EEE 163
System Design Analysis

Lecture 3 – Worked Example

Dr Gavin Williams
Room F167, Mappin Building
g.williams@sheffield.ac.uk

Cheapo Wrist Watch

Quiz!

How many different* components does this product contain?

A	< 10
B	11- 25
C	26- 50
D	51 - 80
E	> 80

(* Multiple-copies count as one component)

Initial Product Analysis

Appearance: Wrist watch

Package: Black plastic case with metal back plate

Primary function: Chronometer (i.e. measuring time)

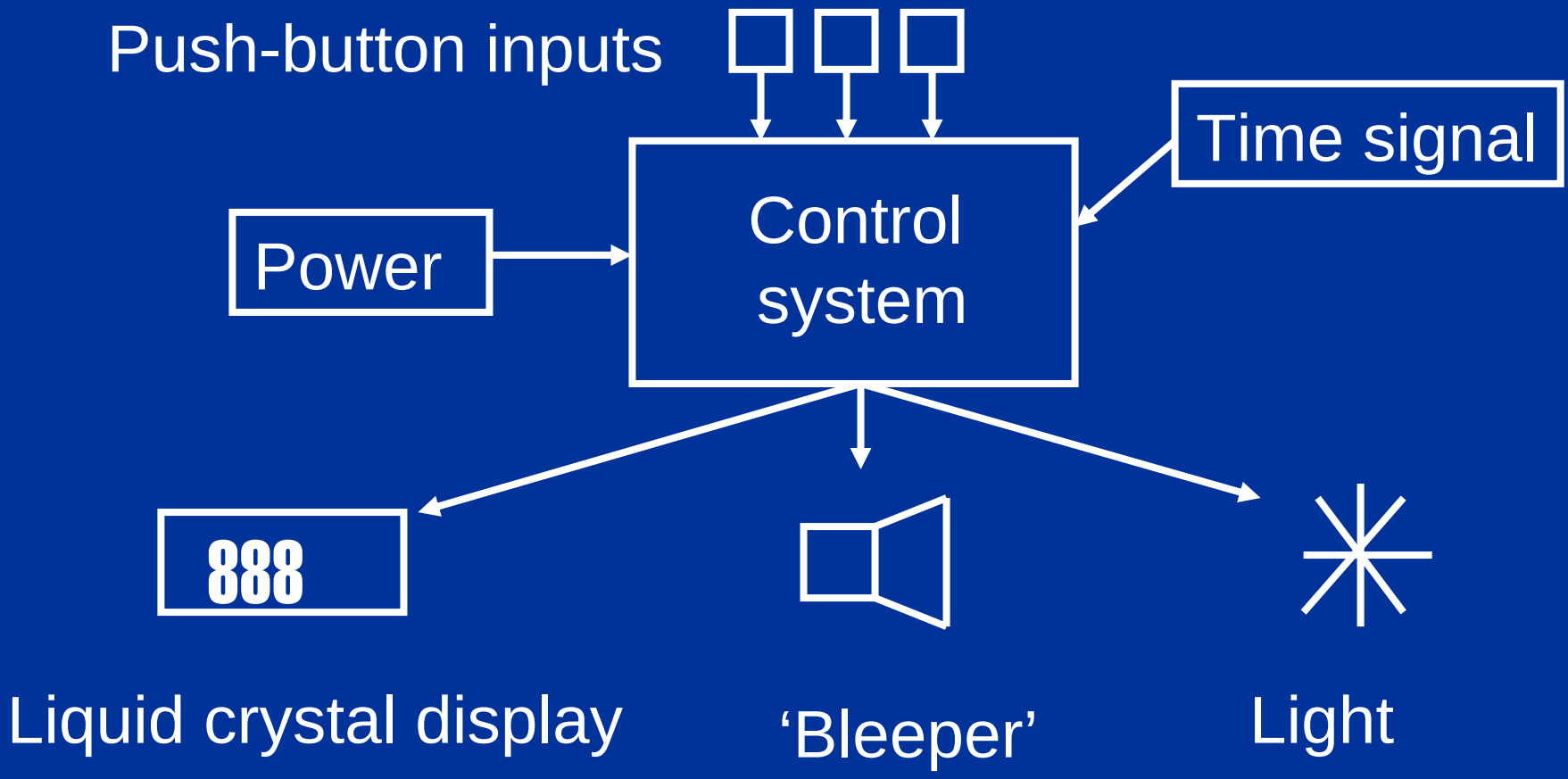
Method: Time signal + electronics

Secondary functions: Alarm, light

Methods: - unknown until we take the lid off!

Power: No socket visible, therefore battery-powered

Initial System Diagram



Packaging

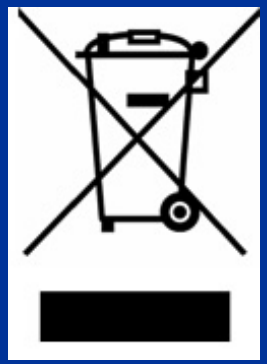
Product identification:

'Casio W-741'

'Water resistant'

'Made in Malaysia'

The ID should be visible before any disassembly is necessary



All recent electronics products will also have this symbol, indicating that it should *not* be added to the general waste stream

Lid off

Back plate

Screws x4

Gasket
(recall: ‘100m water resistant’)

