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## **An eye for the Tiger, the CCD-line MLX90255BA**

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### **1. Introduction**

As versatile as the BASIC-Tiger® and its relatives may be, some electronic areas have remained more or less inaccessible up to now. Such an area, for example, is the electronic picture recording or its processing. Many people think that the Tiger is not set up for this and that there are several manufactured solutions on the market. Hence, few attempts are known to implement him into the area of real optical sensors. This attitude could change with this now available application report. At least the BASIC-Tiger® is not quite as “blind” now as it was before.

As the headline already indicates, we wish to take a closer look at CCD-lines, which have also found their place in technology, next to the well-known CCD area image sensors (digital- and video cameras). Just think of the existing flat-bed scanners' sensors (Figure 1), with which we transfer paper photographs to the PC, or some of the barcode readers, which have an optical line-sensor as a basis. Such sensors can also be used for measurement and control purposes; for example, a moving robot is able to recognise the terrain in front of him and so to follow a white line. Alternatively think of an alarm system which reacts to a change of light distribution on the sensor (something moves from left to right). Line patterns are recognised in the same way – you could for example develop a bar code reader...

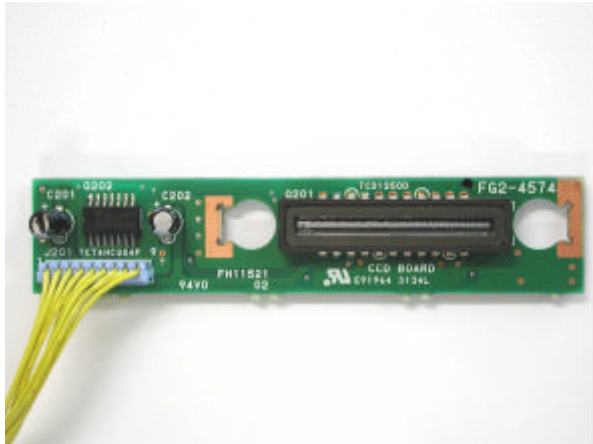
The functional principle in this case is that a variously long line of very small photo elements in a casing catches the light distribution over a distance and processes it. These sensors often need a complicated and quick pulse system to control the light absorption of individual pixels, the short-term storage of values and the mostly serial analogue output. Often for good reasons the speed is so high that the BASIC-Tiger® can't handle it. Not so with the Melexis MLX90255BA, which can be, according to the author's examination, controlled and read out with normal Tiger-BASIC without significant restrictions – an ideal constellation for stepping into digital image processing with the BASIC-Tiger®.

### **2. The Melexis CCD sensor MLX90255BA**

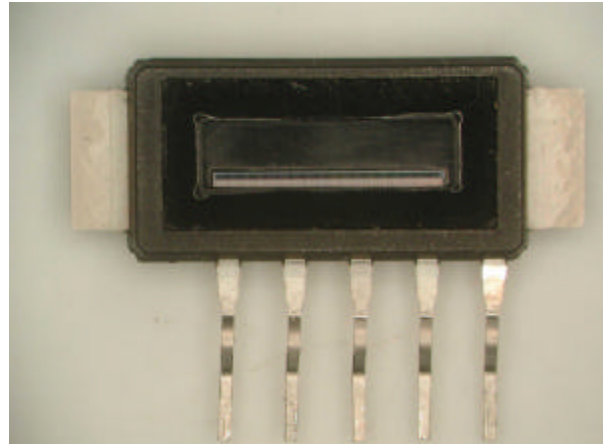
The company Melexis produces mainly customized IC's (ASIC's), but also IC's for general applications. Particularly in the sensor area there are all sorts of innovative solutions, also for the interested developer, for example pressure, optical, acceleration, temperature and reverberation sensors. Especially interesting for us is the optical CCD-sensor-line MLX90255BA (CCD = Charge Coupled Device), which consists of altogether 128 individual sensors, information can be found at:

Data sheet: <http://www.melexis.com/prodfiles/mlx90255ba.pdf>  
Evaluation board: <http://www.melexis.com/prodfiles/evb90255.pdf>

