PC-66
12 channel
D/A card
&
PC-66A
8 channel
D/A card

User manual

Second edition

December 1989

Table of Contents

The PC-66 12 channel D/A card for the IBM PC/XT/AT and compatible Personal Computers

1. DESCRIPTION

The PC-66 digital to analogue board features twelve independent 12-bit DAC's (digital to analogue converters) including remote sensing capability. Eight of the twelve DAC's can be preloaded with new output values and then updated in parallel by an eight bit control word. The settling time of each DAC is less than 2 μs for a 10V output swing. This makes the card particularly suitable for fast three-phase waveform generation, particularly with the use of the parallel trigger facility.

Typical applications for the PC-66 board include complex waveform generation and control of power supplies in test labs. The board can also be used for analogue control in process and laboratory applications where material transfer rates, fluid flow, power consumption, motor speed, temperature levels, etc. are to be controlled with a PC.

Remote sense facility (which prevents voltage drop over long output leads) is provided on all twelve channels. The first eight channels can operate in monopolar or bipolar modes while the remaining four operate in bipolar mode only. The first eight channels support the parallel trigger facility. Selection between monopolar and bipolar mode is at the 37-pin D-connector at the rear mounting bracket. Thus the personal computer need not be opened or recalibrated when changing modes of operation. By setting a reference voltage (common to all the DAC's) the maximum output voltage swing can be set to between ±5V and ±10V. (5V and 10V in monopolar mode). Maximum output current of each channel is 10mA.

2. SPECIFICATIONS

Number of channels	:12 channels; 8 channels bipolar and monopolar and 4 channels bipolar only
Resolution	:12 bit (ie. 0.02% analogue accuracy)
Linearity	:12-bit

Differential non-linearity	: 1 bit
Settling time	: 2 μs (-5V to +5V step)
Temperature drift	: ±6 ppm/°C of full scale voltage
Max. output voltage	: bipolar with remote sensing : ±5V to ±10V (adjustable) : monopolar with remote sensing : +5V to +10V (adjustable)
Max. output current	: ±10mA at ±10V output voltage
Dimensions	: 35 cm long, 11 cm high; board occupies one long slot in an IBM PC/XT/AT; the board can also be used in an AT slot.
Operating temperature	: 0 °C to +70 °C
Relative humidity	: Up to 90%, noncondensing

Offset and full scale errors are adjustable to zero in each channel, and need not be recalibrated when changing modes of operation.

Board address selection: selectable between 300 Hex and 1FFF Hex (default setting is 300 Hex.)

NOTE: If other board addresses are used, make sure you are not using any reserved IBM I/O location. For further information consult your PC's technical reference manual.

3. The 37-pin D-connector:

The PC-66 board is connected to your laboratory equipment, etc. via a standard 37-pin female D-connector which is situated at the rear mounting panel of your

PC. Before making any connections to your board make sure your PC is switched off. Keep the output leads as short as short as possible or use the remote sense facility. For application of remote sense see Fig. 1. When generating waveforms of more than 50 Hz and with output leads longer than 3 metres use separate screened leads for each channel in order to avoid crosstalk. If the remote sense facility is not used the remote sense input of the respective channel must be connected to the respective output directly at the 37-pin D-connector.

The output connector provides 5 ground lines which should all be used to avoid crosstalk between the channels.

