600 FIXED:Y

SETUP:

MODE:ON PEM:05 DYN:7 AFP:99.00 MTP:3

FST:OFF MAXAGE:60

ARROW:

MODE:ON OFS HEAD:000.00 ELEV:00.00 PAR MAXEL:45 MAXER:0.010

LEN:00.000 NOT CALIBRATED

4) Heading, Baseline initially Unknown, Calibration Over:

STATUS:

TIME:326916800 FIXED:Y

SETUP:

MODE:ON PEM:05 DYN:7 AFP:99.00 MTP:3

FST:OFF MAXAGE:60

ARROW:

MODE:ON OFS HEAD:000.00 ELEV:00.00 PAR MAXEL:45 MAXER:0.010

LEN:00.000 CALIB:18.621

New Commands Specific to Heading

$PASHS,CPD,ARR,MOD

Function: This command is used to turn the rover into Heading mode.

Format: $PASHS,CPD,ARR,MOD,x<CR><LF>

Parameter	Action
x=OFF	Disables Heading mode (default).
x=ON	Enables Heading mode.

$PASHS,CPD,ARR,LEN

Function: This command is used to set the baseline length between the base and the rover.

Format: $PASHS,CPD,ARR,LEN,x<CR><LF>

Parameter	Action
x	Sets the baseline length to x, where x is the baseline length in meters. • If x ≠ 0, The Heading mode is started assuming the baseline length is x. • If x = 0, the receiver interprets this as an absence of baseline information. A calibration mode will then be started to determine the value of baseline length with the objectives of 100% reliability and sub-centimeter accuracy. Once the baseline length is determined, it is saved as the current value of baseline length and the receiver switches from calibration to heading mode. Warning! The Heading mode will fail if the baseline length is less than 0.05 meters.

$PASHS,CPD,ARR,OFS

Function: This command is used to set the heading and elevation offsets from the vehicle centerline.

Format: $PASHS,CPD,ARR,OFS,x1[,x2]<CR><LF>

Parameter	Definition
x1	Baseline heading (azimuth) offset angle, in degrees. Range: 0°.. 360°. Default: 0°.
x2	Baseline elevation offset angle, in degrees. Range: -90°.. +90°. Default: 0°.

Comments: It is recommended to use a baseline elevation offset as close as possible to zero and a baseline heading offset as close as possible to n x 90 degrees.

If the azimuth offset is close to 0 or 180°, then the vehicle's pitch and heading will be estimated and output.

If the azimuth offset is close to 90 or 270°, then the vehicle's roll and heading will be estimated and output.

If the heading offset from either North, South, West or East exceeds 15 degrees, then the receiver does not output pitch and roll, but instead delivers the heading component of attitude.

If the elevation offset is greater than 45 degrees or less than -45 degrees, then the receiver considers installation to be invalid and does not output any attitude information (i.e. no pitch, no roll and no heading).

The specified values of offsets have an effect only when the rover is operating in heading mode.

$PASHS,CPD,ARR,PAR

Function: This command is used to set the upper limits of baseline elevation and baseline length error.

Format: $PASHS,CPD,ARR,PAR,x1[,x2]<CR><LF>

Parameter	Definition
x1	Maximum value of expected baseline elevation, in degrees. Default: 15°. Parameter x1 only affects the heading mode and is not applied during baseline length auto-calibration.
x2	Maximum value of tolerated baseline length error, in meters. Default: 0.01 m.

Output Message Settings and Output Messages

The new two messages described below are related to RTK with moving base. When RTK with moving base is running (including heading option), the position reported in POS, GGA and other NMEA messages has specific meaning:

1. Rover position is the sum of the received base position and the RTK baseline estimate. So position accuracy is affected by reference position accuracy. It is obviously not the same as in standalone GPS mode.
2. Rover velocity in fact refers to baseline velocity. For example, if the base is moving and the rover is static, the reported rover velocity is actually that of the base, with opposite sign.
3. The position flag (fixed/float) refers to the status of the baseline.

In case of moving base operation, the most adequate information is contained in VEC/ATT messages which are transparent to static/moving base operation.

$PASHS,NME,ATT

Function: This command is used to enable or disable the output of ATT messages via one of the receiver ports at the specified rate.

