GILL INSTRUMENTS

3 AXIS RESEARCH ULTRASONIC ANEMOMETER

PRODUCT SPECIFICATION

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ANEMOMETER SOFTWARE   VERSION 4.XX
PC SOFTWARE (FASTCOM.EXE) VERSION 4.XX

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DIAGRAMS:-

1.   DESCRIPTION OF ANEMOMETER AND AUXILIARY EQUIPMENT

The following equipment will be supplied as standard :-

1 anemometer unit.
1 power supply and interface unit (PSIU).
1 anemometer connector (unless a cable is ordered).
1 IEC type mains cable.
1 360k 5 1/4" disk containing PC communications programme
fastcom.exe and file conversion utility convert.exe.
1 mounting kit consisting of stainless M4 machine screws and a
base mounting gasket.
Associated documentation.

The following equipment can be supplied to order at extra
cost:-
Additional anemometer connectors.
Completed anemometer to PSIU cable. This is available in a
range of standard lengths.
Analogue input connector.

The research ultrasonic anemometer consists of a sensing head
with six ultrasonic transducers arranged in three pairs,
surmounting a cylindrical electronic base housing. The onboard
electronics provide all ultrasonic processing and vector
computations required to output wind data in a processed form.
 Also supplied is a power supply and interface unit (PSIU).
This must be connected to the anemometer by a suitable cable
made to drawing 1012-G-092 at the end of this document. Cable
should be STC PS6P22, BELDEN 8778 or equivalent. Alternatively
as detailed above a completed cable can be supplied. When the
PSIU is connected to the anemometer the unit provides power for
the anemometer and also converts the RS422 serial output from
the anemometer to standard RS232 format. This signal is output
from the PSIU via a 25 way D type connector that can be
connected to a PC by any 1 to 1 cable. A suitable cable may be
made to drawing 1012-K-091. Other computers may require a
customised cable between the PSIU and the computer. The
analogue outputs are also routed to the PSIU and are available
on a 9 way D connector.
A second connector in the base of the anemometer provides
connections for up to 5 analogue inputs. A mating connector to
enable the user to make up an analogue input cable can be
supplied on request.

2. PRINCIPLE OF OPERATION

The basic time-of-flight operating principle is physically fundamental and provides vector measurement of air velocity dependent mainly on the dimensions and geometry of the transducer array. A pair of transducers act alternately as transmitters and receivers, sending pulses of high frequency ultrasound between themselves. The times of flight in each direction, say t_1 and t_2, are measured. If c is the speed of sound, L the distance between the transducers and there is an air flow v along the line of the transducers, the following relationships are readily derived:-

$$t_1 = L/(c+v) \quad ; \quad t_2 = L/(c-v)$$

By inverting and subtracting, v is solved explicitly:-

$$v = 0.5L(1/t_1-1/t_2)$$

This wind vector derivation is not affected by c or any other parameters such as temperature or contaminant content.

Conversely, c is obtained by inverting and adding:-

$$c = 0.5L(1/t_1+1/t_2)$$

It can be seen that there will be little effect on t_1 and t_2 caused by air flow normal to the line of the transducers. Therefore v represents the vector component of air flow resolved along the line of the pair of transducers. By arranging three pairs of transducers in different orientations, the direction and magnitude of the incident air flow may be unambiguously derived. The transducer pairs do not have to conform to cartesian axes. For optimum undisturbed airflow a non orthogonal arrangement is employed. Speed of sound (c) is useful for example in calculating air temperature with a rapid response.

The three main functions of the electronics are operation of the ultrasonics, processing of raw measurement data, and high level data analysis, storage and transmission. Operation of the ultrasonics requires timing measurements to be made with a repeatability of about 10ppm (parts per million) at low airflows. Newly developed techniques for achieving this

performance with an ultrasound system allow major reduction of electronics volume compared with previous realisations of this technology.

The timing measurements are first checked to ensure they are within reasonable limits. If the anemometer is operating in a UVW mode (see below) further calculation is carried out:- calculation of velocities along the transducer axes (as described above), followed by a transformation to calculate the velocities in an u, v, w format. If operating in a calibrated mode a correction operation is then applied to calibrate out the affects of the transducers and head framework. The UVW processed data is output on both the serial and analogue outputs. The transit count data is output on the serial output only.

Serial communications conform to RS422. Commands can be sent to the anemometer to configure its operation. Four analogue outputs provide fast response real-time data to conventional recording instruments. Five analogue inputs enable the user to interface to other instruments via the anemometer. High level language programming of the internal microprocessor makes customisation of the interface specification practical for OEM applications.

A protective electrical barrier is incorporated internally.

3.   SOFTWARE SPECIFICATION

3.1. SUMMARY OF OPERATION

The anemometer carries out one ultrasonic firing every 1mS. The time of flight of the ultrasonic pulse is measured, and a figure subtracted to allow for transducer delay. This delay figure is measured and programmed in for each axis during the test procedure.

The anemometer first carries out a firing in each direction on axis 1. The transit counts for each direction are stored individually in their raw form. Additionally a fast calculation method is used to calculate the wind velocity along that axis (using the 0.5L/t1 - 0.5L/t2 formula). The operation is then repeated on axes 2 and 3. A complete set of firings (ie/ enough to calculate a single wind velocity) thus takes 6 mS (1mS * 3 axes * 2 firings per axis) and yields six transit counts and three axis velocities. Results from successive sets of firings are added together to enable averages for the transit counts and axis velocities to be obtained.

The anemometer either outputs data 21 times a second or 56 times a second. The slower update rate is obtained by averaging together the results of eight complete sets of firings ie/ speed data is output every 48mS. The faster update rate is obtained by averaging together the results of three complete sets of firings ie/ speed data is output every 18mS.

The anemometer has four basic modes of operation selected by commands received via its serial interface:-

MODE 1: CALIBRATED UVW.

In this mode the anemometer calculates calibrated UVW speed data 21 times per second. The unit first calculates the average axis velocity for each axis (by dividing each total axis velocity by 8). It then carries out a vector transformation on the three average axes velocities to convert them to conventional UVW axes. The three vector speeds are then corrected and calibrated to allow for the effects of the framework and transducers.

A fourth parameter representing the measured speed of sound is also calculated from the stored transit counts.

As soon as the velocities and speed of sound have been calculated they are output on the analogue outputs (see section 3.3). They are also stored in the speed data buffer for serial data transmission (see section 3.5 below).

MODE 2: UNCALIBRATED UVW.
This mode is identical to Mode 1 operation except that the calibration operation is not carried out on the UVW velocities. This enables the user to carry out more data intensive and complex calibration schemes such as three dimensional matrices. The calibration curves for each anemometer are included in two files on the programme disk supplied with the anemometer. The file containing the horizontal cal curves is XXXXRCAL.H where XXXX is the serial number of your anemometer (thus for anemometer 10 the file would be 0010rcal.h). The file containing the vertical calibration curve is WCAL.H. APPENDIX A details the format of these files.

