KMAG4

260-MHz Magnetometer Counter
Version 3.27.11

Sales, Support and Customisation

www.GeoResults.com.au
Ph: 0428 147 973

GENERAL

A magnetometer counter is a specific continuous to discrete converter in its nature. It converts the continuous signal from the magnetometer sensors, representing the value of the ambient magnetic field to discrete readings, representing the average magnetic field values for consecutive sampling intervals.

It is not unusual the magnetic field to contain noise components that need to be filtered out during data processing. This can be done properly only if the counter sample rate was at least twice higher than the highest frequency component of the ambient magnetic field. The nature of the noise, and hence its frequency composition can be different. Therefore, to reduce the likelihood of aliasing, would be better to use as higher, as possible sampling rate. KMAG4 allows 1,000 different sampling rates. Any sample interval between 1s (1 sample per second) and 1ms (1,000 samples per second) can be selected.

It seems, it would be the best always to use the highest possible sample rate. Unfortunately, higher sample rates have some drawbacks. One of them is the reduced resolution of the individual samples. The resolution of any individual sample depends on the length of the sample interval. Twice shorter sample interval would result in twice worse sample resolution for example. The solution of this problem is to increase the reference frequency of the counter. Twice higher reference frequency would result in twice better resolutrion of the individual magnetic field samples and compensate for the shorter sample intervals. KMAG4 uses 260MHz reference frequency, which provides more than 3 times better resolution than the counters on the market, using 80MHz reference frequency, for example.

Another drawback of the higher sample rate is the increased amount of data to be recorded and processed later. KMAG4 provides a soulution for this problem too. Its primary data, consisting of 1,000 samples per second, would properly represent the original magnetic field, even if it had very high frequency noise components. Then, the built-in low-pass filter can be used to filter out the noise and the resulting sequence of 1,000 samples per second will be a proper representation of the original magnetic field, not containing the noise already. Finally, the instrument can provide down sampling to the specified sample rate to reduce the amount of the output data.

KMAG4 can also be set to sample only during specified time intervals (for example, only during the transmitter OFF time of a time domain EM system) and can be easily integrated in virtually every data acquisition system, because it is not designed to be part of a particular one. Each KMAG4 sample has a precise time tag.

DIMENSIONS

Box Width ~ 17cm
Box Height ~ 5.5cm
Box Depth ~ 16.5cm
Weight ~ 850g
Note: *The specified depth is without cables connected.*

ELECTRICAL SPECIFICATIONS

Power Supply – (12 – 34)VDC

The instrument works on a very wide range of power supply voltages. The actual restrictions on the power supply will come from the sensors, because they are powered from the same power supply as the instrument.

Current Consumption - ~30mA from 28VDC

This is the consumption of the instrument itself, without any sensors connected.

Sample Time – (0.25 – 1024) ms

See commands ***$KCMDN, $KCMDM*** and ***$KCMDL*** for more details.

Magnetic Field Range – (10,000 – 100,000) nT.

In fact, the instrument is capable of measuring even higher magnetic field values, but in such a case, the first character of the magnetic field value will be a hex digit. For example, B12345678 would mean a value of 111,234.5678 nT. The reason for such a representation was to always keep a 9-character output value.

Absolute Resolution ***- R = B / (260 * T)***, where

R is the resolution in pT
B is the magnetic field in nT
T is the sample duration in ms

SyncIn and PPS signals

-15V **≤ Input Voltage Range ≤** +15V

Positive-going Input Threshold Voltage ≥ +2.4V

Negative-going Input Threshold Voltage ≤ 0.6V

Typical input hysteresis = 0.5V

SyncOut signal

Low level voltage ≤ -5V

High level voltage ≥ +5V

KroumVS Instruments

OPENING AND CLOSING THE BOX

- Unscrew almost completely the 4 front plate (the one with the coaxial connectors) screws.
- Unscrew completely the 4 back plate screws.
- Remove the back plate and the associated open bezel.
- Slide the top belly plate out.
- Follow the reverse order to close the box.

Use the above procedure when necessary to change jumper settings or to replace a fuse.

The built-in filter

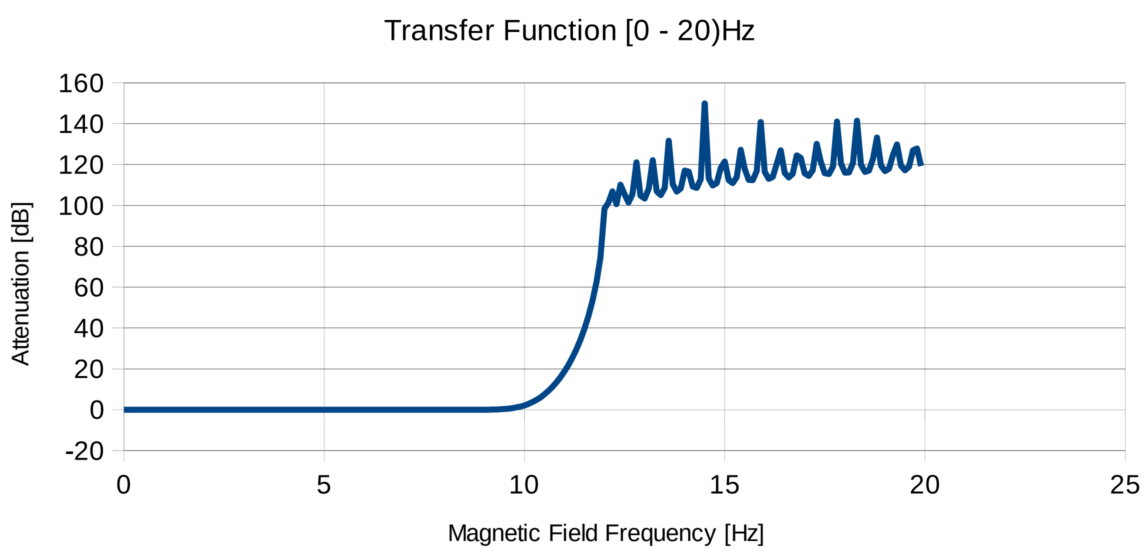
Attention!

- The filter is meant to be used only when KMAG4 is set for Free Run Mode.

- The filtered data are delayed for 1000ms after the raw data.

A low frequency filter can be assigned to one of the four MAG inputs. It provides more than 100dB (100,000 times) attenuation for frequencies above 12Hz and can be used to get rid of the high-frequency noise components in the magnetic field, like the noise, introduced by the helicopter blades, or the power lines 50/60Hz noise for example. The instrument can be configured to output only the filtered data, only the raw data or both, the raw and the filtered data. Chart 1 shows the filter transfer function from 0 to 20Hz magnetic field frequency, using logarithmic scale. For frequency components above 20Hz, the attenuation is even higher. It is more than 120dB (1,000,000 times). The filter uses an internal fixed sample rate of 1000 samples per second that is independent on the output data sample rate. Thus, a correct filtered data (without aliases) are guaranteed for noise frequencies up to 500Hz.

Chart 1



Linear transfer functions for the separate one-hertz ranges are shown in the charts below.Chart 2 shows that the ripple amplitude in the region from 0 to 1 Hz is less than 0.6ppm.

Chart 3 shows that the ripple amplitude in the region from 1 to 2 Hz is 0.7ppm.

Chart 4 shows that the ripple amplitude in the region from 2 to 3 Hz is less than 1ppm.

Chart 5 shows that the ripple amplitude in the region from 3 to 4 Hz is about 1.3ppm.

Chart 6 shows that the ripple amplitude in the region from 4 to 5 Hz is about 1.7ppm.

Chart 7 shows that the ripple amplitude in the region from 5 to 6 Hz is about 2.7ppm.

Chart 8 shows that the ripple amplitude in the region from 6 to 7 Hz is about 4.5ppm.

