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Report Information	
Report Publish Date	5/5/2017
SI Number	45079
Analyst Name	T. Mroczkowski
Product Description	
Product Type	E-Cigarette
Brand	Philip Morris
Device Name	IQOS
Device Model #	A1402
Official Release Date	11/15/2016
Target Market	Worldwide
Retail Price	$109.99
Weight (grams)	19.6 (Measured)
Device Dimensions (mm)	93.3 x 14.7 x 13.9 (Measured at Longest/Widest/Thickest Points)
Product Features	
Operating System	Proprietary
Processor Spec	16-Bit Mixed Signal Microcontroller
RAM Support	N/A
Connectivity	MiniUSB
User Interface	Trigger, Control & Cover Lock Buttons, LED Indicators
Storage	N/A
Battery Type	3.2 V, 120 mAh, Li-ion (Device); 3.7 V, 2900 mAh, Li-ion (Pocket Charger)
Battery Life (Hrs.)	20 puffs / 1 hour charging in pocket charger

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Device Analysis

Design Wins

Design Wins		
Function	Manufacturer	Part Number
Microcontroller (E-Cigarette)	Texas Instruments	MSP430F2272
Microcontroller (Charger)	Texas Instruments	MSP430F5524
Battery Charger	Texas Instruments	BQ24190

Texas Instruments has almost all of the design wins in the Philip Morris IQOS (A1402) e-cigarette, supplying 13 of the 15 ICs. These include the two microcontrollers (one for the holder & one for the charger) and a Li-ion battery charger IC.

Device Analysis

Analysis Summary

Integrated Circuit Metrics		
IC Die Count**	16	
IC Package Count**	16	
Cost Metrics		
Retail Price	$109.99	
Total Manufacturing Cost*	$19.26	
Electronics Cost**	$8.87	
Manufacturing Cost Breakdown		
Integrated Circuits	$2.98	15.5%
Modules, Discretes & Connectors	$3.68	19.1%
Substrates	$0.42	2.2%
Component Insertion	$1.11	5.8%
Card Test	$0.21	1.1%
Battery Subsystem	$3.16	16.4%
Non-Electronic Parts	$7.16	37.2%
Final Assembly & Test	$0.55	2.8%
Total	**$19.26**	**100.0%**

*Excluding Supporting Materials' Cost
**Including Subsystems

The Philip Morris IQOS (A1402) is the company's first smoke-free e-cigarette in its new line of "reduced-risk products" (RRPs). It allows nicotine to be extracted from tobacco without burning. The entire system includes charger, holder, and tobacco stick.

The tobacco stick is inserted into the holder, which resembles a pen, and then heated to 350° C. Instead of smoke, it generates a vapor that contains nicotine. According to the manufacturer, the vapor has less than 10% of the harmful constituents found in regular cigarette smoke and far less odor, though it still contains nicotine and tobacco flavors.

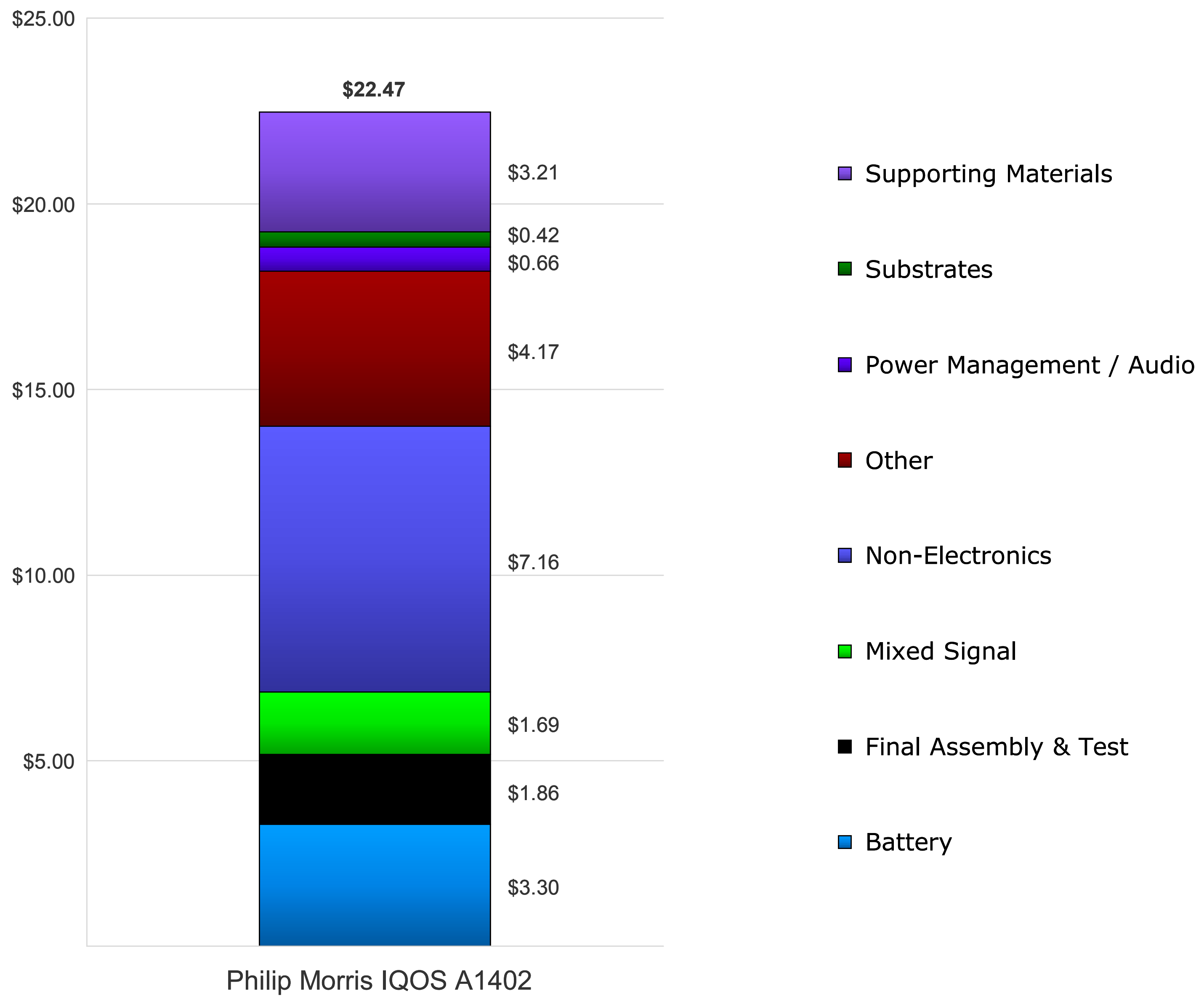
The charger, holder, and tobacco stick are all solidly constructed and small enough to fit into a shirt pocket. In fact, they're smaller than a pack of standard cigarettes. A handy cleaning kit is also included in the package.

Most of the minor ICs used here (such as the LDOs and converter) have been seen in previous analyses. The main #MSP430F2272 microcontroller has been seen before in the Honeywell Prestige IAQ programmable thermostat. The #MSP430F5524 microcontroller in the charger has been seen four times before, most recently in the Honeywell Wireless Adapter THM4000R1000.

Device Analysis

Cost Drivers

Item	Function	Location	Component Category	Description	Pkg Form	Qty	Piece Cost	Extended Cost	Pin Count, Each*	Pin Count, Total	IC Ref #	Pkg Brand	Pkg PN	Category
83	Supporting Materials					1	$3.2100	$3.2100						Supporting Materials
50	Subsystems			Battery Subsystem		1	$3.1596	$3.1596						Battery
85	Insertion					1	$1.1065	$1.1065						Final Assembly & Test
51	Non-Electronics	Charger Main Enclosures		Top Enclosure		1	$1.0500	$1.0500						Non-Electronics
52	Non-Electronics	Charger Main Enclosures		Bottom Enclosure		1	$1.0500	$1.0500						Non-Electronics
2	Mixed Signal	Charger Main Board - Side 1	IC	16-Bit Mixed-Signal Microcontroller	BGA	1	$0.9900	$0.9900	64	64	Main - IC.8	Texas Instruments	MSP430F5524	Mixed Signal
45	Other	Main Board - Side 2	Module	Misc: Heater		1	$0.8900	$0.8900	2	2				Other
53	Non-Electronics	Charger Main Enclosures		Internal Enclosure		1	$0.7900	$0.7900						Non-Electronics
1	Mixed Signal	Main Board - Side 1	IC	16-Bit Mixed Signal Microcontroller	Flip Chip, Solder	1	$0.7000	$0.7000	49	49	Main - IC.1	Texas Instruments	MSP430F2272	Mixed Signal
71	Non-Electronics	Device Main Enclosures		Long Enclosure		1	$0.6600	$0.6600						Non-Electronics



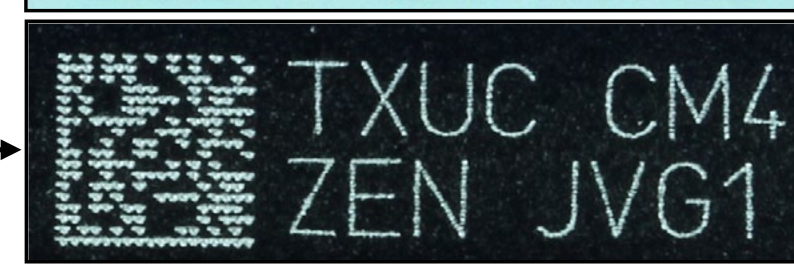
NOTE: Occasional inconsistencies in totals may be present due to rounding error.

Product Label

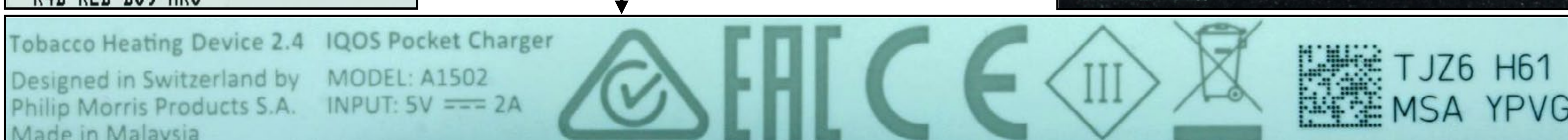
Box

Charger

E-cigarette



Pocket Charger

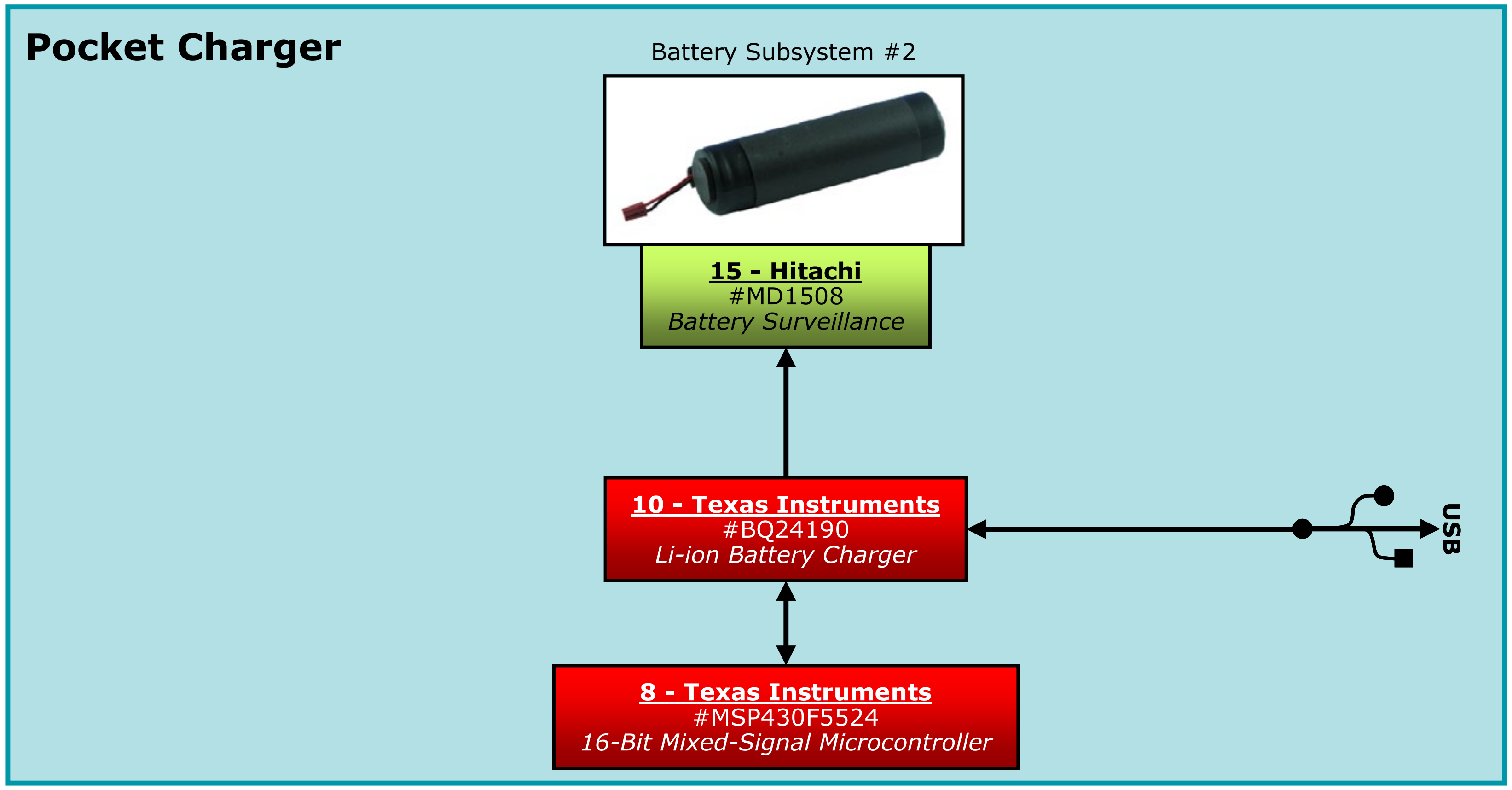


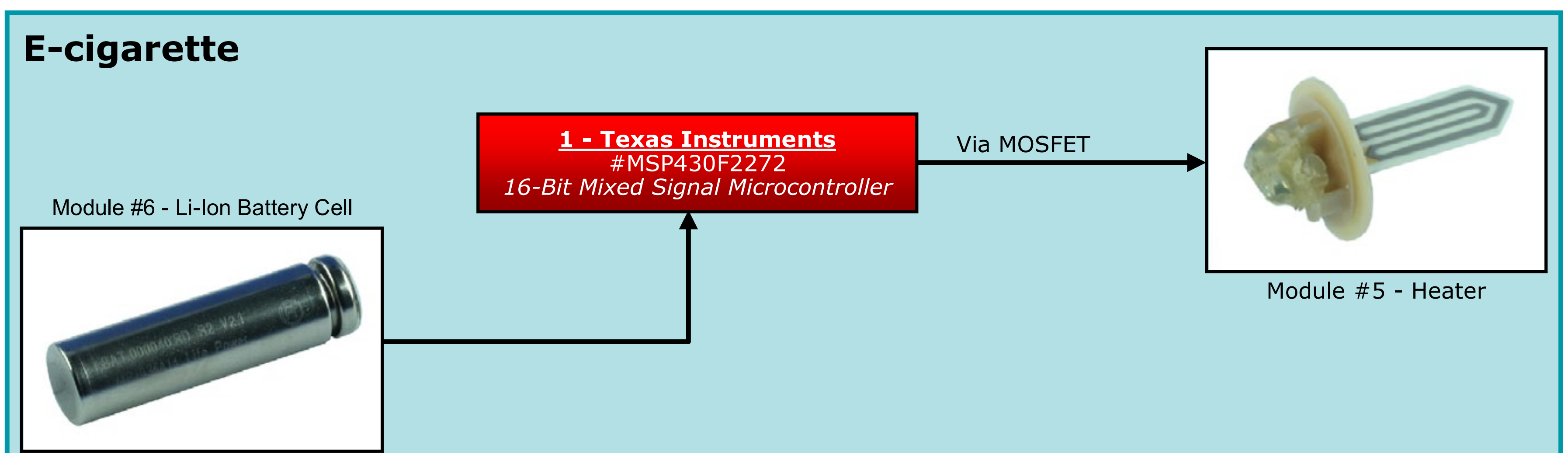
Supporting Materials

Block Diagram

System Block

Manufacturer:
- Hitachi
- Texas Instruments





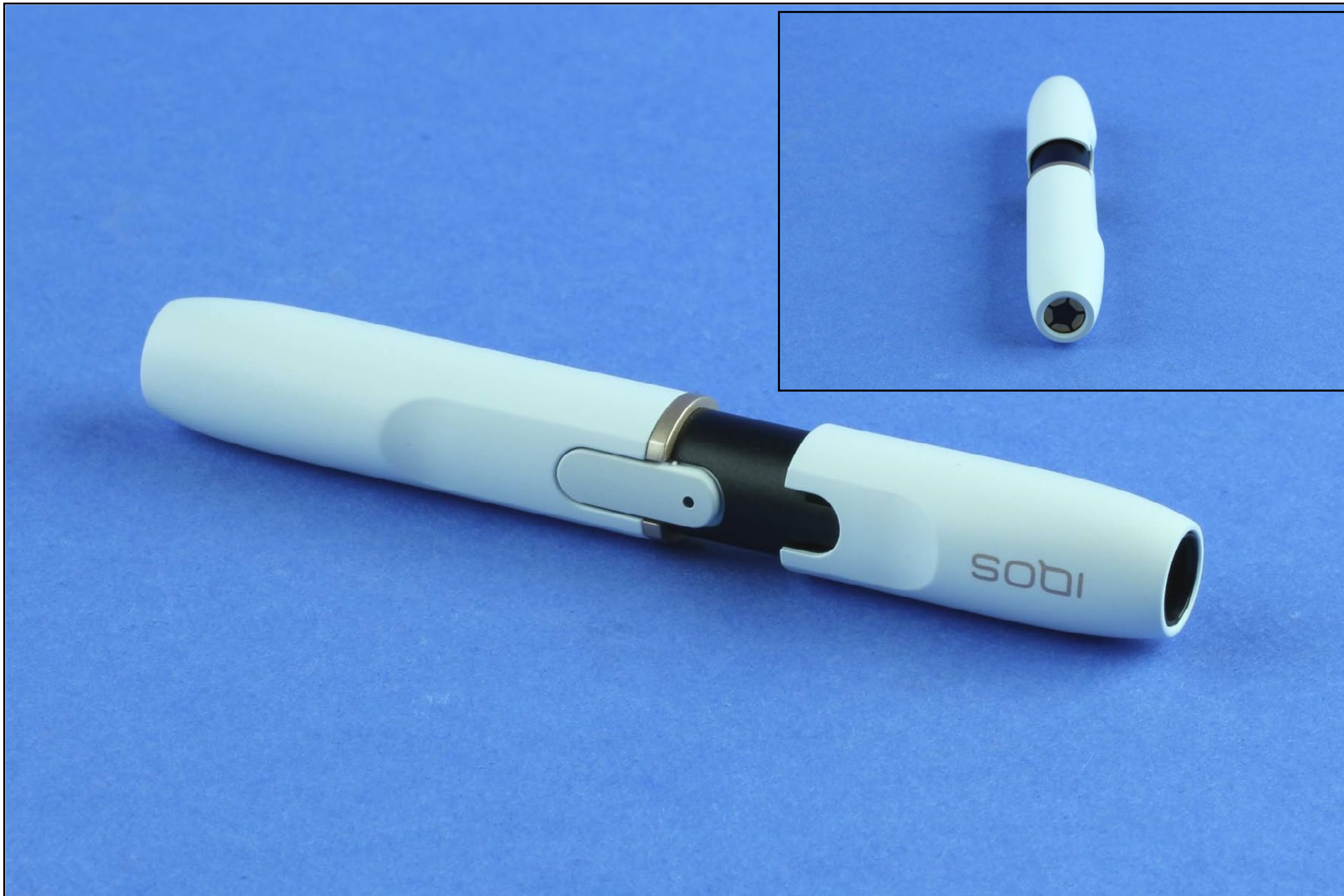
Estimated block diagram based on observation of this specific product implementation, manufacturer's data sheets where available, and best engineering judgment. Certain details of the interface circuitry are not reflected in this block diagram. Partitioning and connectivity are speculative.