Format: $PASHS,NME,ATT,c,s[,f]<CR><LF>

Parameter	Action	Range
c	Receiver port ID delivering the data	"A", "B" or "C"
s	Enables ("ON") or disables ("OFF") data output	"ON" or "OFF"
[f]	Message output rate (optional). If "f" is omitted, the output rate of the ATT message is as defined with $PASHS,NME,PER (see page 245 in DG14 Reference Manual). **Important!** ATT messages are necessarily synchronized with the data received from the base (time-tagged output mode). The Fast RTK output mode cannot be implemented in this case.	Base provides data at 1 Hz: • f= 1 to 999 seconds (increment step: 1 second). Base provides data at 2 Hz: • f=0.5 second or • f=1 to 999 seconds (increment step: 1 second). Base provides data at 5 Hz: • f=0.2, 0.4, 0.6 or 0.8 second or • f=1 to 999 seconds (increment step: 1 second). Base provides data at 10 Hz: • f=0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.8, 0.9 second* or • f=1 to 999 seconds (increment step: 1 second). * Note that "f" cannot be equal to 0.7 second because this number is not a submultiple of 3600.

In response to this command, the receiver generates the following:

$PASHR,ACK*3D if the received command is valid, or
$PASHR,NAK*30 if it's not.

Comments: As explained in the above table, if "f" is omitted, the output rate is as defined by the last run $PASHS,NME,PER command. In addition, if a $PASHS,NME,PER command is sent after a specific output rate has been defined for the ATT message through the $PASHS,NME,ATT command, then the ATT message will also be issued according to the output rate defined by that $PASHS,NME,PER command.

$PASHR,ATT

$PASHR,ATT is the header of the ATT message. The format of this message is detailed below.

$PASHR,ATT,time,heading,pitch,roll,MRMS,BRMS,att_flag*cc

Parameter	Definition
time	Week time in seconds (format: ssssss.ss)
heading	Heading angle in degrees (format: ddd.dd)
pitch	Pitch angle in degrees (format: ±ddd.dd)
roll	Roll angle in degrees (format: ±dd.dd)
MRMS	Carrier measurement RMS error in meters (format: m.mmmm)
BRMS	Baseline RMS error in meters (format: m.mmmm). During calibration, this parameter is maintained to “0”
att_flag	“0” if integer ambiguity is fixed, otherwise >0.
*cc	Standard checksum

In standard RTK or Moving Base, the heading value should be interpreted as the baseline azimuth and the pitch value as the baseline elevation. The roll field is empty.

In Heading mode, the heading value should be understood as the vehicle heading, and not the baseline heading. If the baseline is aligned with the centerline of the vehicle, the pitch value indicates the pitch of the vehicle and the roll field is empty. Conversely, if the baseline is perpendicular to the centerline of the vehicle, the roll value indicates the roll of the vehicle and the pitch field is empty.

The MRMS value is equal to the value found in the carr_res field, in the VEC message.

The BRMS value is only valid in Heading mode. It gives the difference between the baseline length, as currently determined by the receiver, and the estimated value (user-entered or as determined through calibration). Throughout the calibration process, BRMS=0. In standard or advanced RTK mode, BRMS also equals zero.

The att_flag parameter can be used to reject all heading values associated with float ambiguity. However, att_flag>0 does not mean that the heading measurement is bad. For example, with a relatively long baseline (>50 meters), the heading measurement may feature sub-degree accuracy although integer ambiguity remains non-fixed (float).

Definitions of Heading, Pitch and Roll Angles in Heading Mode

General definitions:

1. In heading mode, the baseline is defined as the 3D vector pointing from the base antenna to the rover antenna.
2. The vehicle plane is defined as a primary horizontal plane in the vehicle.
3. The vehicle centerline is defined as the 3D vector pointing from the back to the front of the vehicle, and lying in the vehicle plane.
4. The vehicle crossline is defined as the 3D vector rotated by 90 degrees clockwise from the vehicle centerline.

Baseline offset definitions:

1. You can specify the baseline azimuth offset (0-360 degrees), which is the angle from the vehicle centerline to the projection of the baseline onto the vehicle plane. The angle is counted clockwise.
2. You can specify the baseline elevation offset (0...+90 degrees), which is the angle between the vehicle plane and the baseline. The "+" sign corresponds to a baseline pointing "above" the vehicle plane.

