Positioning with Photodiode Arrays

Reproduced courtesy of Elektor Electronics, Summer circuits issue July/August 2007.

Industrial production-line robots require high-resolution sensors to measure the position of robotic actuators so that the tools can be accurately guided onto the work piece. A photo diode array together with an external light source is often used as a sensor in this application. This chip contains a line of photo diodes together with a series of sample and hold (S/H) circuits which take a snapshot of the readings of each photo diodes at the same instant and then outputs these integrated analogue values serially from a single output. The S/H circuits are important because the sensitivity of each element to the light quanta is dependent on the integration period; without the S/H the last element would show the highest sensitivity.

The accompanying table lists the most important properties of the Melexis photodiode array. The sensitivity is dependant on the active diode surface area and the integration time.

Photodiode Array properties	
Array	**MLX90255**
Pixel (*see text):	128 (+ 4*)
Pitch (DPI):	385
Weighting:	Cosine
Length x width (µm):	200 x 66
Output (V):	0.125 - 2.4

From the outside these arrays look very simple, apart from the two supply connections there are only three signals for connection to a microcontroller: A clock input (CLK), a start impulse (SI) input and an analogue output signal (AO). AO should be loaded with a 330 Ω resistor to ground.

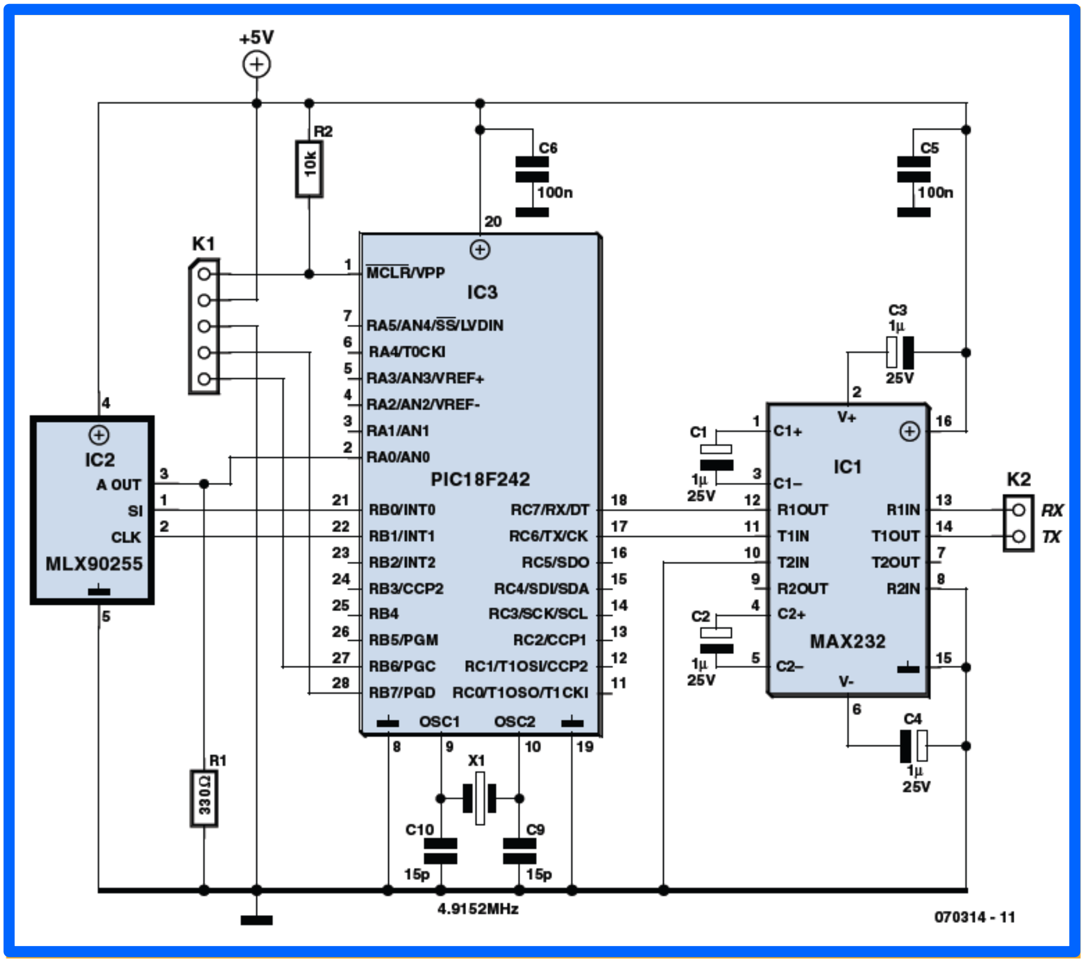
To readout the array values the controller firstly generates the clock signal and then sets SI high (with sufficient set-up time) before a rising clock edge.
On successive falling clock edges the value of each individual pixel will be output at AO. The microcontroller reads each level and stores its value.

A feature of the MLX90255 type array is that the first two values read out are dummies, the first of the 128 real values appears at the third clock edge. The two values after the 128th value are also dummies, the read out therefore requires 132 clock edges in total to read all the data and the final 133rd edge reinitialises the shift register. The gain of the pixels at either end of the array is about 15 % greater than those in the centre (cosine weighting) this compensates for the light loss experienced at the edges when the array illumination is provided by a single LED.

The integration period begins at the 18^{th} clock edge and continues until the next SI signal. The output values are the result of the previous integration period so if the array is not continuously scanned then it is necessary to make two complete scans to get meaningful results. The first scan cycle after power up is used to initialise digital levels on the chip, the values read are invalid and should be discarded. The integration time is equal to the pixel count minus 18 divided by the clock frequency. The sensitivity can be easily controlled by the microcontroller.
The circuit diagram shown here consists of the photodiode array together with a basic PIC microcontroller and a driver chip for an RS232 serial interface connection.

The author has produced a program written in C which can be used in the controller. The source files (070314-11.zip) are available to download free of charge from the Elektor Electronics website. A scan cycle is initiated using a terminal program by entering ‘Strg S’. The values are separated with semicolons so they can be easily used in an Excel table.

Typical Circuit



Conclusion

Photodiode arrays can be used in robotics for imaging based on the pinhole camera principle, they have also been used in line-following applications where they offer good resolution and can be mounted relatively far away from the floor. Together with a prism or optical grating the array can be used to perform simple yet precise colour recognition.