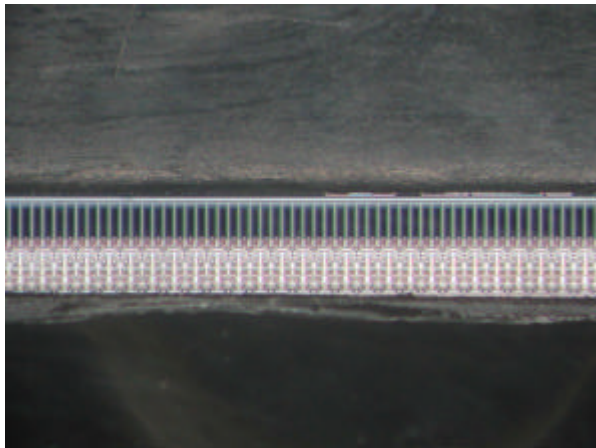
Figure 2 shows an overview of the IC, figures 3 and 4 show interesting details of the inner chip.



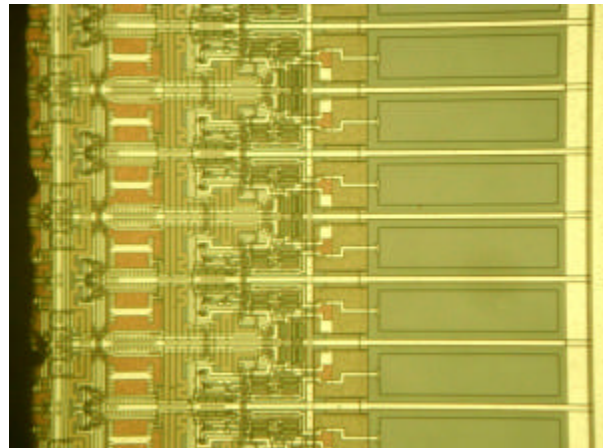
*Fig. 1 A typical CCD-line from the flat bed scanner*



*Fig. 2 the MLX90255BA in 5-pole plastic-casing (GLP5 package)*



*Fig. 3 individual photo sensors in a line*



*Fig. 4 individual sensor areas and their electronics can be recognised using greater enlargement (presented horizontally here)*

Each cell contains a photo diode (pixel), a load amplifier as well as a hold circuit for the pixel brightness value. The 128 cells are read serially. The function is split into two cycles, into an integration period and into an output period. During the integration phase light quanta are gathered for a specific time and with the resulting photo current a capacitor is loaded. During the output phase the potentials, which are stored on the capacitors are switched via analogous switches one by the (serially) onto the analogous output. Here they are available as potentials between 0 V and 2.4 V (very dark or rather bright) at the output AO. Everything is controlled

mainly by the input SI, which with a high pulse sets off both the integration phase and the data output. The second input of the IC is the CLK (clock) input, which controls the load transfer to the output as well as the inner charging of the storage capacitors. After every clock cycle the analogous value of the next pixel is queuing at the output. The sensor therefore not only recognises light and dark, but also intermediate stages (grey tones) - ideal for the evaluation using the analogous inputs which exist on the BASIC-Tiger®. The main question for the usage of such a sensor during the experiments had been: is it possible to organise the interaction between the start impulse at the SI, the according (at least) 128 CLK pulses, the thereafter resulting output at the analogous output, the reading of an analogous BASIC-Tiger® input and the storing for example in an array using Tiger-Basic or are the MLX90255BA timing demands unrealizable? According to the data sheet a minimal frequency of 64 kHz is demanded – that would already mean the end for our Tiger. However it does work – the simple clocking with individual outputs of Low and High are sufficient to implement a reasonable function, i.e. first of all the exposition of the pixels, the load storage and the ending of the integration phase. After this you can take your time– the MLX90255BA tolerates very long signal evaluation times. This enables us to use a much slower pulse during reading than during scanning. Each pixel value can be measured, processed and stored very calmly. Only a new SI impulse will start a new integration phase. As the impulse at SI and CLK must be interlaced to a certain extent, it is inevitable that the impulse will experience a time delay using Tiger-Basic for the insertion of a SI edge into the running CLK pulse. This is always the case during the first clock pulse and therefore the first pixel – fortunately this does not affect the MLX90255BA at all, it has two so-called dummy pixels there, which do not represent a real brightness value. Overall a cycle (integration or output) needs 133 pulses each. The last ones are required for the re-initialisation of the internal shift register. With this insight we move on to the circuit development, if we may call the simple coupling to BASIC-Tiger® so.