Heading, pitch and roll definitions:

1. The heading is defined as the angle between the direction of Local North and the projection of the vehicle centerline to the local horizon. The angle is counted clockwise.
2. The pitch is estimated if the baseline azimuth offset is close to 0 or 180 degrees. The pitch is the angle between the local horizon and the vehicle centerline. A positive pitch angle means:
   - The centerline is pointing "above" the horizon, if the azimuth offset is close to 0 degree.
   - Or the centerline is pointing "below" the horizon, if the azimuth offset is close to 180 degrees.
3. The roll is estimated if the baseline azimuth offset is close to 90 or 270 degrees. The roll is the angle between the local horizon and the vehicle crossline. A positive roll angle means:
   - The crossline is pointing 'above' the horizon, if the azimuth offset is close to 90 degrees.
   - Or the crossline is pointing 'below' the horizon, if the azimuth offset is close to 270 degrees.

$PASHS,NME,VEC

Function: This command is used to enable or disable the output of VEC messages via one of the receiver ports at the specified rate.

Format: $PASHS,NME,VEC,c,s[,f]<CR><LF>

Parameter	Action	Range
c	Receiver port ID delivering the data	"A", "B" or "C"
s	Enables ("ON") or disables ("OFF") data output	"ON" or "OFF"
[f]	Message output rate (optional). If "f" is omitted, the output rate of the VEC message is as defined with $PASHS,NME,PER (see page 245 in DG14 Reference Manual). **Important!** VEC messages are necessarily synchronized with the data received from the base (time-tagged output mode). The Fast RTK output mode cannot be implemented in this case.	Base provides data at 1 Hz: • f= 1 to 999 seconds (increment step: 1 second). Base provides data at 2 Hz: • f=0.5 second or • f=1 to 999 seconds (increment step: 1 second). Base provides data at 5 Hz: • f=0.2, 0.4, 0.6 or 0.8 second or • f=1 to 999 seconds (increment step: 1 second). Base provides data at 10 Hz: • f=0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.8, 0.9 second* or • f=1 to 999 seconds (increment step: 1 second). * Note that "f" cannot be equal to 0.7 second because this number is not a submultiple of 3600.

In response to this command, the receiver generates the following:

$PASHR,ACK*3D if the received command is valid, or

$PASHR,NAK*30 if it's not.

Comments: As explained in the above table, if "f" is omitted, the output rate is as defined by the last run $PASHS,NME,PER command. In addition, if a $PASHS,NME,PER command is sent after a specific output rate has been defined for the VEC message through the $PASHS,NME,VEC command, then the VEC message will also be issued according to the output rate defined by that $PASHS,NME,PER command.

$PASHR,VEC

$PASHR,VEC is the header of the VEC message. The format of this message is detailed below.

$PASHR,VEC,time,n1,n2,n3,n4,n_rov,n_bas,n_used,age,ltn,project_time,frame,x1,x2,x3,rms1,rms2,rms3,carr_res,amb_rat*cc

Parameter	Definition
time	UTC time (format: hhmmss.ss)
n1	Source of base coordinates (0: No base, 1: Computed base, 2: Received base, 3: Entered base)
n2	Type of baseline estimate (0: No baseline, 1: Time-tagged estimate, 2: Fast RTK estimate)
n3	Baseline reset flag (0: Updated estimate, >0: Initialized estimate)
n4	Internal RTK ambiguity flag (0: Float ambiguity, 1:Fixed ambiguity).
n_rov	Number of SVs used in the RTK processing (L1 portion) on rover side. This field is always empty in the current DG14 RTK version.
n_bas	Number of SVs seen by the base. This field is always empty in the current DG14 RTK version.
n_used	Number of SVs used in the baseline computation (L1 portion).
age	Age of last received base data, in seconds
ltn	Overall baseline estimate latency, in milliseconds
project_time	Interval of base L1 carrier data interpolation to rover time tag
frame	Coordinate frame flag defining the meaning of the next 6 fields. In the current version, the frame flag is always equal to 1 (indicating that an East/North/Up rectilinear frame centered around the rover is used).
x1	First (East) component of baseline, in meters.
x2	Second (North) component of baseline, in meters.
x3	Third (Up) component of baseline, in meters.
rms1	RMS error for x1 component, in meters.
rms2	RMS error for x2 component, in meters.
rms3	RMS error for x3 component, in meters.
carr_res	Scaled norm of L1 carrier residuals, in meters (0 if carriers were not processed).
code_res	Scaled norm of L1 code residuals, in meters (0 if codes were not processed).
amb_rat	Internal ambiguity ratio (0 if the ambiguity search is not called).
*cc	Standard checksum.