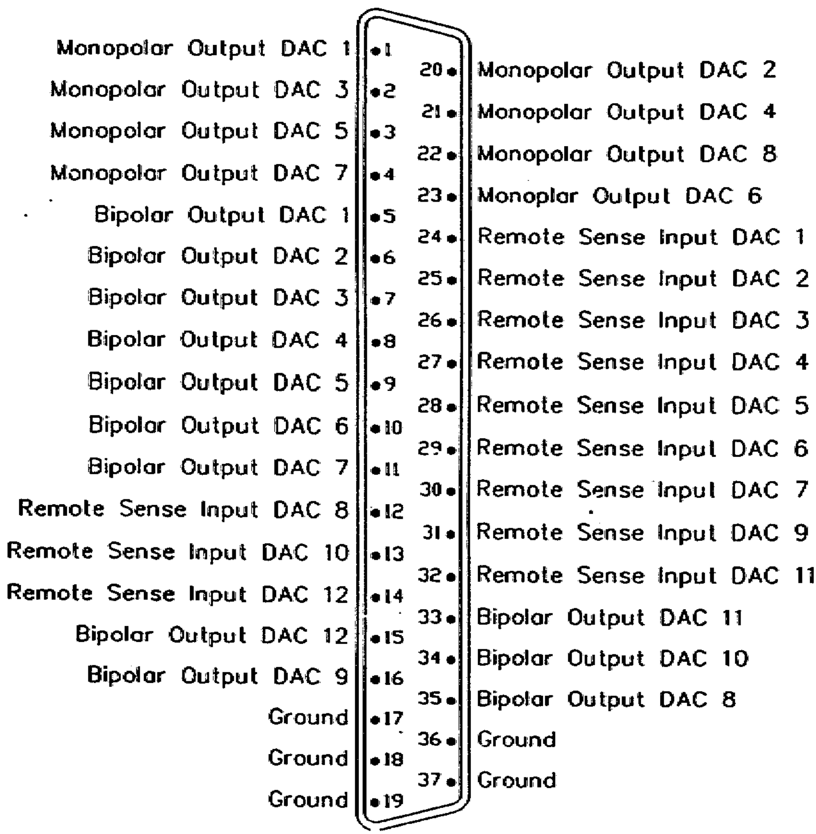

Figure 1: Pin Layout of 37-pin D-connector

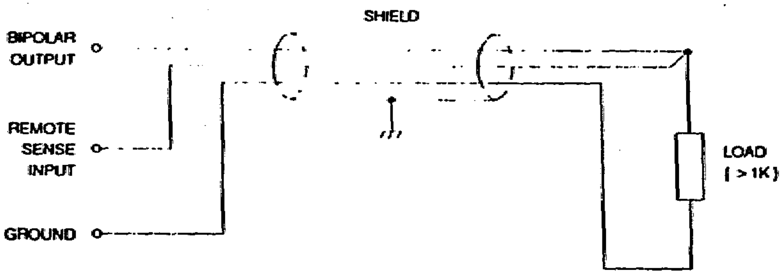

Figure 2: Remote sense application

NOTE: For proper operation the respective remote sense inputs and bipolar outputs must be connected.

4. Addressing the PC-66 board:

The DAC's of the PC-66 board are accessed via 24 consecutive 8-bit ports of the I/O space. These port addresses are located above the Base Address (BA) of the PC-66 board. The base address is selected via 8 DIP switches. Each of the DIP switches has a binary weight as indicated below.

Selection of the board address with the DIP switch:

Switch Number	Hex Weight
1	20
2	40
3	80
4	100
5	200
6	400
7	800
8	1000

To select a Hex weight put the respective switch in the OFF position. Thus to select the default board address (Hex 300) switches 4 and 5 must be in the OFF position. All other switches must be ON. For example: to select a base address of Hex A00 switches 7 and 5 must be in the OFF position and all other switches must be ON.

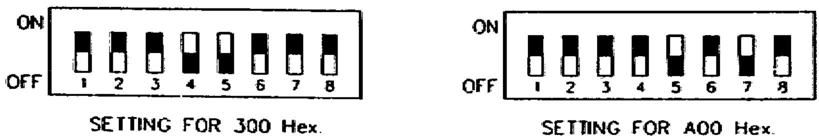

Figure 3: Examples of DIP switch settings

The internal data latches of the double buffered DAC's are accessed via 24 8-bit ports as indicated below.

DAC No.	1	2	3	4	5	6
MSB	BA + 01	BA + 03	BA + 05	BA + 07	BA + 09	BA + 0B
LSB	BA + 00	BA + 02	BA + 04	BA + 06	BA + 08	BA + 0A

DAC No.	7	8	9	10	11	12
MSB	BA + 0D	BA + 0F	BA + 11	BA + 13	BA + 15	BA + 17
LSB	BA + 0C	BA + 0E	BA + 10	BA + 12	BA + 14	BA + 16

Figure 4: I/O space above the Base Address (BA)

5. Loading sequence of the D/A:

The input registers of the DAC's are arranged to accept a left-justified data word from the PC with the most significant 8 bits coming first (msb) and the lower (lsb) second. Left justification simply means the binary point is assumed to be located to the left of the most significant bit. Fig. 2 shows how the 12 bits of the DAC data should be arranged in the two I/O ports of the PC.

