ST Octal TOF Project

Introduction

This document provides an overview of the Kairos ST Octal TOF project and looks at our current implementation of the technology. An in-depth background is provided on the communication protocol for integration into the Ardupilot autopilot software.

The TOF Sensor

The VL53L5CX is a multi-zone ranging sensor from STMicroelectronics, capable of measuring distances up to 4 meters with a resolution of 8x8 pixels. It leverages time-of-flight technology to deliver accurate, multi-zone distance measurements for applications such as gesture recognition, presence detection, and obstacle avoidance.

- Operating Range: Up to 4 meters
- Resolution: 8x8 pixels (64 zones)
- Measurement Timing Budget: 5 ms to 100 ms per measurement
- Field of View: 45° x 45°
- Accuracy: ± 5 mm (typical, up to 1.2 m), ± 1% (typical, above 1.2 m)
- Interface: I²C (up to 1 MHz)
- Supply Voltage: 2.6V to 3.5V
- Power Consumption:
  - Typical active: 10 mW
  - Typical idle: 5 µW
- Operating Temperature Range: -30°C to +85°C
- Dimensions: 6.4 mm x 3.0 mm x 1.5 mm

Kairos Built TOF L5CX Board

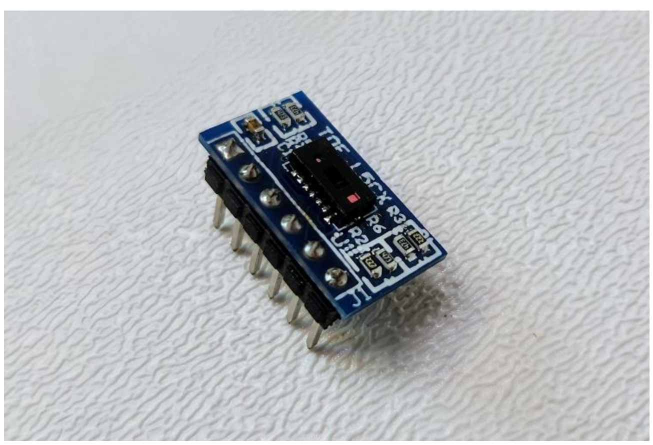

Figure 1 The TOF L5CX Board utilizing the VL53L5CX Sensor

The Kairos built ST Octal TOF Board

For TOF use on the Uxv/35 platform, Kairos has created a solution that allows a user to place up to 8 sensors around a vehicle.

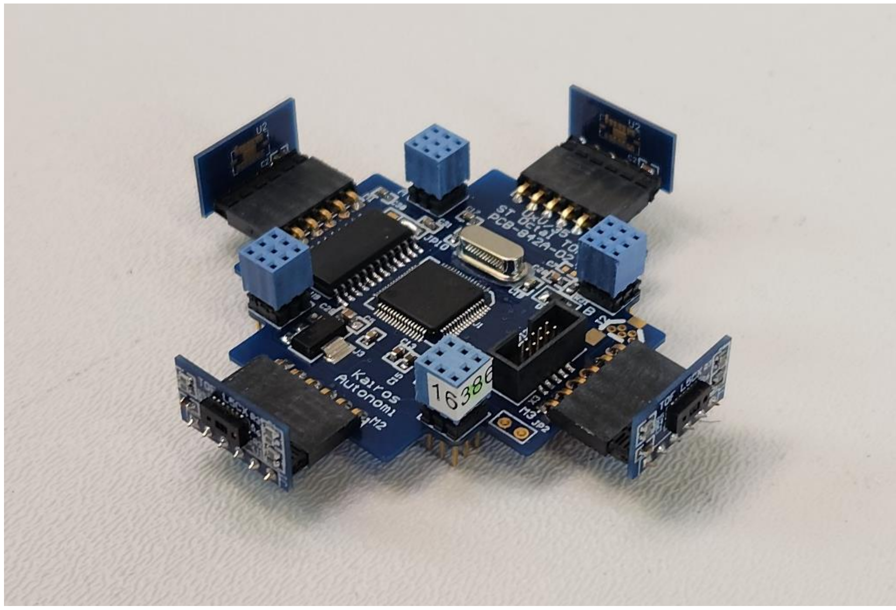

Figure 2 The ST Octal TOF board with 4 TOF L5CX sensor boards connected

The following screenshot is taken from the Mission Planner GCS in the proximity window which is displaying the active distance measurements being sent from the ST Octal TOF board. The FOV and orientation of the sensor is represented here which provides insight into potential blind spots.