Chart 2

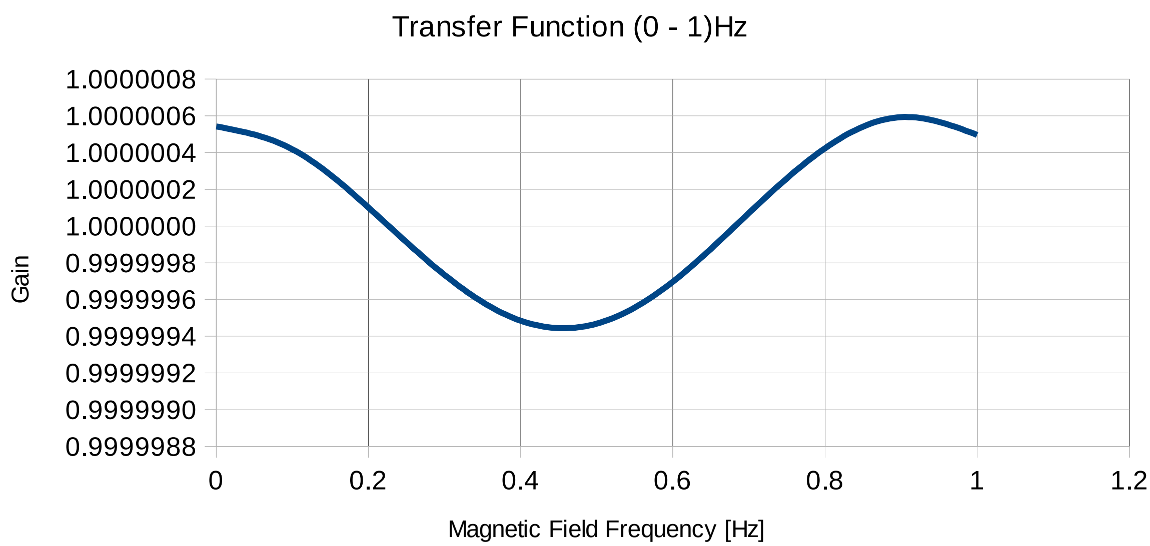


Chart 3

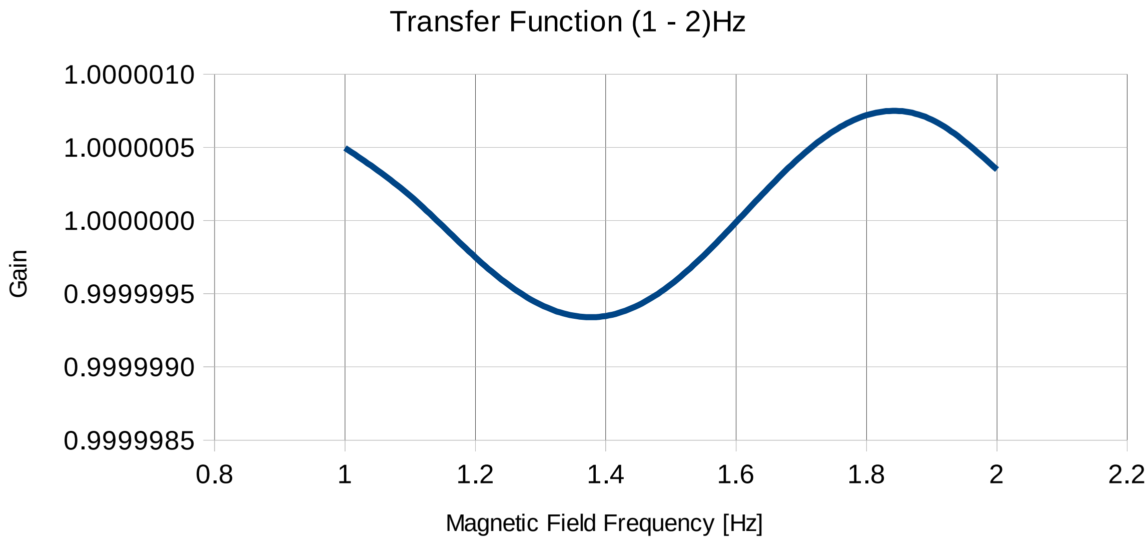


Chart 4

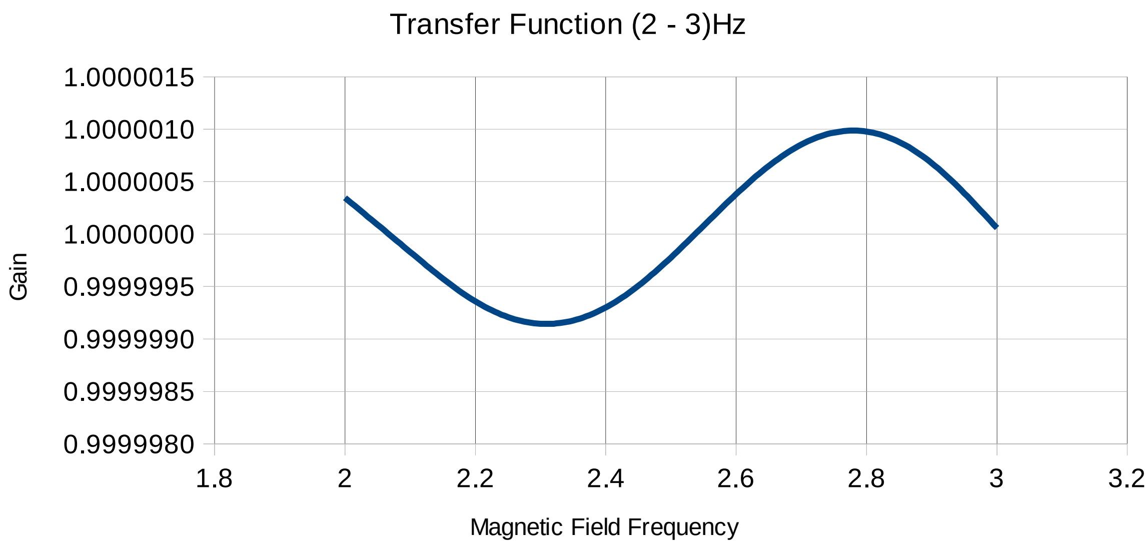


Chart 5

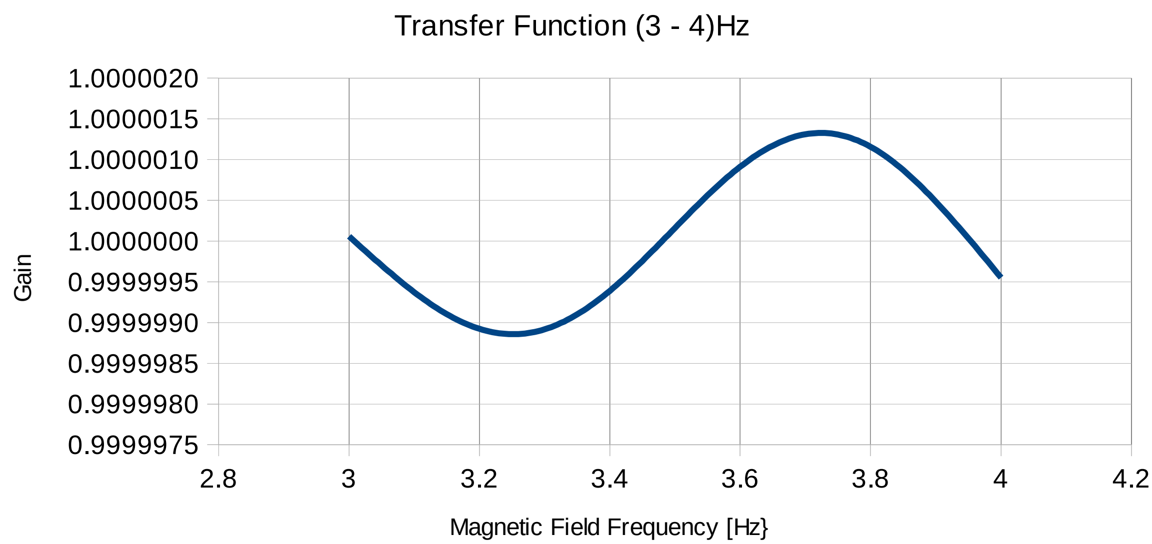


Chart 6

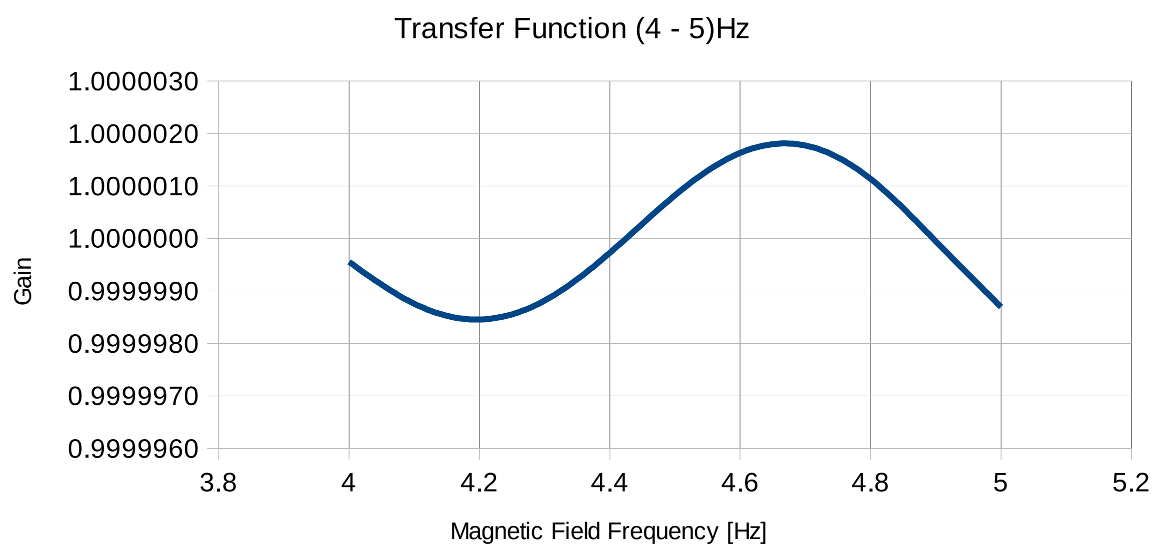