Baseline estimates refer to the vector between the phase center of the moving or static base antenna and the phase center of the rover antenna.

6. Useful Supplementary Settings

This section describes some of the DG14 receiver settings not directly related to RTK operation but that may help, in many cases, to improve the receiver performance, including RTK performance.

To get the best RTK performance in some situations, it is desirable to take advantage of the following serial commands:

- $PASHS,SMI
- $PASHS,CRR
- $PASHS,DYN

Note that these commands are not all directly RTK related.

$PASHS,SMI

Format: $PASHS,SMI,d1,d2<CR><LF>

Parameter	Definition
0<d1<1200	Code-carrier smoothing interval, in seconds. Default: 100.
d2=1 or 2	Order of smoothing. Default: 1.

Advanced, second-order code-carrier smoothing can be enabled in the DG14. This reduces multipath error while not inducing code/carrier divergence because of the ionosphere.

Setting $PASHS,SMI,600,2 in most cases reduces the code multipath error by half, which leads to better raw data quality and position (including RTK) results.

See also *page 128 in DG14 Reference Manual*.

$PASHS,CRR

Syntax: $PASHS,CRR,c1<CR><LF>

Parameter	Definition
c1= E or S	Code correlator type: E: Edge correlator (default) S: Strobe correlator.

If the strobe option (S) is enabled in DG14 RTK, then the Magellan multipath mitigation technique (strobe correlator) will be enabled. This technique can generally reduce the code multipath error by a factor of up to 1.5.

See also *page 73 in DG14 Reference Manual*.

$PASHS,DYN

Format: $PASHS,DYN,d1<CR><LF>

Parameter	Definition
d1 (1 to 8)	Dynamic index: 1: Static 2: Quasi-static 3: Wlaking 4: Ship 5: Automobile 6: Aircraft 7: Unlimited 8: Adaptive (default)

When the user is not able to set the actual dynamic index, then the receiver will work in default adaptive dynamic mode, trying to detect the actual dynamic internally.

Often, when actual dynamic is known a priori, it is recommended to set the appropriate index. In this case, better RTK performance can be expected, especially in harsh GPS reception conditions.

See also *page 83 in DG14 Reference Manual*.

7. Quick Reference

Typical Command Set for Standard RTK

Base	Rover
$PASHS,RST $PASHS,SPD $PASHS,RTC,TYP $PASHS,RTC,BAS $PASHS,ELM $PASHS,PEM $PASHS,SMI $PASHS,RTC,SPD $PASHS,POS $PASHS,RTC,STI $PASHS,SAV	$PASHS,RST $PASHS,SPD $PASHS,SMI $PASHS,PEM $PASHS,RTC,AUT,Y $PASHSCPD,AFP $PASHS,CPD,MAX $PASHS,CPD,MOD,ROV $PASHS,CPD,FST $PASHS,CPD,BAS $PASHS,NME,GGA $PASHS,SAV

Typical Command Set for Advanced RTK

Base (‘Moving Base or Heading)	Rover (Moving Base)	Rover (Heading)
$PASHS,RST $PASHS,SPD $PASHS,RTC,TYP $PASHS,POS,MOV $PASHS,RTC,BAS $PASHS,ELM $PASHS,PEM $PASHS,SMI $PASHS,RTC,SPD $PASHS,RTC,STI $PASHS,SAV	$PASHS,RST $PASHS,SPD $PASHS,SMI $PASHS,PEM $PASHS,RTC,AUT,Y $PASHSCPD,AFP $PASHS,CPD,MAX $PASHS,CPD,MOD,ROV $PASHS,CPD,FST $PASHS,CPD,BAS $PASHS,NME,VEC $PASHS,SAV	$PASHS,RST $PASHS,SPD $PASHS,SMI $PASHS,PEM $PASHS,RTC,AUT,Y $PASHSCPD,AFP $PASHS,CPD,MAX $PASHS,CPD,MOD,ROV $PASHS,CPD,FST $PASHS,NME,ATT $PASHS,CPD,BAS $PASHS,CPD,ARR,MOD $PASHS,CPD,ARR,LEN $PASHS,SAV

DG14™ RTK

Supplement to DG14 Reference Manual

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