Features

Exterior Features

Features

Exterior Features 2



Features

Exterior Features 3

Features

Exterior Features 4

Features

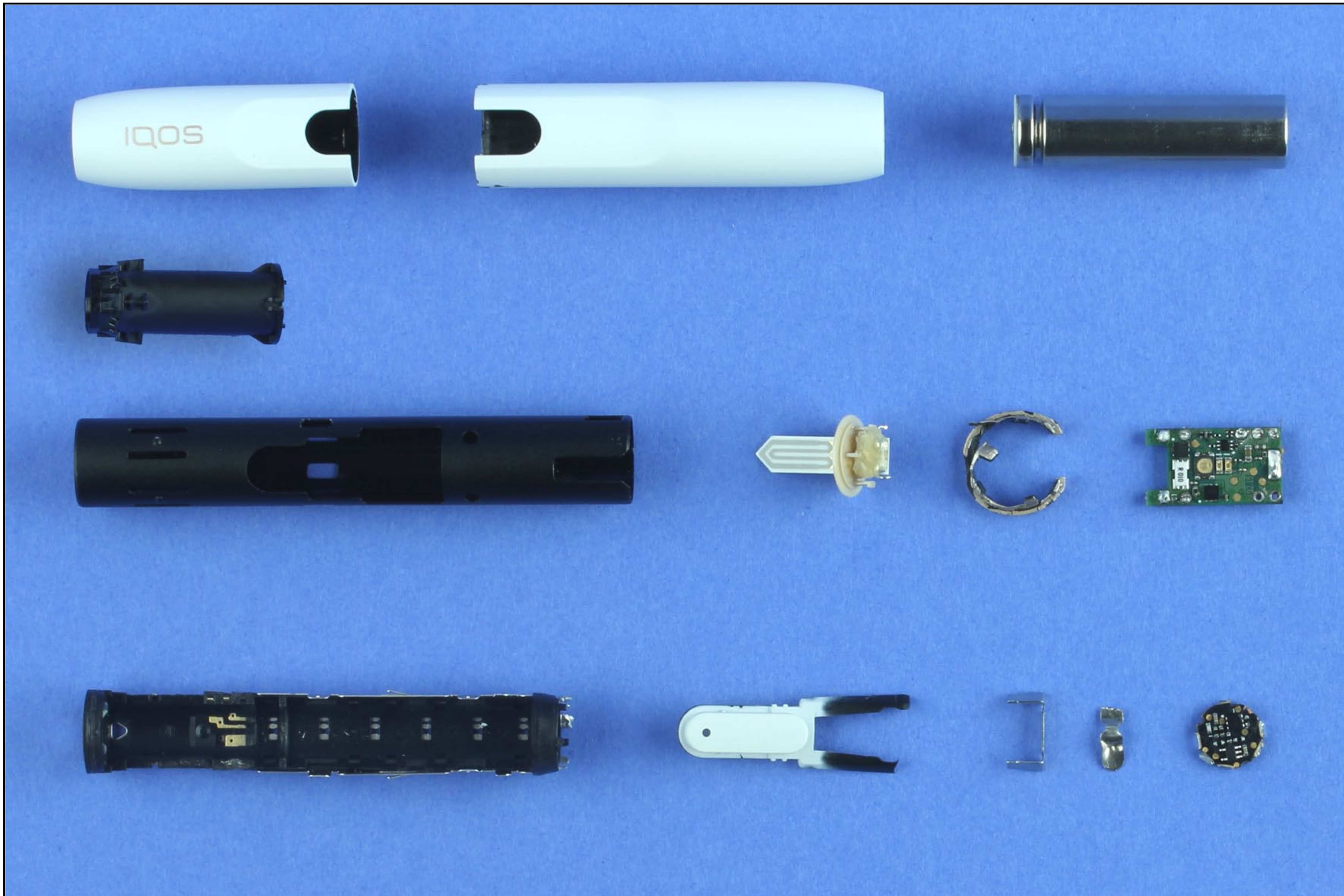
Exterior Features 5

Features

Exterior Features 6

Components

Major Components 1 Side 1



Components

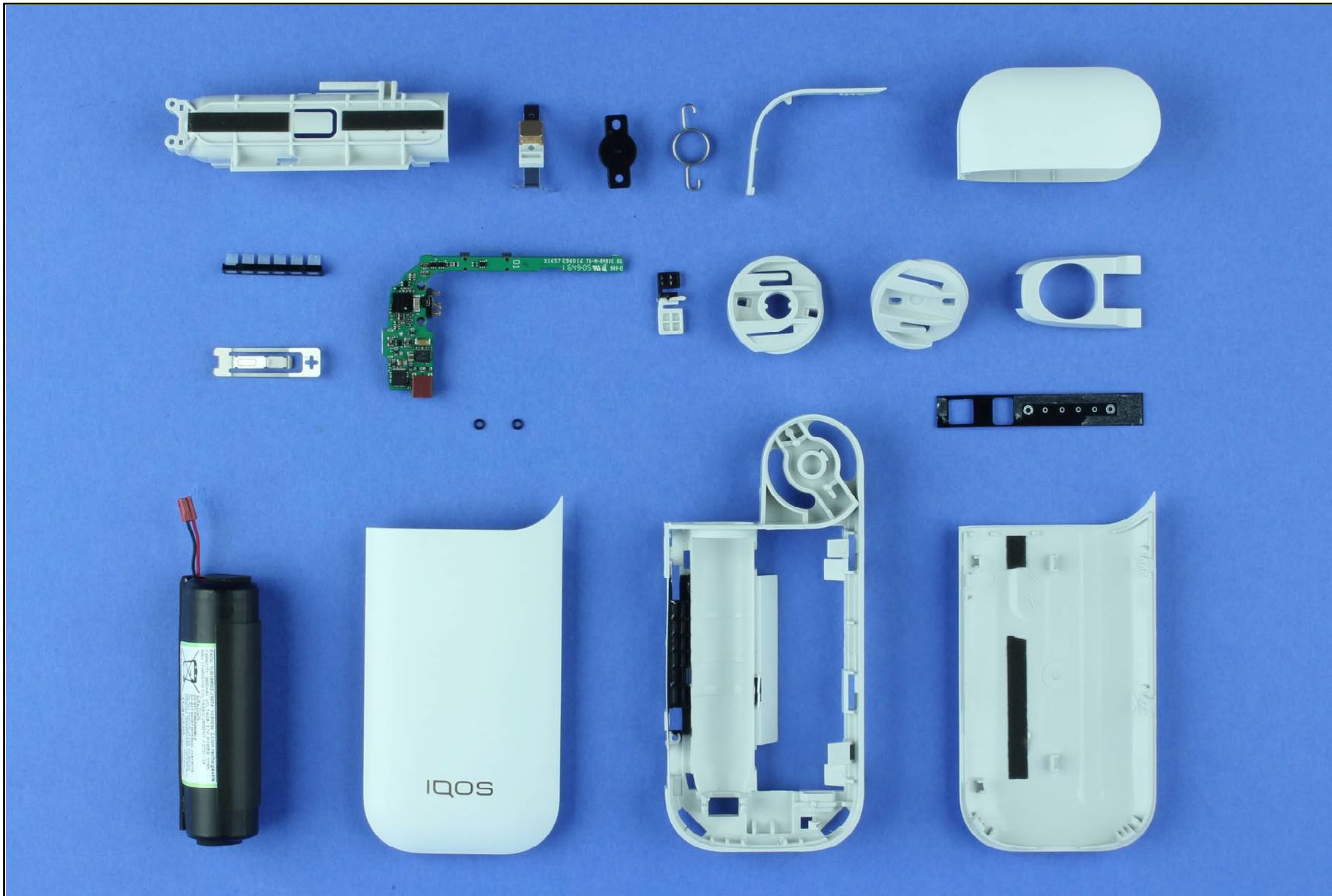
Major Components 1 Side 2

Components

Major Components 2 Side 1

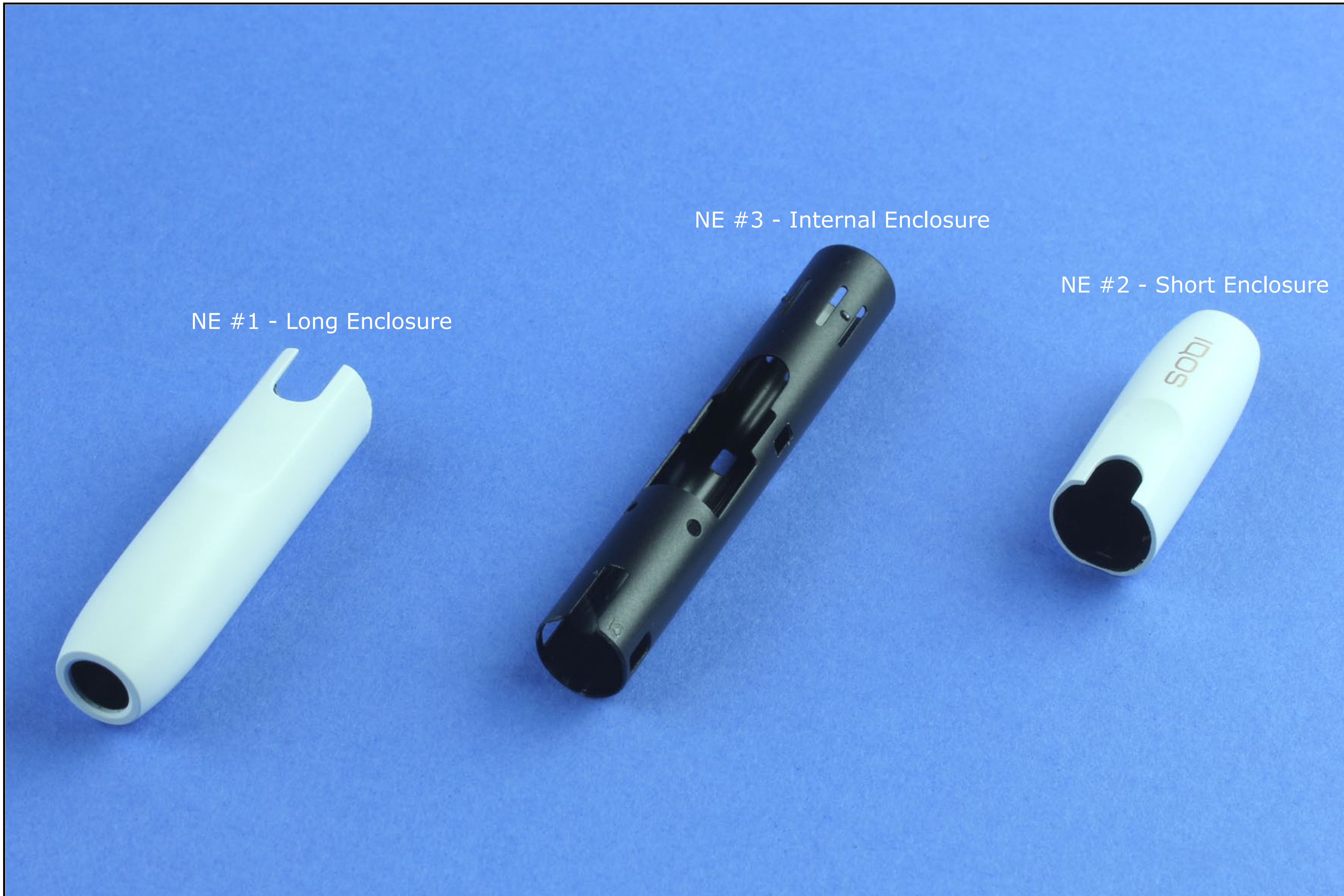
Components

Major Components 2 Side 2



Components

Main Enclosures 1 Side 1

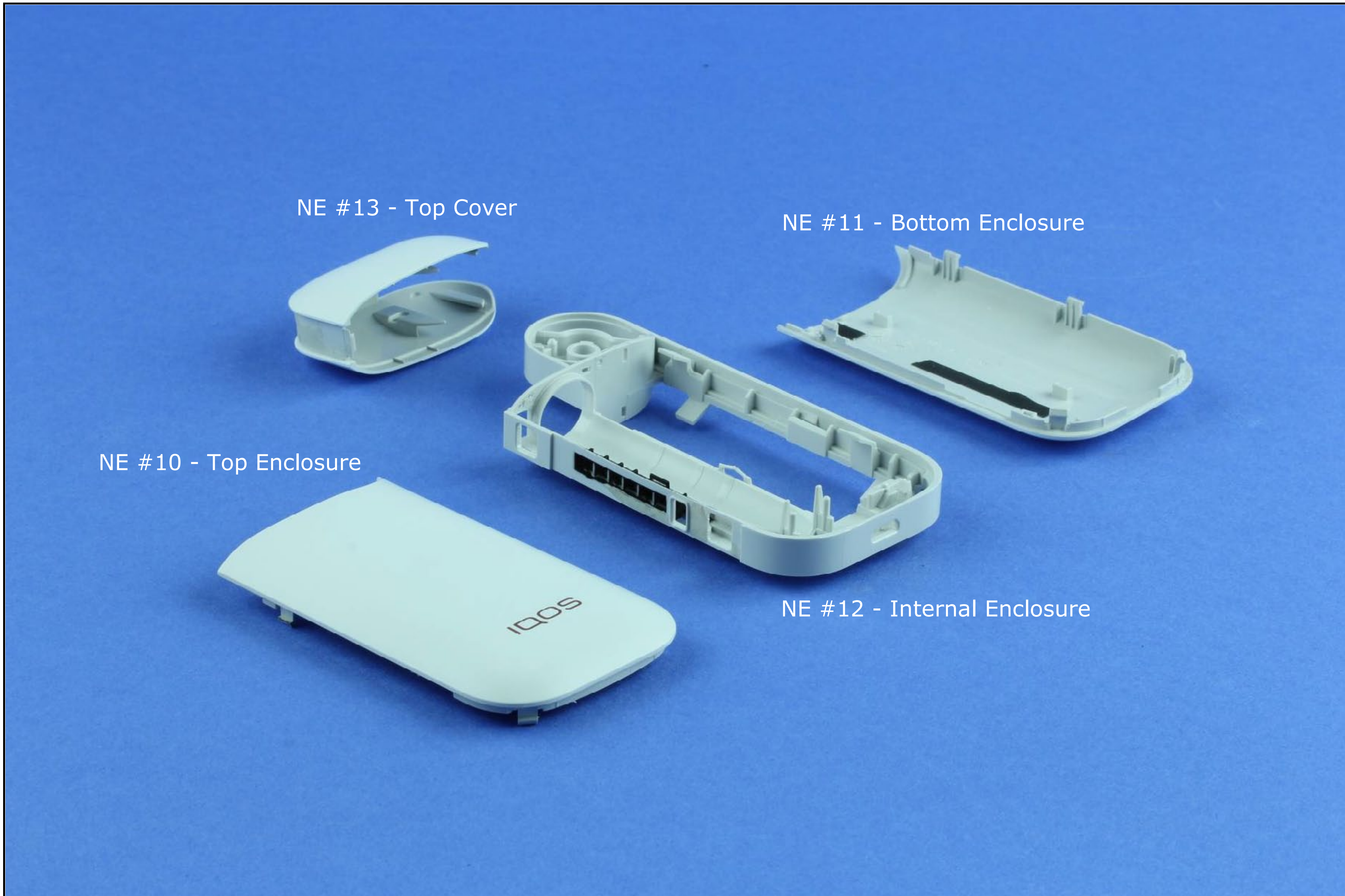


Components

Main Enclosures 1 Side 2

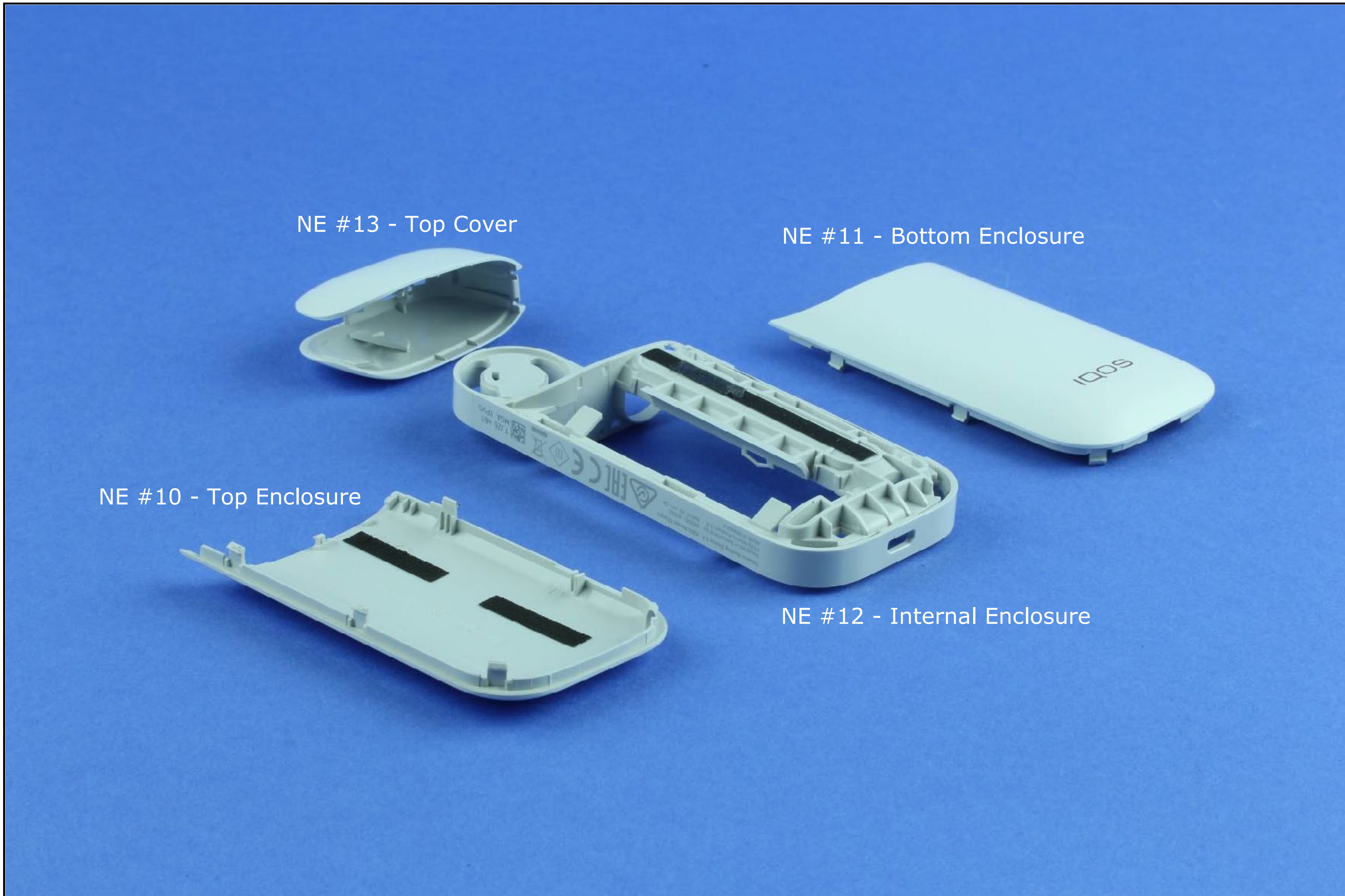
Components

Main Enclosures 2 Side 1



Components

Main Enclosures 2 Side 2



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Philip Morris IQOS A1402 - SI45079-TMd