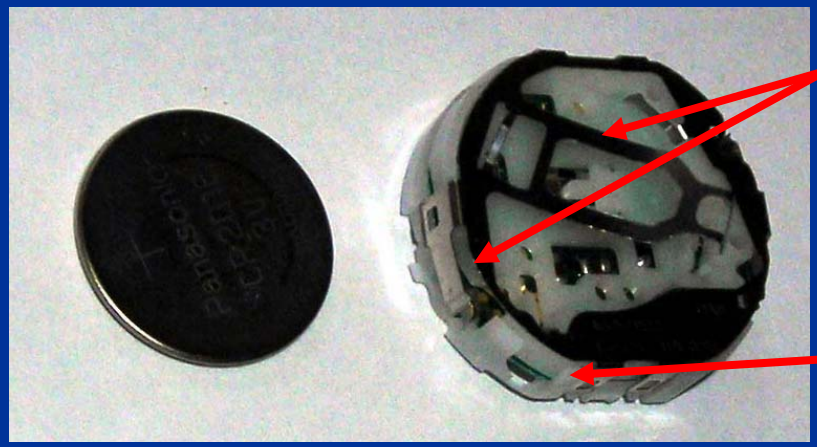
Battery, held by clip

Battery

Battery:

‘Panasonic CR2016 3V’

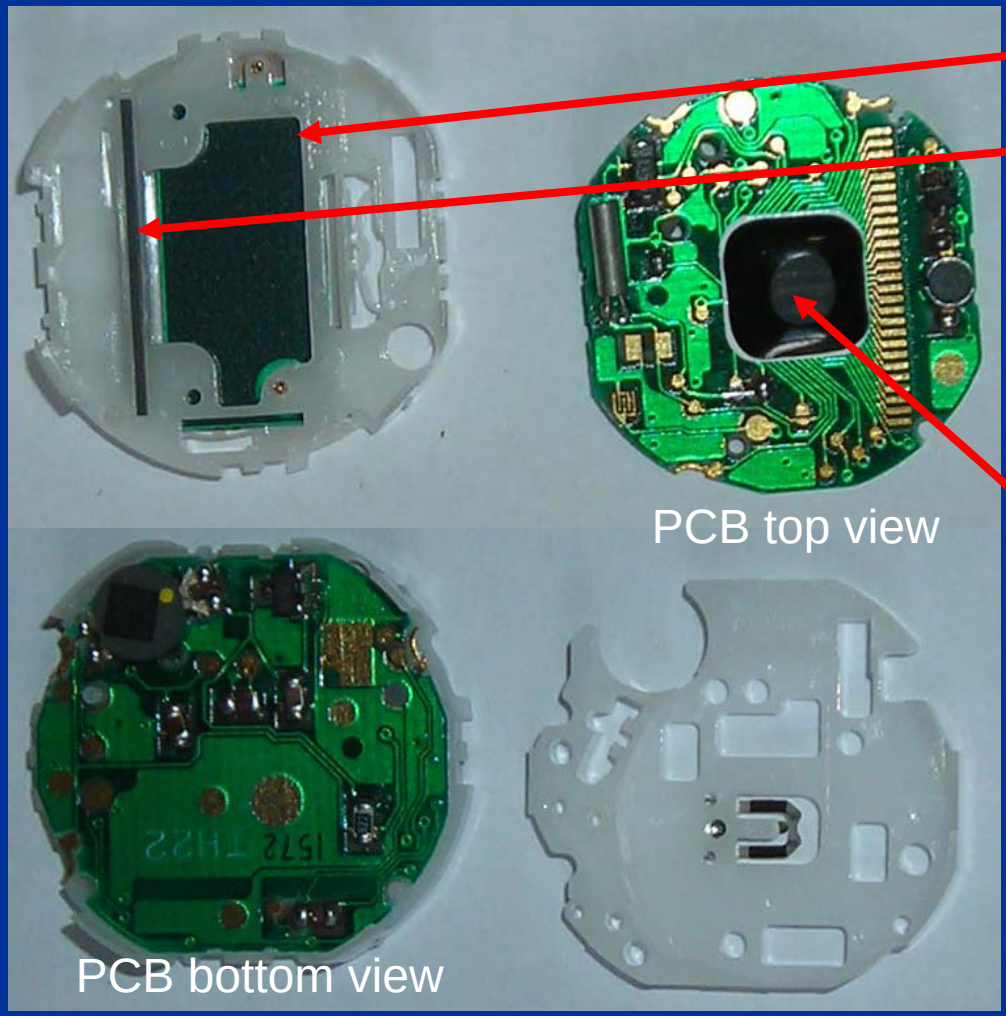
- easy to remove (i.e. replaceable item)