MODE 3: TRANSIT COUNTS.
In this mode the anemometer calculates the six average transit counts 21 times a second. After 8 complete sets of firings the unit divides each of the six stored transit count sums by 8 to obtain average transit counts. The axis velocities are ignored. No further calculations are carried out on this data. The six transit counts are stored in the data buffer and then transmitted on the digital serial interface as described in section 3.5. In this mode the analogue outputs are left inactive.
The equations used in the anemometer to calculate the U, V and W vectors from the transit counts are detailed in APPENDIX B.

MODE 4: FAST TRANSIT COUNTS.
This mode is identical to Mode 3 operation except that the transit counts are calculated 56 times a second ie/ each stored measurement is the average of three actual transit count measurements.
This faster output rate is not available in a UVW format as the vector transformation required takes too long to carry out.
The equations used in the anemometer to calculate the U, V and W vectors from the transit counts are detailed in APPENDIX B.

<u>DEFAULT POWER UP SETTINGS</u>
Whenever it is powered up the mode in which the anemometer will start operating is dictated by links 2 and 3. This enables the user to select any of the four Modes as the default mode. This means that the anemometer can be used in any mode without the need for serial commands to select that mode.
On power-up the interface is always configured in the unprompted mode (see section 3.5 below). The baud rate is dependant on the mode selected.
The link positions for each mode are defined below. A link is defined as ON if moved towards the top of the anemometer, and OFF if moved towards the bottom of the anemometer.

LINK 2 OFF, LINK 3 OFF:- Mode 1 operation, 4800 baud, unprompted.
LINK 2 ON, LINK 3 OFF:- Mode 2 operation, 4800 baud, unprompted.
LINK 2 OFF, LINK 3 ON :- Mode 3 operation, 4800 baud, unprompted.
LINK 2 ON , LINK 3 ON :- Mode 4 operation, 9600 baud, unprompted.

Note that the anemometer is always powered up with all analogue inputs inactive. If analogue input data is required the inputs must be switched on using the relevant anemometer command.

<u>3.2. SPECIFICATION OF VECTOR AXES</u>
At the end of this document there are two drawings that define the UVW and transducer axes. One (1012-K-055) applies to the symmetrical head. The other (1012-K-125) applies to the asymmetrical head. These should be referred to when studying this section.

<u>UVW AXES</u>
On the label on the top boss of the anemometer there is an arrow defining the nominal north direction of the anemometer. On both versions of the head there is an arm lined up with this arrow. On the symmetrical version of the anemometer the arm is in front of the arrow and on the asymmetrical it is behind it. There is a transducer 30 degrees anti-clockwise from this nominal north direction. This is the top transducer of axis 1. The u speed axis is aligned with this pair of transducers. A

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positive speed on this axis indicates that the flow is from the top transducer towards the bottom transducer ie/ North to South. The v axis is obviously at right angles to the u axis, a positive speed indicating that the flow is East to West. The w speed axis is vertical. A positive speed indicates that the flow is in an upwards direction.

TRANSIT COUNT AXES

The transducer axes are nominally called axis 1, axis 2 and axis 3. In the head drawings the transducers are labelled T1, T2 and T3 to denote which axis each transducer is on.

The head geometry dictates that the transducer axes are all at 45 degrees to the horizontal. From the drawings it can be seen that axis 1 is in line with the U vector but tilted at 45 degrees to it. Axis 1 could be transformed to axis 2 by a 120 degree rotation in a clockwise direction about the vertical axis. Axis 2 could be transformed to axis 3 by the same operation.

The six transit times are always output from the anemometer in the order top to bottom axis 1, bottom to top axis 1, top to bottom axis 2, bottom to top axis 2, top to bottom axis 3, bottom to top axis 3. They are also stored in this order in all files produced by the fastcom.exe package.

3.3. SPECIFICATION OF ANALOGUE OUTPUTS AND INPUTS

ANALOGUE OUTPUTS

When operating in modes 3 or 4 the analogue outputs are inactive.
When operating in a UVW mode (1 or 2) the following specification applies:-

Output 1 represents the u axis speed.
Output 2 represents the v axis speed.
Output 3 represents the w axis speed.
Output 4 represents the speed of sound or a 2.5V reference.

All outputs have a range of 0 - 5V.

LINK 4 controls the analogue output speed range for outputs 1 to 3.

If LINK 4 is set to ON (towards the processor.)
2.50V represents a speed of zero.
5.00V represents a speed of +60m/s.
0.00V represents a speed of -60m/s.

If LINK 4 is set to OFF (away from the processor.)
2.50V represents a speed of zero.
5.00V represents a speed of +30m/s.
0.00V represents a speed of -30m/s.

Output 4 is not affected by LINK 4. The information available via output 4 is set by LINK 5. If LINK 5 is set to OFF (away from the processor) output 4 represents the speed of sound measured.

5.00V represents a speed of sound of 370m/s
0.00V represents a speed of sound of 290m/s

If LINK 5 is set to ON (towards the processor) output 4 is held at a constant 2.50V for use as a zero speed reference.

The total resolution of the outputs over the full 0-5V range is 11 bits, ie. approx 2.5mV. An analogue output test sequence is available that enables the output levels to be checked. This sequence is called when the unit is first powered up, and also

can be called by blocking the ultrasonic paths, for example by placing a hand in the middle of the probe (note that if the obstruction is removed the unit will immediately return to normal operation without completing the sequence). All outputs will first be set to 5.00V for 3 seconds, then to 3.75V for 3 seconds, then to 2.50V for 3 seconds, then to 1.25V for 3 seconds, then to 0.00V for 3 seconds. If the ultrasonic paths are still blocked all speed outputs will then be set to a value corresponding to zero speed ie. 2.50V. The speed of sound output will be set to a value corresponding to 290m/s ie. 0.00V. Note when using the analogue outputs it is advisable to feed the outputs into a low pass filter to remove any high frequency noise.

If the unit is operating in modes 3 or 4 the analogue outputs are left inactive.

ANALOGUE INPUTS
The unit has 5 analogue inputs. These appear on the second (8 way) connector in the base of the anemometer as detailed in the pin out list at the end of this specification. They are normally left inactive but can switched on via a command from the P.C. The user can switch on any number of inputs from 1 to 5 to avoid storing and transmitting unwanted data.
Once analogue inputs have been switched on the readings on the activated inputs are stored and transmitted with each speed reading. In the serial transmission they will appear immediately after each packet of speed data. The format of the data is described in section 3.5 below.

The resolution of the inputs is 11 bits and the range is 0 to 5 volts. It is strongly recommended that the inputs are restricted to these limits. However if absolutely necessary the input will correctly read voltages up to around 0.5 volts outside these limits. Outside the range -0.5 to 5.5V the voltage will be clamped by the input circuitry. Although they have some protection the analogue inputs must be prevented from going outside these limits.

