INTERFACE

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SIMPLE DIGITAL TO ANALOGUE CONVERSION FOR PCs

THE previous *Interface* article provided details of a simple and inexpensive form of digital to analogue converter. This type of circuit is fine where good precision is not important, but it is of little use where high accuracy is required. Good accuracy and resolution require the use of a proper digital to analogue converter, and various devices offering from 8-to 16-bit resolution are available. For many practical purposes there is no point in going beyond 8-bit resolution, and noise problems can make it difficult to realise the theoretical accuracy of 12- and 16-bit devices.

There are two basic types of converter chip, which are parallel and serial interfacing types. The chips that use serial interfacing are not necessarily designed with an RS232C port in mind. In fact the vast majority of them are designed to interface to the processor via a few ordinary digital lines configured to act as a synchronous serial link. This enables the chip to be interfaced via just a few input and output lines, but the data transfers tend to be relatively slow. Using a synchronous serial link also complicates the control software.

Parallel interfacing requires more lines than the serial variety, but eight output lines and a ground connection are all that is needed for an 8-bit digital to analogue converter. A big advantage of parallel interfacing is that there is normally no need for any handshaking. Driving the chip is just a matter of writing the data to it each time a change in output voltage is required. The output will not respond instantly to changes, and the delay is known as the "settling time". However, the delay is quite small and is typically about one microsecond.

AD557JN

A 12-bit digital-to-analogue converter was covered in previous *Interface* articles, so this time a parallel converter will be described. The old Ferranti converter chips were very good when a simple 8-bit parallel digital to analogue or analogue to digital converter was required. Unfortunately, devices such as the ZN426E (D/A) and ZN427E (A/D) would seem to have disappeared with the company itself.

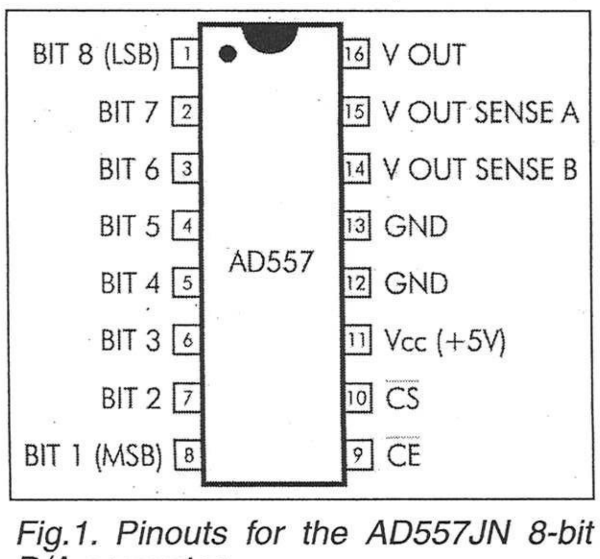

Fig.1. Pinouts for the AD557JN 8-bit D/A converter.

The nearest thing to the ZN426E currently available is probably the AD557JN. This is manufactured by Analogue Devices and in the UK it can be obtained from Rapid Electronics.

The AD557JN has a 16-pin d.i.l. (dual-in-line) encapsulation with the pin configuration shown in Fig.1. Conveniently, the eight data inputs are grouped together on one side of the device (pins 1 to 8), and in the right order.

The manufacturer's labelling for the data inputs and outputs of converter chips can be a bit confusing. Rather than the usual D0 to D7 they are often marked Bit 1 to Bit 8, as in this case. Bit 1 is the most significant bit (D7) and Bit 8 is the least significant bit (D0), which is the opposite of what one would probably expect.

On the other side of the device there are two ground pins and a positive supply input. The chip is designed to operate on an ordinary 5V logic supply, and the supply must be within the range 4·5V to 5·5V. The typical supply current is 15mA, and it will not exceed 25mA. Both ground pins are combined digital and analogue types. The data sheet for the AD557 gives a suggested earthing and decoupling arrangement for use where the lowest possible noise level is important. However, digital noise is not really a major problem with a chip that has 8-bit resolution.

