

# MERIT internship (internal) report

Takeya Watanabe laboratory, Department of Advanced Material Science,  
Graduate School of Frontier Science  
D3 /9th student of MERIT course  
Taiki Sawada

## Date

June 3, 2023, ~ August 4, 2023

## Company

Pi-crystal inc.

## Theme

Circuit development for organic semiconductor sensing devices

## Summary of internship

Organic semiconductors (OSC) are expected as next-generation electronic device materials due to mechanical flexibility and their processability near room temperature. Since OSCs exhibit a significant piezoresistive effect where carrier mobility changes drastically under applied strain, it indicates high industrial application demand for OSCs as a sensing device. In this context, Pi-Crystal Inc. is a company involved in the manufacturing and development of film sensors utilizing high-performance organic semiconductors. It offers solution services in various fields such as logistics, facility management, agriculture, livestock, and healthcare by utilizing film sensors capable of measuring temperature, vibration, and acceleration,

During this internship, my work was the development of circuits related to sensing devices, primarily focusing on circuit simulations using Spice. The central aspects I worked on included the differential amplifier for sensing devices and A-D converter, and the frequency divider circuit necessary for communication between devices and generation of clock waves in digital circuits. Utilizing model data from the solution-processed transistor devices manufactured by Pi-Crystal Corporation, I calculated the appropriate transistor design parameters for each circuit. Additionally, I

evaluated aspects such as DC and AC responses, as well as frequency dependencies, for each circuit.

In the development of frequency divider circuits, I investigated a circuit configuration known as the Injection-Locked Frequency Divider, proposed by Mr. Tsurumi, a member of Pi-Crystal Inc. In this circuit, the capacitance of the transistors plays a crucial role. I utilized the theoretical formula known as Meyer's capacitance model to perform calculations and conducted simulations for a frequency divider circuit capable of operation in the high-frequency range. Furthermore, I discuss with Mr. Tsurumi, Mr. Kamada and Mr. Makita to evaluate the feasibility of implementing this circuit within the solution-processed transistors manufactured by Pi-Crystal Inc.

### Acknowledgments

I would like to express my gratitude to everyone at Pi-Crystal inc. for accepting me for this internship opportunity. I am deeply thankful to Mr. Hiroyuki Kamata, Mr. Junto Tsurumi, Mr. Tatsuyuki Makita, and Mr. Takuya Higuchi for their direct guidance on the internship activities and their detailed consultations regarding the outcomes of my work. I would like to thank them very much for their invaluable support.

Furthermore, I would like to extend my appreciation to Prof. Jun Takeya, my supervisor, and Prof. Shinichi Takagi, the associate supervisor from the MERIT program, for granting their approval for my participation in this internship. Additionally, I am grateful to the MERIT-WINGS program for providing such a wonderful opportunity.