



# Dual Axis Microscanners

## for Infra-red Camera

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Loss of image information is a profound problem with conventional infrared cameras using focal plane array (FPA) technology. This is due to the limitation of semiconductor fabrication technology that resulted in ineffective area between the cells of the FPA detector. In this project, dual axis microscanners have been developed to capture the undetected image, as a result, improving the overall image resolution of the infrared cameras. The new design concept is presented in this paper. The overall image resolution is increased, thus enhancing the detection range of the infrared cameras.

### MICROSCANNER ASSEMBLY:

A pair of microscanners perform image displacement on the thermal detector plane in both x and y axes, so that ineffective area will be covered. The assembly (as shown in Fig. 1) consists of various components, namely, flex-pivoted mirror, electro-mechanical actuator, angular position sensor and housing structure. All components are critical for the scanning performance.

### MAIN COMPONENTS:

#### LVPZ Actuators

Unlike other scanners that are activated by DC motors, the microscanner is implemented with two low voltage piezo translators (LVPZ). The actuators applied in a differential mode, provide better temperature stability. The choice of LVPZ is based mainly on the stiffness and volume considerations. Its velocity of expansion in linear dimension depends on the maximum output current from driver electronics, for which high voltage stability and low noise level are of particular importance. Furthermore, stringent requirement on the positioning accuracy of LVPZ demands special consideration to the temperature response. Its linear expansion, expansion repeatability and home return offset are of main concern.

#### Angular Position Sensor

The sensor consists of two components, namely, infrared LED and Bi-cell detector incorporated as one unit as well as an arm with an optical window being clamped to a mirror shaft. An example of the configuration of angular position sensor is shown in Fig. 2.

According to the dimensions given in Fig. 2, the following relations exist between the mirror shaft angle ( $\alpha$ ) and displacement of an optical window in the detector plane (x):

$$x = \tan \alpha * \text{arm length}$$

for  $\alpha = 0.292 \text{ mRad}$  (requirement), we have  $x = 5.1 \mu\text{m}$ .

Assuming that a light spot on the detector surface is twice bigger than the optical window size, the maximal allowable displacement is:

$$x_{\text{max}} = (b - d * 2) / 2 = 0.43 \text{ mm}$$

Obviously, the full dynamic range of the sensor is not utilised.

The possible way to improve its efficiency is to extend the arm length. In this way, it will reduce the sensor's sensitivity to the microscanner housing deformation and improve the signal to noise ratio.

#### Mirror Unit

The mirror unit consists of various parts, namely, the mirror, actuator arm and flexural pivots. The actuator arm is clamped to the mirror shaft and transforms the linear movement of the LVPZ actuator into angular movement of the mirror. The mechanical interface between the actuator and its arm includes steel balls rolled on glass pads to minimise the frictional effect. An example of the configuration of actuator mechanism is shown in Fig. 3.

In Fig. 3, both the actuators have radial preloads to compensate for the relative thermal expansion of the actuators ( $\Delta l$ ) with respect to the scanner housing.

The flexural pivots combine the features of a shaft bearing and a torsional spring. They are implemented to support the mirror shaft. The preload force is relative to the flex pivot radial stiffness, mirror shaft stiffness,  $\alpha$  and  $\beta$  angles and  $\Delta l$ .

#### Close Loop Controller

The implemented controller (as shown in Fig. 4) is of a regular proportional integral derivative (PID) type and the used networks are integrator and second order low pass filter.

