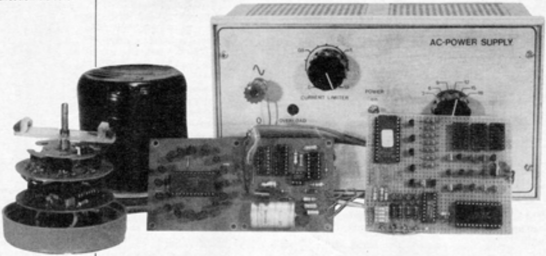


wind direction indicator

The article featuring the wind speed meter (anemometer) published in our November 1983 issue prompted us to expand the 'Elektor weather station' by adding an electronic wind direction meter. This instrument consists of a 'pick-up' and a read-out, connected together by means of two wires. The read-out indicates the wind direction with 16 LEDs. This could also be expanded so that the read-out is shown on an alphanumeric display.

R. Bakx

"revolving pointer often in shape of cock mounted in high place esp. on church spire to show whence wind blows," (OED)

In this electronic wind direction indicator the position of a wind vane is first translated into a code, which is sent below to display the wind direction on a wind compass card made up of 16 LEDs. The great advantage of the set-up used here is that only two wires are needed for interconnection between the pick-up section (at the wind vane) and the read-out section (with the wind compass). These two wires are used to provide the power for both sections and at the same time to carry the wind direction information to the read-out.

The principle

Because a simple connection between the two sections was considered important in this design, an easy method had to be found to allow both the measurement signal and the supply voltage to be transmitted over a single line. As we will see later, we solved this problem in a very unusual way.
The direction of the wind is translated into a four bit code by means of a coding disc fixed to the wind vane and four reflection sensors mounted below the disc. This code must now be sent in serial form to the receiver. There the signal is reconverted into a four bit code that is used to drive the 16 LEDs of the wind compass. The block diagram of figure 1a shows the main parts of the circuit.

Before going on to look at the circuit diagram, we must first see how the power and the wind direction information are carried on the same line. This will then make the layout of the circuit much easier to understand. The diagram of figure 1b shows how this two-wire 'traffic' is achieved. In principle the supply transformer is situated between the pick-up and the read-out sections. Each section has its own supply buffer consisting of a diode and an electrolytic capacitor. Data is transferred between the two sections by means of a transistor in the 'transmitter' end and an opto coupler in the 'receiver' (display) end. The transformer is linked to the connecting cable via a diode and a resistor as shown.
Positive half-cycles of the mains frequency are now treated differently from the negative. What happens during a positive half-cycle is shown in figure 1c. The transformer voltage is half-wave rectified by a diode so that the two electrolytic capacitors are charged and the two sections of the circuit are provided with a d.c. voltage. The diodes prevent the capacitors from discharging during negative half-cycles. As we have said, the negative half-cycles are treated differently, and this is illustrated in figure 1d. If transistor T conducts the two wires are short circuited. If T is not conducting a current will flow through the LED in the opto coupler of the read-out section, so that

the opto transistor will give a pulse. The operation of the whole circuit is as easy as it is clever; when T is conducting no pulse appears at the output of the opto coupler, but when T is not conducting the opto coupler gives one pulse for each negative half-cycle. In this way signals can be transmitted during the time when there are no supply pulses on the line.
The lines therefore carry positive pulses with a frequency of 50 Hz and negative pulses 'supplied' by T. The result is shown in figure 1d. We use the number of 50 Hz pulses between two negative pulses as information relating to the wind direction. As far as logic is concerned, the circuit for the wind direction indicator is also split into two sections; the pick-up (figure 2) and the read-out (figure 3). We will begin with the pick-up circuit, which will later be fixed to the wind vane. The power supply for this section is handled by D5, C2, C3 and regulator IC3. The 50 Hz pulses appearing at point P are formed into a square wave by N3. High frequency interference on the lines is suppressed by RC network R18/C4. Negative signals on the line are blocked by diode D6.