The analogue readings are appended to each speed reading ie/ they will be output 21 or 56 times a second. It should be noted however that each input is only read 10 times a second.
This limits the resolvable input frequency to 5Hz.

Note that the unregulated anemometer supply is present on the input connector and can be used for powering other instruments. However using the standard anemometer PSIU only around 50mA is available. If any more than this is taken problems will occur with the operation of the anemometer. Supplying the anemometer from a higher capacity supply will enable more current to be taken from the auxiliary connector.

3.5. SPECIFICATION OF DIGITAL SERIAL OUTPUT
The serial interface is bidirectional ie/ commands can be sent
from the computer to the anemometer and data can be transmitted
from the anemometer to the computer. This enables the user to
control the mode of operation from the computer.   The
bidirectional coms also enables more than one anemometer to be
linked up to the same computer.

The output of data on the serial link can be in three formats:
continuous, unprompted or prompted. These are described below:-

CONTINUOUS MODE
The continuous mode is selected by an internal link- LINK 6. If
this link is set to ON (towards the processor) the serial
communications will be in continuous mode and the other two
modes will not be accessible. If this link is set to OFF (away
from the processor) the interface can be switched between
prompted and unprompted modes via a serial interface command.

In continuous mode speed data is transmitted via the serial
interface as soon as it is calculated. This mode is not
normally used as the continuous stream of data means that the
there are no breaks in the transmission when the computer has
time to carry out other tasks such as storing the data. However
some systems that can carry out serial communications as a
background task may find this format convenient.

LINK 6 will normally be set to OFF enabling either of the other
two transmission formats to be selected by a serial interface
command. When using the supplied FASTCOM.EXE programme LINK 6
must be set to OFF.

UNPROMPTED MODE
Unprompted mode is selected by the U command (see below).
In unprompted mode the speed data is buffered for approximately
one second and then output automatically in a one continuous
block. This is done in order to give the computer/data logger
time in which to store the data on disk or display it.

When operating in modes 1,2 or 3 20 speed readings are buffered
before being sent. This will take 20 * 48ms = .960 sec. These
are then transmitted in a block to the logger. For modes 1 and
2 this will take about .4 of a second at the slowest baud rate
(assuming no analogue inputs are activated). For mode 3 this

will take .6 of a second as there are more bytes to transmit.
The computer/logger then has around .5 seconds (modes 1 and 2)
or .3 seconds (mode 3) to store and or display this data before
the next block is sent. At the higher baud rates this free time
will be increased.

In mode 4 56 speed readings are buffered before being sent.
When operating in mode 4 the baud rate must be set to either of
the two higher rates as otherwise coms overrun errors will
occur.

If any analogue inputs have been activated each speed packet
will have a number of analogue input readings appended to it.
The transmissions will therefore take longer hence it may be
necessary to use a higher baud rate. The following table shows
the minimum baud rate that must be used when operating in a
given mode with a given number of analogue inputs activated:-

	NUMBER OF ACTIVATED ANALOGUE INPUTS					
	0	1	2	3	4	5
MODE OF OPERATION	MINIMUM REQUIRED BAUD RATE					
MODE 1 & 2 4800	4800	4800	4800	4800	9600	
MODE 3	4800	4800	4800	9600	9600	9600
MODE 4	9600	19200	19200	19200	19200	19200

PROMPTED MODE
Prompted mode is selected by the P command (see below).
In prompted mode the anemometer will buffer all speed data
until it receives a command from the computer telling it to
transmit the contents of its buffer (the T command, see below).
It will then transmit all the data stored in the buffer (up to
the time the transmit data command was received) as one record
(data gathered during the time taken to transmit the record
will not be transmitted until the next time). With no analogue
inputs activated the buffer in the anemometer can contain up to
170 seconds worth of data when operating in modes 1 and 2, up
to 115 seconds when operating in mode 3 and up to 40 seconds in
mode 4. Activating analogue inputs will reduce this time. At
the end of this period the earliest data will be overwritten by
the latest enabling the instrument to be left running until an
event of interest occurs.
The prompted mode of operation offers significant advantages at
the computer end as it means that the computer can ask for data

when it is ready and will therefore not miss data due to long disk accesses etc. However the same restrictions on baud rate as shown in the table above still apply. If a baud rate that is too slow is selected in this mode it will be found that the time between downloads will keep increasing until it exceeds the maximum buffer time. Data will then be lost as the anemometer overwrites its earliest records.

The rest of this section contains a details how the serial
interface functions and is intended for users who wish to write
their own interfacing software. However if this is not required
the user can simply use the FASTCOM.EXE programme supplied with
the unit. All serial interface functions will then be taken
care of and the following section can then be safely ignored.

GENERAL INTERFACE SPECIFICATION
The serial link from the anemometer to the PSIU uses a standard
RS422 format. The transmission format is 1 start, 8 data and 1
stop bits. The baud rate can be set to 4800, 9600 or 19200 via
a serial interface command (see below). The PSIU converts the
RS422 output levels to RS232 output levels without affecting
the baud rate or bit lengths. This RS232 signal can be fed
directly into most computers via the computer connector of the
PSIU.

The PSIU interface is bi-directional. The direction of the
communications is controlled by the RTS line from the computer
to the PSIU (pin 4 of the PSIU's computer connector). This must
be pulled to the RS232 LOW state (ie nominally -12V) to enable
the anemometer to transmit to the computer. When it is required
to transmit a command to the anemometer the line should be set
to the RS232 high state. The timing considerations involved in
this procedure are discussed below.

GENERAL FORMAT OF ANEMOMETER DATA TRANSMISSIONS
All transmissions from the anemometer have the same general
format. Transmissions must be processed as a series of two byte
binary integers. The first integer to be transmitted (ie bytes
1 and 2) will be the binary integer hex 8181 (-32383). This
signifies the start of transmission and is a value that cannot
occur elsewhere in the data. The second integer (ie bytes 3 and
4) will be the record number. This is incremented every time a
completer record is transmitted and enables the user to check
that no records have been missed. When it reaches 10000 it will
be reset to 0.
The rest of the transmission consists of the wind and (if
activated) analogue input data. In modes 1 and 2 the speed data
is in 4 integer packets, the four integers being the three
vector velocities (ie/ u,v, and w) and a speed of sound
parameter. In modes 3 and 4 the speed data is in 6 integer

packets and consists of the six "raw" transit times measured by the anemometer. If the analogue inputs are activated then integers containing the analogue input information will be appended to each speed packet.

In modes 1 or 2 if no analogue inputs are activated the total number of integers in a packet will be 4. If analogue inputs are activated this number will be 4 + the number of active inputs.

In modes 3 or 4 if no analogue inputs are activated the total number of integers in a packet will be 6. If analogue inputs are activated this number will be 6 + the number of active inputs.