Components

Component Arrangement

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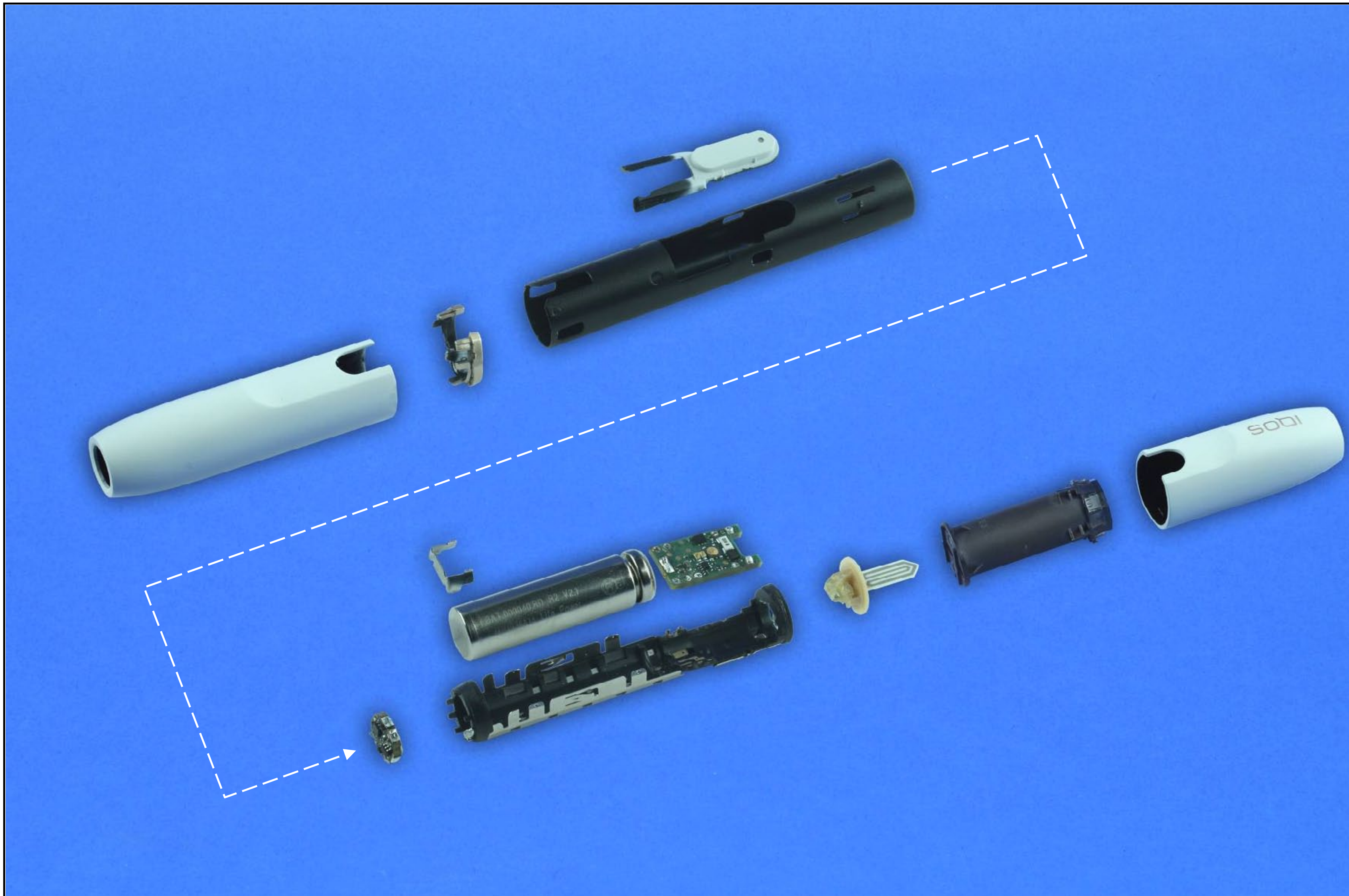

Components

Component Arrangement

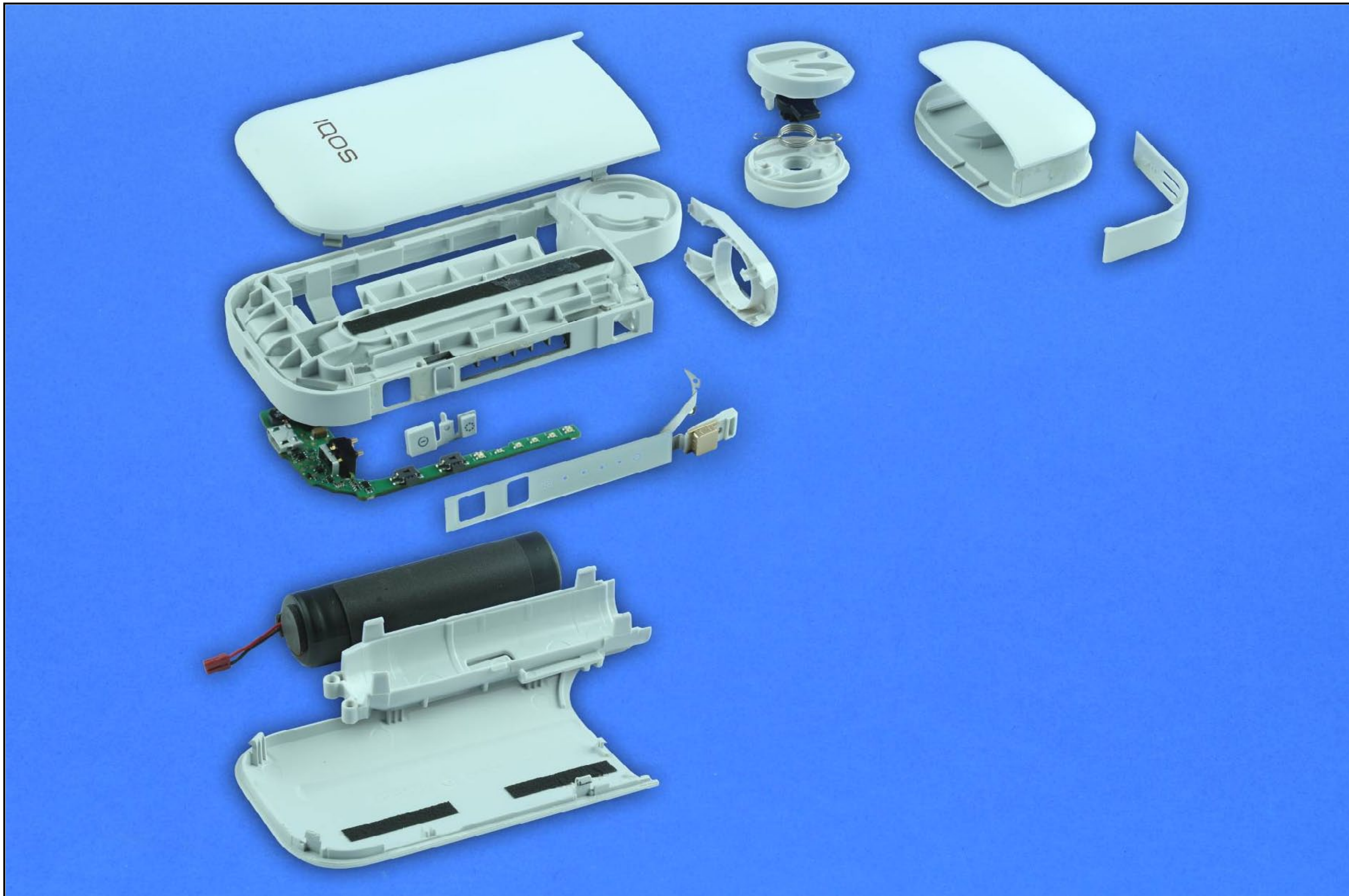

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Photo 1

Teardown

Photo 2

Teardown

Photo 3

Teardown

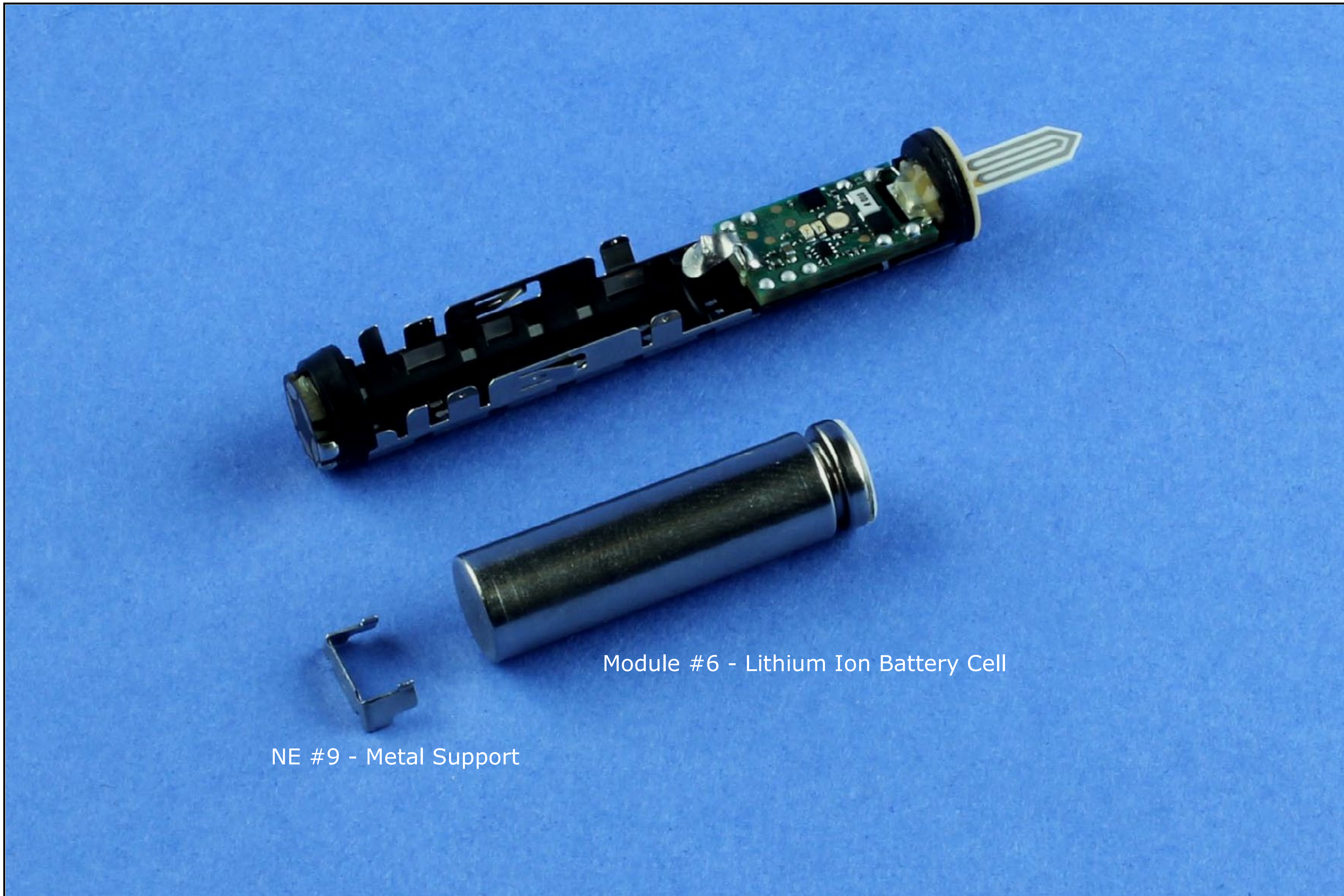
Photo 4

Teardown

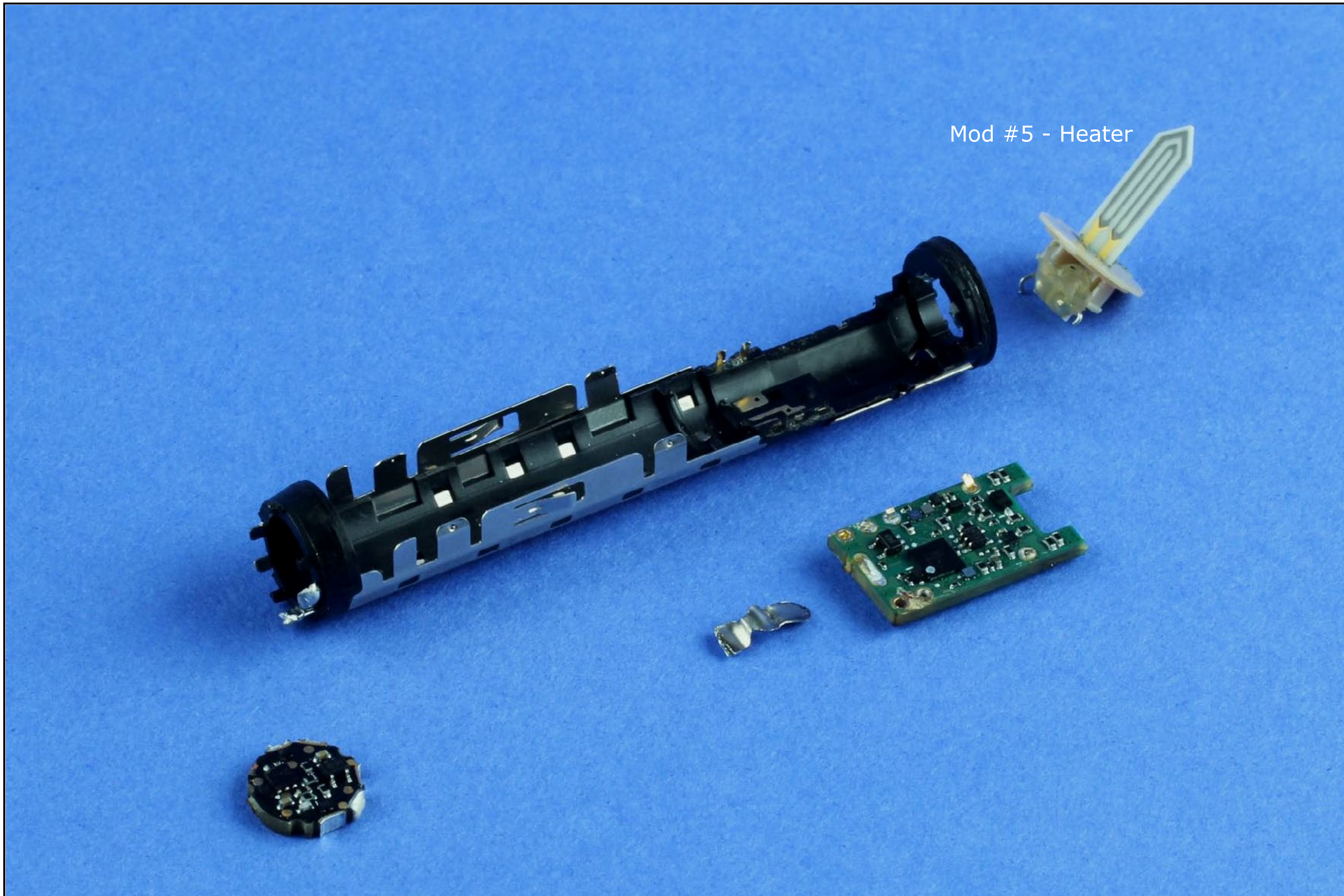
Photo 5

Teardown

Photo 6



Teardown
Photo 7



Teardown

Photo 8

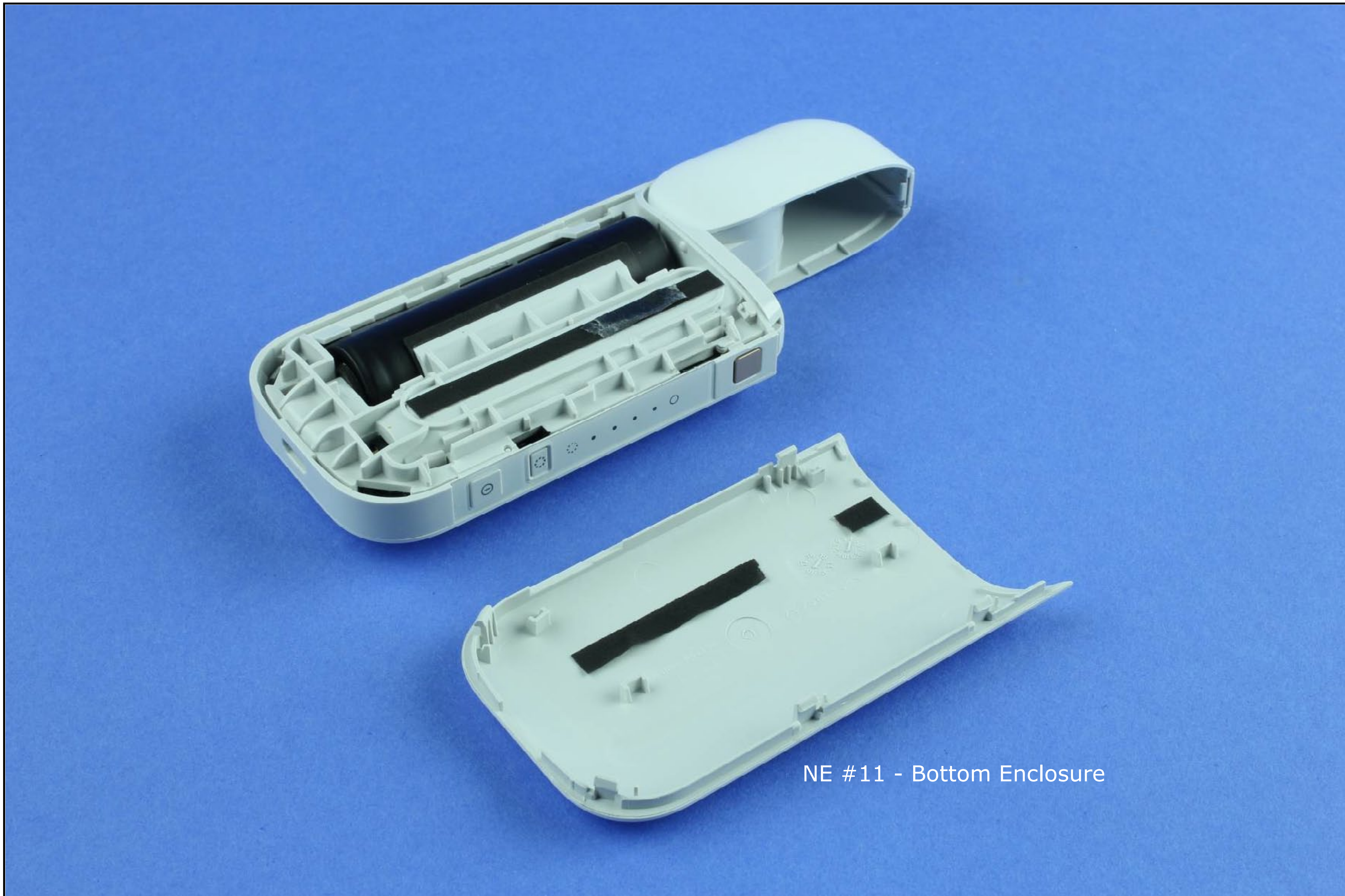


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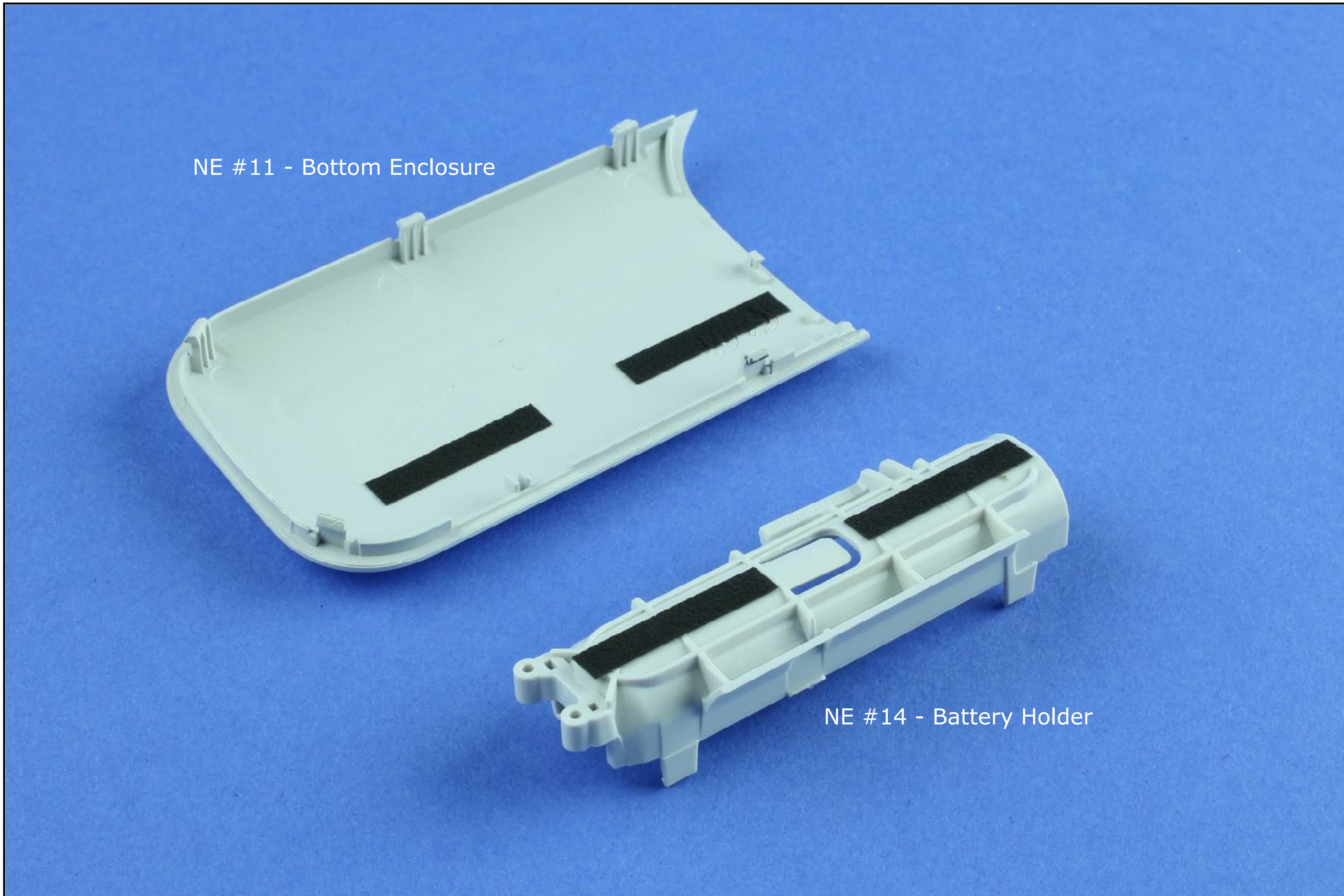
Photo 9