Clip makes battery and push-button contacts

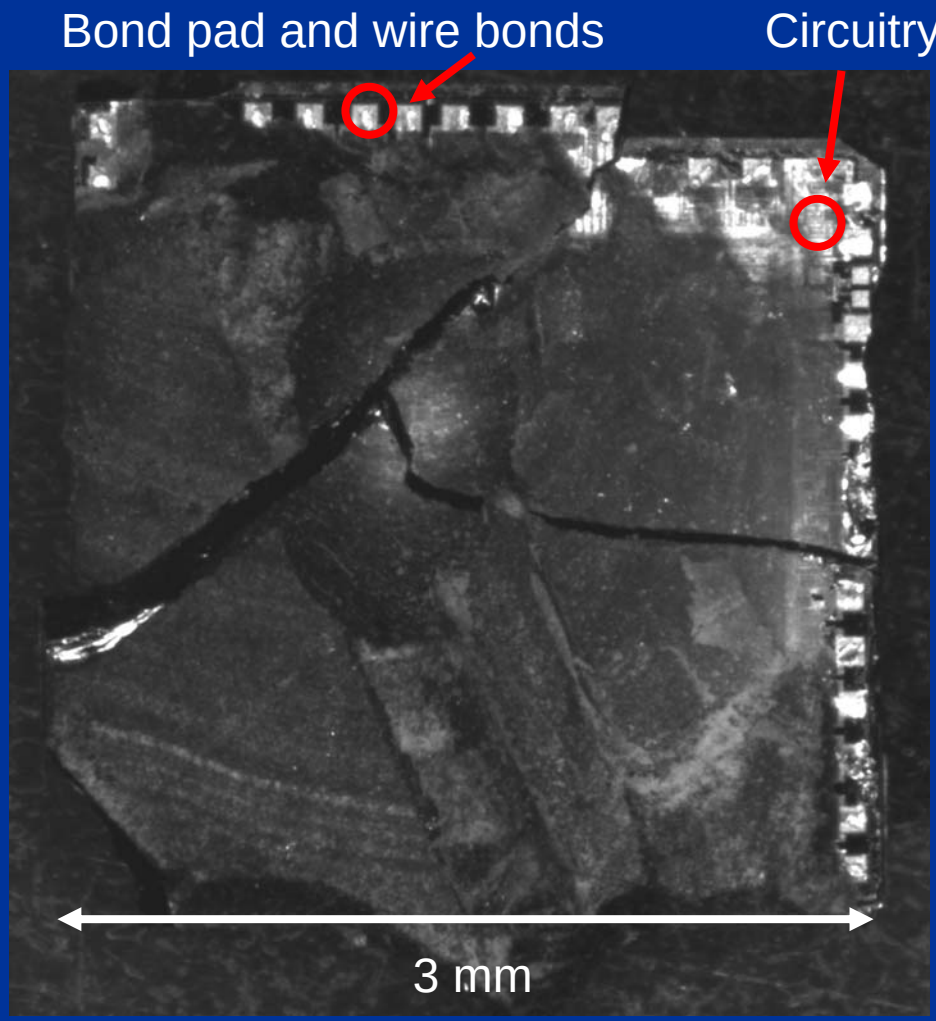
Plastic inner-housing

Inner case disassembly



- Display screen
- Electrical connector
- Printed circuit board
  - electrical tracks and pads
  - blob of epoxy (hiding the chip)
  - various other discrete electrical components

Silicon chip

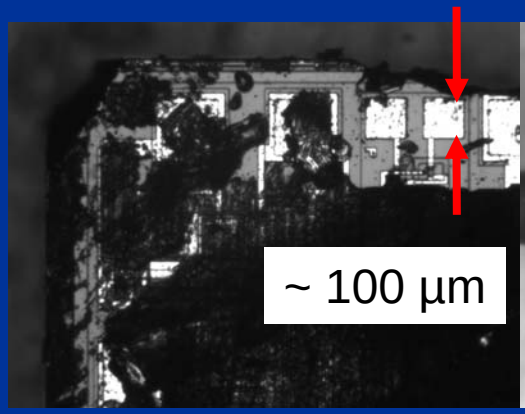


Partially exposed chip after attempted removal of epoxy resin

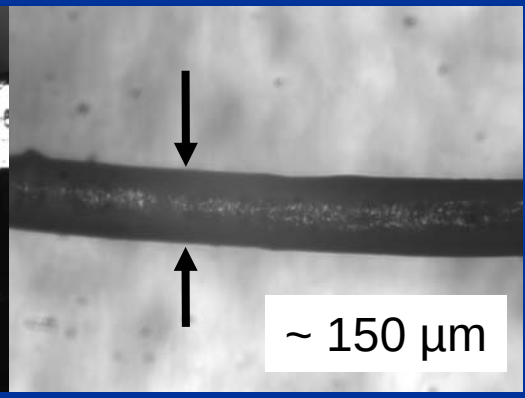
If more successful, part number may become visible…

… but even partial removal can reveal a lot of detail…

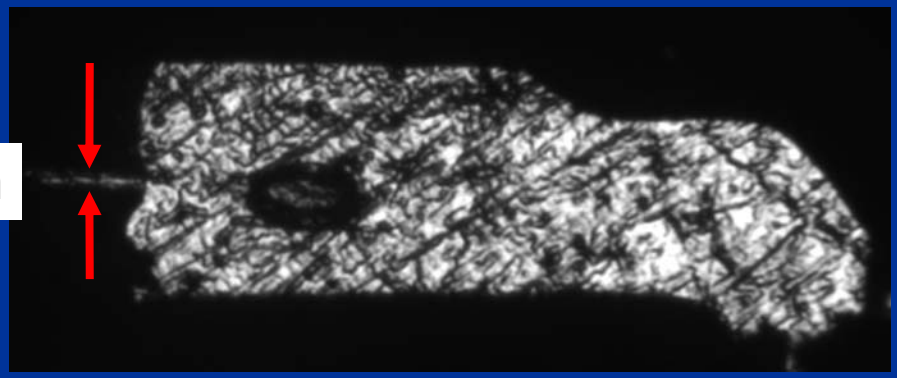
Chip bond pads



Bond pads (gold finish)