The number of these speed packets present in a transmission can vary according to the mode of operation. In continuous mode it will be one, in unprompted modes 1 to 3 it will be 20, in unprompted mode 4 56, and in prompted mode it will vary according to the interval between "transmit data" commands but could be as many as 3750 records. Therefore to detect when the transmission is complete the integer hex 8282 (-32126) is used as an end of transmission marker. This number cannot occur in the speed data and therefore when it is received the computer can conclude that the transmission is complete.

The format of a transmission is detailed below:-

UVW TRANSMISSION
(MODE 1 AND 2)
NO ANALOGUE INPUTS ACTIVATED

```
BYTE POSITION    RANGE OF VALUES     DESCRIPTION
Bytes 1 and 2      HEX 8181 = -32383   Start of tx control
character
Bytes 3 and 4        0 - 10000    Record Number (See Below)

Bytes 5 and 6    -10000 -  6000    U Speed 1
Bytes 7 and 8    -10000 -  6000    V Speed 1
Bytes 9 and 10   -10000 -  6000    W Speed 1
Bytes 11 and 12  -10000 - 18500    Speed of sound 1

Bytes 13 and 14  -10000 -  6000    U Speed 2
Bytes 15 and 16  -10000 -  6000    V Speed 2
Bytes 17 and 18  -10000 -  6000    W Speed 2
Bytes 19 and 20  -10000 - 18500    Speed of sound 2

etc. for speeds 3 onwards ....

End of transmission
```

HEX 8282 = -32126

The first integer is the start of tx control character hex
8181.
It is not possible for this value to occur elsewhere in the
transmission because of the limitations of the other integer
values.

The second integer is the record number. This is simply a count that is incremented every transmission.

The next three integers contain the first u v and w speeds. The integers represent the speed in units of 1/100ths of a m/s ie. a value of 100 represents a speed of 1.00 m/s.
The next integer is the speed of sound in 50ths of a meter per second ie. a value of 17000 represents a speed of sound of 340.00 m/s. These units were chosen to fit in with the maximum value of a signed integer (32767).
For all four of these values if some fault on the anemometer prevented a valid speed from being calculated (eg if something is blocking the ultrasonic paths) a value of -10000 will be transmitted to signify an invalid result.
After a variable number of these speed packets the end of transmission integer HEX 8282 is transmitted.

UVW TRANSMISSION
(MODE 1 AND 2)
2 ANALOGUE INPUTS ACTIVATED

BYTE POSITION	RANGE OF VALUES	DESCRIPTION
Bytes 1 and 2	HEX 8181 = -32383	Start of tx control character
Bytes 3 and 4	0 - 10000	Record Number (See Below)
Bytes 5 and 6	-10000 - 6000	U Speed 1
Bytes 7 and 8	-10000 - 6000	V Speed 1
Bytes 9 and 10	-10000 - 6000	W Speed 1
Bytes 11 and 12	-10000 - 18500	Speed of sound 1
Bytes 13 and 14	0 - 5000	Analogue input 1 count
Bytes 15 and 16	0 - 5000	Analogue input 2 count
Bytes 17 and 18	-10000 - 6000	U Speed 2
Bytes 19 and 20	-10000 - 6000	V Speed 2
Bytes 21 and 22	-10000 - 6000	W Speed 2
Bytes 23 and 24	-10000 - 18500	Speed of sound 2
Bytes 25 and 26	0 - 5000	Analogue input 1 count
Bytes 27 and 28	0 - 5000	Analogue input 2 count

etc. for speeds 3 onwards ....

End of transmission
            HEX 8282 = -32126

The transmission is the same as above with the addition of the
analogue input integers. These represent the voltages on the
input pins in mV. A value of 1257 thus represents 1.257V.

TRANSIT COUNT TRANSMISSION
(MODE 3 AND 4)
NO ANALOGUE INPUTS ACTIVATED

BYTE POSITION   RANGE OF VALUES   DESCRIPTION
Bytes 1 and 2   HEX 8181 = -32383   Start of tx control
character
Bytes 3 and 4   0 - 10000   Record Number (See Below)

Bytes 5 and 6   -10000 - 15000   Transit count top to bottom
                                        axis 1.
Bytes 7 and 8   -10000 - 15000   Transit count bottom to top
                                        axis 1.
Bytes 9 and 10   -10000 - 15000   Transit count top to bottom
                                        axis 2.
Bytes 11 and 12   -10000 - 15000   Transit count bottom to top
                                        axis 2.
Bytes 13 and 14   -10000 - 15000   Transit count top to bottom
                                        axis 3.
Bytes 15 and 16   -10000 - 15000   Transit count bottom to top
                                        axis 3.

etc. for speeds 2 onwards ....

End of transmission
            HEX 8282 = -32126

The first two integers are the same as for the UVW transmission
ie/ the start of tx control character and the record count.

The next six integers contain the six transit counts. The
counts represent the time taken for the ultrasonic pulse to get
from one transducer to another in 29.4912 MHz counts. A count
of 13000 therefore corresponds to a transit time of 440.81 uS.
The counts are always transmitted in the order top to bottom

axis 1, bottom to top axis 1, top to bottom axis 2, bottom to top axis 2, top to bottom axis 3, bottom to top axis 3.

If an ultrasonic fault occurs on any of the axes the two transit counts for that axis will be set to a value of -10000 to signify an invalid result. The transit counts for the other axes will be transmitted as normal.

After a variable number of these speed packets the end of transmission integer HEX 8282 is transmitted.

TRANSIT COUNT TRANSMISSION
(MODE 3 AND 4)
3 ANALOGUE INPUTS ACTIVATED

BYTE POSITION   RANGE OF VALUES   DESCRIPTION
Bytes 1 and 2   HEX 8181 = -32383   Start of tx control
character
Bytes 3 and 4   0 - 10000   Record Number (See Below)

Bytes 5 and 6   -10000 - 15000   Transit count top to bottom
                                    axis 1.
Bytes 7 and 8   -10000 - 15000   Transit count bottom to top
                                    axis 1.
Bytes 9 and 10   -10000 - 15000   Transit count top to bottom
                                    axis 2.
Bytes 11 and 12 -10000 - 15000   Transit count bottom to top
                                    axis 2.
Bytes 13 and 14 -10000 - 15000   Transit count top to bottom
                                    axis 3.
Bytes 15 and 16 -10000 - 15000   Transit count bottom to top
                                    axis 3.
Bytes 17 and 18   0 - 5000   Analogue input 1 count
Bytes 19 and 20   0 - 5000   Analogue input 2 count
Bytes 21 and 22   0 - 5000   Analogue input 3 count

etc. for speeds 2 onwards ....

End of transmission
          HEX 8282 = -32126

The transmission is the same as above with the addition of the
analogue input integers. These represent the voltages on the
input pins in mV. A value of 1257 thus represents 1.257V.