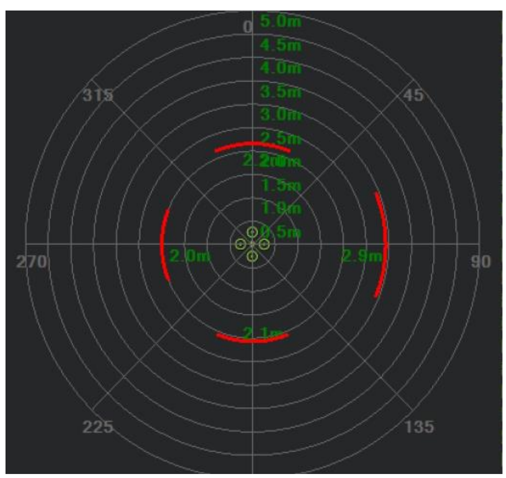

Figure 3 Mission Planner Proximity Window Representing ST Octal TOF Data

Communication Protocol

Kairos uses Serial Channel D (Pins D8 and D9) on the Mission Controller board to receive the distance measurements from all 8 sensors. This channel is configured in ArduPilot for Mavlink2 protocol at a baud rate of 115200. A message format, defined in the MavLink2 library, allows all TOF messages to be sent on the same channel. The following is an outline of the message with a live capture:

D1	D2	D3
D4		D6
D7	D8	D9

Mavlink Distance Sensor Message

- Time since boot
- Minimum distance
- Maximum distance
- Distance Measurement
- Sensor Type
- Sensor ID
- Orientation
- Covariance
- Horizontal FOV
- Vertical FOV
- Signal quality
- Quaternion

The result is a 55-byte string shown here with a logic analyzer capture.

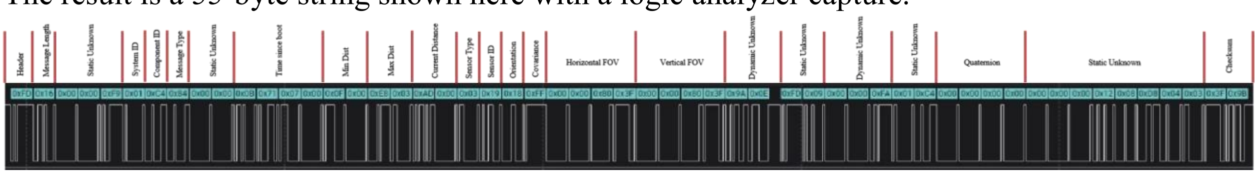

Figure 4 Capture of a Mavlink Distance Packet on the UxV/35 D9 Pin (RxD)

Data packets can also be viewed on the Mission Planner GCS. In the Mavlink Inspector window, ArduPilot will populate a list of components that are active on the vehicle. The following screenshot shows the TOF Controller (Comp 196) and the messages being sent from it. In this example, ID 25 is the downward facing TOF which returned a distance measurement of 174 cm. Horizontal and Vertical FOV are represented in radians.

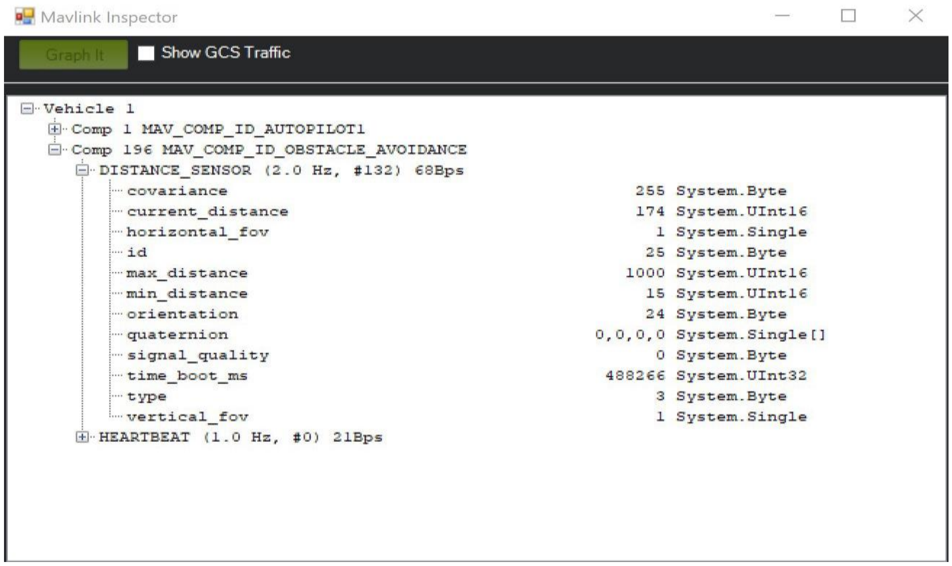

Figure 5 Mavlink Inspector window showing messages received from the ST Octal TOF board

Ardupilot Obstacle Avoidance

Ardupilot, on the Mission Controller board, receives these mavlink distance messages and makes decisions based on the distance measurement and constraining parameters. There are various options for this decision making based on the mode the vehicle is in (Auto or Manual modes).

During Manual Operations:

- Stop
  - This mode brings the vehicle to a stop when an obstacle is detected. The vehicle then waits for the operator to command the vehicle away from the object.
- Backup
  - This mode attempts to keep a set distance away from the detected obstacle even with the object moving towards the vehicle.

During Auto Operations:

- BendyRuler
  - This algorithm looks at all the distance measurements and can attempt to navigate around the obstacle vertically or horizontally. After clearing the obstacle, the vehicle will continue to the next waypoint.
- Dijkstra's
  - This secondary algorithm can be used to improve the efficiency of the path planning around the object. While BendyRuler attempts to only solve the obstacle problem, Dijkstra's can help weight the next waypoint into the decision making to ensure the vehicle continues towards its objective.

Version History

Date and Signature	Revisions	Reasons for Revision
07/20/2024 Jack R.	Document was written. (v01.00.00)	

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