ENGI 128

INTRODUCTION TO ENGINEERING SYSTEMS

Lecture 2: Abstraction and Interfaces

“Understand Your Technical World”

Block Diagrams

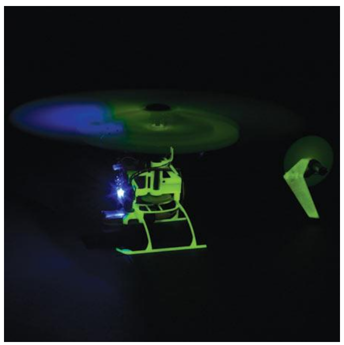
Helicopter power block diagram:

energy storage: battery → **energy conversion:** motor → **energy transmission:** gears → **physical force:** rotor blade

Modularity

Helicopter power block diagrams:

energy storage: battery → energy conversion: motor → energy transmission: gears → physical force: rotor blade



energy storage: battery → energy conversion: motor → energy transmission: belt drive → physical force: glow-in-the-dark blades

energy storage: gas → energy conversion: gas motor → energy transmission: gears → physical force: rotor blades

energy storage: Jet-A → energy conversion: gas turbine → energy transmission: gears → physical force: rotor blades

Abstraction

What does "abstract" mean, anyway?

Van Gogh: "Starry Night"

Picasso: Portrait of Daniel-Henry Kahnweiler

Matisse: The Snail

Don't show me the details!

- Reduce the device/component/system to the simplest possible form
- Hide complexity and implementation details
- Focus on the **inputs and outputs**

Feedback Control Loop:

1. I sense the position of the helicopter by watching it

2. I compute an appropriate reaction

3. I move the sticks on my remote
   - Which magically moves the motors on the helicopter
     (It won't be magic in about 8 weeks. It will just be homework)

4. This moves the helicopter in the world, and we repeat

I am providing control:

1. I sense the position of the helicopter by watching it

2. I compute an appropriate reaction

actuate

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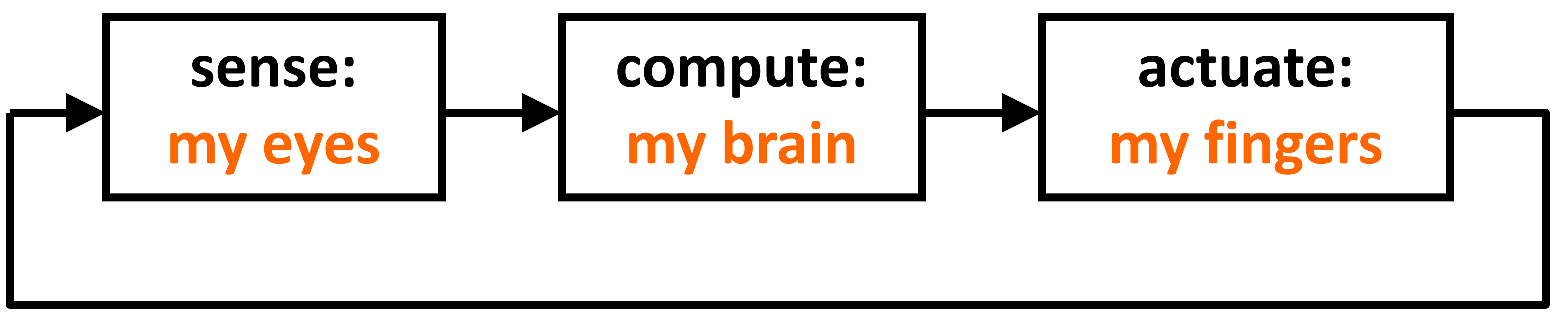


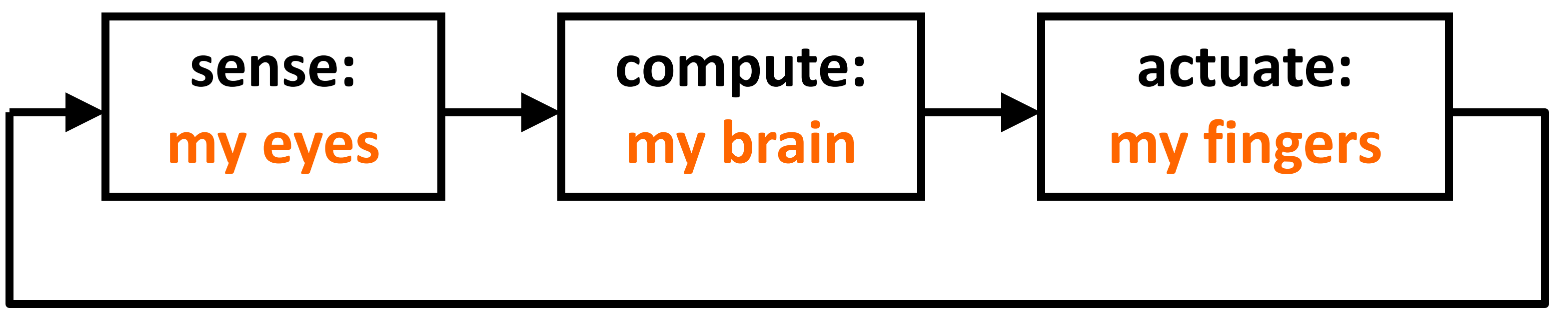
The basic controller block diagram

This is one of the most common system diagrams

We will be using it extensively in this course

This is a **feedback** system. The output "feeds back" to the input.