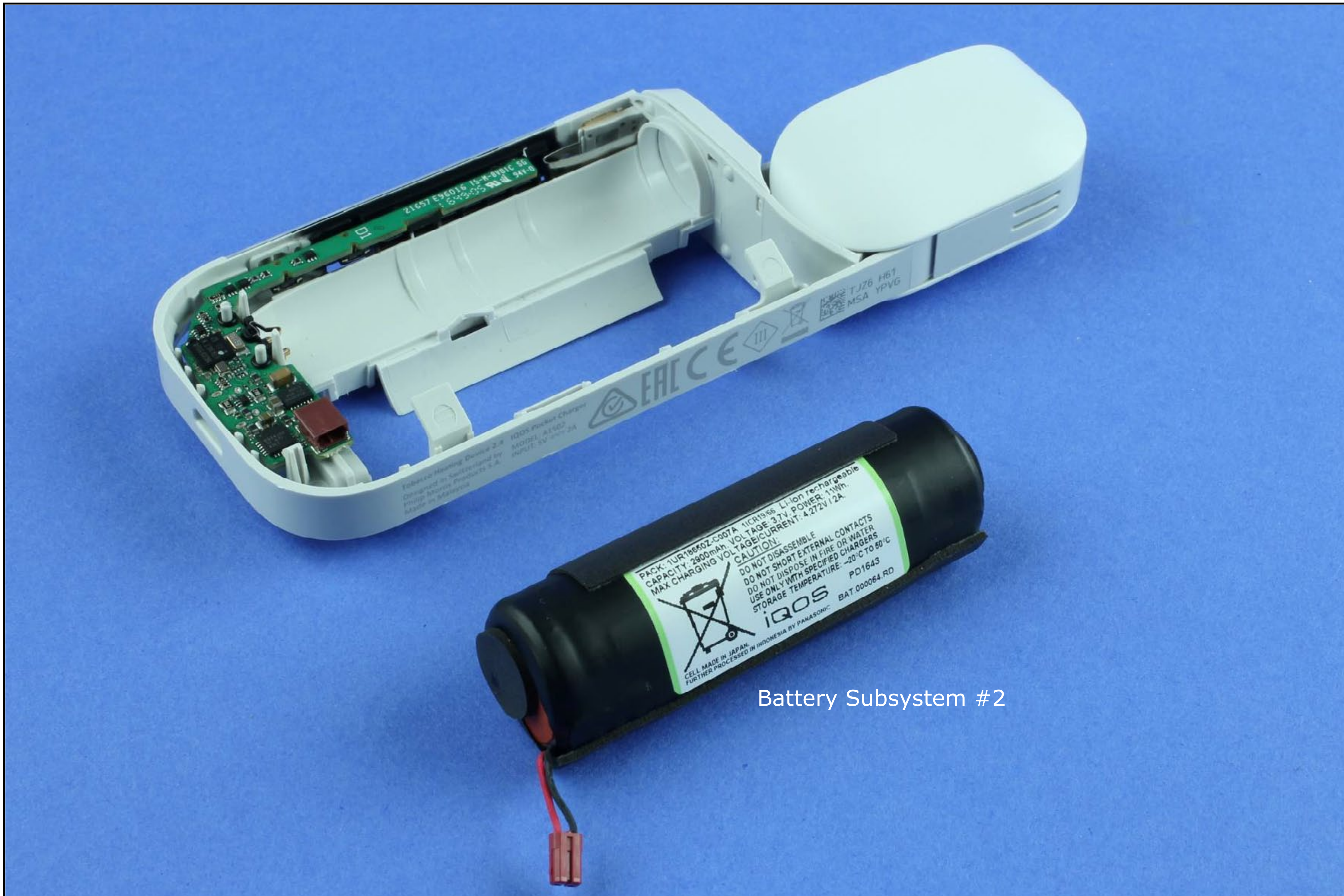
Teardown

Photo 10



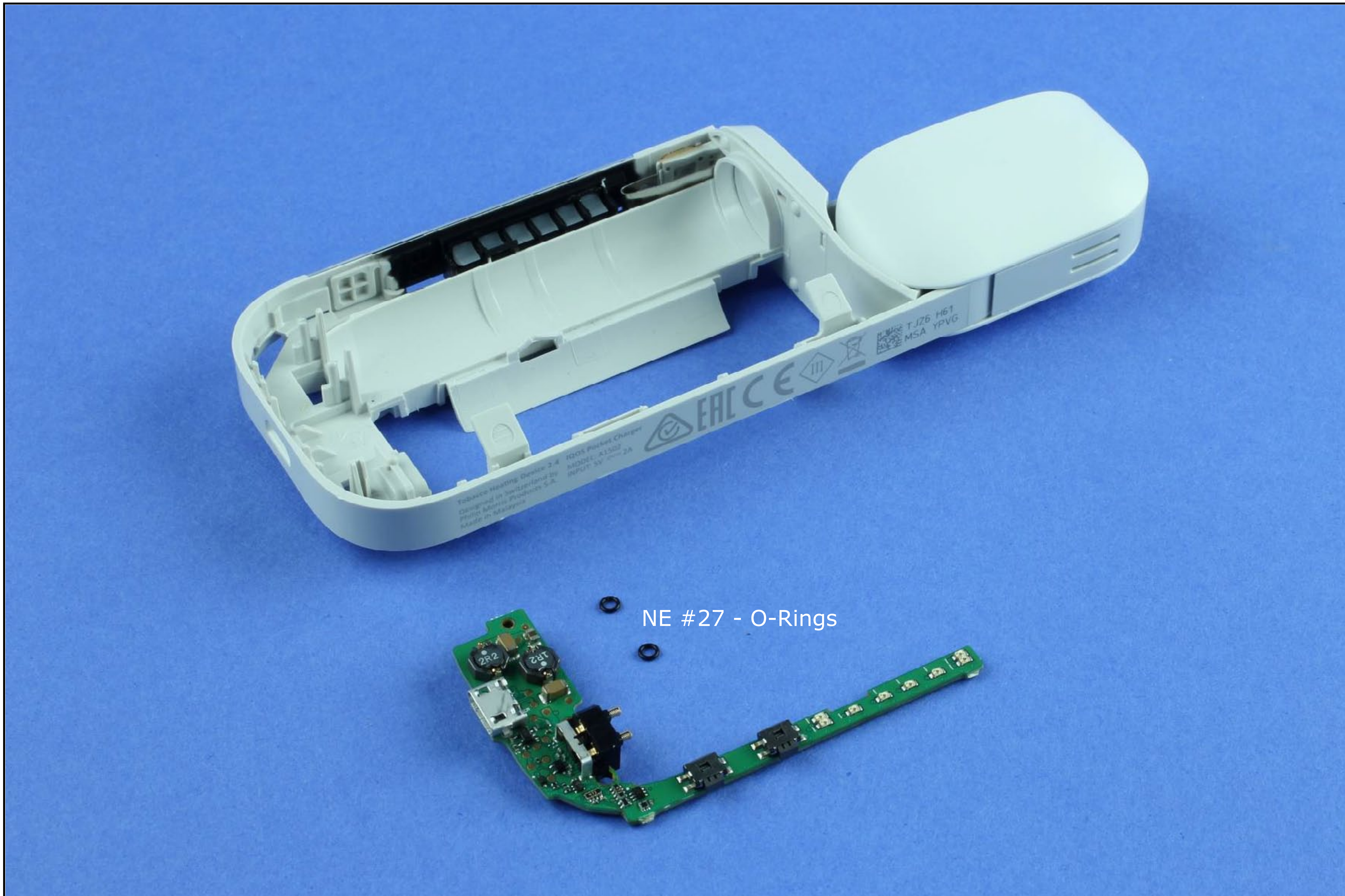
Teardown

Photo 11



Teardown

Photo 12



Teardown

Photo 13

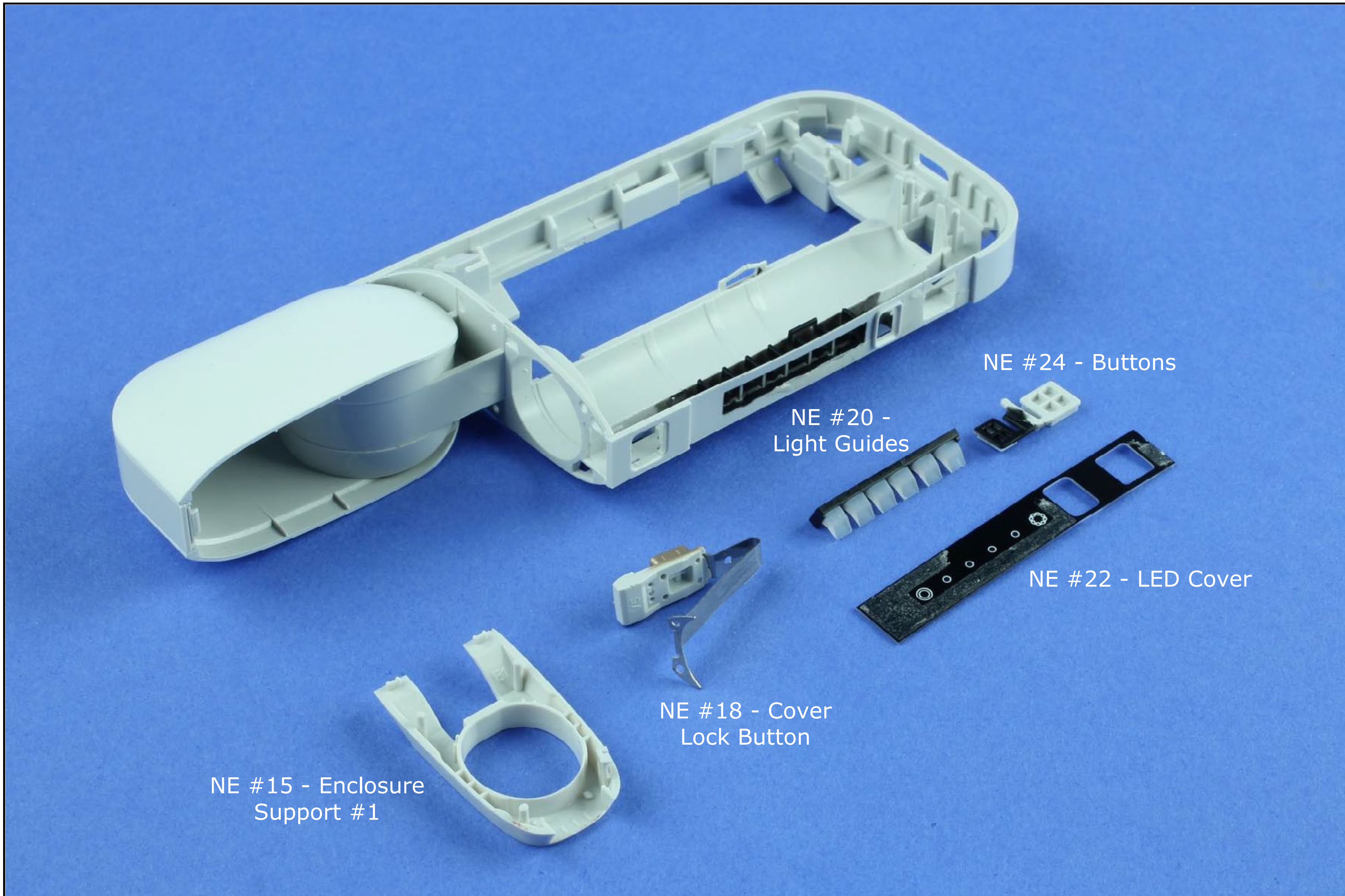


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Photo 14

Component Function Guide

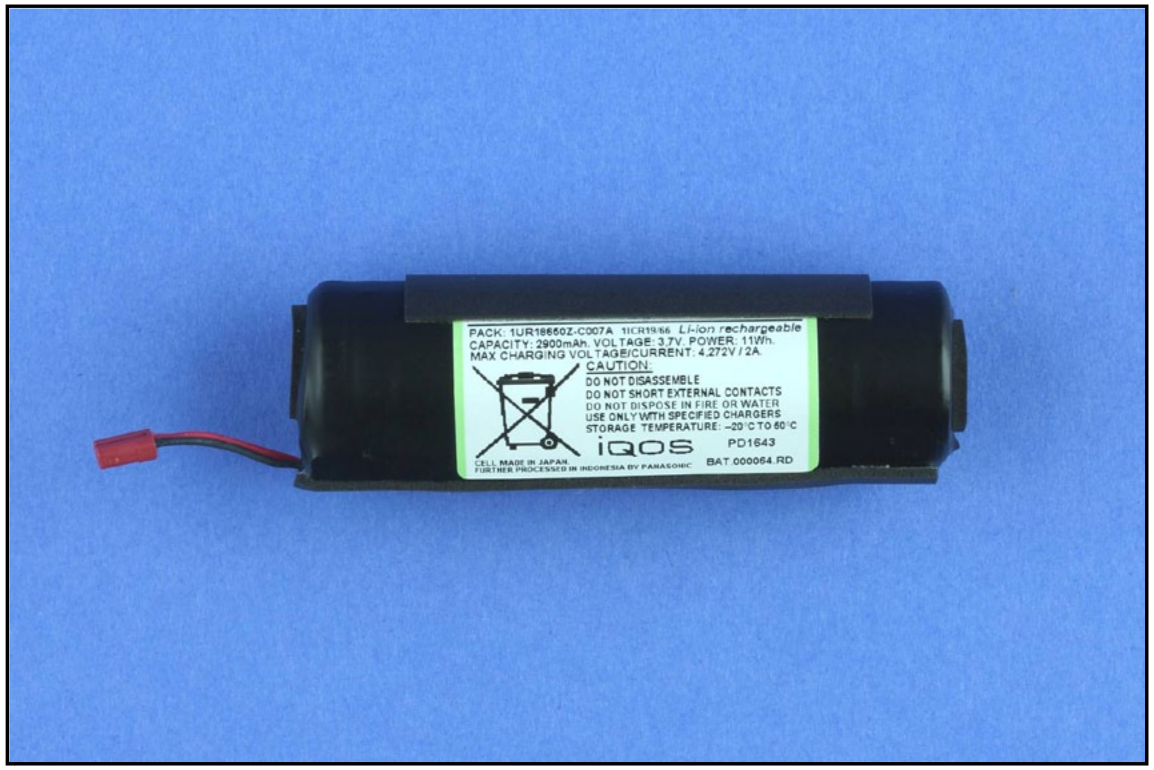
In both the Deep Dive and Survey Plus reports, ICs and modules will be categorized by their function within the system.

These categories are in alignment with the high-level IC function categories currently found in IRIS. The categories will also be found in the updated excel BoM workbooks which are included with each report.

Component Function	
Applications/Baseband Processor	Processors which are both Apps/BB Processors
Application Processor	Main Processor without cellular modem
Baseband Processor	Cellular Modem Processor
Camera / Image	Image Sensors, Video processors, Image co-processors , VGA Camera
Connectivity	Antennas, Bluetooth, GPS, USB, WiFi, ZigBee components
Display / Touchscreen	Display driver, Touchscreen controller, etc.
Logic	CPLD, FPGA, Programmable Logic Array/PLA, PLD
Memory: Mixed	Components with both non-volatile and volatile memory
Memory: Non-Volatile	NAND, NOR, EEPROMs, etc.
Memory: Volatile	RAM, SDRAM, etc.
Mixed Signal	DSPs, MCUs, Mixed-Signal Arrays, (non-audio, non-apps, non-baseband) Processors
Other	Small logic AND, OR gates, LDOs, Transistors, Regulators
Power Management / Audio	Audio CODECs, Envelope Tracking, MEMS Microphone, Power Management
RF Component	Diplexers, RF Antenna, RF antenna switches, RF Filters, RF Power Amplifiers, RF Receivers, RF Transceivers, etc.
Sensor	Accelerometer, Barometer, Compass, Gyroscope, Heart, Pressure, Temperature