Pins 9 and 10 are respectively *chip select* and *chip enable* inputs. These are only needed in applications where the chip will interface direct to the data bus of a processor. They are not needed in a PC project that has the chip driven from the latching outputs of a parallel port. Both pins are simply connected to ground to make the chip "transparent". The data placed on the data inputs is then fed straight through to the converter section.

The output section of the chip consists of an operational amplifier and three resistors in the arrangement shown in Fig.2. In normal use pins 14 to 16 are simply connected together so that all three resistors are used in the negative feedback loop. This gives an output voltage range of 0V to 2·56V. A maximum output

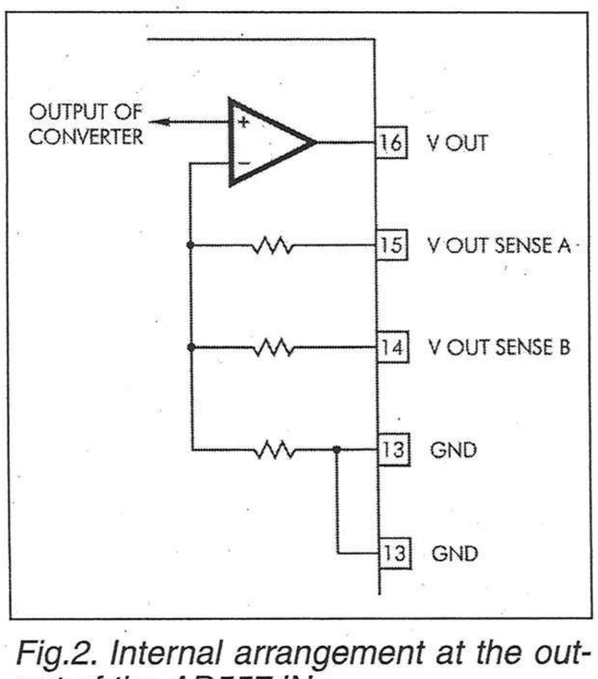

Fig.2. Internal arrangement at the output of the AD557JN.

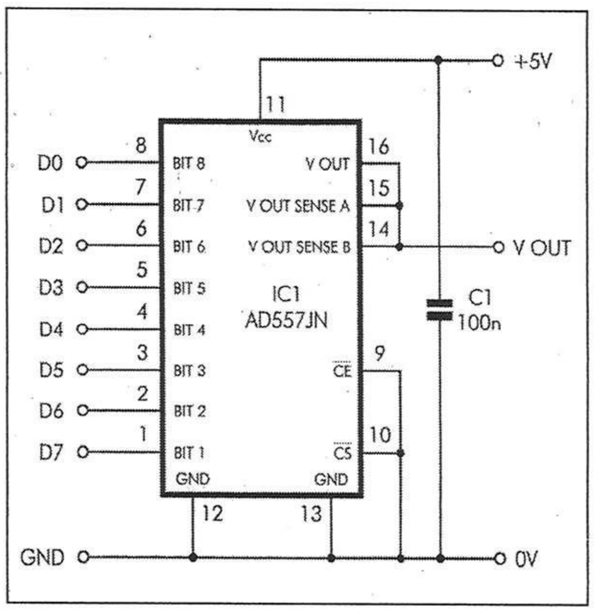

Fig.3. Simplicity of the active AD557JN d/a converter.

potential of 2·55V (10mV bit least significant bit) would have been a more logical choice, and a table in the device's data sheet seems to suggest that this is the correct figure.

Anyway, the exact maximum output voltage is usually of little practical importance. It is possible to trim the output voltage using variable resistors in series with the Sense A and Sense B pins, but in practice the standard output range of 0V to 2·56V is normally used. External amplification and processing is then used to give the required output voltage range.

No external voltage reference is required. The AD557 has a built-in precision band-gap reference source that provides a highly stable 1·2V output. Using a low reference voltage enables the device to operate from a single 5V supply. The full scale accuracy of the chip is plus and minus 2·5 LSB at 25 degrees Celsius, but can be as large as plus and minus 4·5 LSB at extreme temperatures.