### **3. The circuit**

Everything fits immediately, the MLX90255BA requires 5V operation voltage just like BASIC-Tiger® does, both input levels have TTL- or CMOS-format, the analogous output of the MLX90255BA lies completely within the effective range of the BASIC-Tigers® analogous inputs. So we will actually only need 5 direct lines from one to the other.

| BASIC-Tiger®   | Pin               | MLX90255BA | Pin |
|----------------|-------------------|------------|-----|
| Vcc            | 46                | Vdd        | 4   |
| GND            | 23                | Vss        | 5   |
| L80            | 13                | SI         | 1   |
| L81            | 14                | CLK        | 2   |
| Analogous In 0 | 39                | AO         | 3   |
| Analogous GND  | 44 → Pin 23 (GND) |            |     |
| AD Ref. In     | 43 → Pin 46 (Vcc) |            |     |

*Table 1 Wiring of the BASIC-Tiger® with MLX90255BA*

That's it – we can safely do without a figurative depiction of the circuit. Of course you can also change the connections if you wish to. The connections in table 1 fit directly to the OPTO\_01.TIG software.

#### 4. Optics

Generally our sensor chip works exactly like a normal image sensor in digital cameras, only one-dimensional. Hence, if it is used as a line camera it will require a lens and a dimming against influence of stray light. In order to avoid this experiment to get too costly, we will try a construction with a simple lens. Using a simple old rangefinder camera without any electronics can be very elegant; they always have a dimmed casing and a manually operated lens. Such a finished camera with a lens has several advantages:

- The casing is already finished – an important point for most electronics developers,
- The adjustment of the aperture allows an adjustment of the lighting conditions to the sensor,
- The distance can be adjusted comfortably until it is sharp,
- The casing can be lined up elegantly with normal tripods or rather with the camera thread which is always available,
- The sensor is simply fitted on the inside of the camera back wall (isolated and in the middle), so the focus works relatively well and the sensor is easily accessible,
- The clasp naturally must be always open, if this adjustment does not work with your camera an intervention is probably necessary.

Figure 5 shows the author's construction with a finished photo-lens and a homemade casing. When you have put everything together we can begin with the first experiments.



*Fig. 5 the author's camera construction...*

## 5. BASIC-Tiger® software

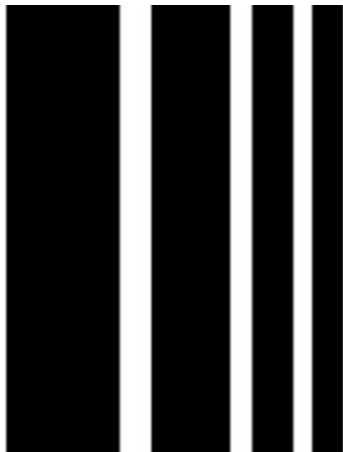
Here things are also kept simple. The CCD\_01.TIG software controls the MLX90255BA sensor line, and reads the results at its analogue output AO through the BASIC-Tigers® Analog-In-0. All BASIC-Tiger® activities in particular those for clock pulse and SI signal run with normal OUT instructions and number loops. “Higher“ and therefore potentially quicker functions with the PLSOUT device drivers were deliberately avoided here, because synchronising with the required data processing steps is difficult to implement. The values are displayed pixel by pixel on the LC display (e.g. of the Plug-and-Play-Lab) and parallel written to the serial output SER1. If you wish, you can let your PC display the results using a terminal program in numerical form. It would be more comfortable to display the light distribution using the PC software CCD\_01.TST. Here a curve will be displayed graphically with all 128 pixels (Figure 8).

## 6. Results

Optical sensors on the CCD basis always have a problem with too much light. The little storage capacitors “overflow” and current flows towards the neighbouring pixel. In its standard surroundings the MLX90255BA controls this between two impulses at SI. If there are big gaps between the impulses much light can be integrated (useful for dark surroundings), if they follow shortly after one another, the sensor can be adjusted to the brighter surroundings. With the simple Tiger-BASIC the timing of the successive SI impulses cannot be manipulated so easily, as a link up with the CLK impulses is necessary in addition. In order to solve this problem, we can control the light sensitivity best optically via the aperture of the lens. The position of the light and dark areas of the object can be observed with an oscilloscope at the analogue output and adjusted with the aperture in the best possible way. Similar results can be obtained through evaluation of the serial data with the terminal software or even more elegant with CCD\_01.TST. For those who do not possess an

oscilloscope, we have added PC software (as a service to you!), with which you can transfer the data of the complete sensor line via the serial interface and will be able to see them on the PC screen. CCD\_01.TST again is based on TestPoint® and you install this runtime module in the same way as described in application report no. 031 “BASIC-Tiger® and PC software”.