Chart 7

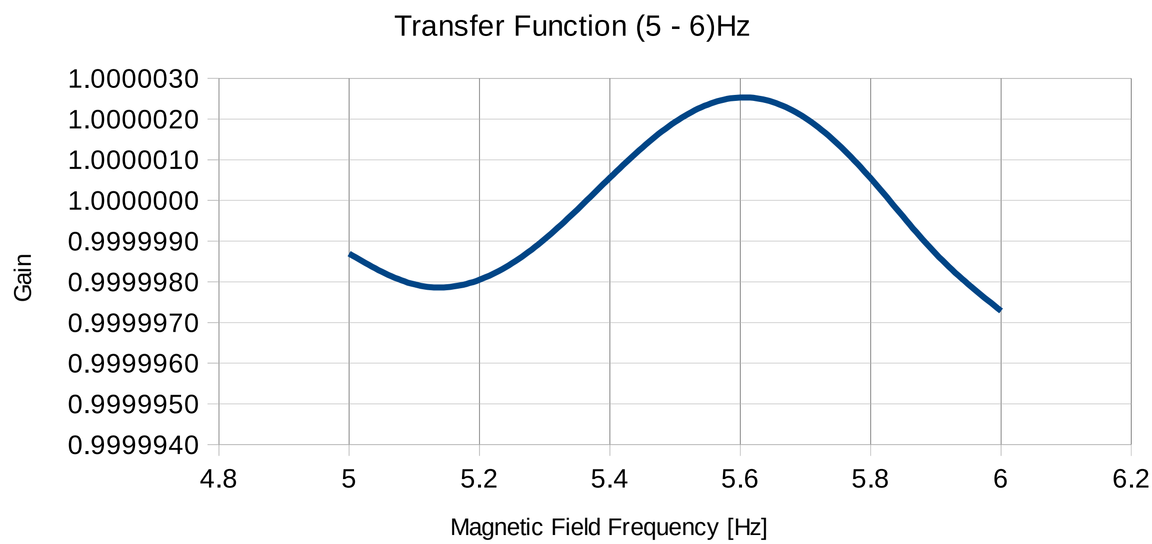


Chart 8

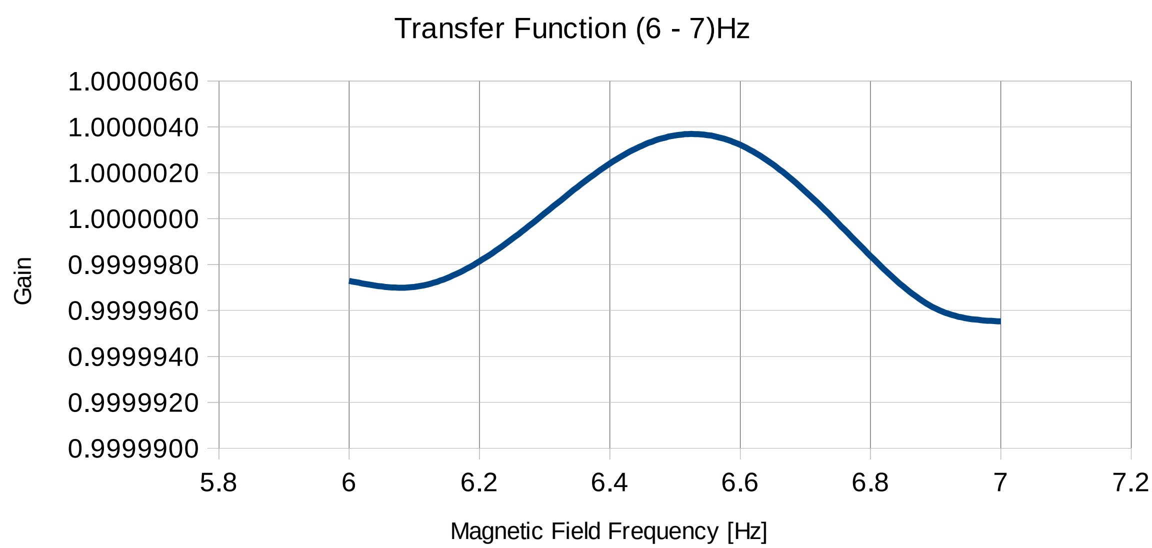


Chart 9

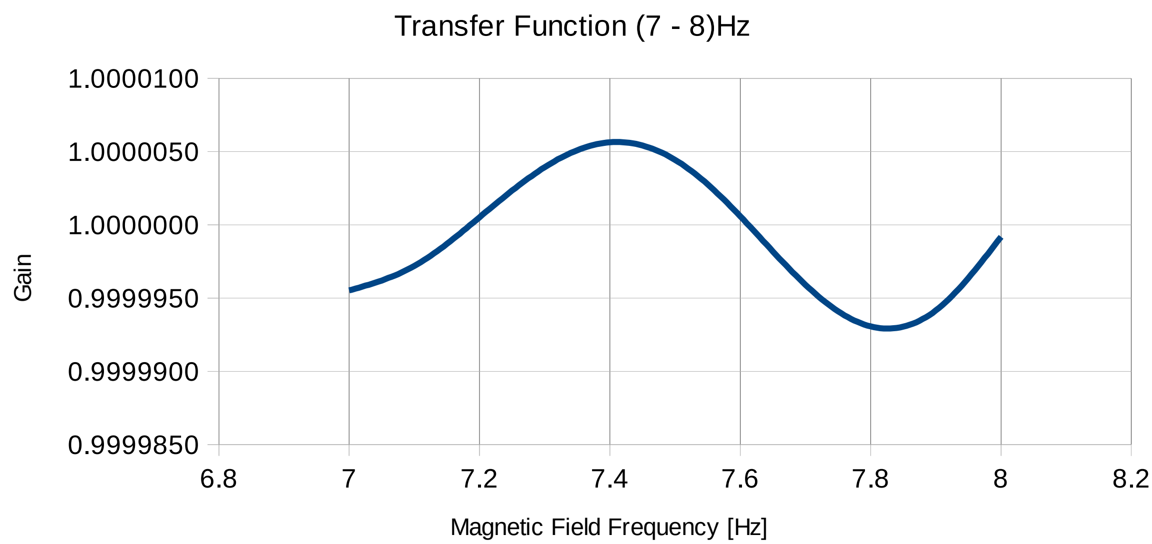


Chart 10

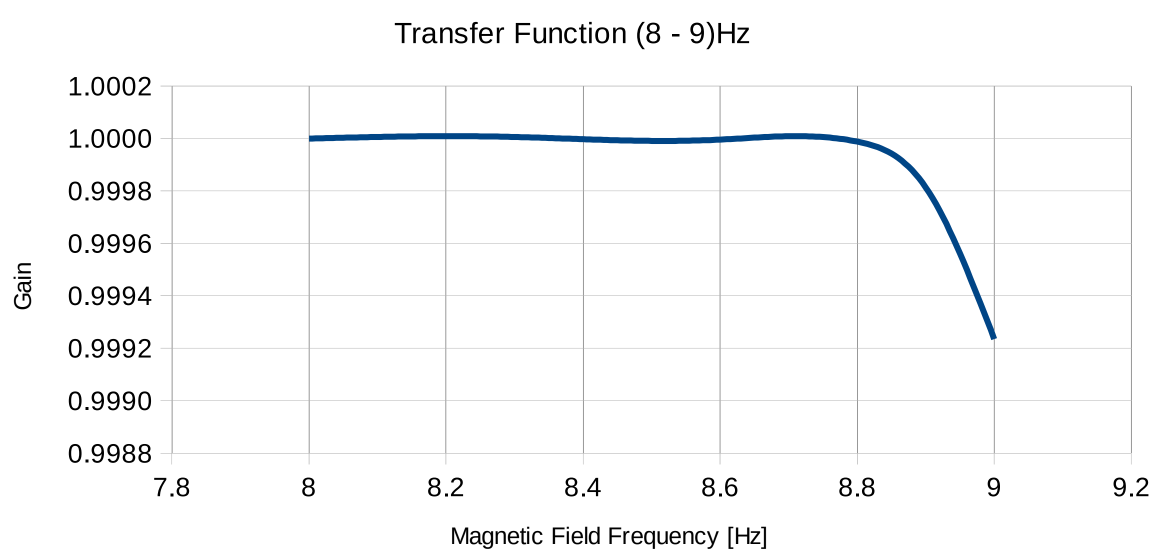
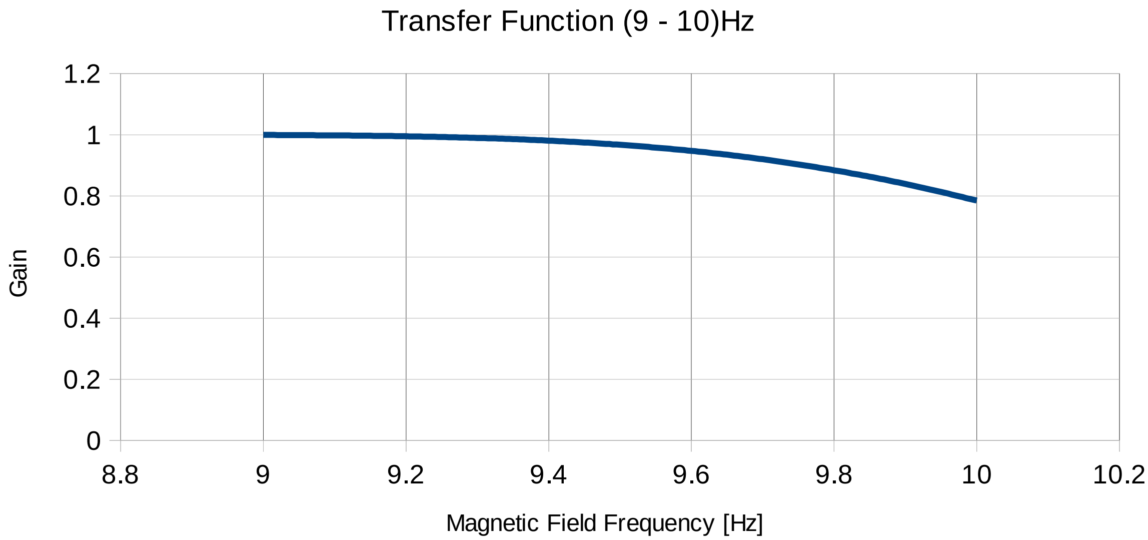