1

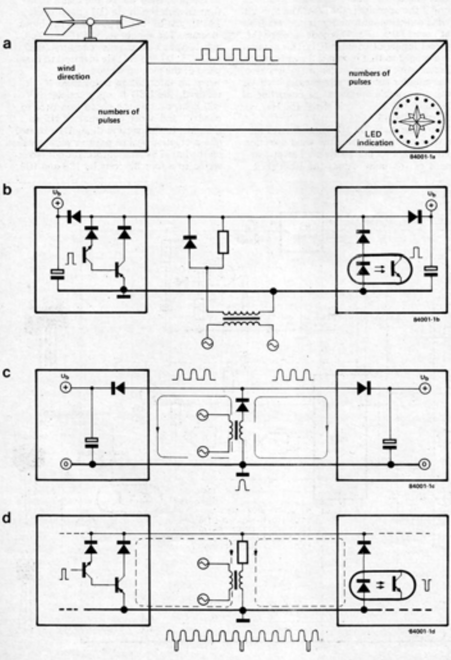


Figure 1. A rough block diagram of the wind direction indicator and three drawings to illustrate how both the power and the information signals are transmitted over the same two wires.

The wind vane is fixed to a four bit Gray code disc, by means of which 16 wind directions are coded into a four bit code. The disc contains opaque and translucent sections, and its layout is shown in figure 5. A digital signal is supplied by four reflection sensors, IC11 . . . IC14, mounted below the disc. Alternatively, four LEDs and four photo transistors could be substituted, with the diodes shining through the disc onto the transistors. These are indicated in the parts list as D1 . . . D4 and T1 . . . T4, which are simply four red LEDs and four ordinary photo transistors.

The signal from each sensor is amplified by a transistor stage (T5 . . . T8), so that the output of each stage is logic zero if no light is falling on the photo transistor and logic one if the opposite is the case. The four-bit wind direction information is now available at points P0 . . . P3. This code is fed to the preset inputs of counter IC1. This counter is arranged so that it counts down from the preset value to zero. When it reaches zero the counter automatically presets itself via the monostable multivibrator consisting of N1 and N2. The clock signal (50 Hz) is supplied by N3.

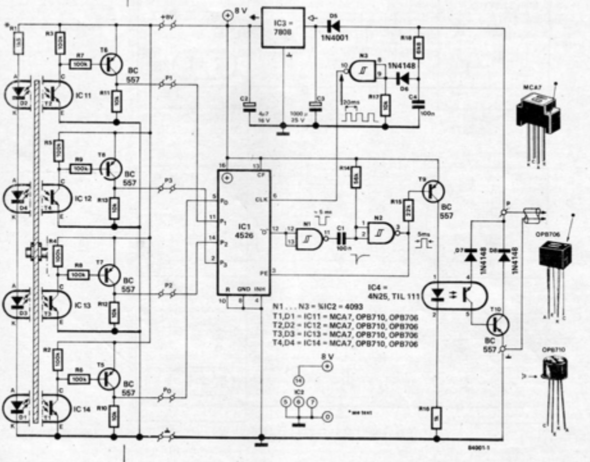
The pulse given by N2 lasts about 5 ms and is used to transmit the wind direction information to the 'receiver'. The appearance of the pulse causes the LED (and therefore the photo transistor) in the opto coupler to be switched off via T9, and this in turn means that T10 is turned off. The moment at which N2 gives the pulse is defined by the preset value of the counter. Because IC1 is clocked at the mains frequency, the number of mains pulses between two successive N2 pulses is exactly equal to the binary code at the preset inputs. Assume, for example, that the binary code is 1001 (= 9), then N2 will give an 'information pulse' after every 9 mains pulses. Because transistor T10 and the photo transistor in IC4 need to be protected against positive mains pulses, two extra diodes, D7 and D8, have been added.

The circuit for the read-out section is shown in figure 3. Here we see the mains transformer with the diode (D11) and resistor (R19), just as they appeared in the block diagram. The supply section (D12, C6, C7 and IC6) and clock pulse circuitry (R20, R21, C5, D9 and N4) are identical to these parts of the pick-up section.