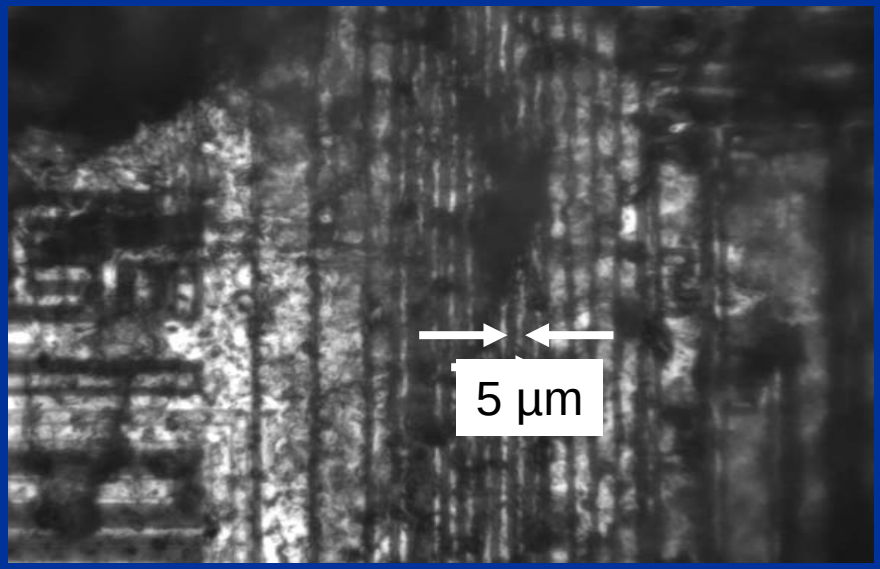


Human hair (same scale)

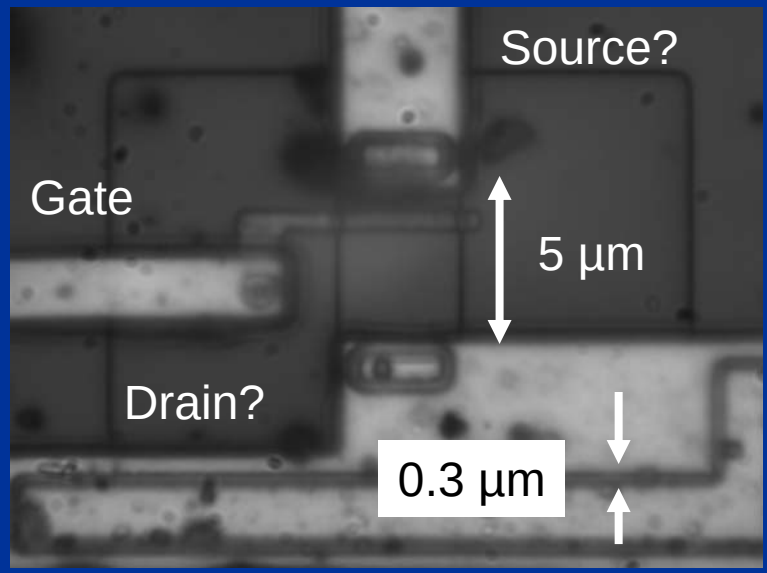


Gold wire bond from chip to PCB pad

Chip Circuitry



Chip routing (i.e. metal tracks)



Transistor (i.e. semiconductor)
0.3 µm minimum feature size (?)

An aside …

Step 4 Edit

- Pentalobe Screws, again? We were somewhat hoping there would be something new to keep us out this year, but it seems like our familiar friends have not moved far from their home at the bottom of the iPhone 4S.
- A couple quick turns with our 5-Point Pentalobe Screwdriver and out they come! And guess what: our all-new pro driver was just released today. It comes in a great blue/black color, and it's guaranteed to be the best Pentalobe driver on the market. Hey, it's not like we haven't done this before.
- *Sorry, Siri. Despite your self-destruction threat, we will not be deterred. Let's see what you're hiding.*

Step 5 Edit

- We continue to tread largely familiar waters as we remove the back cover, the same way we did with the iPhone 4, and reveal the battery along with a mess of padded EMI shields.
- "I must implore you not to go any further, iFixit. You do not have proper authorization," Siri firmly asserts.
- Unfortunately, we have to stop here since the tag says "Authorized Service Provider Only."
- Psych! That silly tag hasn't stopped us before, and today is no different.

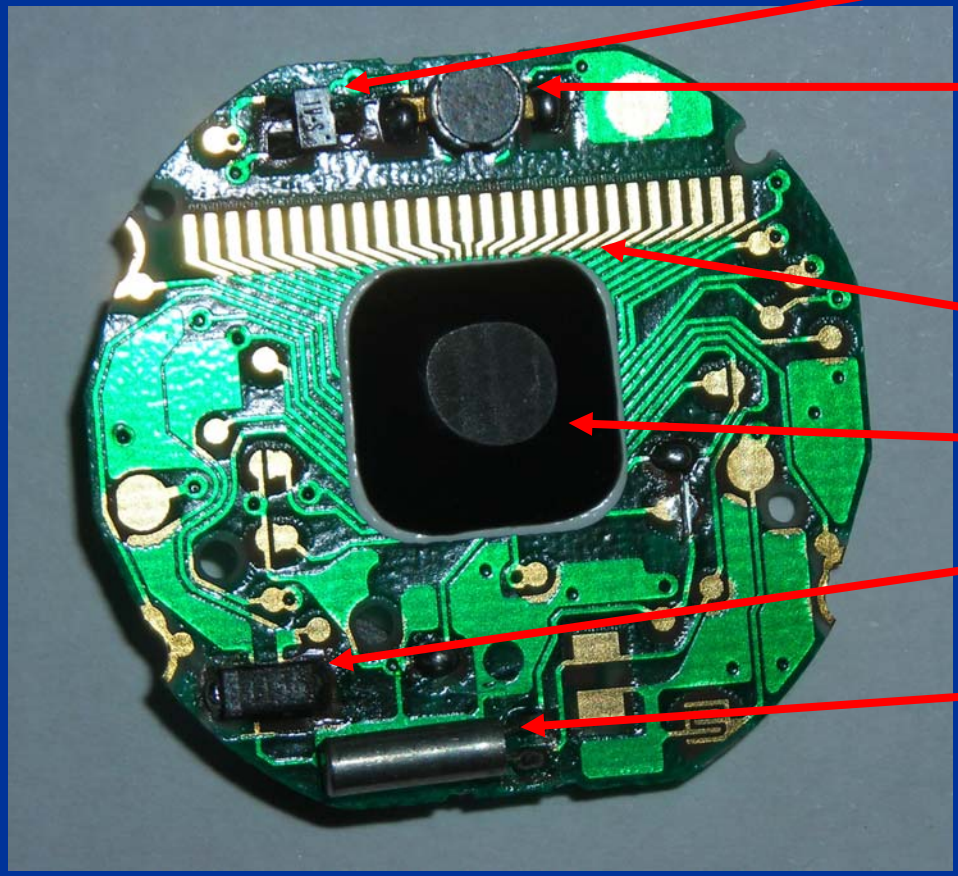
Plenty of free resource on the web: e.g. iPhone 4s ‘teardown’
(http://www.ifixit.com)