With the finished system you can now conduct interesting experiments. An initial test would be the recognition of a striped pattern, e.g. the one in figure 6. When you print the picture and focus the camera on it the analogue output of the MLX90255BA (or even the analogue input An0 of the BASIC-Tiger®) should show an oscillogram just like in figure 7. Figure 8 shows you which “optical impression” the striped pattern has made using CCD\_01.TST on the PC. Experiment with the aperture, focus setting, lighting etc. As you can convert, save and in a simple way evaluate the obtained data with Tiger-BASIC as you wish, you now have a very useful optical tool at your disposal.



*Fig. 6 A test: striped pattern on paper...*

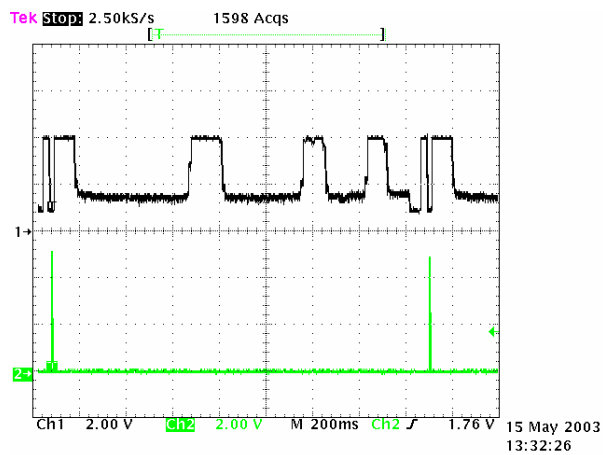


Fig. 7 ...this is how the An0 of the BASIC-Tiger<sup>®</sup> “sees” the pattern from figure 6, white means high potential, black low potential, below the trigger impulse at L87

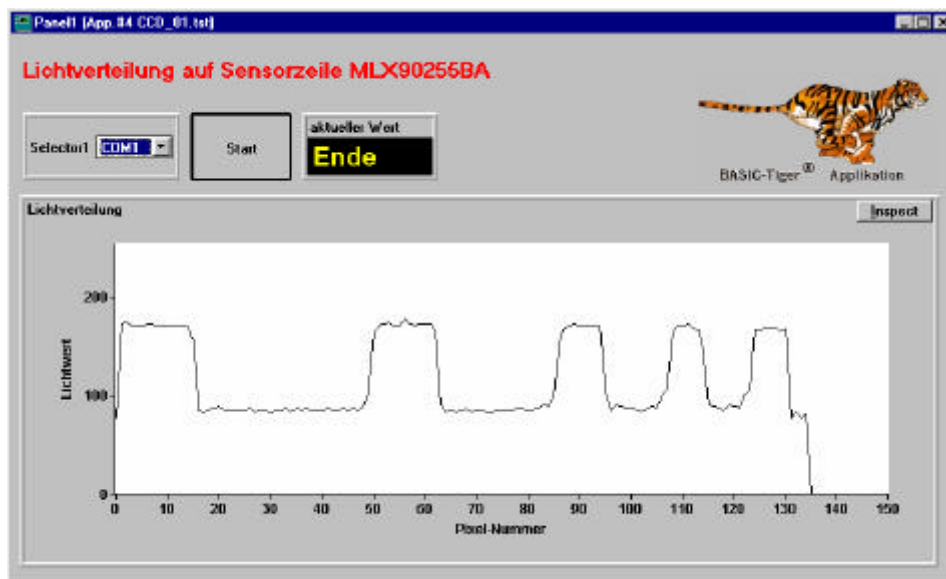


Fig. 8 ...and this how our PC software CCD\_01.TST does via the serial interface

Have fun with the new eye of the Tiger!