Chart 11



Transfer Function (9 - 10)Hz
Gain
1.2
1
0.8
0.6
0.4
0.2
0
8.8
9
9.2
9.4
9.6
9.8
10
10.2
Magnetic Field Frequency [Hz]

Chart 12

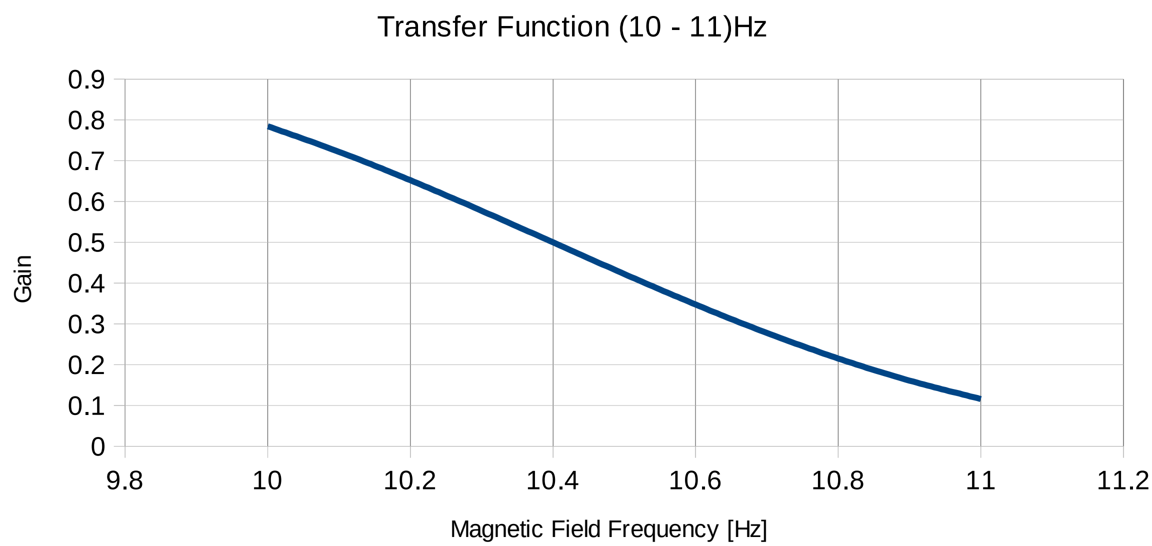


Chart 13

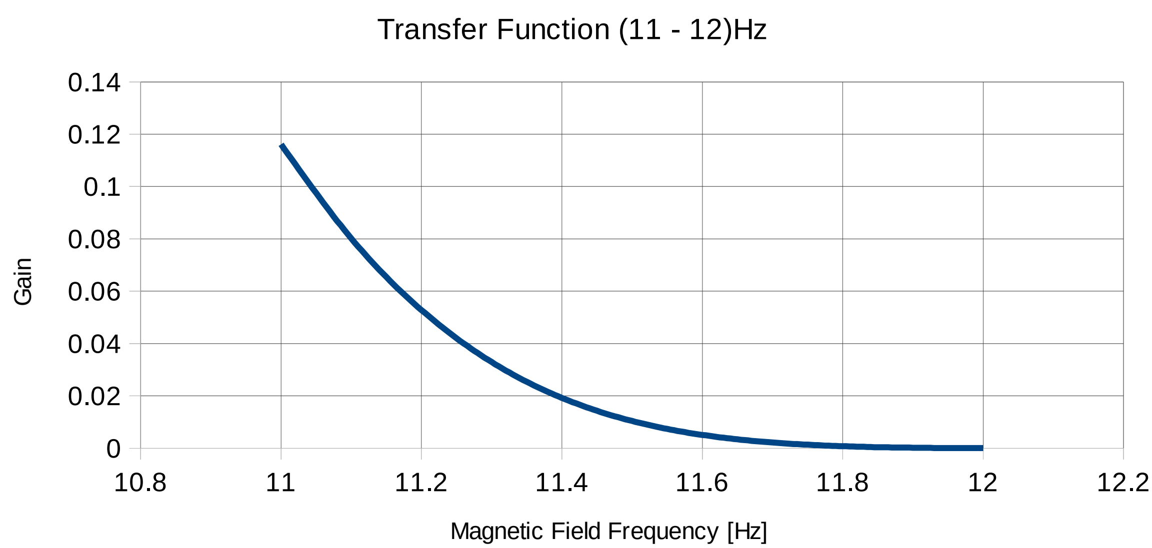


Chart 9 shows that the ripple amplitude in the region from 7 to 8 Hz is about 7ppm.

Chart 10 shows that after 8.8Hz, the Gain begins to decrease faster and at 9Hz it has decreased by almost 800ppm already. The transition region begins. The next 3 charts are for the transition region.

One Hertz magnetic field means, the magnetic field change completes a full sinusoid for one second or if the aircraft speed is 120km/hr, 33.33 meters will be necessary for the magnetic field to complete a full sinusoid. 8.8Hz magnetic field would mean, one full sinusoid would spread over only 3.79 meters.

DESCRIPTION

KMAG4 consists of 4 decouplers and 4 counters, using 260MHz reference frequency. Its front panel has two rows of 4 BNC connectors each. The bottom row is for the sensors. They provide power to the sensors and are connected to the inputs of the 4 decouplers also. There is a fuse, associated with each connector. It protects against short in the sensor cable. SCINTREX and GEOMETRICS caesium sensors can be connected directly.

GEM potassium sensors need first the corresponding fuse to be removed. Otherwise both, the sensor and the counter will be damaged.

A low-frequency filter can be applied to one of the four MAG inputs. Thus, three options are available for the corresponding sensor:

- The instrument outputs both, the filtered and the raw data.
- The instrument outputs only the filtered data.
- The instrument outputs only the raw data.

Attention: The filter is meant to be used only when KMAG4 is set for Free Run Mode!

If some of the sensor inputs are not used, they can be disabled to reduce the output data amount. Command ***$KCMDO*** can be used to specify each sensor type and to disable/enable the data from the different sensor inputs. Separate settings are provided for SCINTREX and GEOMETRICS caesium sensors, because both manufacturers provide slightly different coefficient to calculate the magnetic field.

The top row is for diagnostic purposes. An oscilloscope can be connected to a top row connector to observe the signal from the corresponding sensor. These signals are buffered through a unity gain amplifiers.

Each decoupler output is connected to the corresponding counter input. The counters take samples and output the data through the RS232 port, connected to the connector, named Port 3. This port is usually referred as MAIN.

Two major modes of operations are available (command ***$KCMDN)* -** Free Run Mode (FRM) and External Trigger Mode (ETM). When in FRM, KMAG4 starts sampling at the specified sample interval and sending the data through the MAIN port as soon, as it is powered. The end of the current sample is the start of the next sample in FRM. Command ***$KCMDM*** can be used to specify the sample interval. Any sample interval between 1ms and 1000ms, multiple of 1ms is allowed.

ETM allows KMAG4 sampling to be controlled by an external signal (**SyncIn**). Two External Trigger Modes are available – Continuous Sampling Mode (CSM) and Partial Sampling Mode (PSM). In CSM, the instrument samples during the entire sample interval. The end of the current sample is also the start of the next sample in CSM. The same edge of **SyncIn** signal is used to end the current sample and to start the new one. See command ***$KCMDN*** **–** options 3 and 4 for more details about CSM.

In PSM, the instrument samples only during a part of the sample interval. The end of the current sample is followed by idle time and then starts the next sample. Two Partial Sample Modes are available – Simple Partial Sampling Mode (SPSM) and Parametric Partial Sampling Mode (PPSM). In SPSM, the instrument samples only when **SyncIn** is in a specified state (high or low). See command ***$KCMDN*** **–** options 5 and 6 for more details about SPSM.

In PPSM, only one edge of **SyncIn** is used. The parameters Sample Delay and Sample Length should be specified in advance. Detection of the specified **SyncIn** edge causes KMAG4 to start a sample after the specified Sample Delay and to sample for the specified Sample Length. See command ***$KCMDN*** **–** options 1 and 2 for more details about PPSM. Command ***$KCMDK*** can be used to specify Sample Delay. Any number between 0ms and 1024ms, multiple of 0.25ms is allowed. Command ***$KCMDL*** can be used to specify Sample Length. Any number between 0.25ms and 1024ms, multiple of 0.25ms is allowed.