Commercial companies also do it, e.g.:

chipworks
inside technology

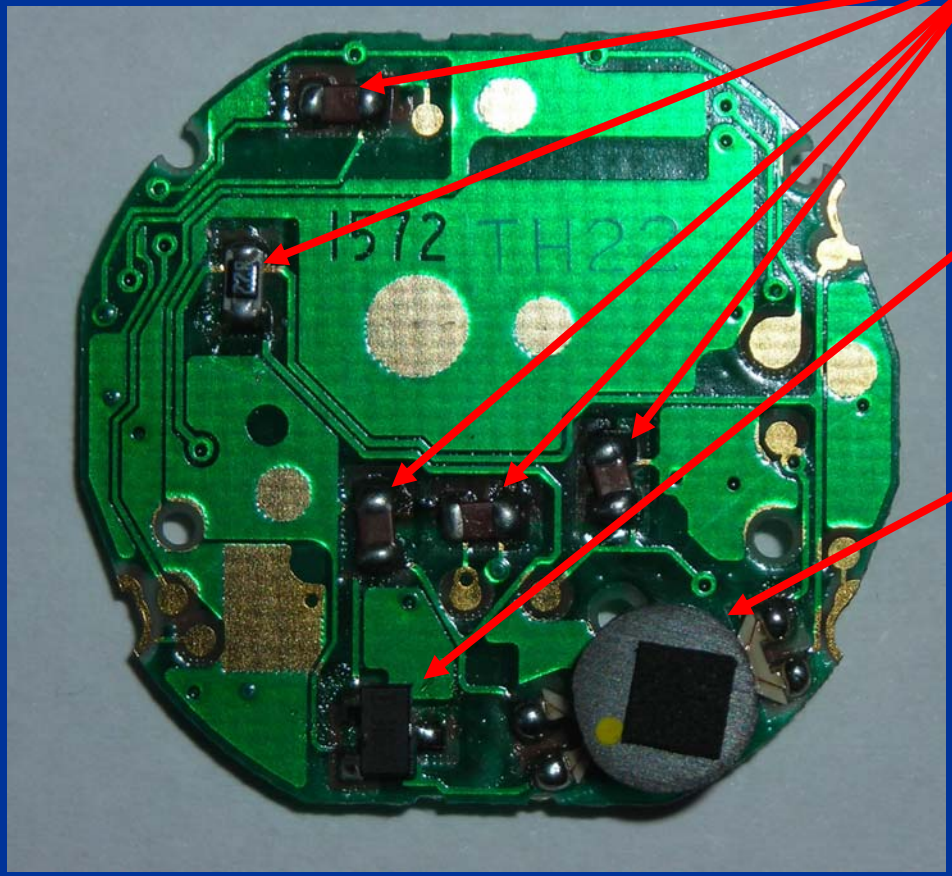
‘the recognized leader in reverse engineering and patent infringement analysis of semiconductors and electronic systems’

PCB – top surface



- Power transistor
- Piezo-oscillator (‘bleeper’)
- Display contact pads
- ‘Glob-topped’ chip
- Capacitor
- Crystal oscillator