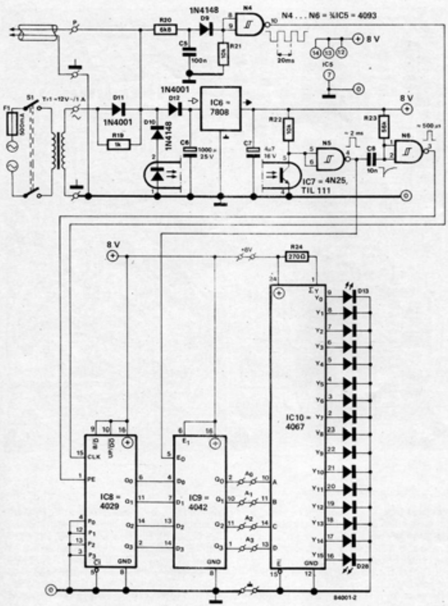
When an information pulse from N2 is received, the LED in opto coupler IC7 will light, causing the photo transistor to conduct and short the input of N5 to ground. In this section diode D10 is used as a protection against positive voltage pulses on the line. The serial information is reconverted to a four bit code by IC8 and IC9.

Figure 2. This is the circuit diagram for the pick-up section with the coding disc and the actual sensors at the left. Depending on the code it receives, IC1 defines when an information pulse must be sent to the read-out section.

2



3



IC14	IC13	IC12	IC11	wind direction
1	1	1	1	NW
1	1	1	0	NNW
1	0	1	0	N
1	0	1	1	NNE
1	0	0	1	NE
1	0	0	0	ENE
0	0	0	0	E
0	0	0	1	ESE
0	0	1	1	SE
0	0	1	0	SSE
0	1	1	0	S
0	1	1	1	SSW
0	1	0	1	SW
0	1	0	0	WSW
1	1	0	0	W
1	1	0	1	WNW

Figure 3. This is the read-out circuit. Here the information received is converted back to a four bit code which defines which one of the 16 LEDs in the 'wind compass' will light.

IC8 is a four bit counter that counts up from 0000 at the clock frequency. Whenever the circuit receives an information pulse the counter is reset via the monostable multivibrator of N5 and N6. Just before IC8 is reset the count is read into latch IC9 with a latch pulse from N5. The latch stores this count until a new information pulse arrives. The outputs of the latch therefore show the same four bit information that was supplied to the preset inputs of IC1. The code then goes to IC10, which acts as a 4 to 16 line decoder. The 16 outputs drive the LEDs that indicate the wind direction.
The current through the LEDs is limited to about 20 mA by resistor R24. The table beside the diagram shows the conditions for indicating each wind direction.

The mechanical layout

All the electronics we have just been describing is located on the four printed circuit boards shown in figure 4. The two circular boards contain the pick-up section, and the read-out section is on the other two boards. These four boards are supplied as one unit through the EPS service and have to be separated. The two read-out boards could also be left together, depending on the amount of room available.
The mechanical construction for the pick-up section with the wind vane is fairly straightforward. There are various details that must be considered, however. One thing that must be decided is whether to use LEDs and photo transistors or reflection sensors. The latter are recommended due to the fact that

4

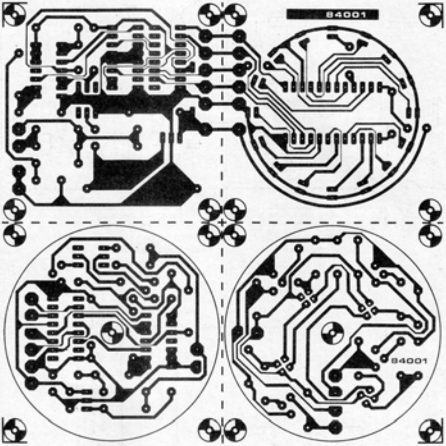


Figure 4. This is the printed circuit board layout for the complete wind direction indicator, consisting of four sections that must be separated from one another. The two read-out boards may be kept as one unit if there is sufficient room to accommodate this.

shielding from stray light can be a major problem when discrete LEDs are used. The layout of the coding disc is shown in figure 5, and also (full size) on the layout pages at the centre of this issue. A disc is made up with either the shape of figure 5a or 5b. If reflection sensors are used then 5a is needed, otherwise 5b is used with LEDs mounted above the disc and phototransistors below them on the printed board. The two pick-up boards are cut into a circular disc shape and the components can then be mounted. Capacitor C3 must be soldered to the track side of the board, ideally with some form of insulation between it and the copper.