Of much greater importance in most practical applications, the relative accuracy is typically plus and minus 0·5 LSB, with a maximum error of plus and minus 1 LSB. This is more than adequate for most applications. The settling time is typically 0·8 microseconds, but can be as much as 1·5 microseconds.

Basic Circuit

Few discrete components are needed in order to produce a basic digital to analogue converter based on the AD557JN. In fact the only discrete component required is a supply decoupling capacitor, as can be seen from the circuit diagram of Fig.3. The data inputs are TTL compatible and can therefore be interfaced direct to any normal PC printer port. The circuit should work equally well with any 9-bit output port that provides latching outputs at TTL levels.

The circuit requires a +5V supply, but this is not available from a PC printer port. Ways of obtaining a +5V supply from a PC have been covered in past issues of *EPE*, and this subject will not be covered again here. The

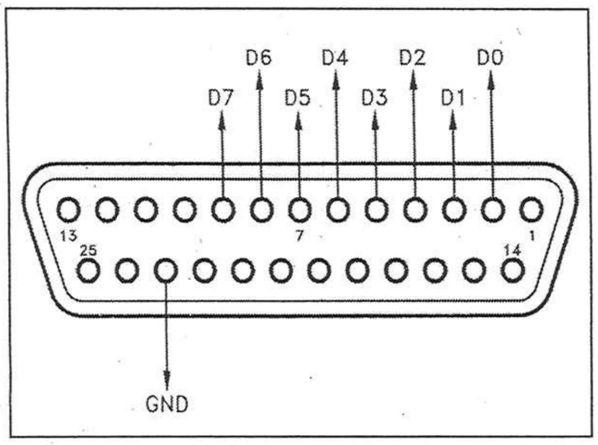

Fig.4. 25-way D connector pinouts for use with the AD557JN circuit in Fig.3.

connections to the PC's printer port are shown in Fig.4. A 25-way male D connector is needed to make the connections to the printer port. One slight drawback of parallel interfacing is that the connecting cable should be no more than about two or three metres long. In this case a somewhat longer cable is acceptable provided high-speed operation is not required.

Digital PSU

In practical applications it will usually be necessary to use some amplification at the output of the converter in order to provide the required output voltage range and output current. The circuit of Fig.5 shows the circuit diagram for a simple computer controlled power supply unit based on the AD557JN. A small monolithic voltage regulator (IC2) is used to produce a 5V supply for the converter from the main supply. The converter has the basic configuration with its nominal 0 to 2·56V output range.

The first requirement in a power supply application is to provide a more useful output voltage range. In this case operational amplifier IC3 is used in the non-inverting mode with a voltage gain of approximately five. This boosts the maximum output voltage to 12·75V with a resolution of 50mV (0·05V). In practice the voltage gain of IC3 must be adjusted to allow for any scaling errors in IC1. With a value of 255 written to the converter, VR1 is adjusted for an output potential of precisely 12·75V.

A buffer stage at the output of IC3 enables currents of up to one amp to be provided. The buffer stage is an emitter-follower type based on Darlington power transistor TR1. The high current gain of this device is needed because of the limited output current available from IC3. An ordinary power transistor is unlikely to give usable results in this circuit.