PCB - bottom surface

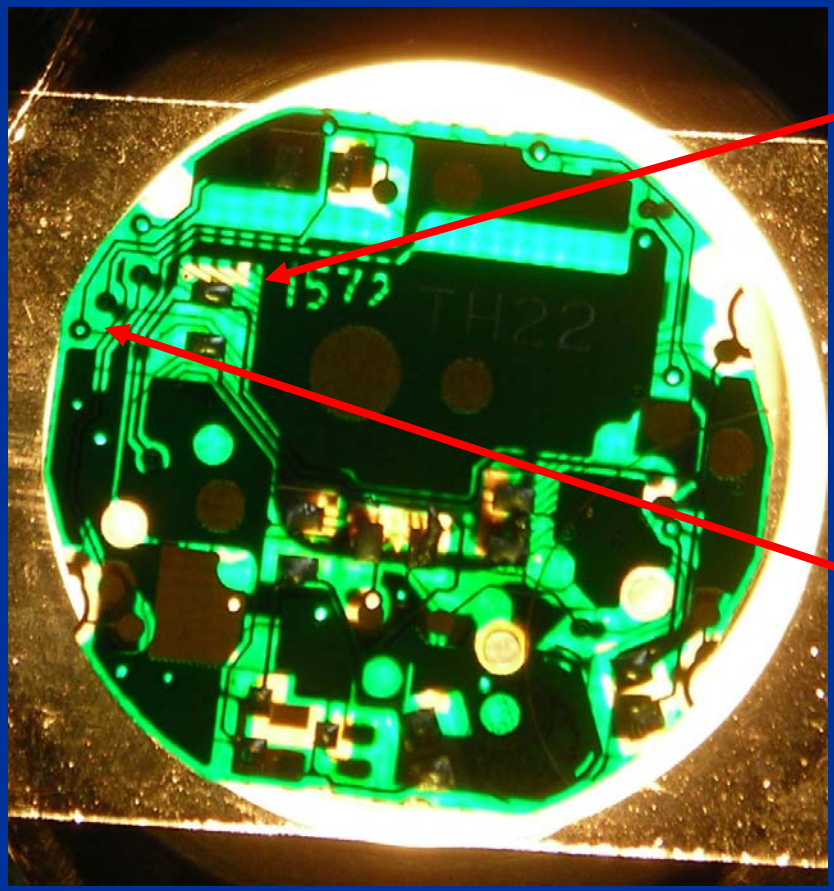


Resistors

Power transistor

Transformer

PCB routing

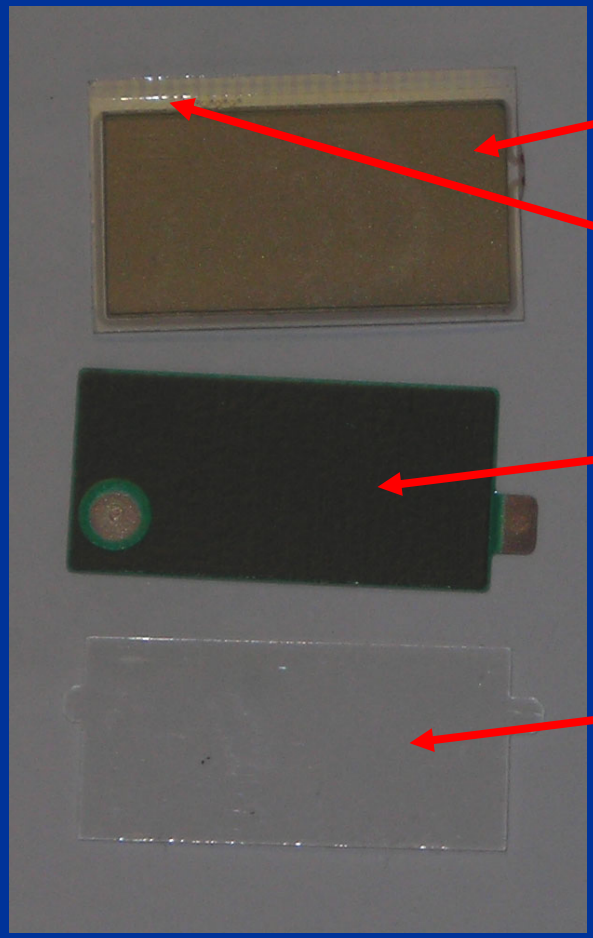


Back-lit PCB

- Two layers of electrical routing (top and bottom surface)
- Min. track pitch = 0.2 mm
- More-complex circuits will have internal layers
- Layers connected using vias (electrically conductive holes)
- All components attached using solder

Note: x-ray systems used to investigate multi-layer PCBs

Display



Sealed liquid crystal display

- with transparent electrodes (indium-doped tin oxide ITO)

Electro-luminescent back light (high voltage required!)