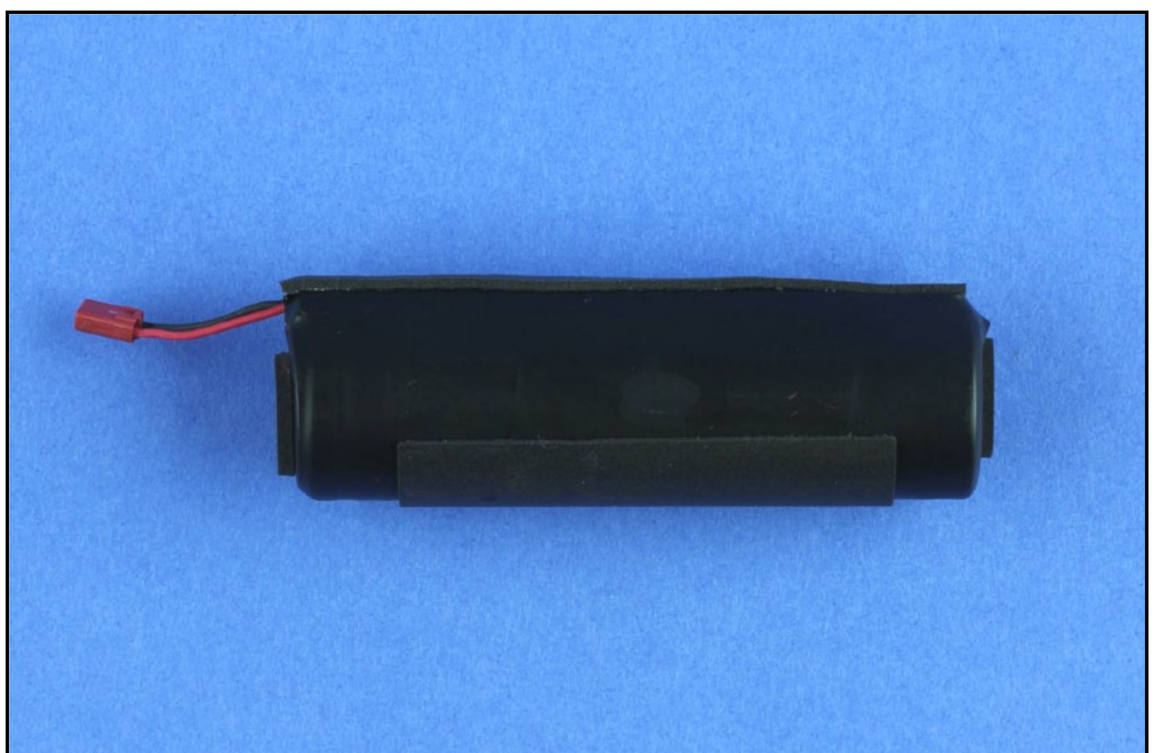
Subsystems

Battery Summary



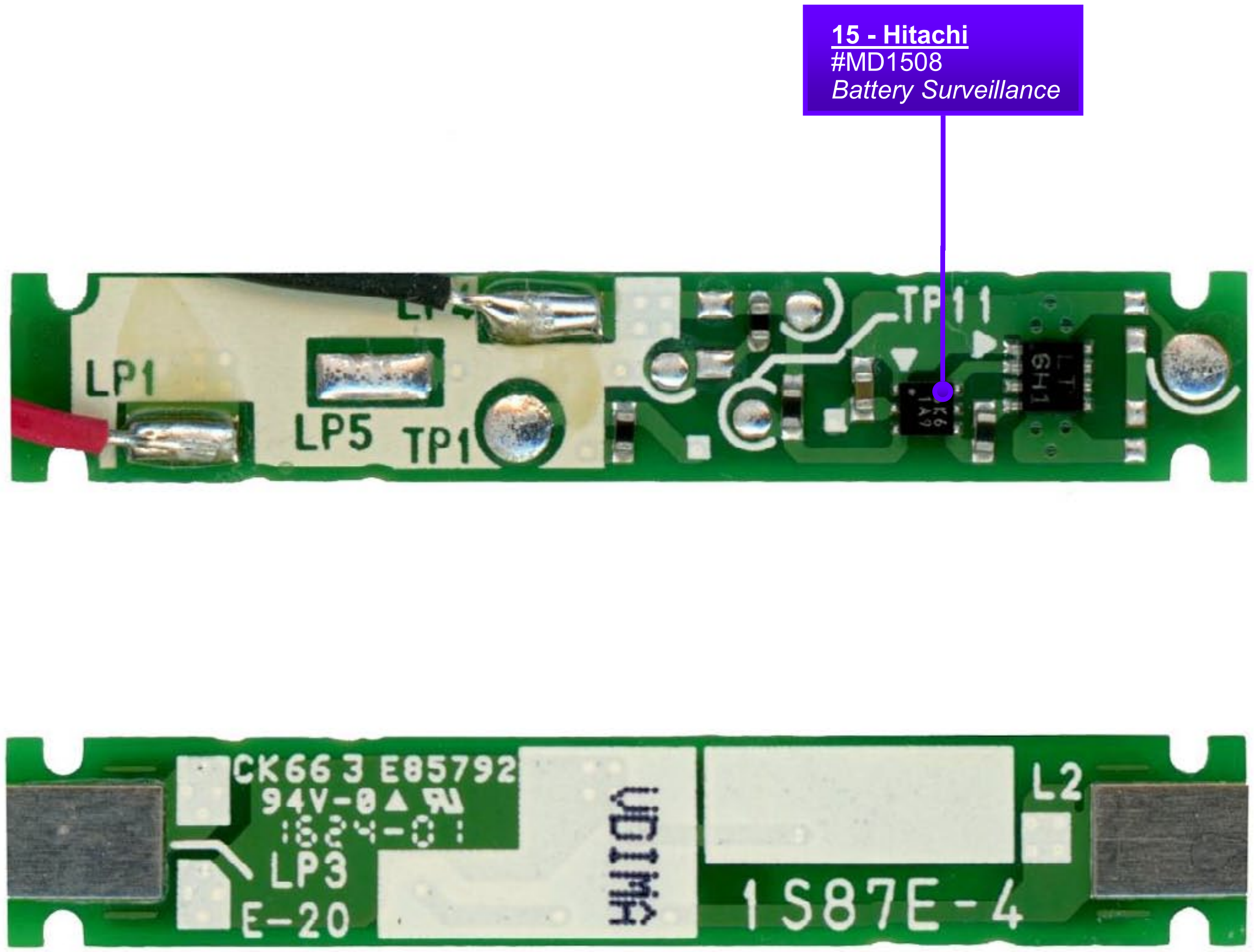
Battery Subsystem		
Pack Brand		Panasonic
Pack Part Number		1UR18650Z-C007A
Pack Voltage		3.7
Cell Type		Lithium Ion
Pack Rating (mAHrs)		2900
Pack Size (mm)		69.5 x 21.3 x 18.5
Vol. Energy Density (mWHrs/cc)		391.8
Pack Weight (grams)		50.6
Wt. Energy Density (mWHrs/g)		212.1
Cell Brand		Sanyo
Estimated Costs	Cell(s)	$1.39
	Electronic Parts	$0.32
	Non-electronic Parts	$0.29
	Assembly	$0.16
	Test	$0.05
	Gross Margin	$0.95
Estimated Pack Price		**$3.16**

A full Subsystem BOM is provided in the included BOM workbook.



Subsystems

Battery IC Identification



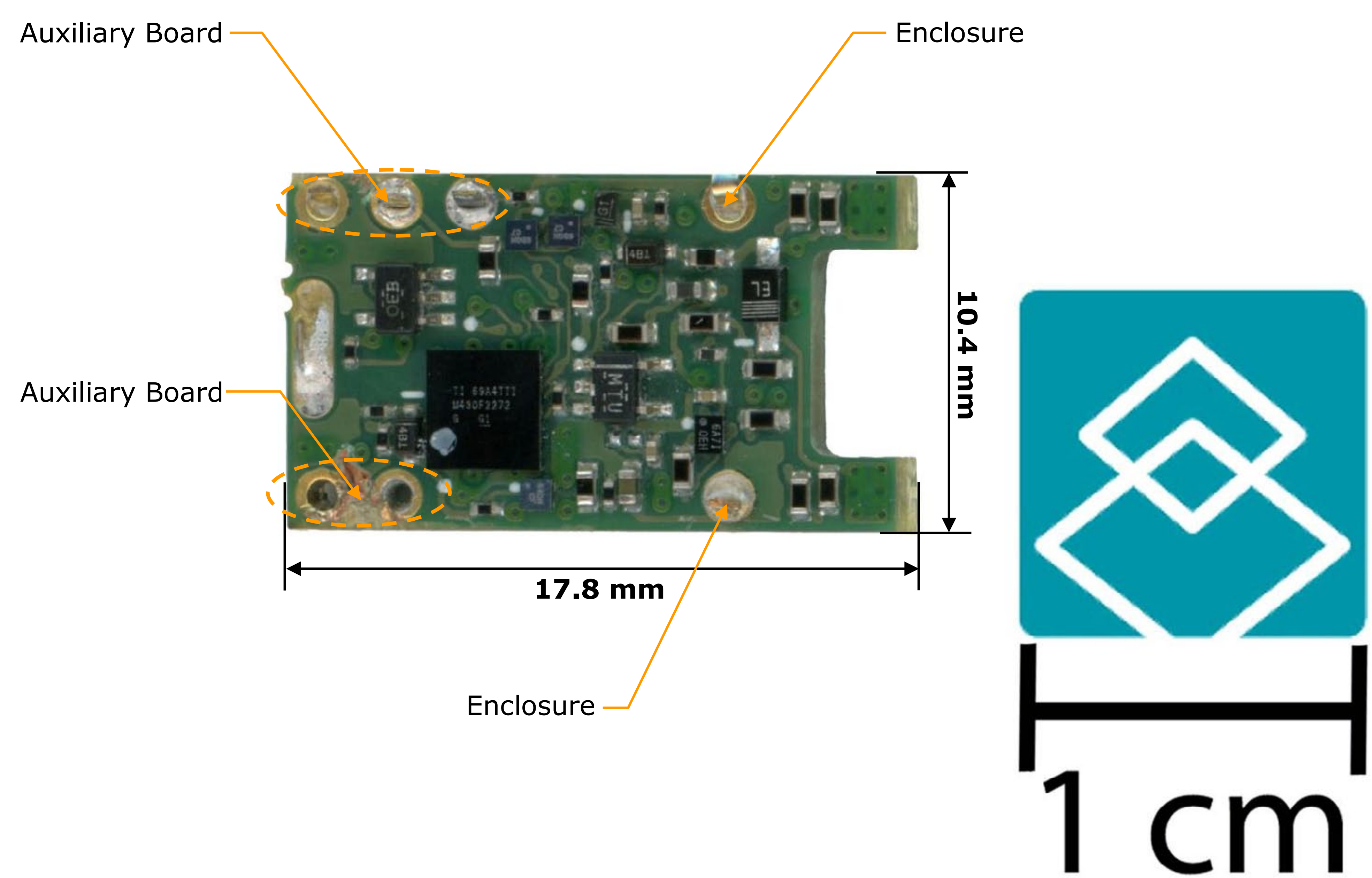
1 cm

Function:

Power Management / Audio

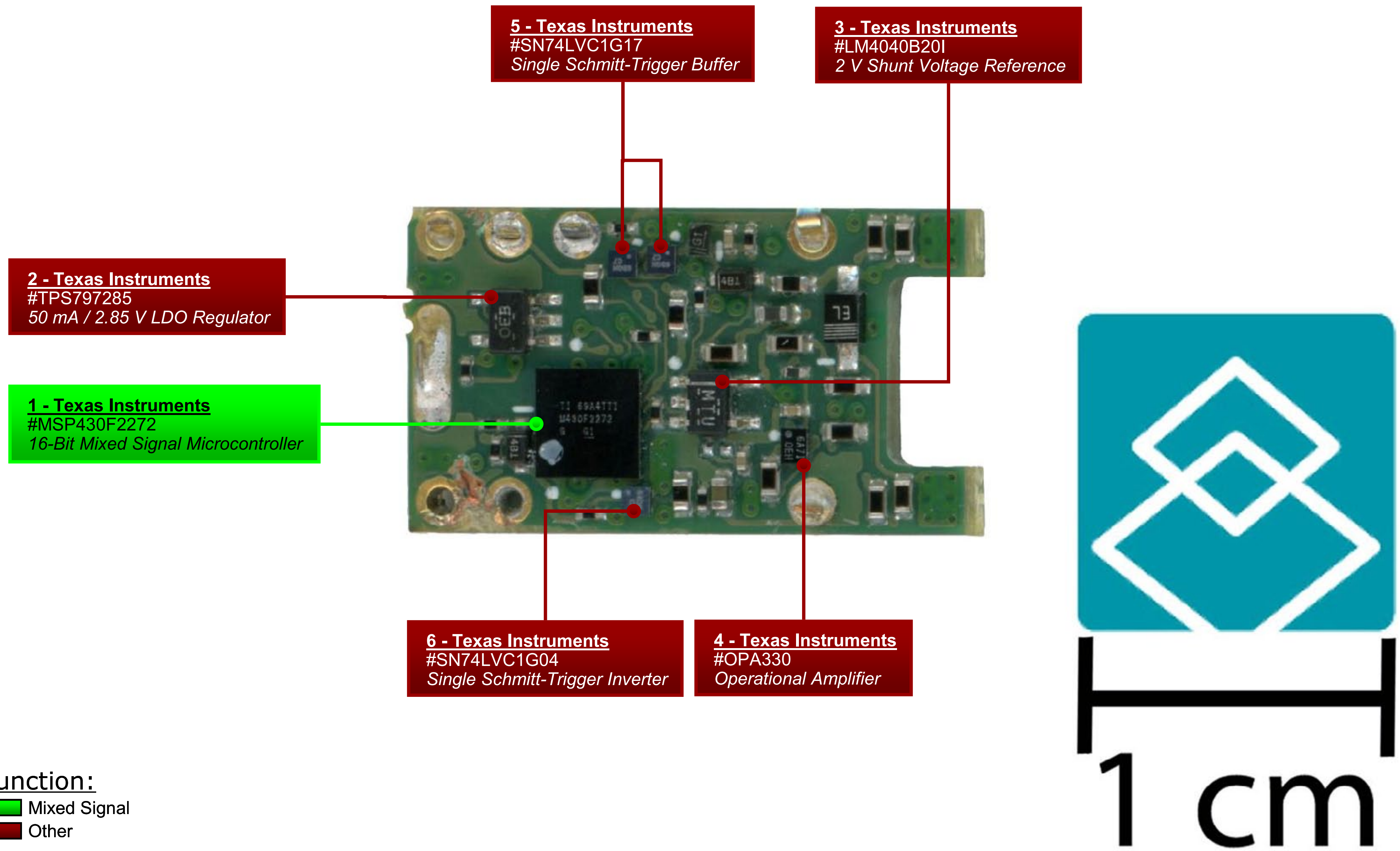
Main Board

Side 1



Main Board

Side 1 IC Identification



Function:

- Mixed Signal
- Other

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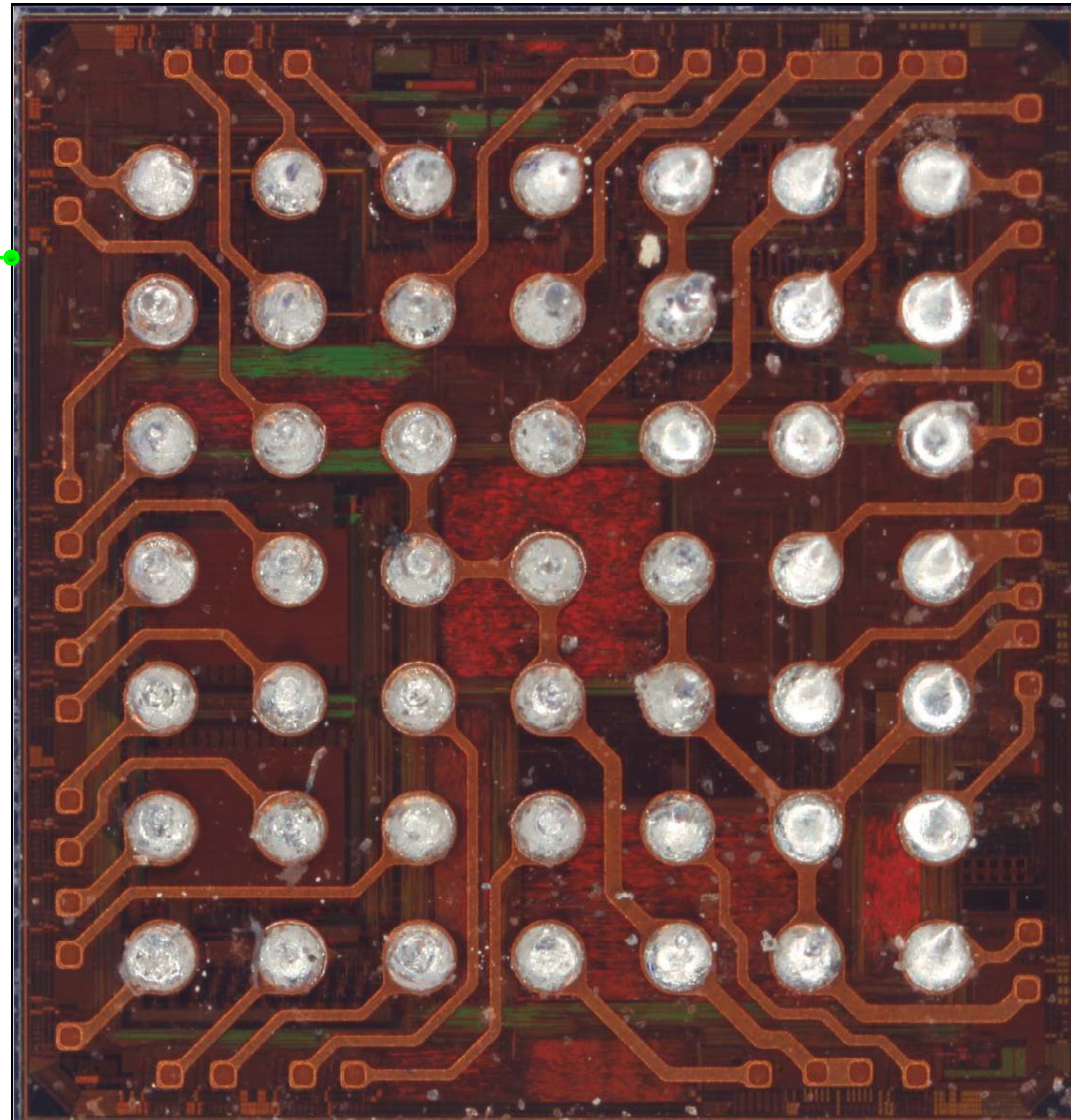
Main Board

Side 1 X-Rays & Die Photos

1 - Texas Instruments
#MSP430F2272
16-Bit Mixed Signal Microcontroller
Pkg. Size: 3.5 x 3.35 mm

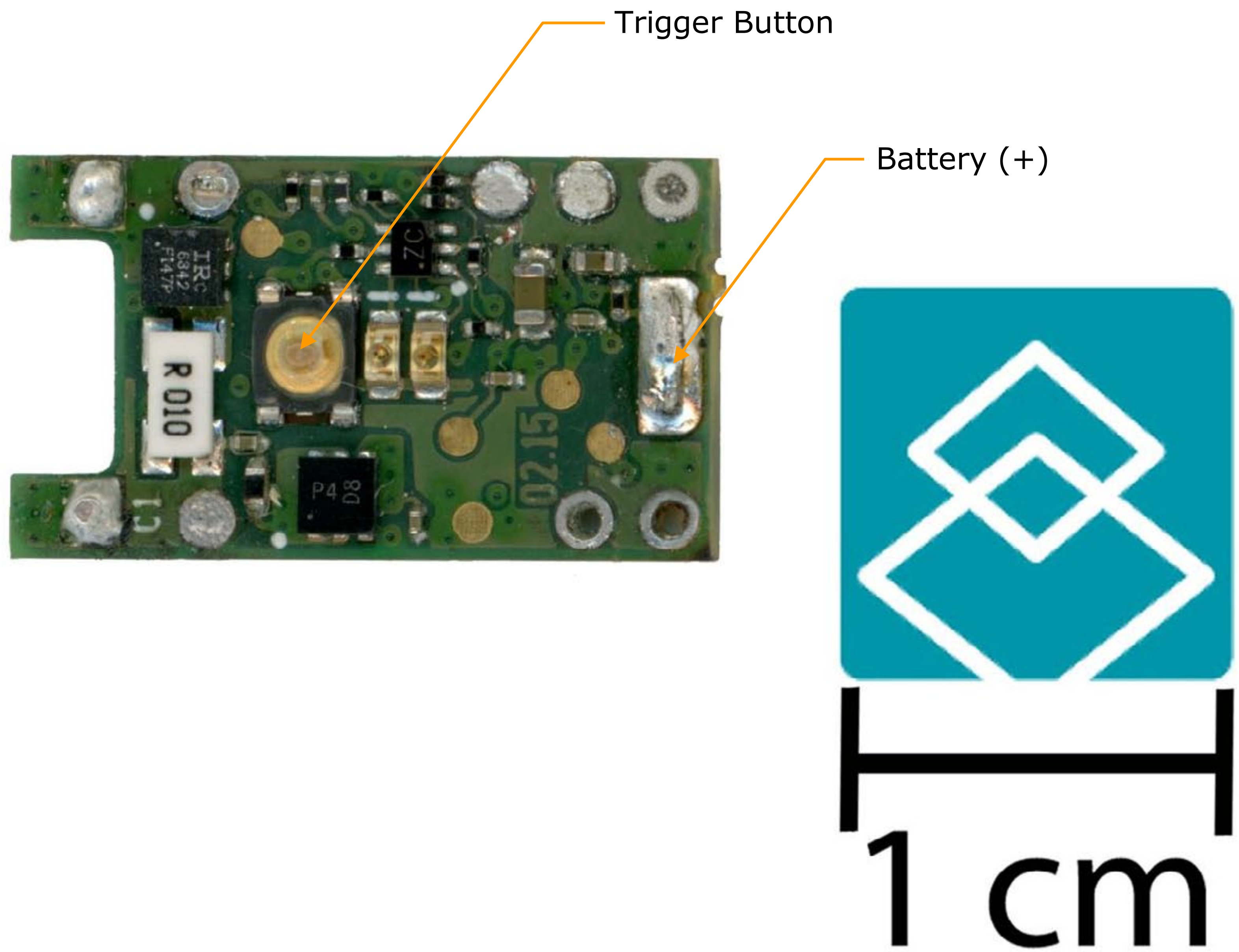
1.1 - Texas Instruments
#MSP430F2274G
16-Bit Mixed Signal Microcontroller
Die Size: 3.5 x 3.35 mm