Six points on the two boards (P0, P1, P2 P3, +8 V and $\perp$) must be connected by means of wires or some ribbon cable. The boards can then be fixed together 'sandwich fashion' held in place by a 5 mm diameter rod that is fixed to the base of the 'transmitter' casing. The coding disc is fitted in such a way that it is allowed to rotate freely about 1 mm above the reflection sensors.

A further plastic disc with two strong magnets glued diametrically opposite each other

5

a b

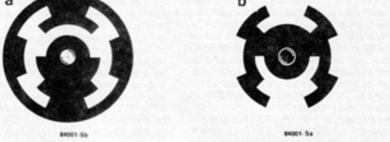
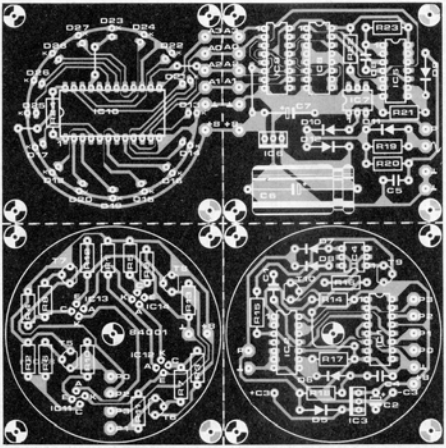


Figure 5. The layout for the coding disc (shown here half size). Possibly the easiest way to make this disc is to cut the required shape from a piece of printed circuit board material with a fret saw. Figure 5a is the design to use with reflection sensors, and figure 5b with LEDs above the disc and phototransistors below. They are also shown full-size on page 1-45.



is fixed above the coding disc such that the two discs rotate together. The whole construction must fit into the (inverted) transparent jar so that the disc with the magnets can rotate freely. The connecting cable is passed through a hole drilled in the lid and soldered to the lower printed circuit board. The opening is then sealed well. The form of construction is illustrated in figure 6 but, as usual, individual ideas will probably change this significantly.
Now all the electronics is protected in a watertight package, but, if the light sensitive components are not to be affected by ambient light, it must also be made lightproof. This can easily be done by painting the outside of the jar black.
Looking at the mechanical construction it is obvious why again we recommend using reflection sensors if possible. If LEDs and photo transistors are used the LEDs must somehow be fixed above the coding disc and they must also be provided with their own power supply.
The construction of the outer casing is very dependent upon what material is available. It could, for example, be made using PVC tubing. This outer casing ideally should have bearings for the shaft of the wind vane and some sort of cap is needed to prevent rainwater from getting at these bearings. Remember to provide a hole at the bottom of the casing to prevent condensation building up.
Another plastic disc (or simply a strip of plastic) with two strong magnets is mounted at the lower end of the wind vane shaft. Be sure to get the 'polarity' of the magnets correct as their purpose is to induce the magnets inside the jar to rotate 'in sympathy' with them.
It may be necessary to experiment with the value of resistor R1. In reflection sensors the sensitivity is often so good that the current through the LEDs can easily be reduced and so help to prevent 'false' reflections. With normal LEDs the current could be increased a little. Trial and error is probably the best method to use here until a value is found that enables all wind directions to be correctly indicated.
Constructing the read-out is very straightforward. Depending on the case used, the two boards can either be left joined or separated, but in this latter case points A0 . . . A3, +8 V and ⊥ must be linked on both boards. To keep this section as small as possible the two boards can again be mounted sandwich fashion.
The transformer is connected to the read-out