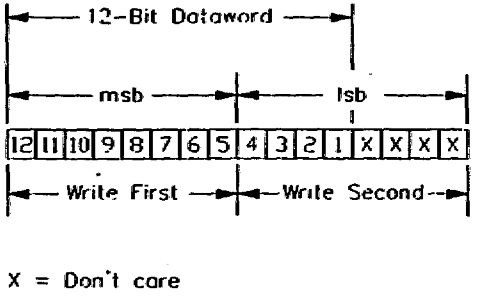

Figure 5: Left-justified data format

If the parallel trigger facility, explained in the next section, is not selected, the output of the DAC is updated when the 4 least significant bits are written to the respective I/O port addresses. Thus a DAC is programmed in the following way:

1. Load the 8 msb's of the 12-bit data word into the msb port of the DAC;

2. Load the 4 lsb's of the 12-bit data word (left justified) into the lsb port of the DAC.

6. Parallel trigger facility:

The first eight DAC's can be updated at the same time (ie. in parallel) by writing a specific control word to port address BA + 18. To enable the parallel trigger facility of a channel, set the onboard jumper of the required channel in the down position (ie. towards PC mother board). Default setting is channel 1, 2 and 3 set for parallel trigger and all other channels set for normal write operation.

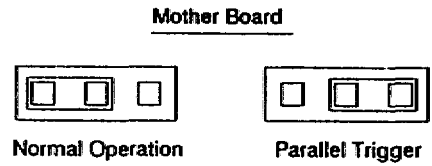

Figure 6: Jumper setting for Parallel Triggering

For parallel trigger of the DAC's, load the ports of all DAC's you want to use with the new 12-bit values as described above,. Then write to the parallel trigger port (BA + 18) a bit pattern in which the bits of the DAC's which are to be updated are set to zero. For example, the following bit pattern will update DAC's number 1, 2 and 3:

1111 1000 = F8 Hex

7. Setting the DAC's:

Warning:

The calibration procedure and formulae supplied allow the DAC's to range from -Full Scale to +Full Scale. This is, however, different to the classical calibration procedure, which only allows the DAC to reach Full Scale - 1 lsb.

Monopolar mode:

When using the monopolar outputs of the DAC's the output voltage V_{out} is defined with a 12-bit data word in the following way:

$$V_{out} = -V_{ref} * D / 4095$$

where V_{ref} is the reference voltage which is used for all DAC's as described in section 8.

To set the output voltage V_{out} of a DAC channel the necessary 12-bit data word D is calculated in TURBO PASCAL in the following way:

```
D: = ROUND((Vout/(-Vref))*4095);
```

where V_{ref} = -5.000V (NOTE: For calculations V_{ref} is exactly -5.000V.)

The msb and lsb values which have to be written to the DAC registers (left justified data format, as described above) are calculated in TURBO PASCAL as follows:

```
msb: = HI(D SHL 4); {msb is HI byte of D shifted 4 places left}

lsb: = LO(D SHL 4);  {lsb is LOW byte of D shifted 4 places left}
```

The msb and lsb are then written to the respective DAC, for example DAC 1:

```
Port [$301]: = msb;

Port [$300]: = lsb;
```

NOTE: The msb must be written first. The DAC is updated when the lsb is written, or the parallel trigger of the respective DAC is set to zero.

Bipolar mode:

When using the bipolar outputs of the DAC's the output voltage V_{out} is defined with a 12-bit data word in the following way:

$$Vout = Vref * (D - 2048)/2048$$

where V_{ref} is the reference voltage as described i section 8. For setting the reference voltage for a specific output voltage range the same procedure is applicable as described in the above monopolar section.

The 12-bit data word necessary for a required output voltage Vout is calculated in TURBO PASCAL as follows:

```
D:=ROUND((Vout*(2048/Vref)) + 2048);
```

where Vref is the set reference voltage (default is -5.000V).

The msb and lsb values which have to be written to the DAC are calculated in the same manner as describes above for monopolar mode.

8. Setting the reference voltage:

The reference voltage of the PC-66 board can be controlled with the potentiometer VR4 in a range between -4.5V up to -10.5V. The reference voltage V_{ref} can be measured on the negative pin of the tantalum capacitor C6. Note that the reference voltage V_{ref} must be set to a voltage 50mV lower than the desired maximum output voltage of the DAC's. This is needed to allow a symmetrical calibration range of ±50mV in each DAC channel (with potentiometer VR1 and VR2). For example if the maximum output voltage is to be 5.000V then set V_{ref} to -5.050V. This is also the default setting of V_{ref}.