KMAG4 can output a synchronizing signal (**SyncOut**) itself. **SyncOut** allows other instruments to be synchronized to KMAG4. It could be two types, depending on the current sampling mode. In Free Run Mode (command ***$KCMDN*** **–** options 0) and Continuous Sampling Modes (command ***$KCMDN*** **–** options 3 and 4) **SyncOut** is a constant width pulse (500us). Its leading edge marks the end of the current sample and the beginning of the next one.

In Partial Sampling Mode (command ***$KCMDN*** **–** options 1, 2, 5 and 6) **SyncOut**, when active, indicates the instrument is sampling. Its leading edge indicates beginning of the sample and the trailing one – the sample end.

Command ***$KCMDS*** can be used to specify the **SyncOut** polarity (Positive or Negative).

The **PPS** signal from the GPS unit is used to attach a precise time (UTC) stamp to each sample. KMAG4 samples it every 20ns to detect precisely its active edge. Command ***$KCMDG*** can be used to specify the active **PPS** signal edge.

HARDWARE SETTINGS

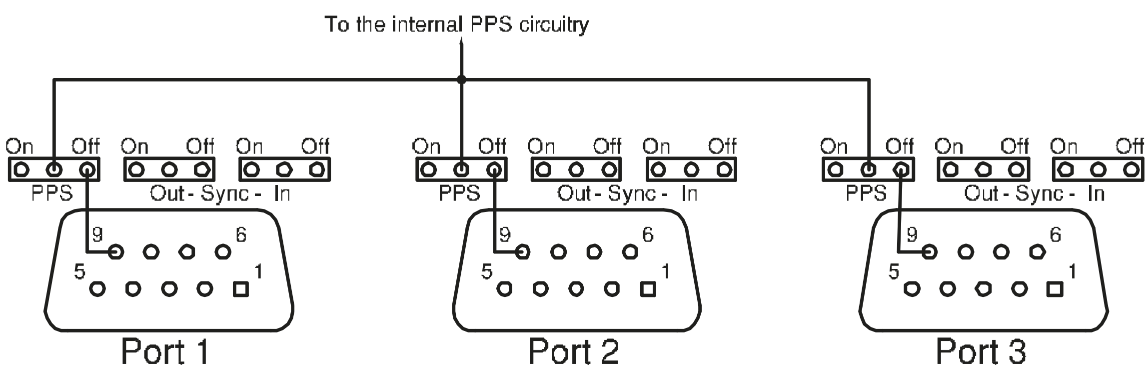
There are three sets of three-pin jumpers associated with each of the three RS232 connectors. These jumpers are labeled as **PPS**, **SyncIn** and **SyncOut**. Each jumper has two possible positions – **ON** and **OFF**.

<u>Warning!</u>

The labels ON and OFF on the board are exchanged. When the board label says ON, that means the associated signal is not connected to the corresponding pin and if the label says OFF, the signal is connected.

<u>PPS Jumpers</u>

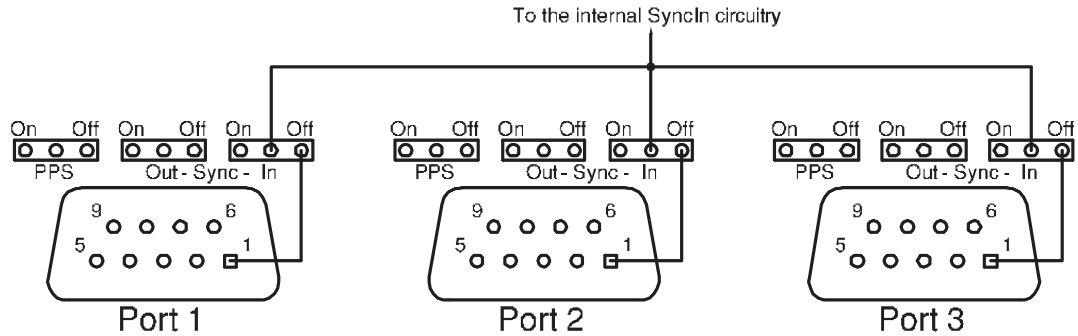
They provide a means to connect pin 9 of any of the three RS232 connectors (Port 1, Port 2, Port 3) to the internal PPS circuitry. They also provide a means to connect those pins between themselves. Thus the PPS signal can be propagated through to other instruments.



Note that the labels ON and OFF on the board are exchanged. If the jumper is in ON position, the associated pin is not connected and if the jumper is in OFF position, the pin is connected.

<u>SyncIn Jumpers</u>

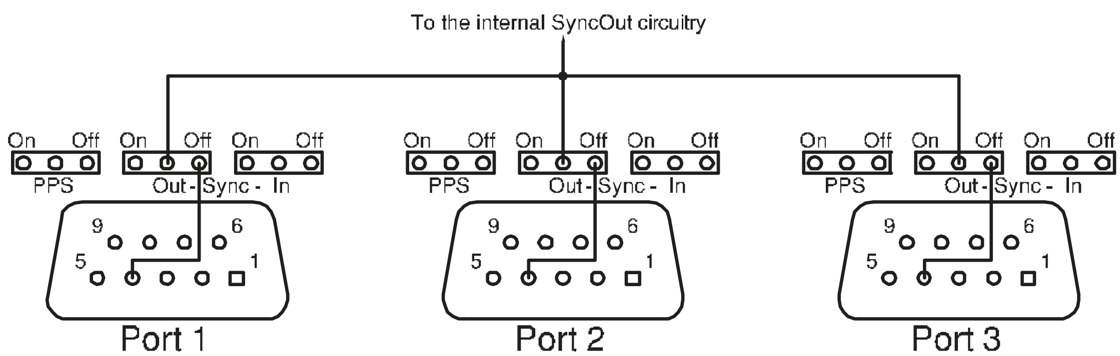
They provide a means to connect pin 1 of any of the three RS232 connectors (Port 1, Port 2, Port 3) to the internal SyncIn circuitry. They also provide a means to connect those pins between themselves. Thus the SyncIn signal can be propagated to other instruments.



Note that the labels ON and OFF on the board are exchanged. If the jumper is in ON position, the associated pin is not connected and if the jumper is in OFF position, the pin is connected.

<u>SyncOut Jumpers</u>

They provide a means to connect the output signal SyncOut to pin 4 of any of the three RS232 connectors (Port 1, Port 2, Port 3).



Note that the labels ON and OFF on the board are exchanged. If the jumper is in ON position, the associated pin is not connected and if the jumper is in OFF position, the pin is connected.

CONNECTORS

Port 3

Pins 2 and 3 are dedicated for the MAIN port. All ports (MAIN, GPS, AUX1, AUX2) behave as DTE (Data Terminal Equipment). No flow control, 8 data bits, No parity, One stop bit setup is used. Only three RS232 lines (RxD, TxD and GND) are required. KMAG4 outputs its data through the MAIN port and data logger can be connected to display and record them. A communication program like Hyper Terminal can be used to modify the instrument settings through this port. The modified settings are saved in a non-volatile memory and stay there until modified again. One-letter commands, preceded by a command prefix (**$KCMD**) are used for this purpose.

Two commands (**$KCMDH** and **$KCMDJ**) are dedicated only for factory use. They must not be used in the field because they can delete the existing firmware and the instrument will have to be sent for repair. If issued by accident, follow the instructions on the screen to abort the command. See section "COMMANDS DESCRIPTION" for details.

The signals on pins 1, 4 and 9 are available on every one of the three connectors - Port 1, Port 2 and Port 3. They are connected to the internal circuitry through individual jumpers for better flexibility. Any of those pins is connected to the internal circuitry only if the corresponding jumper is in ON position. Note that if the jumpers on more than one connector are in ON position, the corresponding pins are connected.

The table below shows Port 3 signal layout.

Pin #	Jumper	Position	Mode	Signal	Type	Note
1	SyncIn	OFF	-	Not Connected	-	-
	SyncIn	ON	ETM	SyncIn	Input	-
	SyncIn	ON	-	Not Used	Input	If AUX2 disabled
	SyncIn	ON	FRM	AUX2-RxD	Input	If AUX2 enabled
2	-	-		MAIN-RxD	Input	-
3	-	-		MAIN-TxD	Output	-
4	SyncOut	OFF	-	Not Connected	-	-
	SyncOut	ON	-	SyncOut	Output	-
5	-	-		GND	-	-
6	-	-		Not Connected	-	-
7	-	-		Not Connected	-	-
8	-	-		Not Connected	-	-
9	PPS	OFF	-	-	-	-
	PPS	ON	-	PPS	Input	-

Attention!

The labels ON and OFF on the board are reversed.

Not Used indicates the pin is connected to an input, but the instrument ignores the signal.

Port 1

Pins 2 is usually used to connect a GPS receiver, but Port 2 – pin2 can be configured for the same purpose instead if AUX1 port is not enabled. Pin 3 can be configured to output a replica of the incoming data GPS data from Port 1 – pin2 or Port 2 – pin2.
The signals on pins 1, 4 and 9 are available on every one of the three connectors - Port 1, Port 2 and Port 3. They are connected to the internal circuitry through individual jumpers for better flexibility. Any of those pins is connected to the internal circuitry only if the corresponding jumper is in ON position. Note that if the jumpers on more than one connector are in ON position, the corresponding pins are connected.
The table below shows Port 1 signal layout.