Parts list

Resistors:
R1 = 1k5 1/8 W (see text)
R2 . . . R9 = 100 k 1/8 W
R10 . . . R13 = 10 k 1/8 W
R14,R23 = 56 k
R15 = 22 k
R16,R19 = 1 k
R17,R21,R22 = 10 k
R18,R20 = 6k8
R24 = 270 Ω

Capacitors:
C1,C4,C5 = 100 n
C2,C7 = 4μ7/16 V
C3,C6 = 1000 μ/25 V
C8 = 10 n

Semiconductors:
D1 . . . D4 = LED, see text
D5,D11,D12 = 1N4001
D6 . . . D10 = 1N4148
D13 . . . D28 = LED, red
T1 . . . T4 = cheap photo transistor, see text
T5 . . . T10 = BC 557
IC1 = 4526
IC2,IC5 = 4093
IC3,IC6 = 7808
IC4,IC7 = 4N25, TIL 111
IC8 = 4029
IC9 = 4042
IC10 = 4067
IC11 . . . IC14 = OPB 706, OPB 710

Miscellaneous:
Tr1 = mains transformer 12 V/1 A
S1 = double pole mains switch
F1 = 500 mA fuse with holder

6

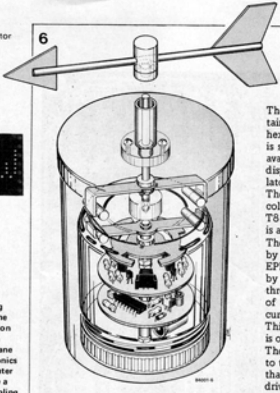


Figure 6. This drawing gives an insight into the mechanical construction of the pick-up section complete with wind vane and 'case'. The electronics are protected from water by sealing them inside a jam jar. Magnetic coupling is used between the wind vane and the coding disc.

section, but if desired it can be moved to some other point on the cable. In this case, of course, D11 and R19 stay with the transformer and are not mounted on the printed circuit board. This unit is then connected to the cable as shown in figure 7. Finally the electronic weathercock must still be calibrated. With the aid of a compass the wind vane is pointed North, and then the whole 'case' is rotated until the read-out shows 'North'. If the pick-up section is already fixed in position on the roof, it could also be calibrated by turning the magnet mounting disc on the shaft of the wind vane.

NSEW

The circuit can be expanded slightly by enabling the 16 wind directions to be shown on three dot matrix displays. The circuit for this 'extra' is given in figure 8. This is connected to the data outputs A0 . . . A3 of the read-out section (the outputs of IC9). The 'data' for driving the displays is contained in a 2 Kbyte EPROM, IC1. The hexdump for the contents of this EPROM is shown in table 1, and this chip is also available from Technomatic Ltd. The displays are multiplexed by counter/oscillator IC3 and 4 to 16 line decoder IC4. The outputs of IC4 drive the 15 LED columns of the displays via transistors T8 . . . T22. The multiplexing frequency is about 3.5 kHz.
The LED rows of the displays are driven by the data outputs D0 . . . D6 of the EPROM. The output signals are amplified by transistors T1 . . . T7, and the current through the LEDs is defined by the values of resistors R3 . . . R9. The maximum current through the LEDs is about 75 mA. This current is needed because each LED is only driven for 1/16 of the time.
The four outputs of IC4 are also connected to the address inputs A0 . . . A3 of IC1, so that when a certain LED column is being driven the appropriate 'switching' data appears at the output. Address inputs A4 . . . A7 receive their data from the latch in the read-out section so that, depending on the wind direction, a specific 16 byte address of the EPROM is selected that contains the information needed to give the correct display. Voltage dividers R12 . . . R15/R16 . . . R19 are included to reduce the 8 V signals of the read-out circuit to the 5 V used by the display. Finally, a link must be connected between pins 12 and 21 of the 2716. This is necessary to select the correct section of the EPROM. The power supply for this section is handled by a separate 5 V stabilizer (IC2). The current consumption of this circuit is about 150 mA. ◼