This is also a **control loop**. (Because it controls and it loops)



Feedback and control loops are everywhere:

	Sensor	Computer	Actuator
Building thermostat			
Automobile cruise control			
R/C helicopter heading lock			

[switch to white board]

Interface

The *interface* to a component is a specification describing what goes in and what comes out

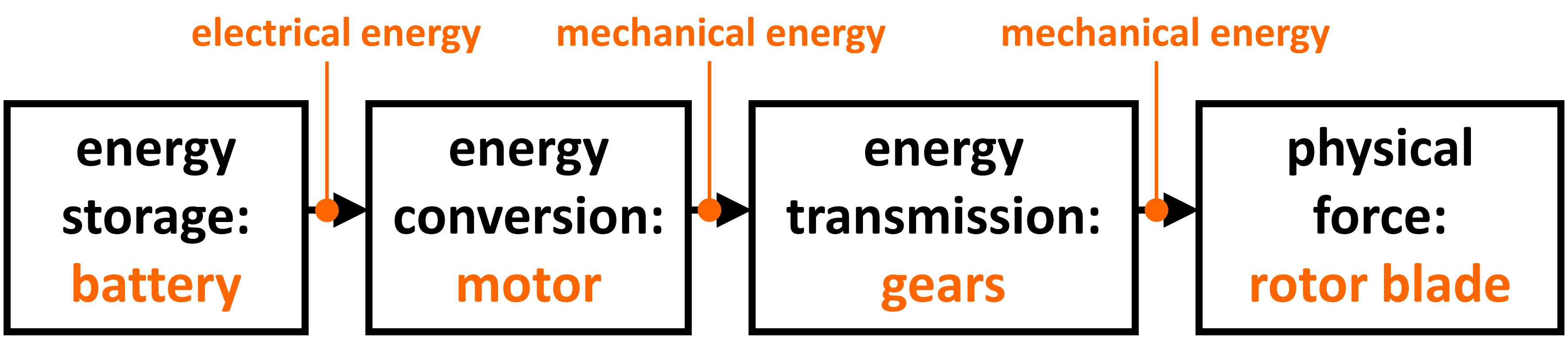
- It does not specify what happens inside (it's abstract, remember?)

Good interface design is the key to drawing block diagrams

- It can take several tries to get it right

What can go in and out?

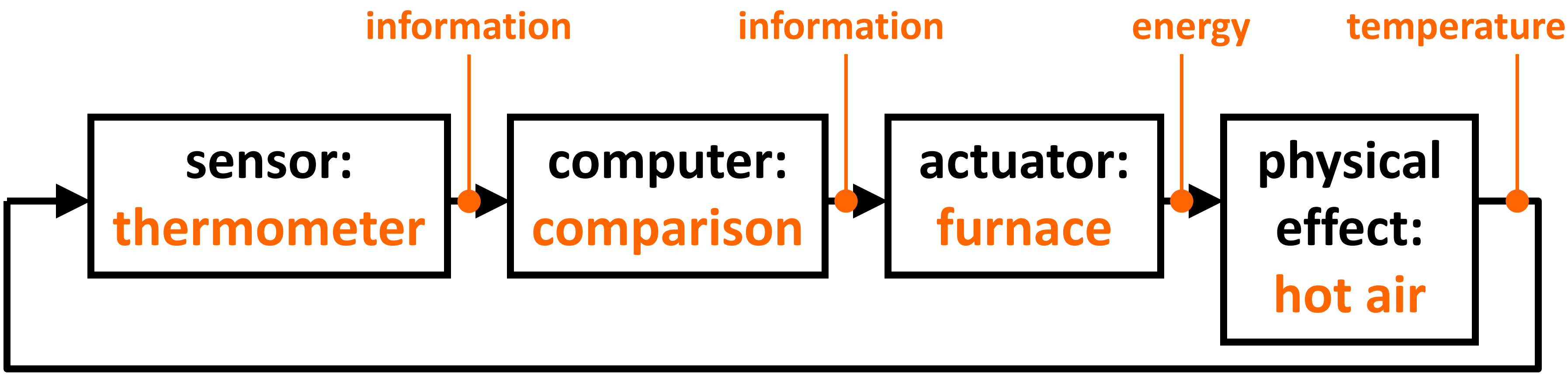
- Power, information, data, motion, force, water, electricity…



Interface

Consider our thermostat example

- What are the most abstract way to represent what is on these links?