Function:
Mixed Signal

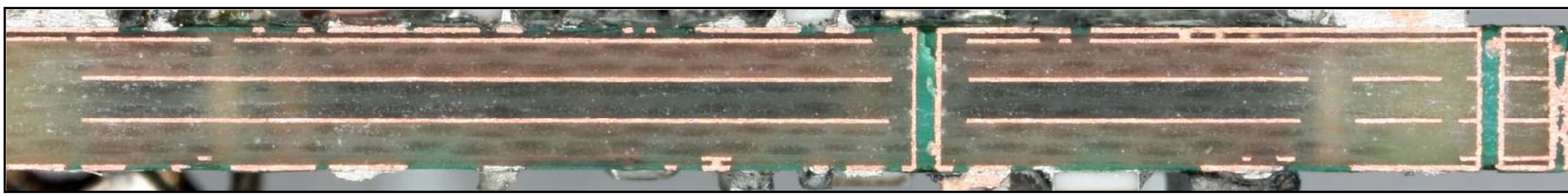
Main Board

Side 2



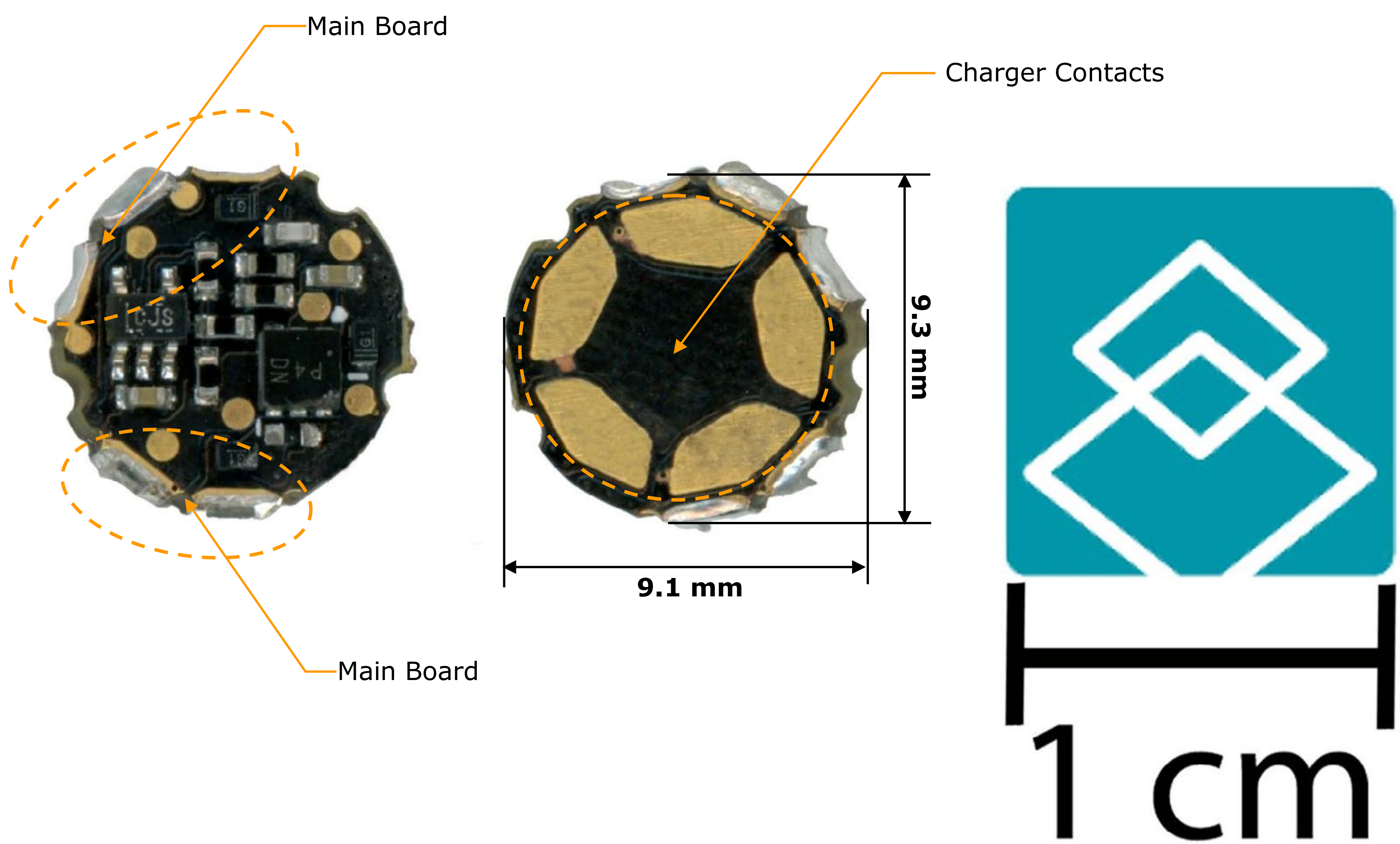
Main Board

Cross - Section



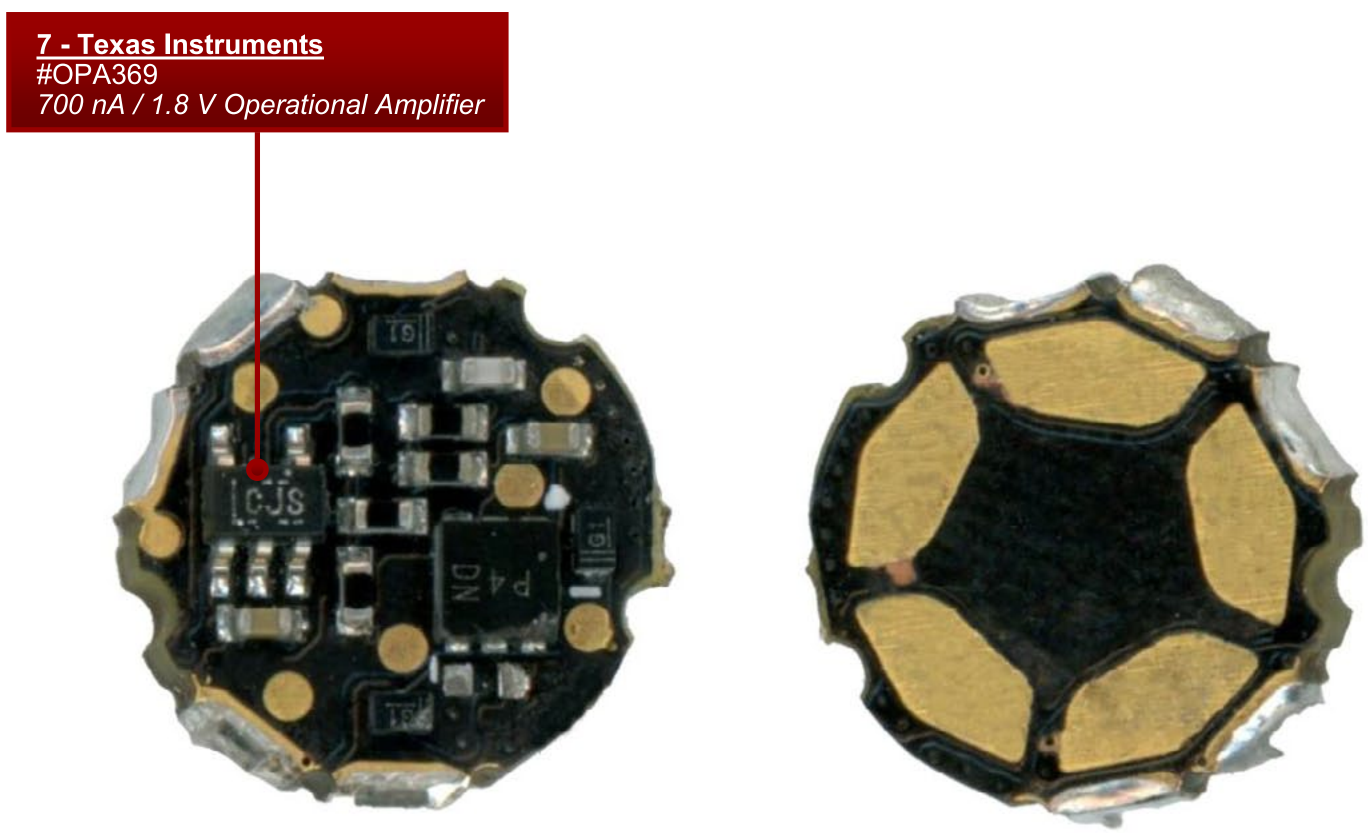
Other Substrates

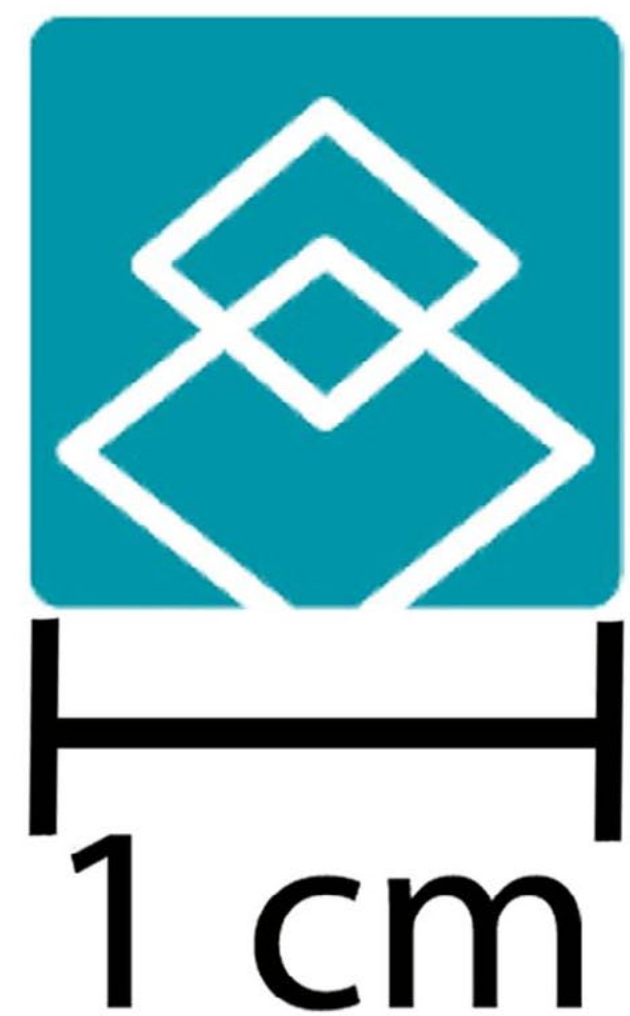
Auxiliary Board (Sides 1 & 2)



Other Substrates

Auxiliary Board (Sides 1 & 2 ICs)

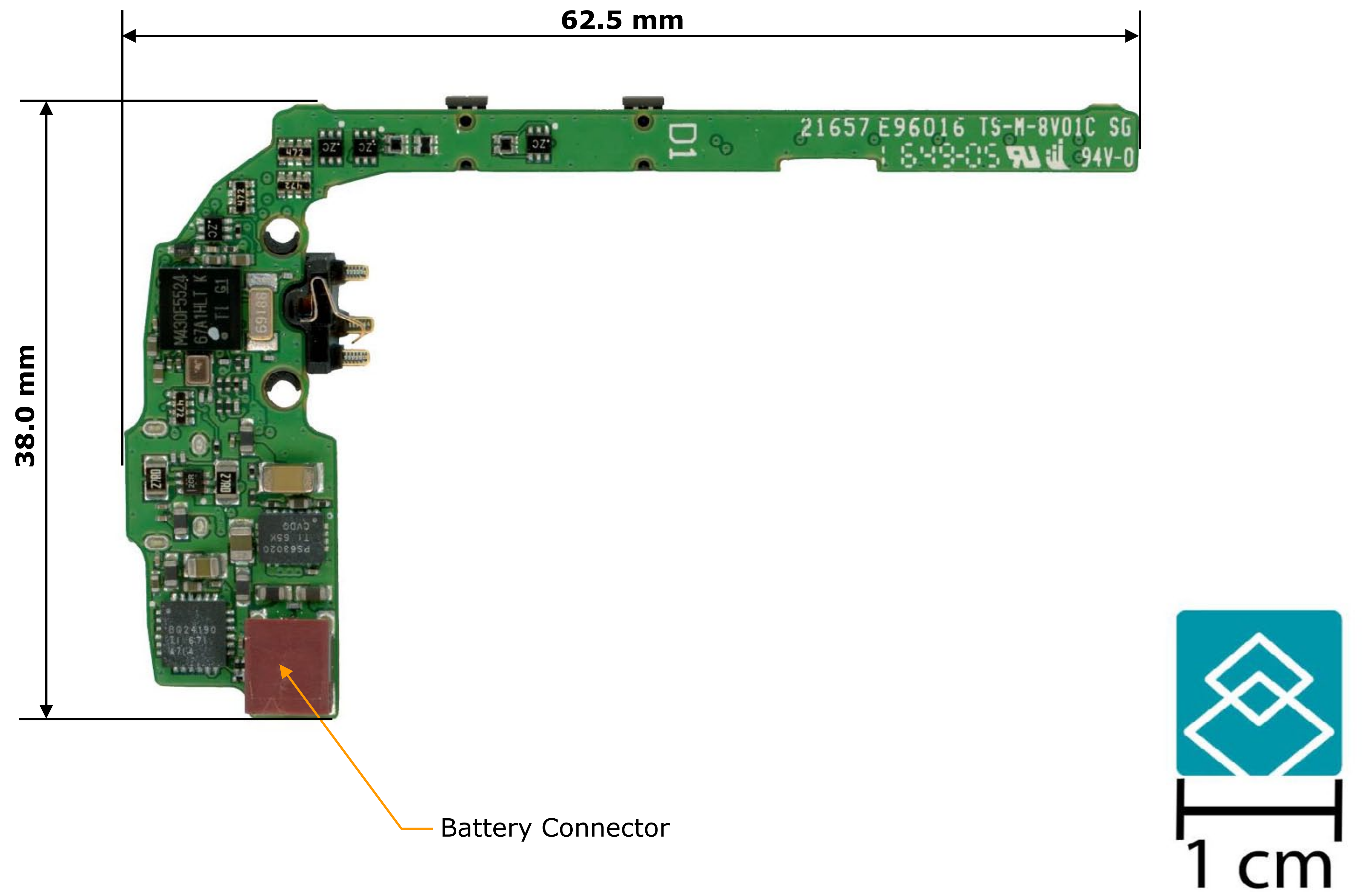




Function:
Other

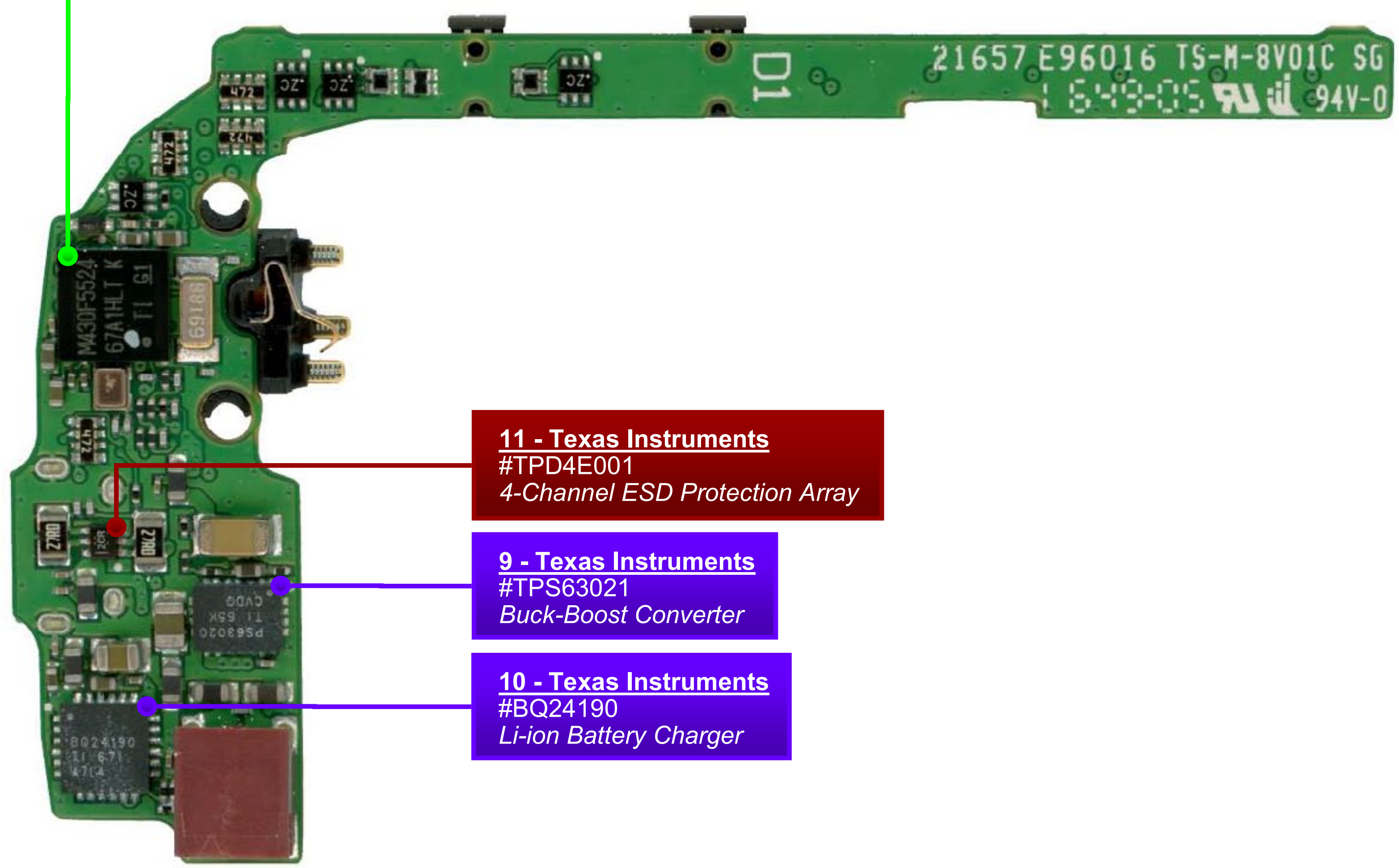
Other Substrates

Charger Main Board (Side 1)



Other Substrates

Charger Main Board (Side 1 ICs)



8 - Texas Instruments
#MSP430F5524
16-Bit Mixed-Signal Microcontroller

11 - Texas Instruments
#TPD4E001
4-Channel ESD Protection Array

9 - Texas Instruments
#TPS63021
Buck-Boost Converter

10 - Texas Instruments
#BQ24190
Li-ion Battery Charger

Function:
- Mixed Signal
- Other
- Power Management / Audio

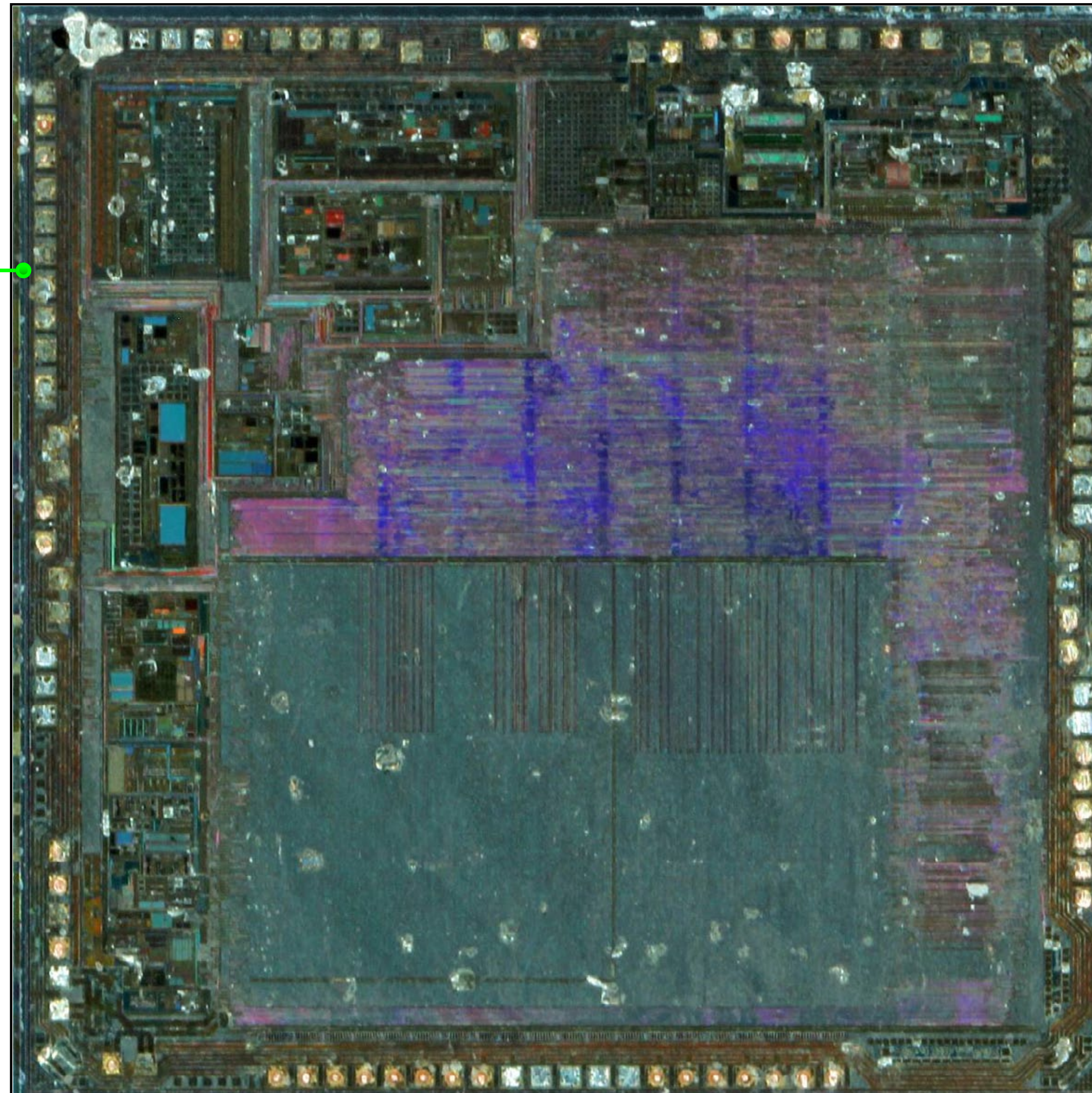
1 cm

Other Substrates

Charger Main Board (Side 1 Die Photos)