7

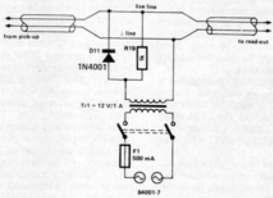
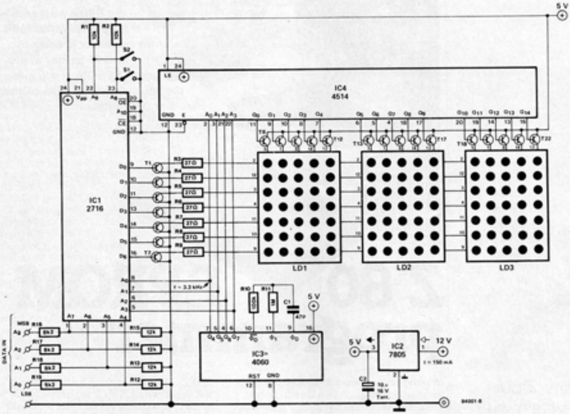


Figure 7. The transformer does not necessarily need to be located near the read-out. It can also be connected to the cable somewhere else. If this is done, D11 and R19 stay with the transformer instead of being mounted on the printed circuit board.

8



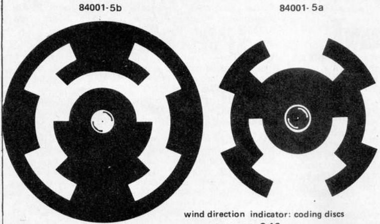
LD1 . . . LD3 = 3xTIL 305 (MAN 2A)
T1 . . . T7 = BC 557B
T8 . . . T22 = BC 547B