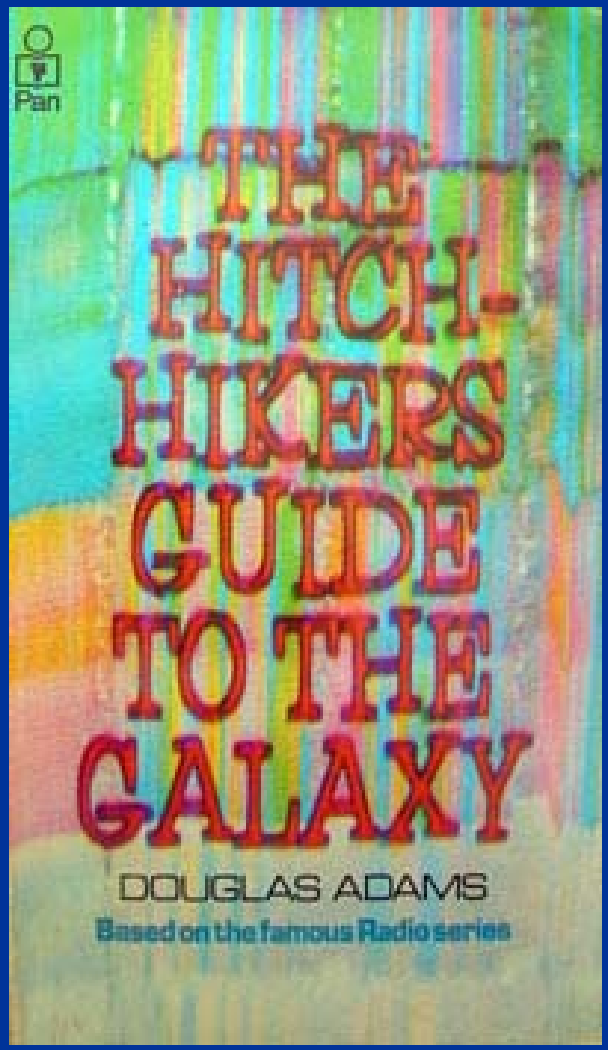
Transparent cover glass

Parts List

Part #	Part name	Purpose	Description	Size	Material	Count
0	Wrist watch	Chronometer	Black plastic wrist watch with liquid crystal display Manufacturer: Casio, Product code: W-741	3x3x1 cm body + 16 cm strap Mass: 25 g,	Various	1
1	Outer case	Case	Black plastic housing for system, including 3 push buttons	25x25x0.8 mm	Thermoplastic (?)	1
1a	Push button	Programming	Metal button with retaining ring and gasket	ϕ2x3 mm	Metal, elastomer	3
2	Strap	Attachment to arm	Black plastic strap (2-part), including 2 spring-loaded pins and buckle	8x1cm	Thermoplastic + metal	2
3	Back plate	Removable lid	Stamped metal plate	25x25x0.5 mm	Stainless steel	1
4	Screw	Secure lid	Cross-head screw	ϕ1x4 mm	Stainless steel	4
4	Gasket	Prevent liquid ingress	Black ring shaped gasket to fit recess in outer case	ϕ0.5xϕ25 mm	Elastomer	1
5	Battery	Electrical power supply	Button battery Panasonic CR2016 3V	ϕ20x1 mm	Sealed steel case + electrolyte	1
6	Battery clip	Make contacts to chip and buttons	Intricate shaped metal sheet, including many sprung sections	25x25x5 mm	Stainless steel	1
7	Inner case (top)	Secure PCB and LCD	Intricate shaped white plastic	25x25x5 mm	Thermoplastic	1
8	Inner case (base)	Secure PCB and LCD	Intricate shaped white plastic	25x25x5 mm	Thermoplastic	1
9	Printed circuit board	Substrate for electronic components	2 layer PCB with components soldered to both sides	ϕ24x1 mm	Glass fibre, epoxy resin, metallization	1
9a	Chip	Electronic control unit	Silicon chip directly attached to PCB and embedded in epoxy resin. Wire bonds from chip to PCB.	3x3 mm	Silicon, silica-loaded epoxy resin, gold wire	1
9b	Oscillator	Stable frequency generator	Surface mount can containing quartz crystal piezo-electric oscillator	ϕ2x5 mm	Metal can containing quartz crystal	1
9c	Resistor	Current regulation, etc	Surface mount resistor	2x1x1 mm	Ceramic block with two metal bond pads	5
9d	Power transistor	Switch large current/voltage	Surface mount ‘SOT23’ package with three legs	3x2x2 mm	Epoxy resin, semiconductor, metal legs	2
9e	Transformer	Generation of high voltage for back light	Minute wire-wound transformer	ϕ4x5 mm	Plastic case, ultra fine wire, magnetic core (?)	1
9f	Capacitor	High frequency decoupling?	Surface mount package	3x2x2 mm	Ceramic block with two metal bond pads	1
9g	'Bleeper'	Audible output signal	Surface mount package containing piezo-electric transducer	ϕ3x4 mm	Plastic, piezo-ceramic	1

Etc… See complete PDF file on EEE163 page of website

How many components? A clue ...