8 - Texas Instruments
#MSP430F5524
16-Bit Mixed-Signal Microcontroller
Pkg. Size: 5 x 5 mm

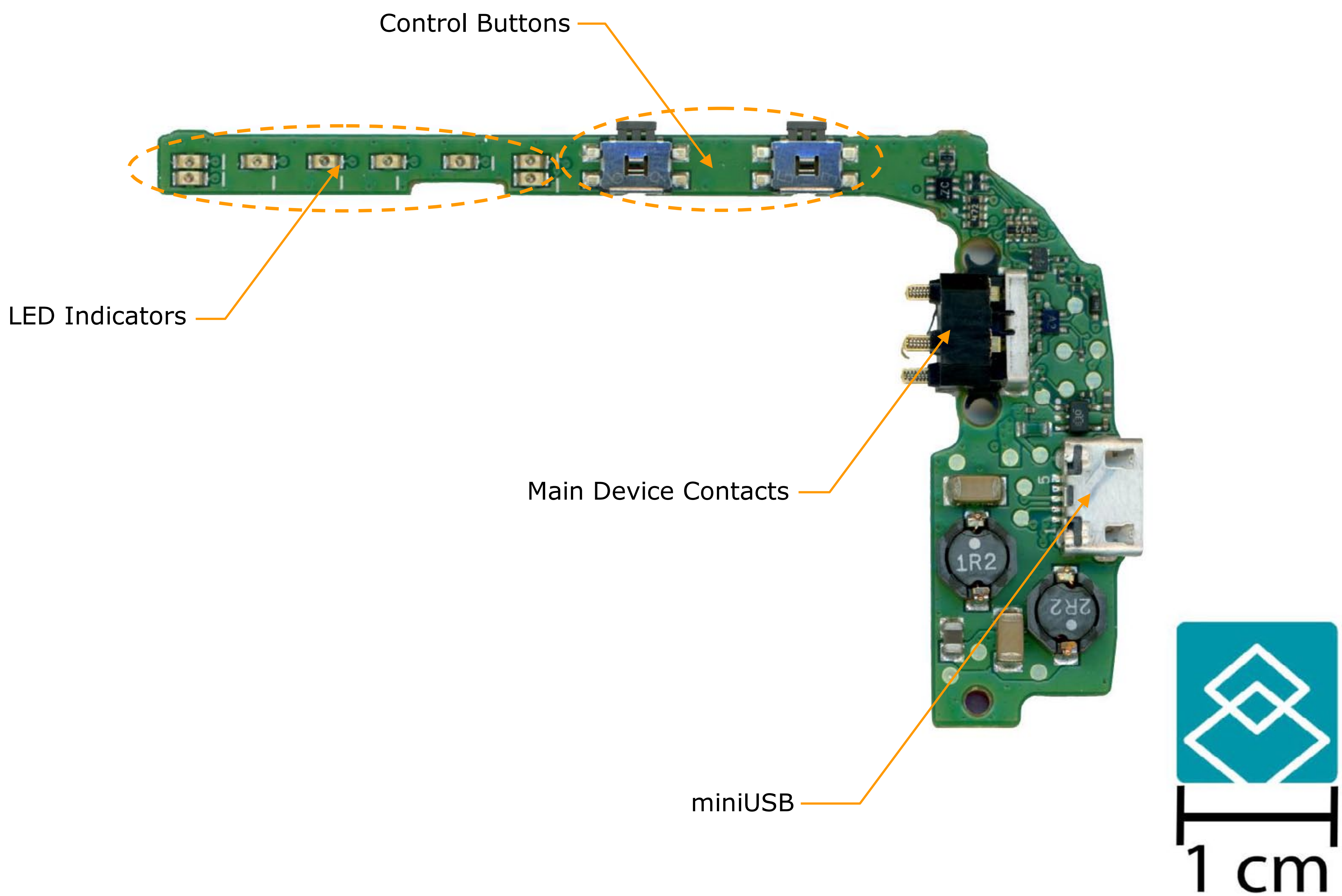
8.1 - Texas Instruments
#MSP430F5529K
16-Bit Mixed-Signal Microcontroller
Die Size: 3.78 x 3.77 mm



Function:
Mixed Signal

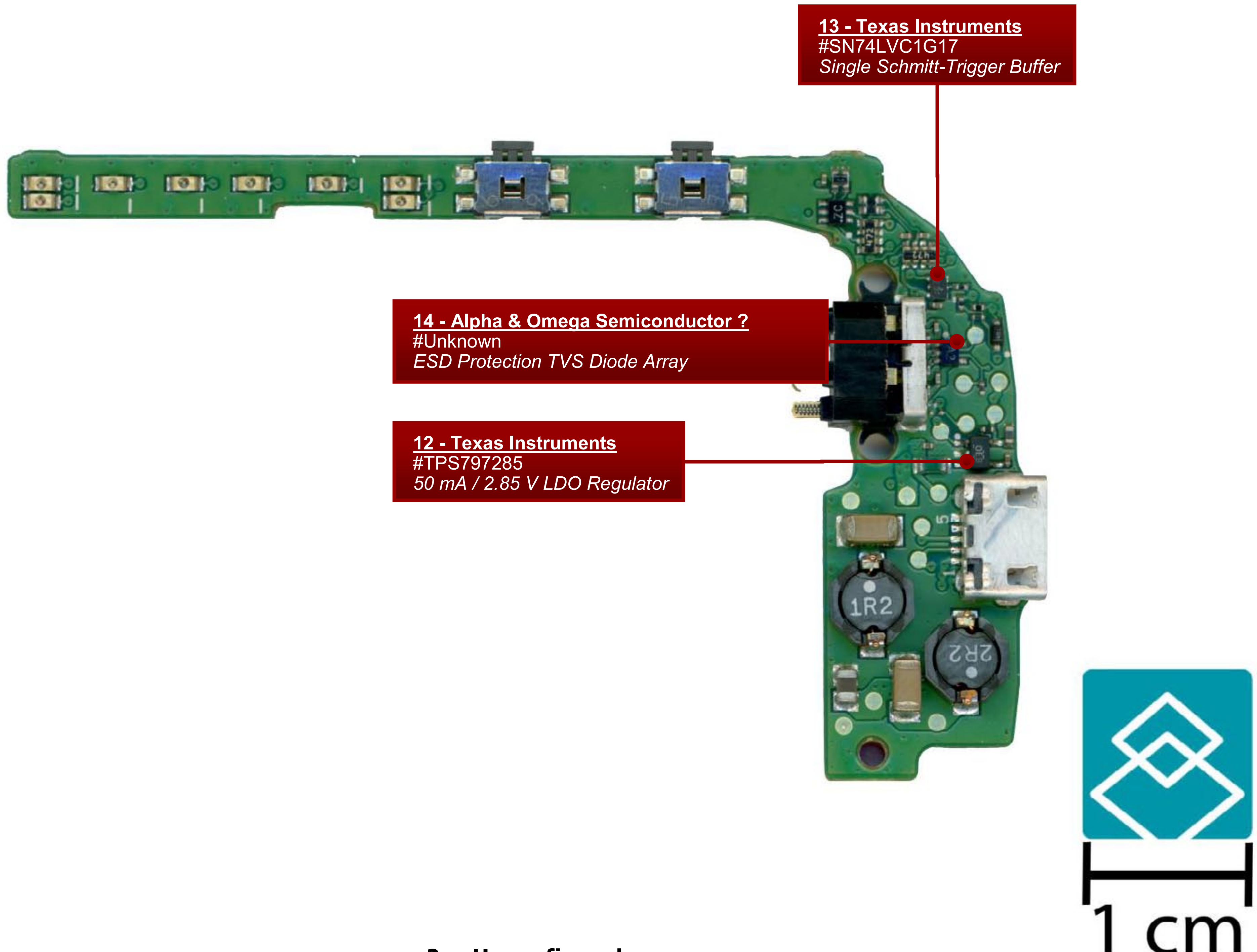
Other Substrates

Charger Main Board (Side 2)



Other Substrates

Charger Main Board (Side 2 ICs)

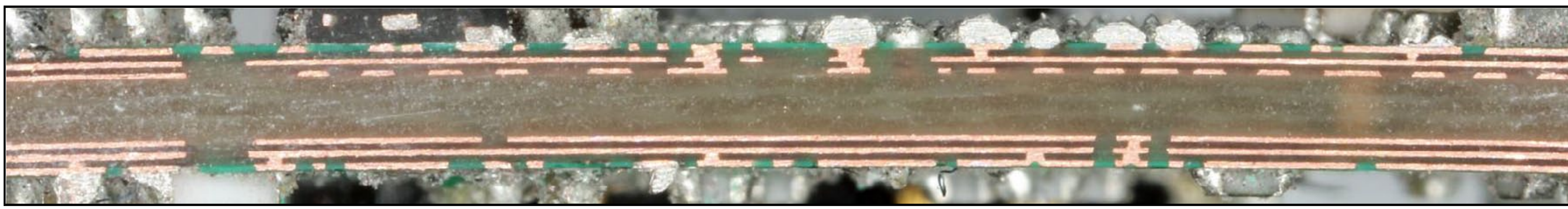


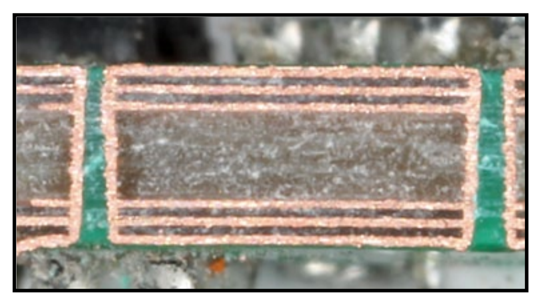
Function:
Other

? = Unconfirmed

Other Substrates

Charger Main Board Cross-Section





Summaries

Substrate Data

Substrates														
Assembly Name	Manufacturer	Core Material	Mfg. Technology	Layers	Area (cm²)	Min. Trace Pitch (mm)	Min. Trace Width (mm)	ThruVia Land Dia (mm)	ThruVia Hole Dia (mm)	BlindVia Land Dia (mm)	BlindVia Hole Dia (mm)	Thickness (mm)	Routing Density	Estimated Costs
Main Board	Unknown	FR4	6 Layer Buildup FR4 / HF	6	1.8	0.30	0.10	0.60	0.20	0.30	0.00	1.6	56.8	$ 0.10
Auxilary Board	Unknown	FR4	4 Layer Conventional FR4 / HF	4	0.7	0.60	0.20	0.40	0.20			1.6	29.8	$ 0.01
Charger Main Board	Topsearch Printed Circuits (HK) LTD	FR4	6 Layer Buildup FR4 / HF	6	5.7	0.20	0.10	0.55	0.22	0.25	0.00	1.0	49.0	$ 0.31

Summaries

Electronic Assembly Metrics

Electronic Assembly Metrics by Assembly											
General Area	Assembly Name	Substrate Area (sq.cm)	Metal Layers	Circuit Area (sq.cm)	Routing Density (cm of routing per sq.cm of substrate)	Number of Components	Number of Connections	Component Density (Components/sq.cm)	Connection Density (Connections/sq.cm)	Avg. Pin Count	Assembly Weight (grams)
Main Electronics	Auxilary Board	0.70	4	2.8	29.8	13	30	18.6	42.9	2.3	0.03
Main Electronics	Charger Main Board	5.70	6	34.2	49.0	120	427	21.1	74.9	3.6	3.20
Main Electronics	Main Board	1.80	6	10.8	56.8	67	208	37.2	115.6	3.1	0.80
Main Electronics Totals		**8.20**	**16**	**47.8**		**200**	**665**	**24.4**	**81.1**	**3.3**	**4.03**
Subsystem Electronics	Battery Subsystem: Battery Board	1.80	2	3.6	19.8	10	28	5.6	15.6	2.8	0.60
Subsystem Electronics Totals		**1.80**	**2**	**3.6**		**10**	**28**	**5.6**	**15.6**	**2.8**	**0.60**
System Totals		**10.0**	**18.0**	**51.4**		**210**	**693**	**21.0**	**69.3**	**3.3**	**4.63**

NOTE: Occasional inconsistencies in totals may be present due to rounding error.

Summaries

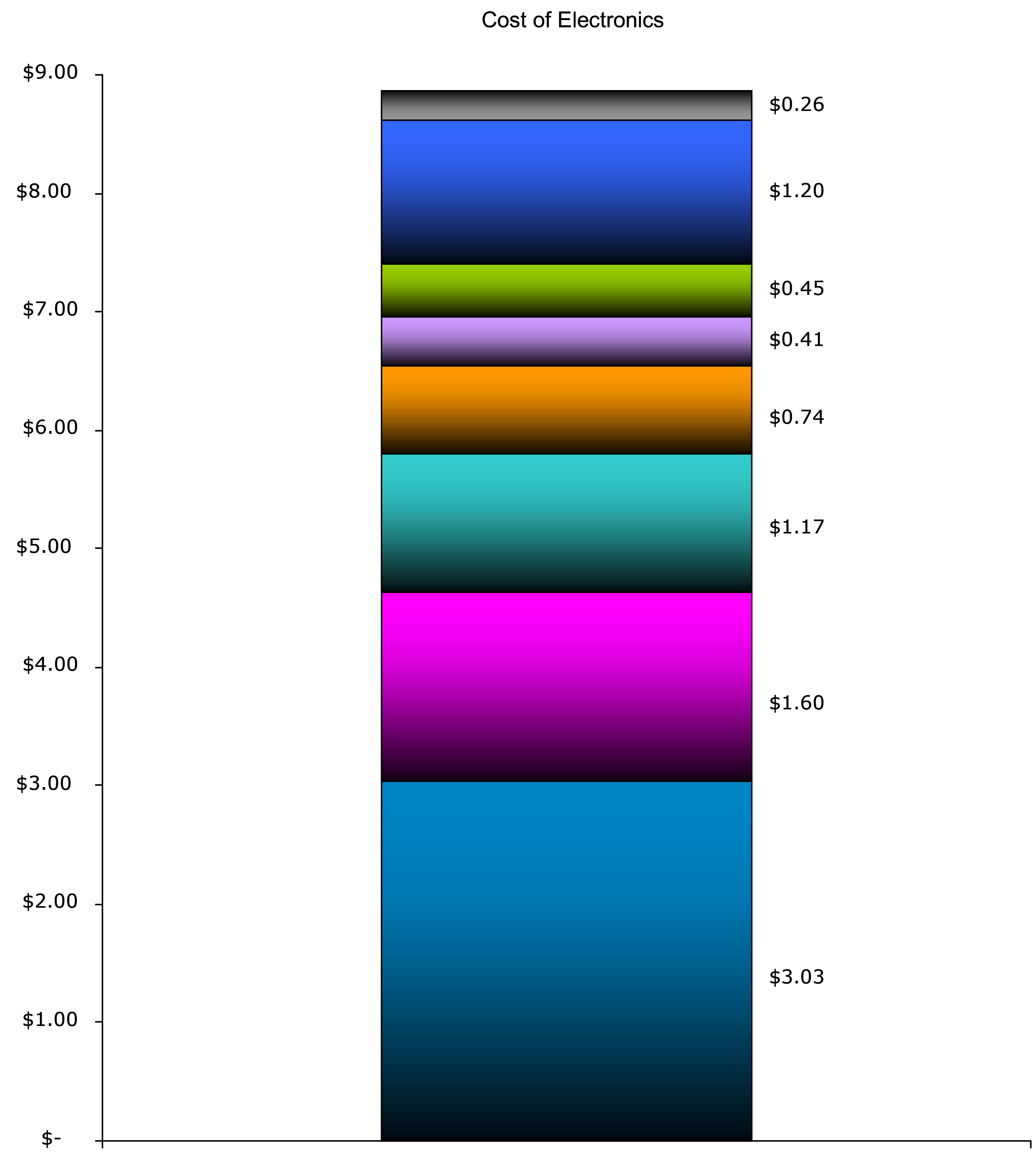
Electronic Cost by Assembly

Electronics Costs by Assembly										
General Area	Assembly Name	Total	Integrated Circuits	Modular & Odd Form Components	Small Active Components	Passive Components	Connector Components	Substrates	Insertion	Card Test
Main Electronics	Auxilary Board	$ 0.31	$ 0.06	$ -	$ 0.13	$ 0.03	$ -	$ 0.01	$ 0.06	$ 0.01
Main Electronics	Charger Main Board	$ 4.81	$ 1.81	$ 0.54	$ 0.58	$ 0.49	$ 0.26	$ 0.31	$ 0.67	$ 0.15
Main Electronics	Main Board	$ 3.29	$ 1.11	$ 1.06	$ 0.37	$ 0.19	$ 0.02	$ 0.10	$ 0.37	$ 0.05
Main Electronics Totals		**$ 8.40**	**$ 2.98**	**$ 1.60**	**$ 1.08**	**$ 0.72**	**$ 0.28**	**$ 0.42**	**$ 1.11**	**$ 0.21**
Subsystem Electronics	Battery Subsystem	$ 0.47	$ 0.05	$ -	$ 0.09	$ 0.02	$ 0.13	$ 0.03	$ 0.10	$ 0.05
Subsystem Electronics Totals		**$ 0.47**	**$ 0.05**	**$ -**	**$ 0.09**	**$ 0.02**	**$ 0.13**	**$ 0.03**	**$ 0.10**	**$ 0.05**
System Totals		**$ 8.87**	**$ 3.03**	**$ 1.60**	**$ 1.17**	**$ 0.74**	**$ 0.41**	**$ 0.45**	**$ 1.20**	**$ 0.26**

NOTE: Occasional inconsistencies in totals may be present due to rounding error.

Summaries

Electronic Component Costs



Estimated Cost of Electronics
(Includes Subsystem Electronics)
$8.87

- Card Test
- Insertion
- Substrates
- Connector Components
- Passive Components
- Small Active Components
- Modular & Odd Form Components
- Integrated Circuits

Summaries

Electronic Counts by Assembly

Counts by Assembly

General Area	Assembly Name	IC Package Count	IC Connections	Modular/Odd Form Components	Modular/Odd Form Component Connections	Small Active Components	Small Active Component Connections	Passive Components	Passive Component Connections	Connectors	Connector Connections	Subsystem IOs	Opportunities
Main Electronics	Auxilary Board	1	5	0	0	4	9	8	16	0	0	0	43
Main Electronics	Charger Main Board	7	124	4	14	15	50	91	228	3	11	0	547
Main Electronics	Main Board	7	76	3	8	9	27	47	96	1	1	0	275
Main Electronics Totals		**15**	**205**	**7**	**22**	**28**	**86**	**146**	**340**	**4**	**12**	**0**	**865**
Subsystem Electronics	Battery Subsystem	1	6	0	0	1	8	5	10	3	4	2	40
Subsystem Electronics Totals		**1**	**6**	**0**	**0**	**1**	**8**	**5**	**10**	**3**	**4**	**2**	**40**
	System Totals	**16**	**211**	**7**	**22**	**29**	**94**	**151**	**350**	**7**	**16**	**2**	**905**

NOTE: Occasional inconsistencies in totals may be present due to rounding error.