9. Disabling the clock interrupt of the PC:

To allow equal spacing of analogue values in fast waveform generation with DAC's in the PC using software loops, it is necessary to disable the clock of the PC. Interrupt 0 of the PC interrupts any program approximately 18 times a second. To disable this interrupt you may use the procedure 'Disable_IRQx(0)', (found in the program PC-66.pas on the supplied disk), just before starting waveform generation. To enable the clock interrupt after waveform generation use procedure 'Enable_IRQx(0)'.

10. Calibration of the PC-66 board:

Your PC-66 board has been calibrated at the factory, so recalibration should not be necessary. However if you need to recalibrate follow the procedure below. The PCB layout of a typical DAC channel is shown below in fig. 7. Note that for proper calibration a 4.5 digit Digital Volt Meter (DVM) is needed.

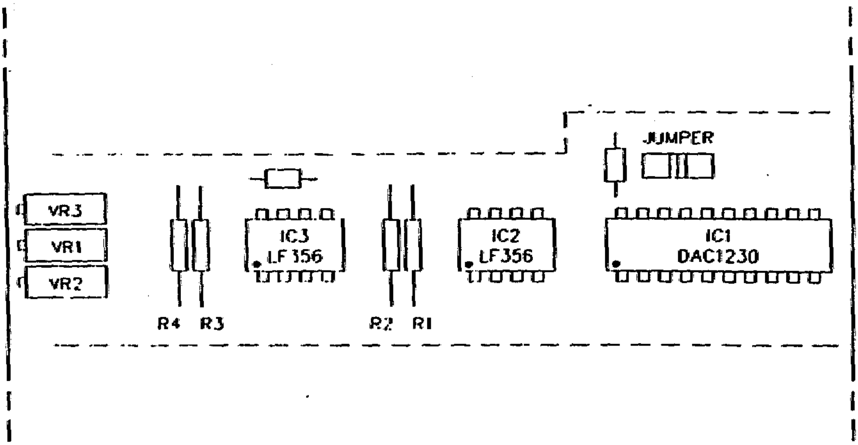

Figure 7: Typical DAC channel - PCB layout

lonopolar mode:

Calibrate the reference voltage as described in section 8.

Calibration of the input offset voltage of the operational amplifiers IC2 of each AC channel:

2.1 Connect a DVM between pins 2 and 3 of IC2.
2.2 Set the output voltage of the DAC to +5.000V.
2.3 With potentiometer VR3 adjust the measured voltage to 0.00mV.
2.4 Repeat this calibration for each DAC channel.

polar mode:

Calibrate the reference voltage as described in section 8.

Calibration of the input offset voltage of the operational amplifiers IC2 of each C channel:

2.1 Connect a DVM between pins 2 and 3 of IC2.
2.2 Set the output voltage of the DAC to +5.000V.
2.3 With potentiometer VR3 adjust the measured voltage to 0.00mV.
2.4 Repeat this calibration for each DAC channel.

3. Calibration of output voltage:

3.1 Set the reference voltage of the DAC's to a voltage which is about 50mV lower than desired maximum output voltage of the DAC's. (ie. to -5.050V if you want a maximum output range of +5.000V.)

3.2 Set output voltage of DAC's to +5.000V.

3.3 With potentiometer VR1 adjust the voltage at the bipolar output of the DAC channel to +5.000V.

3.4 Repeat for each DAC channel.

3.5 Set the output voltage of the DAC's to -5.000V.

3.6 With potentiometer VR2 adjust the voltage at the bipolar output of the DAC channel to -5.000V.

3.7 Repeat for each DAC channel.

For calibration use the appropriate part of the demo program.

11. Programming:

Examples of how to program the PC-66 board are given in the demonstration software which comes with the board. The demonstration disk contains the following files:

PC-66.pas: The TURBO PASCAL source code of the demo program
PC-66.com: The compiled demo program
autoexec.bat: The batch file to boot your PC and start the demo program

To start the demo program type:

PC-66 <enter>

after the the dos prompt. The demonstration software runs on any PC/XT/AT using CGA, EGA or Hercules graphics cards, since no graphics routines are used.

PC-66 D/A CARD TRANSFER LINES

M – Monoplar Out
B – Bipolar Out
R – Remote Sense Bipolar