SENDING COMMANDS TO THE ANEMOMETER
All commands from the computer to the anemometer consist of two
identical ascii characters, the second character being sent as
a check. The characters must be sent one immediately after the
other. If the anemometer receives a single character and then
does not receive the second characters within 50ms it will
discard that character and wait for another identical pair.
In the case of a command that will cause the anemometer to
carry out a transmission the anemometer will wait for at least

10mS after the second character of the command is received before transmitting its data. The computer must thus switch from transmit to receive within this 10mS. NOTE:- ensure that the second command character has finished transmitting before switching the computer to receive. This will occur some time after the transmit data register empty flag is set, as this flag is set when the last character is transferred to the transmit shift register. Either allow for one complete character transmission time after the transmit data register empty flag is set, or use the transmit shift register empty flag (if available).

When an anemometer has finished a transmission it will wait for up to 7mS before switching to receive. The computer must therefore wait at least 8mS after receiving data from the anemometer before transmitting a further command otherwise that command will not be received.

If the anemometer is operating in the unprompted mode ie/ it is transmitting its data automatically every second, to ensure that a command is received by the anemometer it is necessary to first wait for the anemometer to carry out a transmission and then transmit the command immediately after that transmission (having allowed at least 8mS for the anemometer to switch to receive). If this is not done and the command is transmitted whilst the anemometer is itself transmitting that command will not be received.

ANEMOMETER COMMANDS

(1) SELECT MODE 1 OPERATION, COMMAND '1','1'.
To select Mode 1 operation the computer must send two ascii one characters to the anemometer. Mode 1 operation is known as CALIBRATED UVW. The unit outputs the U, V and W components of the wind velocity together with a speed of sound parameter at a 21 Hz update rate on both digital and analogue outputs. These vectors are calibrated according to the instruments own internal calibration table.

(2) SELECT MODE 2 OPERATION, COMMAND '2','2'.
Mode 2 operation is known as UNCALIBRATED UVW. In this mode the instrument still outputs the U, V and W components at 21 Hz on both the digital and analogue outputs, but they are not calibrated by the instrument's own internal table.
The speed of sound output is the same as for MODE 1 operation.

(3) SELECT MODE 3 OPERATION, COMMAND '3','3'.
Mode 3 operation is known as TRANSIT COUNTS. In this mode the instrument directly outputs the six transit counts derived from the three axes. This is done on the digital output only, the analogue outputs being left inactive. The update rate is 21Hz as before.
The transit counts are nominally adjusted for delay but no other calibration operation is carried out.

(4) SELECT MODE 4 OPERATION, COMMAND '4','4'.
Mode 4 operation is known as FAST TRANSIT COUNTS. This mode is
the same as MODE 3 except the output rate is 56 HZ instead of
21Hz. This is achieved by averaging together the results from
just three firings and outputting them.(The output data in
modes 1 to 3 is produced by averaging the data from 8 firings).
Note that in this mode the coms baud rate must be set to a
higher rate than the default 4800 as otherwise it will take
longer to transmit the data than to gather it. This will cause
a lock up situation in unprompted mode, and an ever increasing
transmit time in prompted mode (see below).

(5) SELECT PROMPTED MODE, COMMAND 'P','P'.
    SELECT UNPROMPTED MODE, COMMAND 'U','U'.
    TRANSMIT CONTENTS OF DATA BUFFER, COMMAND 'T','T'.
The 'P' and 'U' commands are used to switch the anemometer
between prompted and unprompted transmission mode. The 'T'
command is used to cause the anemometer to transmit the
contents of its buffer when in prompted mode.

(6) SELECT 4800 BAUD, COMMAND 'L','L'.
    SELECT 9600 BAUD, COMMAND 'M','M'.
    SELECT 19200 BAUD, COMMAND 'F','F'.
These command are used to set the baud rate of the instrument.
The faster bauds rate will be useful when communicating with
more than one anemometer from the same computer. When operating
in mode 4 the baud rate must be set to at least 9600 to cope
with the extra data.
Obviously once the computer has sent the change baud rate
command it must then immediately change the baud rate of its
own interface.

(7) SYNCHRONISE ANEMOMETER, COMMAND 'S','S'.
This command can be used to synchronise the operation of a
group of anemometers. When the command is received the
ultrasonic firing cycle of the instrument is reset to its start
values, and the record count is set to 0.

(8) SWITCH ON ANALOGUE INPUTS, COMMANDS '5','5' - '9','9'
These commands are used to switch on the required number of
analogue inputs. The number of inputs that are switched on is
the command number - 4. Thus command '5' will switch on
analogue input 1 only, '6' will switch on 1 and 2 etc. up to
command '9' which will switch on all 5 inputs.

(9) SWITCH OFF ANALOGUE INPUTS, COMMAND '0','0'
This command switches off all analogue inputs.

3.6 SPECIFICATION OF FASTCOM.EXE

Three programmes are supplied with the anemometer:-

Fastcom.exe is the main communications programme. Fastcom allows a PC or true compatible to communicate with the Gill Research Anemometer. It will take care of all serial interface and format considerations and store anemometer data on disk in a predefined binary format.

Convert.exe is used to convert the binary data files output by fastcom to an easier to handle ascii format (see 3.7 below).

Msherc.com is only of interest to users who have a PC with a hercules graphics system. In this case this programme must be run before fastcom to load a hercules graphics driver. If this is not done errors will occur when displaying some of the fastcom graphics screens. A call to msherc from the computers autoexec.bat file can be used to avoid having to call the programme each time fastcom is run.

Fastcom can either be run in command line entry mode or operator entry mode. The command line entry mode involves entering all the parameters associated with the communications on the command line. The programme will then carry out the data collection operation as specified by the parameters, and no display output will occur. This mode enables fastcom to be called from another programme.
If no command line parameters are entered or incorrect parameters are entered fastcom will operate in operator entry mode. In this mode menu screens will appear and the operator will control the operation of the anemometer and collection of data from the computer keyboard.
N.B. If the P.C. used has a hercules graphics monitor and the programme is being used in operator entry mode the user should run the programme MSHERC.COM before running fastcom. If this is not done errors will occur on the some of the fastcom graphics screens.

3.6.1. STARTUP

The program is run by entering FASTCOM with the anemometer connected to the COM1 serial port. If the correct number of

parameters are entered after fastcom the programme will run in command line entry mode. Otherwise it will run in operator entry mode. In either case the initial procedures for establishing the communications link will be the same.

On startup fastcom assumes that the anemometer is operating unprompted and in mode 1 at 4800 baud. An attempt is thus first made to establish communications with the anemometer at 4800 baud. If this is not successful, fastcom tries to recover the situation by sending the "set baud rate to 4800" command at 9600 baud followed by the "Operate in mode 1" command and "Unprompted" command. If communications are still not established fastcom tries sending the "set baud rate to 4800" command at 19200 baud, followed again by "Operate in mode 1" and "Unprompted". This sequence should recover the coms link from any situation. If however the link has still not been established the following message is displayed.

   "Error: Cannot communicate with anemometer"

Once communications are established the anemometer is switched to prompted operation. FASTCOM always operates the anemometer in prompted mode, ie/ the anemometer only transmits the data when the computer requests it.