Summaries

IC Metrics

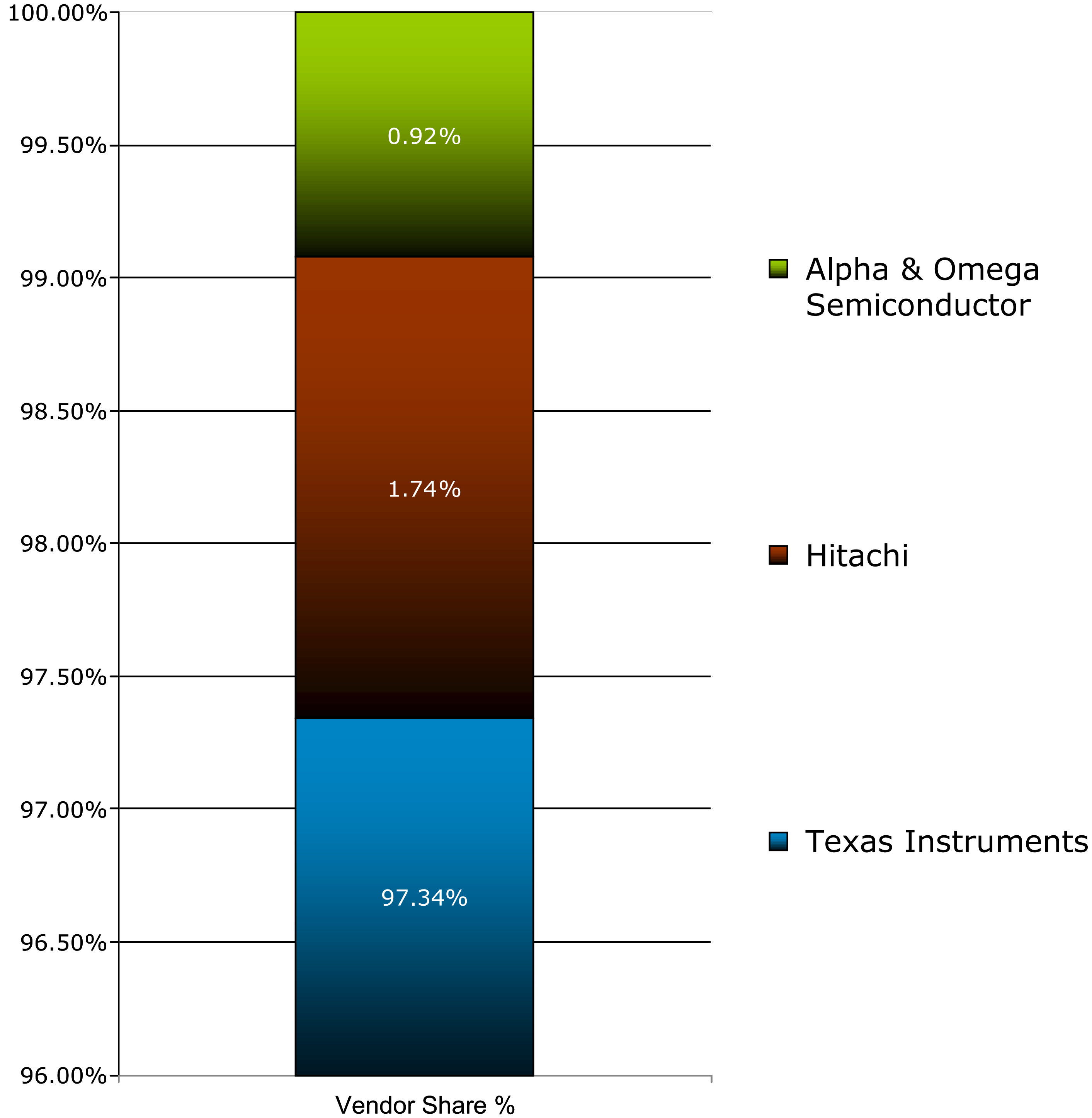
IC Metrics											
General Area	Assembly Name	IC Die Count	IC Package Count	Number of Package Connections	Die Area (sq.mm)	Substrate Tiling Density (die area / substrate area)	Package Area (sq.mm)	Die Area/Package Area Ratio	Package Connections per sq.cm of Package Area	Volatile Memory (KBytes)	Non-Volatile Memory (KBytes)
Main Electronics	Auxilary Board	1	1	5	0.7	0.01	2.8	0.27	181.4	0	0
Main Electronics	Charger Main Board	7	7	124	26.6	0.05	60.6	0.44	204.6	0	0
Main Electronics	Main Board	7	7	76	16.7	0.09	20.6	0.81	369.8	0	0
Main Electronics Totals		**15**	**15**	**205**	**44.0**		**83.9**	**0.52**	**244.3**	**0**	**0**
Subsystems	Battery Subsystem	1	1	6	0.6		2.0	0.29	3.0	0	0
Subsystem Electronics Totals		**1**	**1**	**6**	**0.6**		**2.0**	**0.29**	**300.0**	**0**	**0**
	System Totals	**16**	**16**	**211**	**44.6**		**85.9**	**0.52**	**245.6**	**0**	**0**

NOTE: Occasional inconsistencies in totals may be present due to rounding error.

Summaries

IC Manufacturer Distribution

Pkg. Brand	Cost
Texas Instruments	$2.95
Hitachi	$0.05
Alpha & Omega Semiconductor	$0.03



NOTE: Occasional inconsistencies in totals may be present due to rounding error.

Summaries

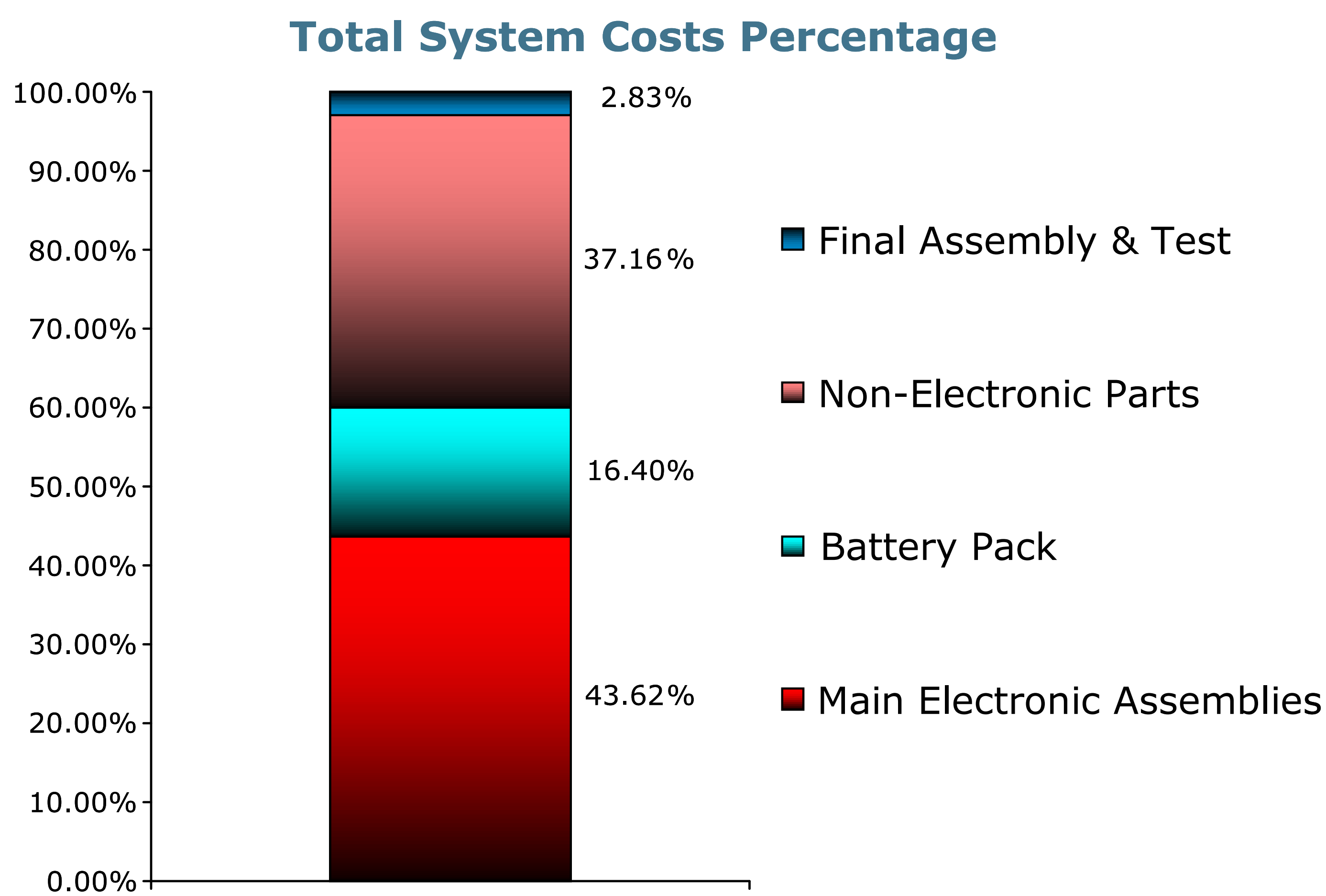
Non-Electronic Cost

Subsystem	Part ID No.	Qty	Description	Fabrication Process	Material	Dimensions (mm)	Total Weight (grams)	Est'd Cost Each	Est'd Extended Cost
Device Main Enclosures	1	1	Long Enclosure	Molded + Pulls + Painted	Plastic	54.3 x 14.95 x 14	3.10	$0.660	$0.660
	2	1	Short Enclosure	Molded + Pulls + Painted + Printed	Plastic	37.2 x 14.6 x 13.9	1.70	$0.610	$0.610
	3	1	Internal Enclosure	Extruded + Machined + Painted + Printed	Aluminum	74.3 x 12 x 11.9	2.30	$0.440	$0.440
Device Miscellaneous	4	1	Internal Support	Stamped + Formed + Co-Molded + Pulls	Metal + Plastic	65 x 11.6 x 11.15	2.60	$0.480	$0.480
	5	1	Cigarette Holder	Molded + Pulls	Plastic	26 x 11.5 x 11.5	0.60	$0.430	$0.430
	6	1	Enclosure Support	Molded + Painted	Plastic	13.9 x 13.7 x 4.8	0.10	$0.020	$0.020
	7	1	Button	Molded + Painted	Plastic	31.3 x 9.6 x 5.9	0.20	$0.020	$0.020
	8	1	Light Guide	Molded	Plastic + Adhesive	10 x 5.65 x 5	0.10	$0.020	$0.020
	9	1	Metal Support	Stamped + Formed	Metal	10.65 x 5 x 3.5	0.12	$0.010	$0.010
Charger Main Enclosures	10	1	Top Enclosure	Molded + Pulls + Printed + Painted	PC + ABS	93.4 x 51 x 11.5	8.90	$1.050	$1.050
	11	1	Bottom Enclosure	Molded + Pulls + Printed + Painted	PC + ABS	93.4 x 51 x 11.5	8.80	$1.050	$1.050
	12	1	Internal Enclosure	Molded + Pulls + Painted + Printed	PC + ABS	112.5 x 51 x 18.8	12.40	$0.790	$0.790
	13	1	Top Cover	Molded + Pulls + Heat Staked + Painted	PC + ABS	51.15 x 27.9 x 21.3	5.60	$0.480	$0.480
Charger Miscellaneous	14	1	Battery Holder	Molded + Pulls	Plastic	72.9 x 24.3 x 16.4	4.30	$0.270	$0.270
	15	1	Enclosure Support #1	Molded + Heat Staked	Plastic	33.3 x 19 x 6.15	0.80	$0.070	$0.070
	16	1	Cover Support #1	Molded + Pulls	Plastic	25.3 x 25.2 x 15	1.50	$0.260	$0.260
	17	1	Cover Support #2	Molded	Plastic	25.3 x 25.2 x 7.8	1.40	$0.050	$0.050
	18	1	Cover Lock Button	Stamped + Formed + Co-Molded + Painted	Metal + Plastic	22.2 x 11.7 x 15.5	0.50	$0.100	$0.100
	19	1	Metal Support	Stamped + Formed	Metal	28.2 x 7.5 x 4.3	0.20	$0.040	$0.040
	20	1	Light Guides	Molded + Co-Molded	Plastic	26.2 x 5 x 4	0.30	$0.020	$0.020
	21	1	Enclosure Support #2	Molded	Plastic + Adhesive	32 x 28 x 8.4	0.50	$0.020	$0.020
	22	1	LED Cover	Molded + Painted	Plastic + Adhesive	54.2 x 8.4 x 0.5	0.30	$0.050	$0.050
	23	1	Spring	Extruded + Formed	Metal	22.1 x 9.6 x 2.4	0.30	$0.020	$0.020
	24	1	Buttons	Molded + Painted + Printed	Plastic	16.4 x 7.4 x 1.9	0.10	$0.030	$0.030
	25	1	Gear	Molded	Plastic	6.8 x 6.8 x 3	0.10	$0.010	$0.010
	26	1	Gear Stick	Molded	Plastic	19 x 10 x 5.5	0.30	$0.100	$0.100
	27	2	O-Ring	Molded	Rubber	3 x 3 x 0.5	0.02	$0.010	$0.020
	28	2	Short Foam Tape	Die-Cut	Plastic + Adhesive	26 x 5.3 x 0.8	0.40	$0.010	$0.020
	29	1	Long Foam Tape	Die-Cut	Plastic + Adhesive	64 x 5.3 x 0.8	0.40	$0.020	$0.020
Total		**31**						**Estimated Cost**	**$7.16**

TechInsights

Summaries

Assembly Cost Total



Estimated Cost Totals		
Main Electronic Assemblies	$	8.40
Battery Pack	$	3.16
Non-Electronic Parts	$	7.16
Final Assembly & Test	$	0.55
Total	**$**	**19.27**

Note: An additional $3.21 estimated for accessories and supporting materials

Cost Total Notes:
Estimated final assembly cost includes labor only.
Total cost does not include Non-recurring, R&D, G&A, IP licensing fees/royalties, software, sales & marketing, distribution.
Assumes fully scaled production.

Final Assembly & Test		
Made in	Malaysia	
Number of parts	38	
Est'd number of steps	122	
Est'd time (seconds)	414	
Est'd final assembly cost	$	0.35
Est'd final test cost	$	0.20

COST ESTIMATION PROCESS

Overview and Discussion

Cost modeling is tricky business. Multiple variables affect the actual production costs a manufacturer will experience, including development expenses, unit volumes, supply-and-demand in component markets, die yield-curve maturity, OEM purchasing power, and even variations in accounting practices. Different cost modeling methods employ different assumptions about how to handle these and other variables, but we can identify two basic approaches: that which seeks to track short-term variations in the inputs to the production process, and that which strives to maintain comparability of the output of the model across product families and over time.
TechInsights' philosophy in cost modeling is to emphasize consistency across products and comparability over time, rather than to track short-term fluctuations. During the past eight years, we have developed an estimation process that, while necessarily lacking an insider's knowledge of the cost factors that impact any one manufacturer, is reasonably accurate in its prediction of unit costs in high-volume production environments. We do not claim that the model will produce the "right" answer for your firm's environment. However, TechInsights does give customers a key analytical tool with a complete set of data in our Bill of Materials (BOM). The BOM allows readers to 1) scrutinize the assumptions behind our cost model and 2) modify the results based on substitution of their own component cost estimates where they have better information based on inside knowledge.

Our estimation process decomposes overall system cost into three major categories: Electronics, Mechanical, and Final Assembly. We begin by creating a complete electronics bill-of-materials (BOM). Each component from the largest ASIC to the smallest discrete resistor is entered into a BOM table with identifying attributes such as size, pitch, I/O count, package type, manufacturer, part number, estimated placement cost, and die size (if the component is an IC). Integrated circuit costs are calculated from measured die area. Using assumptions for wafer size, process type, number of die per wafer, defect density, and profit margin in combination with die area, an estimate of semiconductor cost is derived. Costs for discrete components and interconnect are derived from assumption tables which relate BOM line items to specific cost estimates by component type and estimates for part placement costs are included. For LCD display costs, we employ a model which tabulates expected cost from measurements of glass area, LCD type, and total pixel resolution. When market costs are available from alternative sources, LCD panel costs are taken from and referenced to these sources.

Costs of non-electronic components such as molded plastic enclosures and metallic components are measured in terms of weight, size, thickness, type of material, and complexity to arrive at their estimated cost. Other system items such as optics, antennas, batteries and displays are costed from a set of assumption tables derived from a combination of industry data, average high volume costs, and external sources. For final assembly, we re-build the torn-down product, tabulating stepwise assembly times as the reconstruction proceeds, to reach a total assembly time. Using a labor rate assumption for the country of origin, we then calculate final assembly cost.

The three major categories for system cost contributors can be broken down into the subcategories of ICs, other electronics parts, displays, batteries (as appropriate), camera modules, electronics assembly, non-electronic elements, and final assembly. By adding the cost estimates for each of these subcategories, an overall estimated cost is derived for the system under evaluation. Product packaging and accessories (CDs, cables, etc.) are also documented and estimated for their contribution to total cost as appropriate.

We believe our cost estimates generally fall within 15 percent of the "right answer," which itself can vary depending on the market and OEM-specific factors mentioned earlier. While the TechInsights cost model is imperfect, it yields important insights into technology and business dynamics along with good first-order contributions to system cost by component type. Additionally, the consistency of approach and gradual modification to assumptions (smoothing out frequently-shifting pricing factors) hopefully yields a credible, but user-modifiable, view of OEM high volume cost-to-produce.

Please feel free to contact us at support@techinsights.com with any comments, questions, or proposed corrections with respect to our cost estimates. We welcome your input.

Metrics

Overview and Discussion

In our product teardowns, we gather a series of metrics for product profiling and comparison. Some metrics focus on system characteristics such as total silicon area, total system semiconductor storage capacity, and total connection count. Other metrics reflect more subtle aspects of electronics assembly such as connection density, average component I/O count, and silicon tiling density. Taken as a whole, the metrics allow deeper comparison and benchmarking across multiple disciplines and multiple products. Key metrics we gather on products are described below along with their definitions and what they tend to say about the system under study. Most metrics can be used both in comparing similar products for benchmarking purposes or for quantifying differences in levels of complexity between dissimilar product types. Data fall into two categories; either "raw" measured data or ratios of these measured data sets.

Total Silicon Area : This metric describes the total area of silicon as measured from X-ray or direct measurement of ICs. The area is an expression of the enclosed bare die area and excludes packaging area. The aggregate silicon area is a good benchmark to show how integrated a design might be when making comparisons to similar systems. Total silicon area also reflects the major cost driver for most systems we examine.

Silicon Tiling Density : Ratio of Total Silicon Area to total printed circuit board "projected" area (i.e. the simple board area and not the cumulative surface area of both sides of the board). This metric directly reflects the level of efficiency and aggressiveness in integrated circuit packing and placement. Single digit Silicon Tiling Density is typical but silicon coverage of 10% - 20% has been seen in some of the most advanced products we have examined. Higher Tiling Densities often correspond with the use of chip scale packaging (CSPs) or other small form-factor IC packaging technologies. High density circuit boards are also often a supporting technology.

Number of Parts : Total component count including ICs, passives, modules, connectors, etc., each separated out in our reporting.

Number of Connections : The total number of connections corresponds to the total number of interconnects introduced by the aggregate component set and reflects any electrical connection observed (solder joints, adhesive interconnect, or connector terminal interfaces).

Opportunity Count : Opportunity Count is the total number of parts plus the total number of connections; the name reflects that each of these constituent elements represents an opportunity for failure. A high opportunity count means more complex and riskier electronics assembly.

Average Pin Count (APC) : Ratio of total number of component terminals to total number of parts, at the system level. This metric reflects the 'average' terminal complexity of the components and often provide a signature of integration level and/or "digital-ness" of the overall product. Low APCs reflect a high number of discretes or other low-pincount devices often characteristic of analog circuitry. Conversely, high APCs are characteristic of highly integrated, high-pincount assemblies, often those composed largely of digital integrated circuits.

Connection Density : This metric is a ratio of the total Number of Connections to total printed circuit board assembly area, in units of connections per sq. inch. The metric provides data related to the Silicon Tiling Density above, but with an emphasis on complexity of I/O interconnect. For example, with a fixed Connection Density, high tiling density of low-pincount memory chips is more readily achieved than comparable silicon tiling of high pincount logic.

Part Density : This metric is a ratio of the total Number of Parts to total printed circuit board assembly area, in units of components per sq. inch. The metric provides data related to the Silicon Tiling Density and Connection Density as described above, but with an emphasis on density and complexity of component packing efficiency. For example, low Part Density of high-pincount devices can pose an equal challenge in Connection Density to high Part Density of low-pincount devices. High Part Density does reflect challenges in surface mount assembly in terms of (typically) precision of placement, number of placements, and engineering of part clearances.

Routing Density (heuristic estimate) = $3 \cdot (\text{Average Pin Count}) \cdot \sqrt{\text{Part Density}}$. The Routing Density metric is an empirically derived relationship that characterizes the wiring density of the interconnect used to support the interconnection of components in a planar electronic assembly (i.e. the circuit board). Architectural issues such as bussing or other factors affecting the regularity of wiring impact the actual Routing Density needed to support a given application, but the metric provides a ready measure of wiring complexity.

Revisions

Overview and Discussion

Periodically we will make revisions to these reports. In the event a revision is made, the information below may be referenced as a summary of the changes which were made.

Rev. D - Initial Release