Figure 8. Here we show an additional circuit that can be added to enable the wind direction to be read out on three dot-matrix displays.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
F000:	FF	FF	FF	FF	FF	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F010:	C1	BE	BE	BE	C1	9E	AE	B6	BA	BC	C1	BE	BE	BE	C1	FF
F020:	9E	AE	B6	BA	BC	9E	AE	B6	BA	BC	C1	BE	BE	BE	C1	FF
F030:	9E	AE	B6	BA	BC	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F040:	C0	BF	C7	BF	C0	9E	AE	B6	BA	BC	C0	BF	C7	BF	C0	FF
F050:	9E	AE	B6	BA	BC	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF
F060:	FF	FF	FF	FF	FF	9E	AE	B6	BA	BC	FF	FF	FF	FF	FF	FF
F070:	9E	AE	B6	BA	BC	9E	AE	B6	BA	BC	C0	BF	C7	BF	C0	FF
F080:	C1	BE	BE	BE	C1	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF
F090:	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F0A0:	FF	FF	FF	FF	FF	80	FB	F7	EF	80	FF	FF	FF	FF	FF	FF
F0B0:	80	FB	F7	EF	80	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF
F0C0:	FF	FF	FF	FF	FF	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF
F0D0:	C0	BF	C7	BF	C0	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF
F0E0:	80	FB	F7	EF	80	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF
F0F0:	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF
F100:	FF	FF	FF	FF	FF	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F110:	C1	BE	BE	BE	C1	D9	B6	B6	B6	CD	C1	BE	BE	BE	C1	FF
F120:	D9	B6	B6	B6	CD	D9	B6	B6	B6	CD	C1	BE	BE	BE	C1	FF
F130:	D9	B6	B6	B6	CD	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F140:	C0	BF	C7	BF	C0	D9	B6	B6	B6	CD	C0	BF	C7	BF	C0	FF
F150:	D9	B6	B6	B6	CD	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF
F160:	FF	FF	FF	FF	FF	D9	B6	B6	B6	CD	FF	FF	FF	FF	FF	FF
F170:	D9	B6	B6	B6	CD	D9	B6	B6	B6	CD	C0	BF	C7	BF	C0	FF
F180:	C1	BE	BE	BE	C1	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF
F190:	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F1A0:	FF	FF	FF	FF	FF	80	FB	F7	EF	80	FF	FF	FF	FF	FF	FF
F1B0:	80	FB	F7	EF	80	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF
F1C0:	FF	FF	FF	FF	FF	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF
F1D0:	C0	BF	C7	BF	C0	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF
F1E0:	80	FB	F7	EF	80	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF
F1F0:	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
F200:	FF	FF	FF	FF	FF	80	B6	B6	B6	BE	FF	FF	FF	FF	FF	FF
F210:	80	B6	B6	B6	BE	D9	B6	B6	B6	CD	80	B6	B6	B6	BE	FF
F220:	D9	B6	B6	B6	CD	D9	B6	B6	B6	CD	80	B6	B6	B6	BE	FF
F230:	D9	B6	B6	B6	CD	80	B6	B6	B6	BE	FF	FF	FF	FF	FF	FF
F240:	C0	BF	C7	BF	C0	D9	B6	B6	B6	CD	C0	BF	C7	BF	C0	FF
F250:	D9	B6	B6	B6	CD	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF
F260:	FF	FF	FF	FF	FF	D9	B6	B6	B6	CD	FF	FF	FF	FF	FF	FF
F270:	D9	B6	B6	B6	CD	D9	B6	B6	B6	CD	C0	BF	C7	BF	C0	FF
F280:	80	B6	B6	B6	BE	80	FB	F7	EF	80	80	B6	B6	B6	BE	FF
F290:	80	FB	F7	EF	80	80	B6	B6	B6	BE	FF	FF	FF	FF	FF	FF
F2A0:	FF	FF	FF	FF	FF	80	FB	F7	EF	80	FF	FF	FF	FF	FF	FF
F2B0:	80	FB	F7	EF	80	80	FB	F7	EF	80	80	B6	B6	B6	BE	FF
F2C0:	FF	FF	FF	FF	FF	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF
F2D0:	C0	BF	C7	BF	C0	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF
F2E0:	80	FB	F7	EF	80	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF
F2F0:	80	FB	F7	EF	80	C0	BF	C7	BF	C0	FF	FF	FF	FF	FF	FF
F300:	FF	FF	FF	FF	FF	80	B6	B6	B6	BE	FF	FF	FF	FF	FF	FF
F310:	80	B6	B6	B6	BE	D9	B6	B6	B6	CD	80	B6	B6	B6	BE	FF
F320:	D9	B6	B6	B6	CD	D9	B6	B6	B6	CD	80	B6	B6	B6	BE	FF
F330:	D9	B6	B6	B6	CD	80	B6	B6	B6	BE	FF	FF	FF	FF	FF	FF
F340:	C1	BE	BE	BE	C1	D9	B6	B6	B6	CD	C1	BE	BE	BE	C1	FF
F350:	D9	B6	B6	B6	CD	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F360:	FF	FF	FF	FF	FF	D9	B6	B6	B6	CD	FF	FF	FF	FF	FF	FF
F370:	D9	B6	B6	B6	CD	D9	B6	B6	B6	CD	C1	BE	BE	BE	C1	FF
F380:	80	B6	B6	B6	BE	80	FB	F7	EF	80	80	B6	B6	B6	BE	FF
F390:	80	FB	F7	EF	80	80	B6	B6	B6	BE	FF	FF	FF	FF	FF	FF
F3A0:	FF	FF	FF	FF	FF	80	FB	F7	EF	80	FF	FF	FF	FF	FF	FF
F3B0:	80	FB	F7	EF	80	80	FB	F7	EF	80	80	B6	B6	B6	BE	FF
F3C0:	FF	FF	FF	FF	FF	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F3D0:	C1	BE	BE	BE	C1	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF
F3E0:	80	FB	F7	EF	80	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF
F3F0:	80	FB	F7	EF	80	C1	BE	BE	BE	C1	FF	FF	FF	FF	FF	FF
F400:																

Table 1. Hexdump for the data that must be stored in EPROM IC1.



wind direction indicator: coding discs

see page 2-46