The operation of the programme now diverges dependant on wether it is in command line entry mode or operator entry mode.

3.6.2 COMMAND LINE ENTRY
The command line entry format is as follows:-

fastcom <filename> <mode> <baud rate> <number of readings> <number of active analogue inputs>

Filename specifies the name of the file in which to store the data.

Mode (1-4) specifies the anemometer's mode of operation.

Baud rate specifies the baud rate to be used for the coms:-
1 = 4800 baud
2 = 9600 baud
3 = 19200 baud.

Number of readings specifies the number of speed readings to be stored.

Number of active analogue inputs specifies the number of analogue inputs that are to be switched on.

Fastcom first switches the anemometer to the baud rate and mode of operation specified. The specified number of analogue inputs are activated. A result file is opened with the specified name. The specified number of results are gathered and stored together with analogue readings from the specified inputs (if any) and the file is then closed. The anemometer is then switched back to mode 1, 4800 baud, unprompted operation. The programme then exits.

Thus the following command line would store 1024 sets of six transit times gathered at 56Hz (ie mode 4 operation) in file temp.dat. Three analogue inputs would also be monitored and the data stored alongside the windspeed data in the file. The baud rate employed would be 9600.

fastcom temp.dat 4 2 1024 3.

3.6.3 OPERATOR ENTRY

If the correct command line parameters are not entered fastcom will run in operator entry mode. The programme will first set the anemometer to operate in the mode and baud rate that were used when fastcom was last run and will also activate the same number of analogue inputs (this information is stored in file "FASTCOM.DAT").

The first menu screen will then appear.

As mentioned above whilst running fastcom the set up information (ie the mode, baud rate and number of activated inputs) is saved in fastcom.dat. Upon exit fastcom will automatically set the anemometer back to operating in mode 1, 4800 baud and unprompted. This ensures that the next time fastcom is run communications will be established immediately at 4800 baud. The anemometer will then be switched back to the mode, baud rate and input configuration stored in fastcom.dat. This overall scheme should be invisible to the operator. As far as the user is concerned whenever a mode of operation is selected via fastcom then from that point onwards the same mode will automatically be selected each time fastcom is run.

3.6.4. MENU OPTIONS

The main menu provides 6 options.

1. Tabular data display
2. Graphical data display
3. Data collection
4. Mode/Analogue Input select
5. Baud rate select
6. Exit

Menu selections are made either by moving the highlighted bar to the option required and pressing return or (in the case of Hercules monitors) typing the number associated with the option.

Menu option 1:- Tabular data display

Fastcom continually requests data from the anemometer. This option displays the data in tabular form with a scrolling display as it is received. The format of the display depends on the mode selected. In modes 1 and 2, the display shows the U, V and W speeds and the speed of sound, all in m/s. In modes 3 and 4 the display shows the six transit counts. The counts are shown in the order top to bottom axis 1, bottom to top axis 1, top to bottom axis 2, bottom to top axis 2, top to bottom axis 3, bottom to top axis 3.
If any analogue inputs are activated they will appear on the right hand side of the display. The number shown is the reading in mV.

Menu option 2:- Graphical data display

This option is only available when using mode 1 or mode 2. The display shows the U, V and W values and also gives a calculated direction and magnitude. If being run on a PC with a hercules monitor the programme MSHERC must be run before this screen can be accessed (see above).

Menu option 3:- Data Collection

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This option allows data collected from the anemometer to be saved to disk. The user is first prompted for a filename, then for a number of speed readings to collect. Data is then saved to disk as it is collected, with the number of speed readings left to collect being indicated at the top right of the screen. If a value of 0 is entered as the number of speed readings to collect, then data is collected until the data collection screen is entered again. In this case, the number at the top right of the screen is the number of readings collected. The data is stored in a binary format in order to save disk space. A programme (convert.exe) is provided to convert files to an easier to handle ascii format if required (see below).

Menu option 4:- Mode/Analogue Input select

This screen enables the user to select the mode of operation and the number of active analogue inputs. There are 4 modes available as described in section 3.1.

  Mode 1 gives calibrated UVW values
  Mode 2 gives uncalibrated UVW values
  Mode 3 gives transit counts with a collection rate of 21Hz
  Mode 4 gives transit counts with a collection rate of 56Hz

Mode 4 can only be selected if the baud rate is higher than 4800 baud.

Any number of analogue inputs between 1 and 5 can be selected. Once activated the analogue readings will be appended to each speed reading taken.

Menu option 5:- Baud rate select

This option allows selection of the three baud rates available, 4800, 9600 or 19200 baud. 4800 baud cannot be selected if the anemometer is operating in mode 4.

Menu option 6:- Exit

This option saves the current mode, baud rate and input configuration in the file "FASTCOM.DAT" before exiting the program.

3.7 CONVERT.EXE

This program is used to convert the files produced by FASTCOM to an ascii format. The names of the data file and ascii file are entered on the command line

   convert <data file name> <ascii file name>

The program will produce a file which contains the mode that the data was collected, the time and date of collection and then the data, eg/

```
Mode = 1
Time 11:40:07 Date 08/28/90

  0.07  -0.07   0.16 349.54
  0.04   0.01   0.10 349.56
etc.
```

4. PERFORMANCE SPECIFICATION

4.1. Measurement Characteristics.

```
Windspeed Range                           0-60 m/s.
Windspeed Accuracy (10 second average)      <30m/s ±1.5%
                                            >30m/s ±3%
Windspeed offset                            ±0.02m/s

Instantaneous Accuracy                      <30m/s ±3%
(Incident wind not within ±15° of spar)
Direction Accuracy (10 second average)      <30m/s ±2°
                                            >30m/s ±3°
Ultrasonic Sampling Rate per vector set   168 per second
Serial Output Update Rate               21/second.
Analogue Output Frequency Response      10 Hz
Transit Time Accuracy                       <30m/s ±0.5%
```

Accuracy specification applies from 5°C to 35° and for wind incidence within ±10°of horizontal. Operation not recommended with wind incident more than ±30° from horizontal.