Pin #	Jumper	Position	Mode	Signal	Type	Note
1	SyncIn	OFF	-	Not Connected	-	-
	SyncIn	ON	ETM	SyncIn	Input	-
	SyncIn	ON	-	Not Used	Input	If AUX2 disabled
	SyncIn	ON	FRM	AUX2-RxD	Input	If AUX2 enabled
2	-	-	-	Not Used	Input	If GPS-RxD not selected and AUX1 disabled
				GPS-RxD	Input	If GPS-RxD selected or AUX1 enabled
3	-	-	-	GPS Data	Output	Replica of the incoming GPS data if selected
4	SyncOut	OFF	-	Not Connected	-	-
	SyncOut	ON	-	SyncOut	Output	-
5	-	-		GND	-	-
6	-	-		Not Connected	-	-
7	-	-		Not Connected	-	-
8	-	-		Not Connected	-	-
9	PPS	OFF	-	-	-	-
	PPS	ON	-	PPS	Input	-

Attention!
The labels ON and OFF on the board are reversed.

Port 2

There is no RS232 transmitter available on this port and three possible configurations for pin2:
- receiver for the AUX1 port
- receiver for the incoming GPS data
- Not Used

The signals on pins 1, 4 and 9 are available on every one of the three connectors - Port 1, Port 2 and Port 3. They are connected to the internal circuitry through individual jumpers for better flexibility. Any of those pins is connected to the internal circuitry only if the corresponding jumper is in ON position. Note that if the jumpers on more than one connector are in ON position, the corresponding pins are connected.
The table below shows Port 2 signal layout.

Pin #	Jumper	Position	Mode	Signal	Type	Note
1	SyncIn	OFF	-	Not Connected	-	-
	SyncIn	ON	ETM	SyncIn	Input	-
	SyncIn	ON	-	Not Used	Input	If AUX2 disabled
	SyncIn	ON	FRM	AUX2-RxD	Input	If AUX2 enabled
2	-	-	-	Not Used	Input	If GPS-RxD not selected and AUX1 disabled
				AUX1-RxD	Input	If AUX1 enabled
				GPS-RxD	Input	If GPS-RxD selected and AUX1 disabled
3	-	-	-	Not Connected	-	-
4	SyncOut	OFF	-	Not Connected	-	-
	SyncOut	ON	-	SyncOut	Output	-
5	-	-		GND	-	-
6	-	-		Not Connected	-	-
7	-	-		Not Connected	-	-
8	-	-		Not Connected	-	-
9	PPS	OFF	-	-	-	-
	PPS	ON	-	PPS	Input	-

Attention!
The labels ON and OFF on the board are reversed.
Not Used indicates the pin is connected to an input, but the instrument ignores the signal.

28VDC

This is the power supply connector. The instrument uses this power supply to power its own circuitry and each of the four sensors through a separate fuse. Pin 1 is connected to pin 3 and pin 2 - to pin 4 inside the instrument. Four-wire 16 AWG cable is recommended Pins 1 and 3 connect to the positive wire and pins 2 and 4 – to the negative one. ***Special attention should be payed when making the power cable. The instrument will be damaged if connected to reverse power supply.*** The table below describes the parts, necessary for the power cable.

Item	Description	AMP PART #	Quantity
1	Plug Standard Sex	206060-1	1
2	Socket Contacts 18AWG-16AWG	66181-1	2 (3,4)
3	Cable Clamp	1-206062-6	1

KMAG4 (Version 3) OUTPUT RECORD

KMAG4 output record consists of a record identifier and 7 data fields, separated by commas. The first field is the one, immediately following the first comma (between the first comma and the second one). The n-th field is the one after the n-th comma.
Below are 18 KMAG4 output records.

Example 1

```
$KMAG4,000061800,,,571692830,571692852,571692830,571692852
$KMAG4,000061900,,,571692852,571692830,571692852,571692852
$KMAG4,000062000,,,571692830,571692852,571692830,571692830
$KMAG4,000062100,,,571692852,571692830,571692852,571692830
$KMAG4,000062200,181100,000062000,571692830,571692852,571692830,571692852
$KMAG4,000062300,,,571692852,571692830,571692852,571692830
$KMAG4,000062400,,,571692830,571692852,571692830,571692852
$KMAG4,000062500,,,571692852,571692830,571692852,571692830
$KMAG4,000062600,,,571692830,571692852,571692830,571692852
$KMAG4,000062700,,,571692852,571692830,571692852,571692852
$KMAG4,000062800,,,571692828,571692850,571692828,571692828
$KMAG4,000062900,,,571692852,571692830,571692852,571692852
$KMAG4,000063000,,,571692831,571692853,571692831,571692831
$KMAG4,000063100,,,571692852,571692830,571692852,571692830
$KMAG4,000063200,,,571692830,571692852,571692830,571692852
$KMAG4,000063300,181101,000063000,571692852,571692830,571692852,571692830
$KMAG4,000063400,,,571692830,571692852,571692830,571692852
$KMAG4,000063500,,,571692850,571692828,571692850,571692850
$KMAG4,000063600,,,571692830,571692852,571692830,571692830
```

- The first field contains the reading of the instrument clock. It is the instrument time. The instrument time starts as soon as the power supply is applied to the instrument and increments every millisecond. The difference between two consecutive instrument clock readings is equal to the sample interval in milliseconds. The instrument time corresponds to the end of the current sample interval in FRM and CSM (see command ***$KCMDN*** options 0, 3, 4) and to the beginning of the current sample interval in all Partial Sampling Modes (see command ***$KCMDN*** options 1, 2, 5, 6).
- The second field is the UTC, extracted from the GPS data (the GGA or the GNS string). Its format depends on the GPS, connected to KMAG4 and could be *hhmmss.sss*, *hhmmss.ss*, *hhmmss.s* or *hhmmss*, where:
  hh – hours
  mm - minutes
  ss.sss - seconds

Attention:

The instrument can also be configured to output UTC as field 3. See command $KCMDB for details.

- The third field is called PPS Time (PPST). It contains the instrument clock reading at the arrival of the active PPS pulse edge. The difference between the instrument time and the UTC can be used to convert the instrument time to UTC as it is described bellow. Thus, every sample is time stamped. The time stamp corresponds to the end of the sample in FRM (Free Run Mode) and CSM (Continuous Sampling Mode), and to the beginning of the sample for SPSM (Simple Partial Sampling Mode) and PPSM (Parametric Partial Sampling Mode).

Attention:

The instrument can be configured to output PPST as field 2. See command $KCMDB for details.

- Fields 4 through 7 contain the readings of the four mag sensors. The mag field is in tenth of pico Tesla.

Attention:

One more field for the filtered data will exist and it will be the last one if the instrument is set to output both, the filtered and the raw data. If the instrument is set to output only the filtered data, they will simply replace the corresponding raw data.

There are sensors connected to all sensor inputs in Example1 and the output records contain data in all mag fields. If some of the inputs were left unconnected, the associated output record fields would contain zeroes Example 2 shows the case when no sensors are connected to MAG2 and MAG3 inputs.

Example 2

```
$KMAG4,000015800,,,571692852,000000000,000000000,571692852
$KMAG4,000015900,,,571692874,000000000,000000000,571692852
$KMAG4,000016000,,,571692852,000000000,000000000,571692874
$KMAG4,000016100,,,571692852,000000000,000000000,571692852
$KMAG4,000016200,183345,000016000,571692852,000000000,000000000,571692852
$KMAG4,000016300,,,571692852,000000000,000000000,571692852
$KMAG4,000016400,,,571692852,000000000,000000000,571692852
$KMAG4,000016500,,,571692852,000000000,000000000,571692852
$KMAG4,000016600,,,571692852,000000000,000000000,571692852
$KMAG4,000016700,,,571692852,000000000,000000000,571692852
$KMAG4,000016800,,,571692852,000000000,000000000,571692852
$KMAG4,000016900,,,571692872,000000000,000000000,571692850
$KMAG4,000017000,,,571692853,000000000,000000000,571692853
$KMAG4,000017100,,,571692852,000000000,000000000,571692874
$KMAG4,000017200,,,571692852,000000000,000000000,571692852
$KMAG4,000017300,183346,000017000,571692852,000000000,000000000,571692852
$KMAG4,000017400,,,571692852,000000000,000000000,571692852
$KMAG4,000017500,,,571692852,000000000,000000000,571692852
$KMAG4,000017600,,,571692850,000000000,000000000,571692850
```

If some of the sensor inputs are not used, the data associated with them could be disabled and the corresponding fields will be empty to reduce the amount of data. Example 3 shows the case when the fields 2 and 3 data have been disabled.