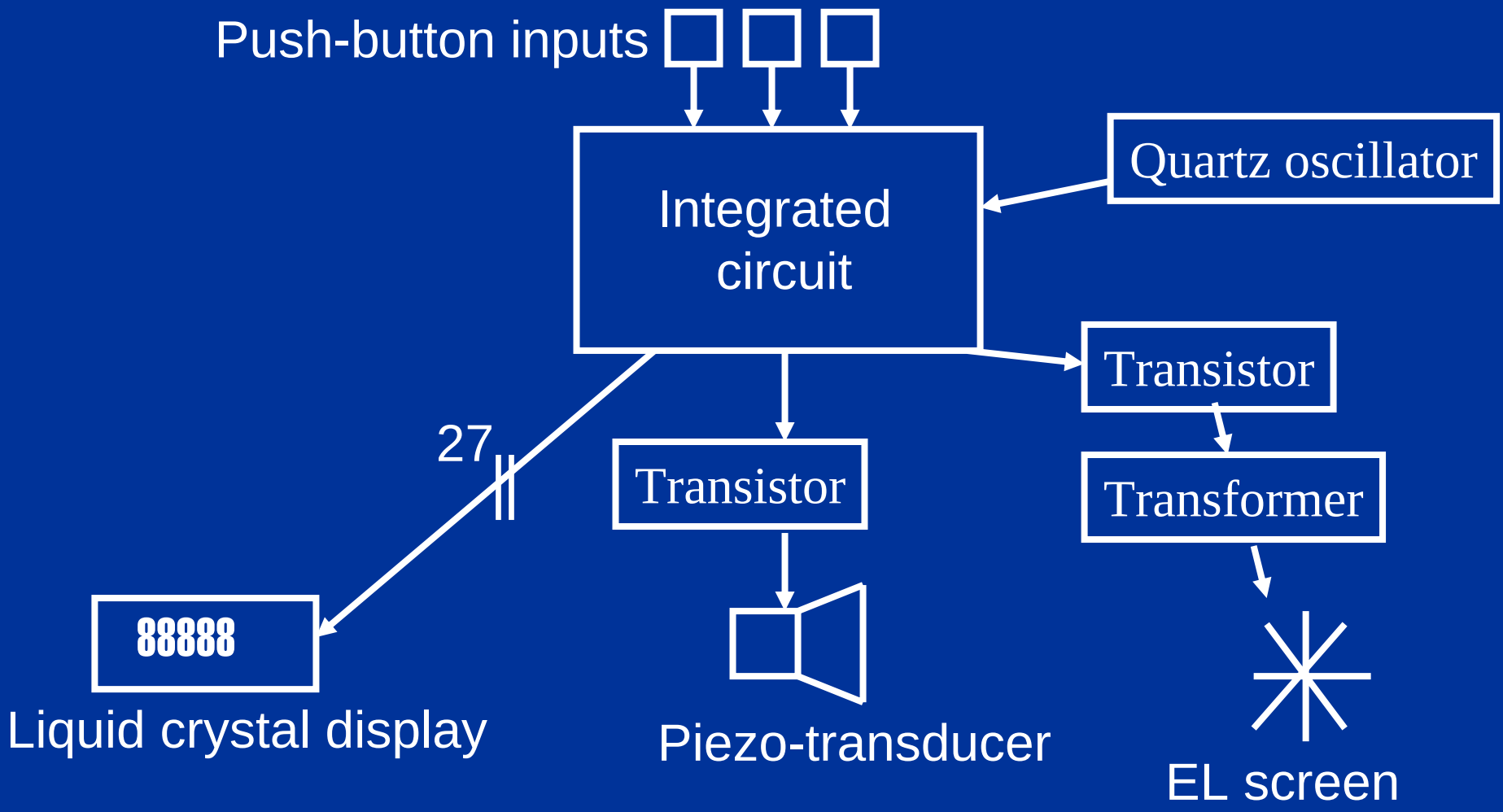


...a group of hyper-intelligent pan-dimensional beings demand to learn the *Ultimate Answer to the Ultimate Question of Life, The Universe, and Everything* from the supercomputer, Deep Thought, specially built for this purpose. It takes Deep Thought 7½ million years to compute and check the answer, which turns out to be...

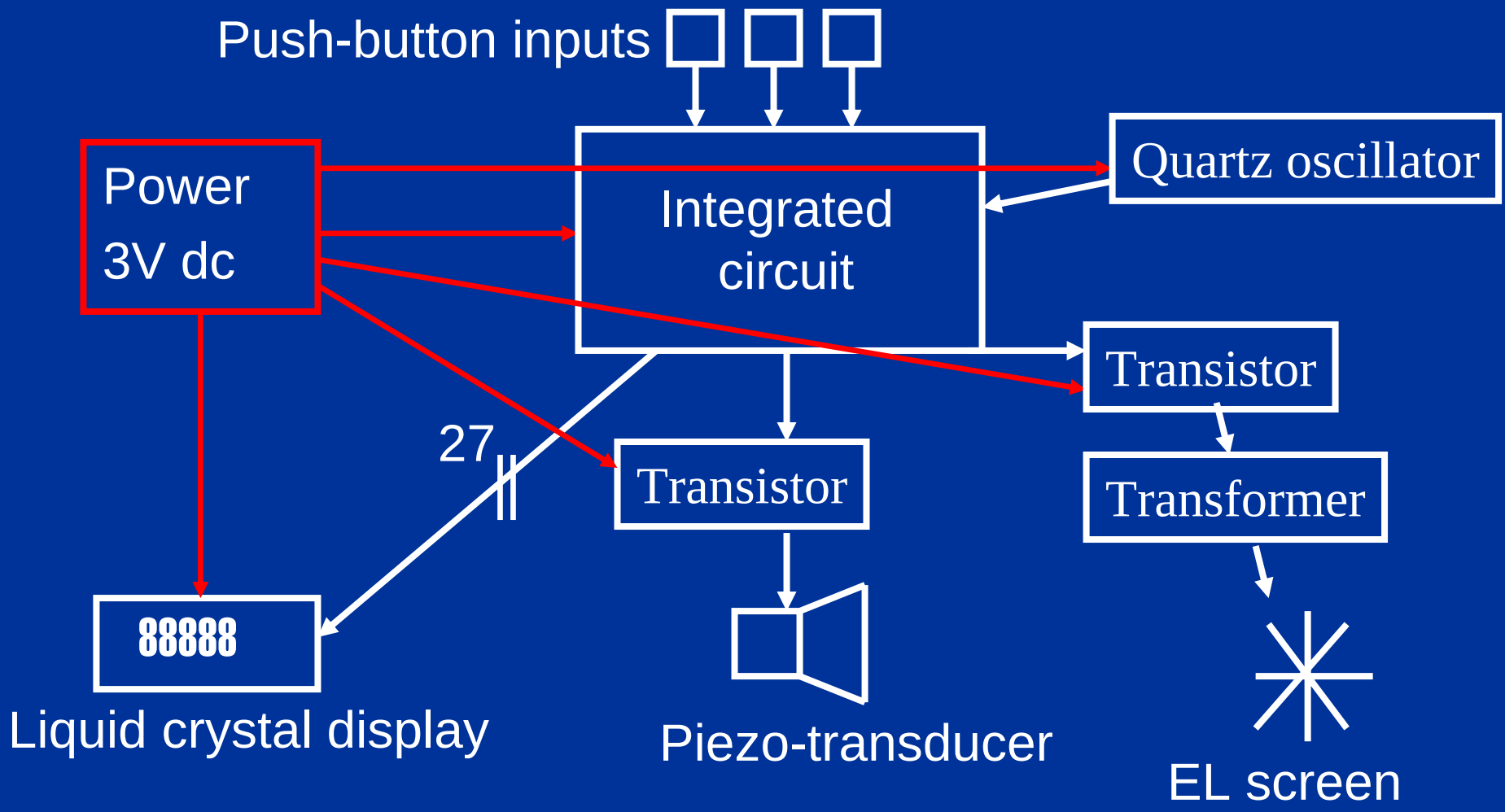
How many components?

42 (approx.)

Revised System Diagram



Revised System Diagram



Lecture 3 Summary:
We have characterized the product

Functions: Watch, Alarm, Light
Methods: Quartz crystal, Piezo-transducer, EL screen + electronics
Inputs: Push buttons, crystal oscillator
Outputs: Liquid crystal display, bleeper, light
Parts list: 42 +
Raw Materials: Steel, gold, copper, solder, thermoset, thermoplastic, elastomer, liquid crystal, Ceramic, piezo-ceramic, Semiconductor, hybrid
Manufacture: Modular, with chip directly on PCB
Power: 3v dc
Working environment: <100 m water
End of life: special disposal recommended
Safety - no issues
Cost ~ £10