#### TEST RESULTS:

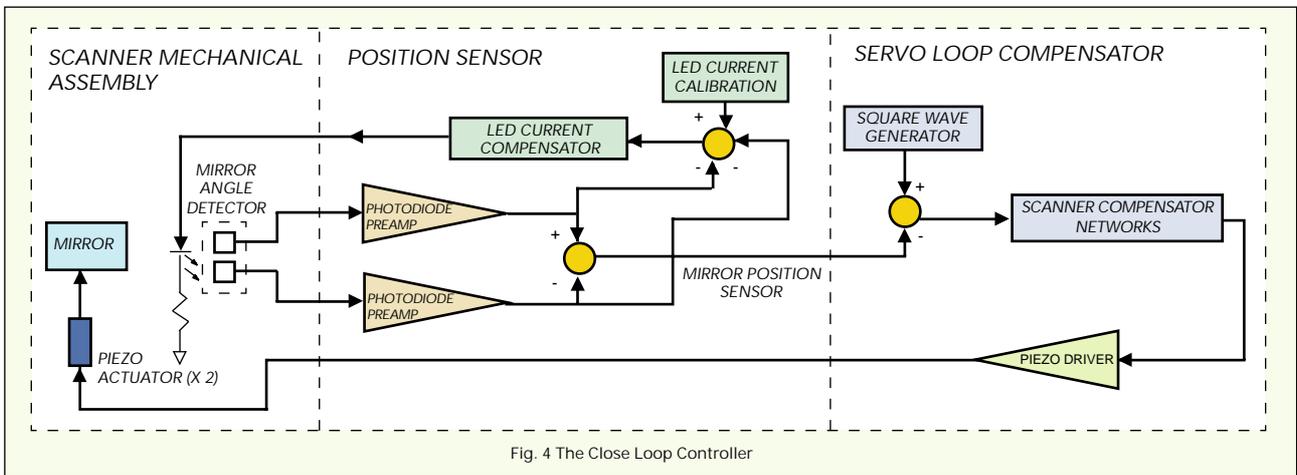
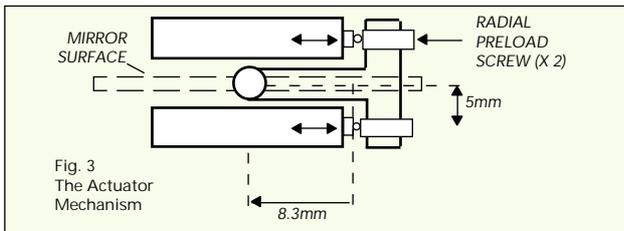
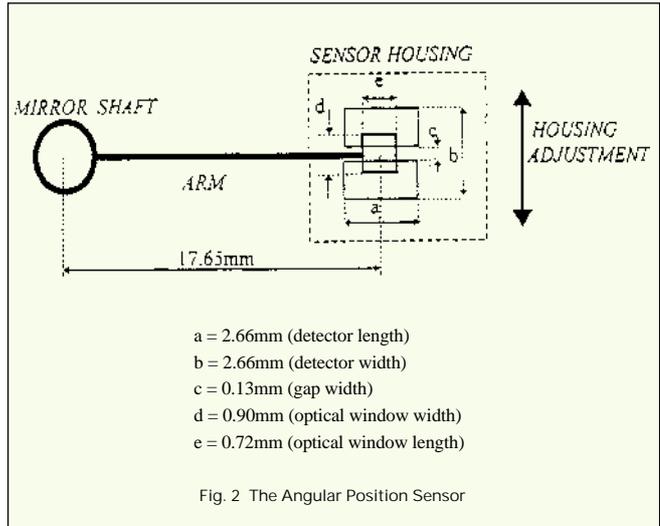
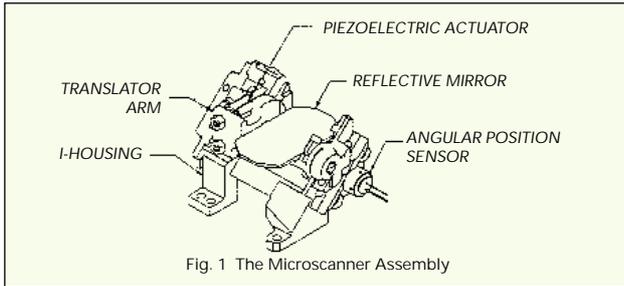
Functional test, temperature test and vibration test were the three main tests conducted. The typical performance requirements of the microscanners are as follows, and the response graphs 1 to 5 are highlighted on the opposite page:

- 1) Angular displacement: Scanner no. 1 : 0.178 mRad  
Scanner no. 2 : 0.292 mRad
- 2) Displacement accuracy:  $\alpha \pm 5\%$  @  $+10^\circ\text{C}$   
 $\alpha \pm 10\%$  @  $-20^\circ\text{C}$  to  $+70^\circ\text{C}$
- 3) Maximal offset angle:  $\pm 20 \mu\text{Rad}$  @  $+10^\circ\text{C}$   
 $\pm 50 \mu\text{Rad}$  @  $-20^\circ\text{C}$  to  $+70^\circ\text{C}$
- 4) Rise & settling time: 2.5 msec max
- 5) Maximal jitter: 20  $\mu\text{Rad}$  rms
- 6) Operational temp:  $-20^\circ\text{C}$  to  $+70^\circ\text{C}$

#### CONCLUSIONS:

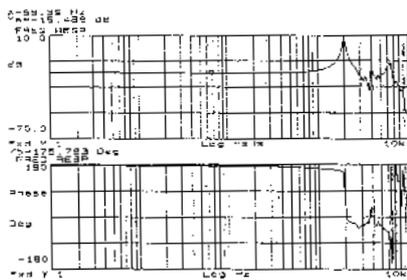
The use of dual axis microscanners to scan undetected image in an infrared camera is demonstrated. The design concept can be implemented in many advanced infrared cameras using FPA technology. A microscanning system that improves the overall image resolution of infrared cameras has been developed.

For more information, circle 113, or contact C L Lee at 4858240, Email: leecl@ceo.st.com.sg



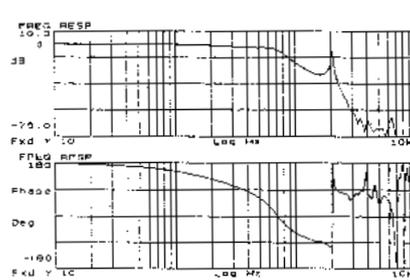
Dynamic Response

Graph 1 shows the dynamic response of the microscanner.\*



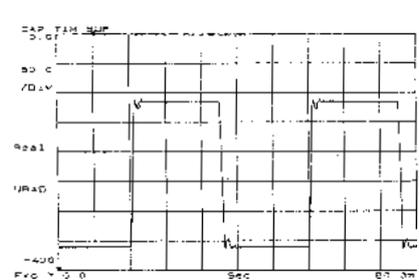
Close Loop Response

Graph 2 shows the result of the designed control loop.



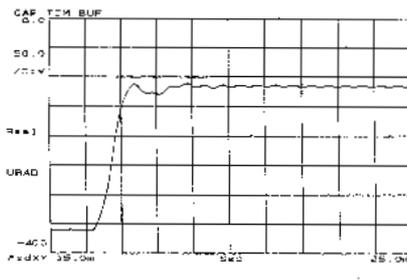
Time Domain Performance

Graph 3 shows the performance of the microscanner in the time domain.

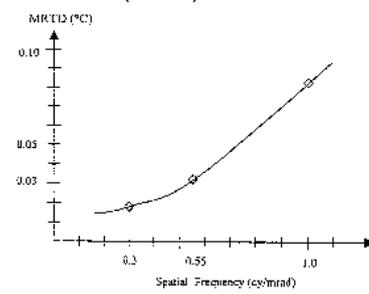


Rise Time and Jitter Performance

Graph shows the achieved rise time and jitter.



Minimum Resolvable Temperature Difference (MRTD) Measurement



\* Measured with spectrum analyzer by introducing sine sweep signal input to both actuators and reading the position sensor output.

Graph 5 shows the sample MRTD measurement of infrared camera (at medium field of view) using dual axis microscanners.