Example 3

```
$KMAG4,000514800,,,571692808,,,571692808
$KMAG4,000514900,,,571692830,,,571692808
$KMAG4,000515000,,,571692787,,,571692809
$KMAG4,000515100,,,571692808,,,571692830
$KMAG4,000515200,184204,000515000,571692830,,,571692808
```

```
$KMAG4,000515300,,,571692808,,,571692808
$KMAG4,000515400,,,571692806,,,571692806
$KMAG4,000515500,,,571692808,,,571692808
$KMAG4,000515600,,,571692808,,,571692808
$KMAG4,000515700,,,571692808,,,571692808
$KMAG4,000515800,,,571692808,,,571692808
$KMAG4,000515900,,,571692808,,,571692808
$KMAG4,000516000,,,571692809,,,571692809
$KMAG4,000516100,,,571692806,,,571692806
$KMAG4,000516200,184205,000516000,571692830,,,571692830
$KMAG4,000516300,,,571692808,,,571692808
$KMAG4,000516400,,,571692808,,,571692808
$KMAG4,000516500,,,571692808,,,571692808
```

Usually the instrument samples more frequently than the GPS. That's why field 2 in some of the output records could be empty. Field 3 will not be empty ones in a second, because the PPS signal (As its name states – Pulse Per Second) is active once per second. In the above examples it is not empty ones per 10 readings, because the instrument was set to sample 10 times/s.
Note:
Some data acquisition systems require constant length output record. KMAG4 can be configured to fill the empty fields 2 and 3 with a specified character in such a case. See Command **$KCMDB** for details.

Instrument Time to UTC conversion procedure

1. Take the UTC from a record (Example 1, the highlighted record, field 2) and convert it to milliseconds
   UTC=181100 = (18 x 3600 + 11 x 60 + 0) x 1000 = 65460000ms
2. Subtract the corresponding third field from the converted value to find how much the instrument clock is behind the UTC time.
   CORR = UTC – PPST = 65460000 – 62000 = 65398000ms
   This difference will be the same for all the samples. That's why it can be calculated only once.
3. Add the calculated correction to field one of every sample to convert the instrument time to UTC time in milliseconds.

   61800 + 65398000 = 65459800
   61900 + 65398000 = 65459900
   62000 + 65398000 = 65460000
   62100 + 65398000 = 65460100
   62200 + 65398000 = 65460200
   62300 + 65398000 = 65460300
   62400 + 65398000 = 65460400
   62500 + 65398000 = 65460500

62600 + 65398000 = 65460600
62700 + 65398000 = 65460700
62800 + 65398000 = 65460800
62900 + 65398000 = 65460900
63000 + 65398000 = 65461000
63100 + 65398000 = 65461100
63200 + 65398000 = 65461200
63300 + 65398000 = 65461300
63400 + 65398000 = 65461300
63500 + 65398000 = 65461400

As a result of the conversion procedure, each sample will have a precise UTC stamp (see the data below) and the KMAG4 output data could be merged with any other data even if they were recorded by another instrument.

```
$KMAG4,065459800,,,571692830,571692852,571692830,571692852
$KMAG4,065459900,,,571692852,571692830,571692852,571692852
$KMAG4,065460000,,,571692830,571692852,571692830,571692830
$KMAG4,065460100,,,571692852,571692830,571692852,571692830
$KMAG4,065460200,181100,000062000,571692830,571692852,571692830,571692852
$KMAG4,065460300,,,571692852,571692830,571692852,571692830
$KMAG4,065460400,,,571692830,571692852,571692830,571692852
$KMAG4,065460500,,,571692852,571692830,571692852,571692830
$KMAG4,065460600,,,571692830,571692852,571692830,571692852
$KMAG4,065460700,,,571692852,571692830,571692852,571692852
$KMAG4,065460800,,,571692828,571692850,571692828,571692828
$KMAG4,065460900,,,571692852,571692830,571692852,571692852
$KMAG4,065461000,,,571692831,571692853,571692831,571692831
$KMAG4,065461100,,,571692852,571692830,571692852,571692830
$KMAG4,065461200,,,571692830,571692852,571692830,571692852
$KMAG4,065461300,181101,000063000,571692852,571692830,571692852,571692830
$KMAG4,065461400,,,571692830,571692852,571692830,571692852
$KMAG4,065461500,,,571692850,571692828,571692850,571692850
$KMAG4,065461600,,,571692830,571692852,571692830,571692830
```

Attention: The filtered data are delayed 1000ms after the raw data!

KMAG4 COMMANDS DESCRIPTION

One-letter commands preceded by a command prefix (**$KCMD**) can be used to modify KMAG4 settings. The following description does not mention the command prefix, but it is mandatory. **Commands will be ignored if not preceded by the command prefix. Only capital letters are accepted as commands.**

Command *$KCMDA*

Can be used to modify the output string identifier. Enter the desired string identifier and press <RETURN>. Allows up to 6-character string identifiers. If no string identifier is desired just press <RETURN>.

Command *$KCMDB*

Fields 2 and 3 in the output record are dedicated for the UTC and its corresponding KMAG4 clock (PPST) fields in the output record. This command allows to:

- Swap field 2 and 3 in the output record.
- Select between constant and flexible length output records

When flexible length output record is used, the PPST field contains information only once per second and UTC field depends on the sample rate of the GPS receiver that is in general different that the KMAG4 sample rate. The output records, containing no information in their UTC and PPST fields are shorter than the records containing information in those fields.

There are data acquisition systems requiring constant length output record. If a constant length output record is selected, the instrument fills in the empty fields with a specified padding character to provide a constant length output record.

Command *$KCMDC*

Versions, earlier than 3.22 does not support this command. It was created to allow configuration of the GPS receiver, if connected to Port 1, through Port 3. That's why this mode is called GPS Setup Mode. In GPS Setup Mode, KMAG4 creates a direct connection between Port 3 and Port 1. The instrument stops immediately sending $KMAG4 strings, sends out all the data from its Port 3 input buffer, sends the message "Connected!" and then switches Port 3 Baud rate to make it equal to the Baud rate of Port 1. If Port 1 Baud rate is 4800, the instrument ignores command $KCMDC and nothing changes. To exit GPS Setup Mode, another $KCMDC command or command

$KCMDD is necessary. Note, that in GPS Setup Mode, the instrument ignores any other command.

Attention!

It is recommended to select in advance option 2 (Random data) of the GPS port settings (command $KCMDI) to make sure, every character, sent from the GPS will pass through immediately.

Configuration Sequence

- Send ***$KCMDC***
- Wait to receive ***Connected!***
- Switch the computer Baud Rate to correspond the current Baud rate of the GPS receiver.
- Wait to start receiving characters from the GPS.
- Send the required data to reconfigure the GPS.
- Send ***$KCMDC*** (***$KCMDD***) again to exit GPS Setup Mode. KMAG4 will restart and switch back to its original settings.

Note:

The third step of the above sequence will not be necessary if the GPS port (Port 1) and the MAIN port (Port 3) were already running at the same Baud rate.

Command *$KCMDG*

Affects the PPS settings. Allows selecting the active PPS edge and enables/disables the instrument clock to stay in-phase with the PPS signal.

Command *$KCMDH*

This is one of the two dangerous commands! It should not be used, because it can delete the existing firmware and make the instrument unfunctional! If issued unintentionally, follow the instructions on the screen to abort the command!

Command *$KCMDI*

Provides a means to configure the GPS port.

- First KMAG4 response:

INPUT
1 - Port 1
2 - Port 2

Option 1 instructs KMAG4 to expect the GPS data on Port 1 (pin 2) and option 2 – on Port 2 (pin 2).

Attention!
Port 2 (pin 2) is used by the AUX1 RS232 receiver, if enabled. In case AUX1 is enabled, the instrument will consider Port 2 (pin 2) as the input for the AUX1 and Port 1 (pin 2) as the input for the GPS data, even if option 2 is selected.

- Second KMAG4 response:

OUTPUT
0 - None
1 - Port 1

Option 1 instructs KMAG4 to replicate the GPS data on Port 1 (pin 3) and option 0 – means no replica. Selecting option 1 provides a convenient connection of the GPS data to another instrument.

- Third KMAG4 response is to send the GPS port Baud rate selection table.
- Fourth KMAG4 response:

GPS DATA IN THE OUTPUT
0 - None
1 - LF-ending strings only
2 - Random

Option 0 means no GPS data will pass through to the output data. The instrument will just use the GGA string to extract the UTC time to time stamp the KMAG4 strings.

If option 2 is selected, KMAG4 will transmit every character, coming from the GPS through Port 3 as soon, as it has arrived.

Option 1 instructs KMAG4 to accumulate the incoming GPS data into its buffer memory untill LF character has been received. Then, all the characters, preceding LF and the LF itself, will be transmitted through Port 3. It guarantees that all LF ending strings, coming from the GPS will appear uninterrupted in the output data.

- Fifth KMAG4 response is to send the AUX1 port Baud rate selection table.
  AUX 1 port uses Port 2 (pin 2) as its input.
- Sixth KMAG4 response:

AUX1 DATA IN THE OUTPUT
0 - None
1 - LF-ending strings only
2 - Random

Option 0 disables the port and options 1 and 2 enable it.

Attention!
The instrument will switch its GPS port input to Port 1 (pin 2), if AUX1 is enabled, regardless of the selected option in the first step of this command. This is to free Port 2 (pin 2) for the AUX1 port.