4.2. Environmental.

```
Operational temperature range     -20°C to 50°C.
Storage temperature range         -40°C to 75°C.
Altitude                          0 to 3000m
Humidity                          RH range 5%-100%
Precipitation           Operation maintained up to 300mm/hr.
                        Suitable for exposure to marine
                        environment.
```

4.3. Electrical characteristics.

```
Anemometer supply                 9 to 30 Volts DC
                                  at connector.
Anemometer current                150mA max.
Protection          All circuits in main connector
                        protected to 1 Joule transient
                        energy.
```

4.4. Interface.

```
Connectors. Main:          10way socket Hirose RM15WTR-10S.
           Auxiliary:      8way socket Hirose RM15WTR-8S.


Analogue outputs (4)            0-5V  11bits.
Analogue output speed range         +30m/s or ±60m/s


    Output impedance                500 ohms.
Serial data                     RS422. 4800 baud. 1 start,
                                8 data and 1 stop bits.
Auxiliary analogue inputs (5). 0 to 5 V. 11bits.
                    Sampled 10 times
                                per second.
```

4.5. Physical.

```
Size                            750mm H. 240mm Dia.
Weight                          1kg.
External metalwork              Anodised aluminium
                    alloy. Stainless
                                steel fixings.
Transit pack                    900*300*300mm  3kG.
```

4.6. Main Connector Pin Allocation

```
Pin Number          Signal Name

   1                +V supply
   2                Serial -
   3                Serial +
   4                Signal Ground
   5                Analogue Output 2
   6                Analogue Output 4
   7                Analogue Output 1
   8                Analogue Output 3
   9                -V Supply
  10                Chassis
```

4.7. Auxiliary Connector Pin Allocation

Pin Number	Signal Name
1	Analogue input 5
2	+V supply
3	Signal Ground
4	Analogue input 2
5	Analogue input 1
6	Analogue input 3
7	Analogue input 4
8	-V Supply

This product range is in continuous development and specifications are subject to change without notice.

5.   LINK OPTIONS

A link is on when it is in the position nearest the processor, ie. towards the top of the board. A link is off when it is in the position farthest from the processor ie. towards the bottom of the board.

LINKS 2 and 3 Control the power up mode of operation.
(see section 3.1).
LINK 2 OFF, LINK 3 OFF   Anemometer powers up in mode 1.
LINK 2 ON, LINK 3 OFF   Anemometer powers up in mode 2.
LINK 2 OFF, LINK 3 ON   Anemometer powers up in mode 3.
LINK 2 ON, LINK 3 ON   Anemometer powers up in mode 4.

LINK 4 OFFD to A output range +/-30m/s
LINK 4 ON   D to A output range +/-60m/s

LINK 5 OFFD to A output 4 indicates speed of sound
LINK 5 ON   D to A output 4 set to 2.50V reference

LINK 6 OFFBlock format serial output
LINK 6 ON   Continuous format serial output

Unless otherwise specified by the customer the above links will be set to OFF as a default. However links can be set to whatever is required by the customer. The link settings on your instrument are shown below:-

INSTRUMENT SERIAL NUMBER :- _____R.

LINK 2 :- _____

LINK 3 :- _____

LINK 4 :- _____

LINK 5 :- _____

LINK 6 :- _____

6.   POWER SUPPLY AND INTERFACE UNIT

SPECIFICATION

A.C. SUPPLY   100-120V OR 200-250V Switch Selectable
                     1O VA

D.C. SUPPLY   ANEMOMETER 10-30 V D.C.   150mA max.

                     INTERFACE 8-15 V D.C.   50mA max.

PROTECTION   An earthing stud is provided. When locally
               earthed this provides protection to 1 Joule
               of transient energy.

Anemometer Connector   15 Way D Type

Pin Number   Signal Name

```
  1                         Screen
  2              }          Anemometer Supply V-
  3              }
  4                         Analogue Output 2
  5                         N/C
  6                         Analogue Output 4
  7              }          Anemometer Supply V+
 14              }
  8                         Serial B
  9              }          Signal GND
 10              }
 11                         Analogue Output 1
 12                         Serial A
 13                         Analogue Output 3
 15                         Analogue GND
```

```
Analogue Outputs          9 Way D Type

Pin Number

  3                       Analogue Output 1
  4                       Analogue Output 4
  5                       Analogue Ground
  8                       Analogue Output 2
  9                       Analogue Output 3



PC Connector              25 Way D Type

Pin Number

  1                       Screen
  2                       RX Data
  3                       TX Data
  4                       RTS
  5                       CTS
  6                       DSR
  7                       Signal Ground
  8                       DCD
 20                       DTR




D.C. SUPPLY

Cable Connector : Amphenol C91A Screw Lock 4 Way Socket
                  Part  No.  T3301-001    (STC  No.  032620C)


Pin Number

  1                       Interface   V +
  2                       Interface   V -
  3                       Anemometer  V -
  4                       Anemometer  V +
```
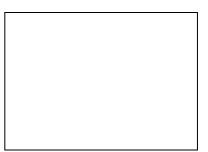
```
          View Of Interface

            Unit Plug
```

The unit is fitted with separate D.C. supply connections for the anemometer and for the serial communications adapter. This allows operation with a wide range of cable lengths. For short cable lengths the anemometer may be operated with these supplies commoned.

Example

50m length of standard cable (STC PS6P22).
Supply voltage drop along this cable is 0.5 V maximum in each direction (Total supply voltage drop 1 V).
Supply voltage drop of D.C. power supply = 1 V maximum.
D.C. supply at anemometer = 9 V minimum.
The anemometer will operate with a common D.C. supply to the anemometer and adapter in the range 11 V to 15 V.

Note that in this example OV at the anemometer is up to 0.5 V above signal ground at the interface unit (and PC if connected).
Voltage difference between anemometer and interface unit ground must not exceed 2V.
Analogue outputs must be measured relative to analogue ground.
 If analogue ground is required to be at the same potential as signal ground at the adapter, separate isolated D.C. supplies must be used for the anemometer and the interface unit.

7. INSTALLATION

7.1. General

A suitable mounting surface should be prepared, according to the details in diagram 1012-K-096. The anemometer is secured by four M4 screws and washers, using nuts or tapped holes in the mounting surface. A mounting kit is supplied, containing stainless steel screws, washers, nuts, and a neoprene gasket.

7.2. Sealing

The anemometer is fully sealed against water ingress over all exposed parts. The connector compartment is expected to be protected against direct water ingress and the instrument is deliberately vented in this area to avoid unnecessary pressure buildup. It is vital that the instrument is sealed to the mounting surface by use of the rubber gasket, with extra sealant employed if the mounting surface is not smooth. The design of the mounting should be such as to avoid direct exposure of the connector area, although the connectors themselves are sealed when mated. Fit the blanking cap (supplied) to the auxiliary connector if this is not used.

7.3. Alignment

The instrument base has slotted fixing holes permitting +/-5° rotation for alignment. To avoid damage to these slotted holes, washers must be used under the screw heads (or nuts, if the screws are fitted from below). One of the fixing holes points North (or other reference direction).

7.4. Corrosion

The instrument mounting base is anodised aluminium alloy and careful note should be taken of the possibility of galvanic corrosion by incorrect mounting. It is VITAL that only stainless steel fixing screws and washers are used, and that the instrument is insulated from the metal of the mounting surface with the rubber gasket. This system will be entirely satisfactory for long term marine exposure.
REMINDER: Only compatible metals can be allowed to come into contact with the anemometer (aluminium) metalwork; e.g. Stainless steel, aluminium.

7.5. Earthing.

The anemometer metalwork is isolated from the electronic system ground, and can float by up to 10 volts. The metalwork is intended to be locally grounded via the mounting, and this is essential for the internal protection barrier to be fully effective. This ground is connected to the cable screen.

