Quick Start Guide

[01 June 2020]

1 Introduction

DIGIT [1], is an inexpensive, compact, and high-resolution tactile sensor geared towards in-hand manipulation. DIGIT improves upon past vision-based tactile sensors by miniaturizing the form factor to be mountable on multi-fingered hands, and by providing several design improvements that result in an easier, more repeatable manufacturing process, and enhanced reliability. To provide the robotic community access to reliable and low-cost tactile sensors, we open-source the DIGIT design at `www.digit.ml`.

This white paper aims to provide manufacturing, assembly and quick start instructions for the DIGIT tactile sensor.

2 Repositories

There are two main repositories which contain the open-sourced sensor design, and a Python library for interfacing with the DIGIT sensor.

`https://github.com/facebookresearch/digit-design`

`https://github.com/facebookresearch/digit-interface`

3 Required Materials

3.1 Components List

DIGIT assembly requires the following tools and off-the-shelf components:

Part No.	Description	Quantity
1	1.5 mm Metric Hex Driver	1
2	Hex Socket Screw M2 x 0.4 mm Thread, 5 mm Long	3
3	Hex Socket Screw M2 x 0.4 mm Thread, 3 mm Long	1

The following components compose the DIGIT main electrical and mechanical design, which are manufactured through internal or external vendors.

Part No.	Description	Quantity
1	DIGIT Printed Circuit Board (PCB)	1
2	DIGIT Lighting PCB	1
3	DIGIT Rear Housing	1
4	DIGIT Main Housing	1
5	DIGIT Acrylic Clip Housing	1
6	Acrylic Window	1
7	Gel	1

4 Manufacturing Recommendations

4.1 Electrical

Two components are required which can be manufactured via a turnkey printed circuit board assembly service, or by hand populating manufactured PCBs.

- Main PCB containing camera system
- Lighting flex PCB

The Gerber design files are found within the digit-design repository and are manufactured with the following specifications:

	Specification
Layer Count	4
Material	370HR or FR4
Min Track/Spacing	4mil/4mil
Thickness	1.6mm
Solder Mask	Black
Silk Screen	Top and Bottom
Silk Screen Color	White
Surface Finish	ENIG
Via Process	Tented Via
Finished Copper	1 oz.

(a) Main PCB specifications

	Specification
Layer Count	2
Material	Polymide Flex
Min Track/Spacing	3mil/3mil
Thickness	0.23mm
Solder Mask	Black
Silk Screen	Top
Silk Screen Color	White
Surface Finish	ENIG
Via Process	Tented Via
Finished Copper	1.5 oz.

(b) Flex PCB specifications

The PCB stackup for the 4 layer main PCB board is as follows,

- Top Layer - digit_copper_signal_top.gbr
- Internal Layer 1 - digit_copper_signal_1.gbr
- Internal Layer 2 - digit_copper_signal_2.gbr
- Bottom Layer - digit_copper_signal_bot.gbr

4.2 Mechanical

The DIGIT mechanical body consists of three 3D-printed parts and one laser cut part. The 3D printed parts are the main, back, and acrylic clip housings shown in figure 1.

(a) Rear (b) Main (c) Acrylic Holder

Figure 1: Mechanical housing components

We recommend using the following 3D printer specifications,

	Specification
3D Printer	Stratasys J750
Layer Height	Default
Material	Vero Black Plus
Finish	Glossy

Additionally, the gel acrylic window is laser cut from a sheet of 4 mm thick optically clear acrylic.

5 Assembly

Upon manufacturing both the mechanical and electrical parts, DIGIT can be assembled within 5 minutes.

Step 1

Press fit the DIGIT PCB into the back housing as shown in figure.x.

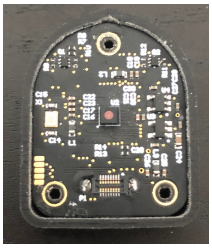

Figure 2: PCB inserted into back housing

Step 2

Bend the flex PCB connector 90 degrees and insert the DIGIT flex PCB into the perimeter of the main housing as shown in Figure 3.

Figure 3: Flex PCB inserted into main housing

Step 3

Press fit the back and main housings together,

Figure 4: Back and main housing coupled together

Using your finger connect the flex PCB to the main PCB with a firm push, you should feel the connector snapping into place.

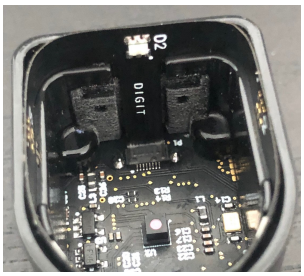

Figure 5: Flex PCB connected to main PCB

Step 4

Insert the gel into the acrylic holder housing,

Figure 6: Gel and acrylic holder housing

Following this, snap fit the acrylic holder to the main housing,

Figure 7: Main housing with acrylic housing

Step 5

Insert and fasten the three 5 mm hex screws into the back housing,

Figure 8: Back housing with inserted screws

Insert and fasten one 3mm hex screw into the acrylic housing,

Figure 9: Acrylic housing with inserted screw

6 Flashing Firmware

The DIGIT sensor can be programmed with any DFU flashing utility. We have provided such utility inside the digit-design repository.

Upon manufacturing your DIGIT, connect the device to a host computer. The sensor should enumerate in DFU mode.

Flash the firmware with a unique integer only serial number.

```
$ python3 flash.py digit.serial=45
```

When finished flashing, cycle the power on the device by removing and re-inserting the USB cable to the host computer. The sensor will first enumerate in DFU mode for 3 seconds and then re-enumerate as a DIGIT device.

7 Quick Start Example

Install the digit-interface Python package and connect the DIGIT sensor to a host computer using a Micro USB cable and specify the DIGIT serial number.

Record the serial number which is either located on the sensor label, or specified through the programming tool.

The following example can be used to connect to a DIGIT and acquire live sensor output, additional examples are located in the digit-interface repository.

```python
from digit_interface.digit import Digit
from digit_interface.digit_handler import DigitHandler

# Change D12345 to your DIGIT serial number,
# and specify a friendly name
digit = Digit("D12345", "Left Gripper")
digit.connect()

# Print device info
print(digit.info())

# Display stream obtained from DIGIT
digit.show_view()

# Disconnect DIGIT stream
digit.disconnect()
```

References

[1] Mike Lambeta, Po-Wei Chou, Stephen Tian, Brian Yang, Benjamin Maloon, Victoria Rose Most, Dave Stroud, Raymond Santos, Ahmad Byagowi, Gregg Kammerer, Dinesh Jayaraman, and Roberto Calandra. DIGIT: A novel design for a low-cost compact high-resolution tactile sensor with application to in-hand manipulation. *IEEE Robotics and Automation Letters (RA-L)*, 5(3):3838–3845, 2020.