- Seventh KMAG4 response is to send the AUX2 port Baud rate selection table.
- Eighth KMAG4 response:

AUX2 DATA IN THE OUTPUT
0 - None
1 - LF-ending strings only
2 - Random

Attention!
AUX2 receiver uses pin 1 of any of the three RS232 connector. The same pin is also used in External Trigger Mode (ETM) as an input for the SyncIn signal. Trigger mode takes precedence over the AUX2 port. KMAG4 will not enable its AUX2 port even if option 1 or 2 is selected, in ETM. Thus pin 2 is preserved fot the SyncIn signal in ETM. AUX2 can be used only in Free Run Mode. Only SyncIn can be connected to pin 1 in ETM.

- Ninth KMAG4 response:

Press ENTER to continue!

KMAG4 restarts after ENTER has been pressed.

Command *$KCMDJ*

This is one of the two dangerous commands! It should not be used, because it can delete the existing firmware and make the instrument unfunctional! If issued unintentionally, follow the instructions on the screen to abort the command!

Command *$KCMDK*

Affects the instrument operation only in trigger mode. Allows to select the desired sample delay (t_d = T1-T0). See command **$KCMDN** for details.

Command *$KCMDL*

Affects the instrument operation only in trigger mode. Allows to select the desired sample length (t_s = T2-T1). See command **$KCMDN** for details.

Command $KCMDM

Affects the instrument operation only in Free Run Mode. Allows to select the desired sample interval. It is necessary to enter the desired sample interval in milliseconds and to press <ENTER>. Sample intervals between 1 and 1024 milliseconds are accepted.

Command *$KCMDN*

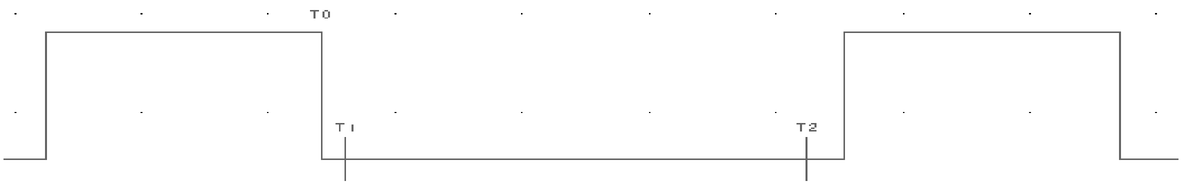
Allows to select between **Free Run Mode** and six variations of **External Trigger Mode**.

Below is the instrument response:

```
TRIGGER MODE
0 - FRM
1 - PPSM,H2L
2 - PPSM,L2H
3 - CSM,H2L
4 - CSM,L2H
5 - SPSM,LOW
6 - SPSM,HIGH
```

- **Option 0** specifies **Free Run Mode (FRM).** The instrument starts sampling and sending data as soon as its power supply is turned on in this mode. The sample interval can be selected using the command ***$KCMDM***.
- **Options 1 and 2** select **Parametric Partial Sampling Mode**. These two options and the remaining 4 define the External Trigger Mode. The difference between the two options is the active **SyncIn** edge. When one of these two options is selected, the instrument samples only during part of the sampling interval. The active **SyncIn** edge and **Start Delay** control the start of the sample and **Sample Length** control the end of the sample. During the rest of the sample interval, until the next active **SyncIn** edge, the instrument does not sample. Commands ***$KCMDK*** and ***$KCMDL*** can be used to specify **Sample Delay** and **Sample Length** accordingly. Below is a chart, illustrating Parametric Partial Sampling Mode.

T0 *specifies the time, the active SyncIn edge arrives*
T1-T0 *is the Sample Delay*
T2-T1 *is the Sample Length*



- **Options 3 and 4** select **Continuous Sampling Mode**. The instrument samples during the entire sample interval in this mode. The end of the current sample is also the start of the next sample. The same **SyncIn** edge defines the end of the current sample and the start of the next one. The difference between these 2 options is the active **SyncIn** edge.
- **Options 5 and 6** select **Simple Partial Sampling Mode**. The instrument samples only between the active **SyncIn** edge and the opposite **SyncIn** edge in this mode. The difference between the two options is the active **SyncIn** edge. If the transition from low to high is the active **SyncIn** edge, the instrument samples only when **SyncIn** is high. If the transition from high to low is the active **SyncIn** edge, the instrument samples only when **SyncIn** is low.

Command *$KCMDO*

- Modifies the settings of the four sensor inputs. Four options are available for each input - turned off, set for Geometrics sensor, set for Scintrex sensor or set for GEM sensor. Geometrics and Scintrex sensors have the same physical interface. They can be connected directly to KMAG4.

***Attention!** GEM sensors use different physical interface. They require removing the fuse inside KMAG4. Leaving it in place will damage both, the sensor and KMAG4.*

- Assigns the filter to one of the four sensors, connected to MAG inputs. Three options are available for the associated MAG input.

R – Only the raw data are included in the output record.

F – Only the filtered data are included in the output record. They appear in the field, designated for the associated MAG data.

B – Both, the raw and the filtered data are included in the output record. The filtered data appear in an additional data field, immediately following the one for the MAG4 data.

Attention: The filter is meant to be used only when KMAG4 is set for Free Run Mode!

Command *$KCMDQ*

Modifies Port 3 Baud Rate. Port 3 uses the following protocol: No flow control, 8 data bits, No parity, 1 stop bit. A standard communication program like *Hyper Terminal* can be used to watch and record the output data. KMAG4 first sends the Baud rate selection table after receiving the command. Then, after the Baud rate option is selected, KMAG4 responds with:

```
RESTART?
0 - LATER
1 - NOW
```

If chosen to restart later, the instrument will continue to use its previous Baud rate. It will switch to the new Baud rate after the first restart. The choice between the immediate restart and the later one is given for convenience – to provide time for switching the communication program Baud rate. At the end, the instrument must be restarted to reload all its settings.

Command *$KCMDR*

This command displays the instrument version, serial number and current settings. Below is a possible instrument response:

```
KROUM VS INSTRUMENTS LIMITED
KMAG4 SN220
VERSION 3.27.11
MAG1    - SCINTREX,RAW,FILTERED
MAG2    - SCINTREX
MAG3    - SCINTREX
MAG4    - SCINTREX
UTC     - Field 2
FRM     - 0050
PPS     - L2H,CLOCK SYNCHRONIZED
SyncOut - L2H
GPS     - IN-PORT1,OUT-NONE,LF-END,019200
AUX1    - LF-END,115200
AUX2    - LF-END,115200
Press ENTER to continue!
```

The output record field 2 will contain the UTC in this case and field 3 – the PPST.

The instrument is set in Free Run Mode. The number, following **FRM** represents the sample interval in milliseconds.

The setting, labelled as **SYNC**, is about the **SyncOut** signal (see command **$KCMDS**). In should not be confused with the **SyncIn** signal, used in External Trigger Modes.

At the end are the three RS232 port settings available through command ***$KCMDI***.

Command *$KCMDS*

Allows to specify **SyncOut** polarity. KMAG4 responds to this command with:

SyncOut Polarity
0 - Positive
1 – Negative

Two types of SyncOut signals exist, depending on the trigger mode, KMAG4 currently uses.

- The first type is a constant width pulse. The active pulse edge is the low to high (L2H) transition, if option 0 is selected, and – high to low (H2L) transition if option 1 is selected. This type **SyncOut** is generated in **FRM** (command ***$KCMDN*** – option **0**) and **ETM-CSM** (command ***$KCMDN*** – options **3** and **4**).
- The second type is generated when the instrument uses one of the partial sampling modes (command ***$KCMDN*** – options **1**, **2**, **5** or **6**). The level of the signal indicates when KMAG4 is sampling in this case.

SPECIAL SETUP PROCEDURE

This procedure unconditionally modifies the MAIN port Baud Rate to 9600bit/s and selects one-second sample interval. It is to be used when an inappropriate MAIN Port Baud rate was selected by mistake or when the instrument Baud rate is unknown.

1. Disconnect the power from the instrument.
2. Plug a connector with its pins 2 and 3 shorted to Port 3.
3. Connect the power to the instrument.
4. Wait long enough for the instrument to start.
5. Remove the connector.
6. Disconnect the power and connect it again.

Modifications List

Version 3.27.11

- Fixed the time stamp in SPSM(Simple Partial Sampling Mode).
- Fixed a bug in command $KCMDC

Version 3.26.10

Fixed a bug, concerning the case when non integer number of samples per second is selected (for example, 47ms sample interval).

Version 3.25.10

A new option is implemented in command **$KCMDB**. It allows to swap the UTC and PPST fields of the output record. Thus, the UTC field will appear in field 3, as it is in version 1 KMAG4.

Version 3.24.10

Two additional RS232 ports are implemented – **AUX1** and **AUX2**. They can be used to connect other instruments, providing RS232 outpur, and their data to be included in the KMAG4 output data, sent through Port 2 for recording and display. See **$KCMDI** for more details. This command is modified to allow configuring the two AUX ports. **$KCMDR** is modified also to show the **AUX1** and **AUX2** settings.

Version 3.23

Command **$KCMDB** is modified to allow any padding character in fixed record mode. Only 0 (zero) could be used as a padding character up to now.

Version 3.22

New command (**$KCMDC**) is introduced. Version 3.22 behaves exactly as version 3.20 if **$KCMDC** is not used.