7.6. Power Supply and Interface Unit

This unit is not sealed and is intended for use in a protected environment.

ANEMOMETER CALIBRATION SYSTEM
Two files containing calibration data are included on the
programme disk. These are intended as a guide to help the user
to calibrate the anemometer when operating in any mode other
than 1.

GENERAL CALIBRATION SYSTEM
The calibration system is used to correct the u, v, and w
vectors for variations that occur as a function of direction.
For example when a strut is upwind of the measurement area the
measured horizontal magnitude will decrease typically by around
7 percent. The ratio of u to v will also be altered very
slightly by the anemometer giving perceived errors in the
direction. The vertical wind component will tend be shaded by
the transducers when the transducer is in line with the
vertical component.

As a result four calibration tables are required:-
(1) direction_calibration_table is used to correct the ratio of
the u and v vectors ie/ to correct any direction error in the
horizontal vector.
(2) Once the direction calibration has been carried out
magnitude_calibration_table is used to correct the overall
magnitude of the horizontal vector.
(3) up_w_calibration_table is used to correct upwards w vectors
(ie/ if w is positive this table is used).
(4) down_w_calibration_table is used to correct downwards w
vectors (ie/ if w is negative this table is used).
Two w calibration tables are necessary because the shading of
the vertical vector when the flow is upwards is different from
when the flow is downwards.

CALIBRATION CALCULATIONS
All calibration factors are indexed relative to the apparent
horizontal direction of the wind. The first stage of the
standard calibration procedure is thus to use u and v to
calculate this angle in whole degrees. The direction is
expressed as a standard compass direction relative to the north
strut (see diagram 1012-K-055). For example if the u vector is
positive and the v vector is 0 this means that the wind is
coming from a direction of 330. If the u vector is zero and the
v vector positive the wind is coming from a direction of 60.
The formula for the direction calculation is atan(v/u)-30
degrees. Note that it is the UNCORRECTED direction that is used
for indexing all the calibration tables.

Each of the four calibration tables consists of 361 calibration
factors. The horizontal angle expressed as a whole number of
degrees is used as an index to retrieve the relevant
calibration factors. Thus if the horizontal angle is 0 the
first element in each table will be retrieved, if the angle is
274 degrees then the 275th element of each table will be
retrieved.

All calibration calculations are carried out by multiplying the
required vector by the number in the table and then dividing by
65536. This is done because decimal 65536 is hex 1000, and
therefore dividing by 65536 can be achieved by a simple shift
operation. A calibration number of 65536 thus corresponds to a
calibration factor of 1.00. 71072 corresponds to 71072/65536 =
1.08447. 58089 corresponds to 58089/65536 = 0.88637.

DIRECTION CORRECTION
The direction correction calculation is of the form
u' = u – Dv
v' = v + Du
where u and v are the measured uncorrected vectors and D is the
calibration factor retrieved from the table.

For example if u was 8.00m/s and v was –4.00:-

direction = atan(-4.00/8.00)-30 = 303.4 degrees.
(see diagram 1012-k-0055).

The 304th value in the direction correction table would be accessed. If this was for example -550 the calculation would be

u' = 8.00 - ((-550/65536) * -4.00) = 7.97
v' = -4.00 + ((-550/65536) * 8.00) = -4.07

This has changed the overall direction to 302.9.

MAGNITUDE CORRECTION

Once the direction correction has been carried out the value retrieved from the magnitude_correction_table is used to correct both the u' and v' vectors ie/

u'' = Mu'
v'' = Mv'

where u' and v' are the direction corrected vectors.
If we continue the example above the 304th value in the magnitude_calibration_table is retrieved (note that the UNCORRECTED direction is used for indexing all the calibration factors). If this value was 69405 the new final values of u'' and v'' would be:-

u'' = 7.97 * 69405/65536 = 8.44
v'' = -4.07 * 69405/65536 = -4.31

VERTICAL VELOCITY CORRECTION

If the w component is positive the relevant value from the up_w_calibration_table is used to correct the w vector. If the w vector is negative the relevant value from the down_w_calibration_table is used to correct the w vector.

If we continue the example above if the w vector is -0.65 the 304th value in the down_w_calibration_table will be retrieved. If this value was 73693 the w vector would become

w' = -0.65 * 73693/65536 = -0.73.

FILE FORMATS
The horizontal calibration data is in file XXXXRCAL.H where
XXXX is the serial number of your particular anemometer. The
vertical calibration data is in file WCAL.H. These files are
part of the 'C' language source code which is actually used to
generate the programme.

The format of the XXXXRCAL.H file is as follows:-

```
int an_serial_number = 29;
long magnitude_calibration_table[361] = {
71072 71035 71087 71139 71191 71243 71295 71380 71465 71550
71635 .........
                                       ........71146 71109
71072 };

long direction_calibration_table[361] = {
00100 00200 00300 00400 00500 00150 -0200 -0550 -0900 -1250
-0804 .........
                                       ........00662 00632
00602 };
```

The first line contains the anemometer serial number.
This is followed by the magnitude_calibration_table and the
direction_calibration_table.

WCAL.H   contains   the   up_w_calibration_table   and
down_w_calibration_table in the same format as the horizontal
tables.

APPENDIX B
CALCULATION OF UVW VECTORS FROM TRANSIT COUNTS
This section details the equations used within the anemometer
to calculate the U, V and W vectors from the six transit times.
There are two stages to this calculation, firstly calculation
of the velocity vectors along each transducer axis, and
secondly a vector transformation into the standard U, V and W
axes. For a definition of the transducer axes see section 3.2.

CALCULATION OF AXIS SPEEDS
The transit times output are in 29.4912Mhz counts. Transducer
and circuit delays (as measured during the test and calibration
procedure) have already been deducted from these counts.
The equation used to calculate axis velocity av is

av = 0.5L/t1 - 0.5L/t2
Where L is the axis length.

Note that t1 is the top to bottom transit time (the first of
each pair as transmitted by the anemometer) and t2 is the
bottom to top transit time. Note that as transmitted by the
anemometer and stored by fastcom.exe the transit counts are in
this order:-

t1 axis1, t2 axis2, t1 axis2, t2 axis2, t1 axis3, t2 axis3.

For maximum accuracy L must be measured. Nominally the path
length between the transducer faces should be 0.149 metres, but
it will be found to vary slightly from this figure. See section
3.2 for a definition of which axis is which.

If we require av in m/s, assuming L is in metres and t is in
29.4912Mhz counts the equation becomes:-

av = 0.5L*29491200/t1 - 0.5L*29491200/t2

Thus
av = L*14745600/t1 - L*14745600/t2.

VECTOR TRANSFORMATION

a1 = axis1 velocity
a2 = axis2 velocity
a3 = axis3 velocity

Standard vector mathematics leads to the following equations:-

U velocity = (2a1 - a2 - a3)/2.1213
V velocity = (a2 - a3)/1.2247
W velocity = (-a1 - a2 - a3)/2.1213