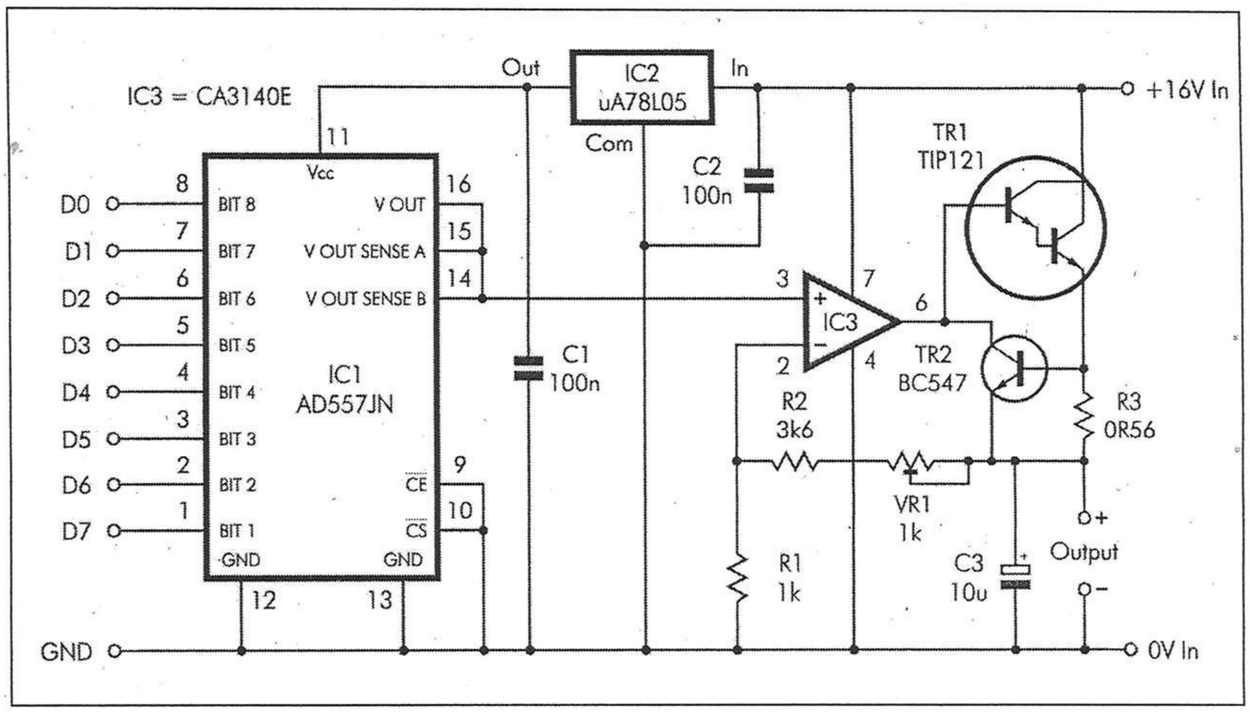

Fig.5. Circuit diagram for the computer-controlled PSU. TR1 requires a large heatsink.

The occasional short-circuit or major overload on the output is inevitable with this type of equipment, so some form of overcurrent protection is essential. This circuit has a conventional current limiter which has R3 as the current sensing resistor. An output current of more than about 1·1A results in TR2 turning on and pulling the output of IC3 lower in voltage.

The output short-circuit current is typically a little over 1·2A. Other output currents can be accommodated by altering the value of R3. The correct value is obtained by dividing 0·6 by the required output current (in amps). The circuit should work well with output currents of up to about 2A or so.

Points to Note

Due to the voltage drop through the output stage it is essential for the supply voltage to the circuit to be at least 3V more than the output potential. The input supply must not exceed about 30V with no loading on the output. A wide range of supply voltages can therefore be tolerated, and there is no requirement to use a stabilised supply. However, using a regulated supply of about 18V to 20V would probably give a slightly improvement in the stability of the output voltage.

Resistor R3 should have a power rating of at least one watt. IC3 has a PMOS input stage, and the usual anti-static handling precautions should therefore be observed when dealing with this component. The CA3140E used for IC3 is a type that will work in d.c. circuits without using a negative supply rail. Most other operational amplifiers require dual supplies and will not work properly in this circuit.

Transistor TR1 has to dissipate several watts when the unit is used at low output voltages and high currents. Consequently, it must be mounted on a substantial heatsink. Note that the collector terminal connects internally to TR1's heat-tab. Where appropriate, an insulating kit must be used when mounting this device on its heatsink. The TIP121 and TIP122 are both suitable for use in this circuit.

Some refinements to the circuit and the controlling software will be provided in the next *Interface* article.