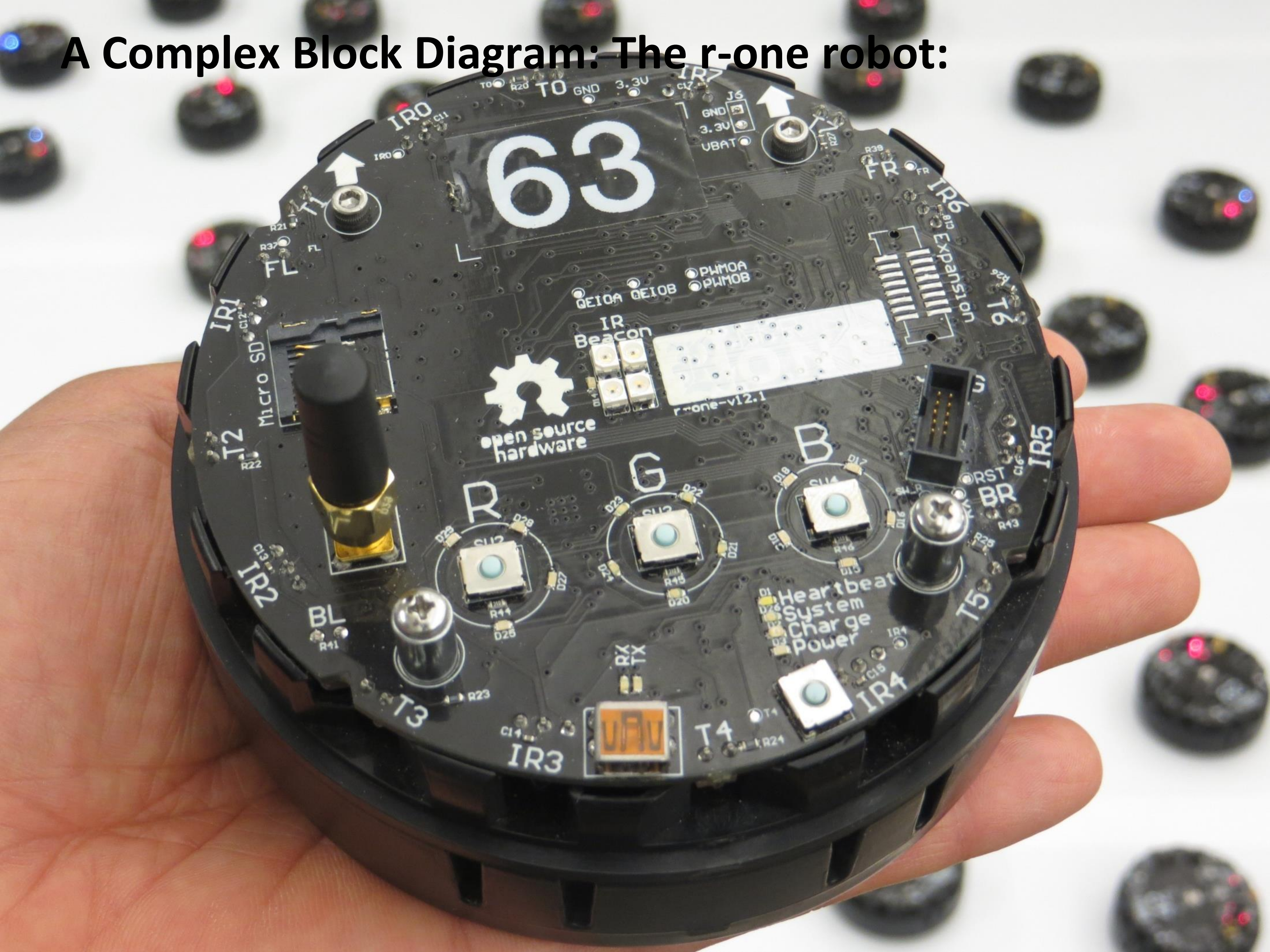


We don’t care about the details.

- Electrical signals? Hydraulic actuators? Smoke signals?
- The interface to each component defines it’s input and output:

Block Diagramapalooza!

A Complex Block Diagram: The r-one robot:



Measuring distance on the r-one robot:

Measure distance in three easy steps:

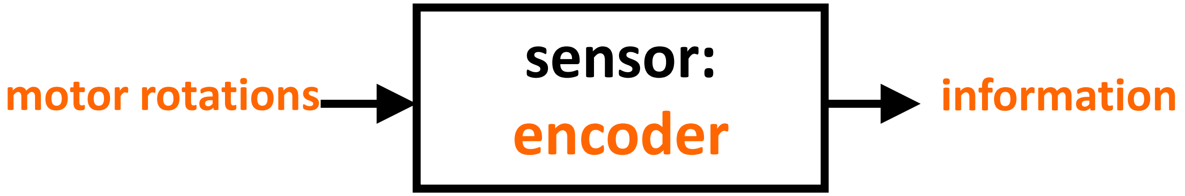
1. Each robot has two sensors that tell the computer how many turns the motor makes (Problem Set 3)

2. The motor is connected to the wheels, so the computer can also figure out how many turns the wheel makes (Problem Set 6)

3. With information about wheel rotations, the computer can compute the distance the robot has traveled (Problem Set 8)

Measuring distance on the r-one robot:

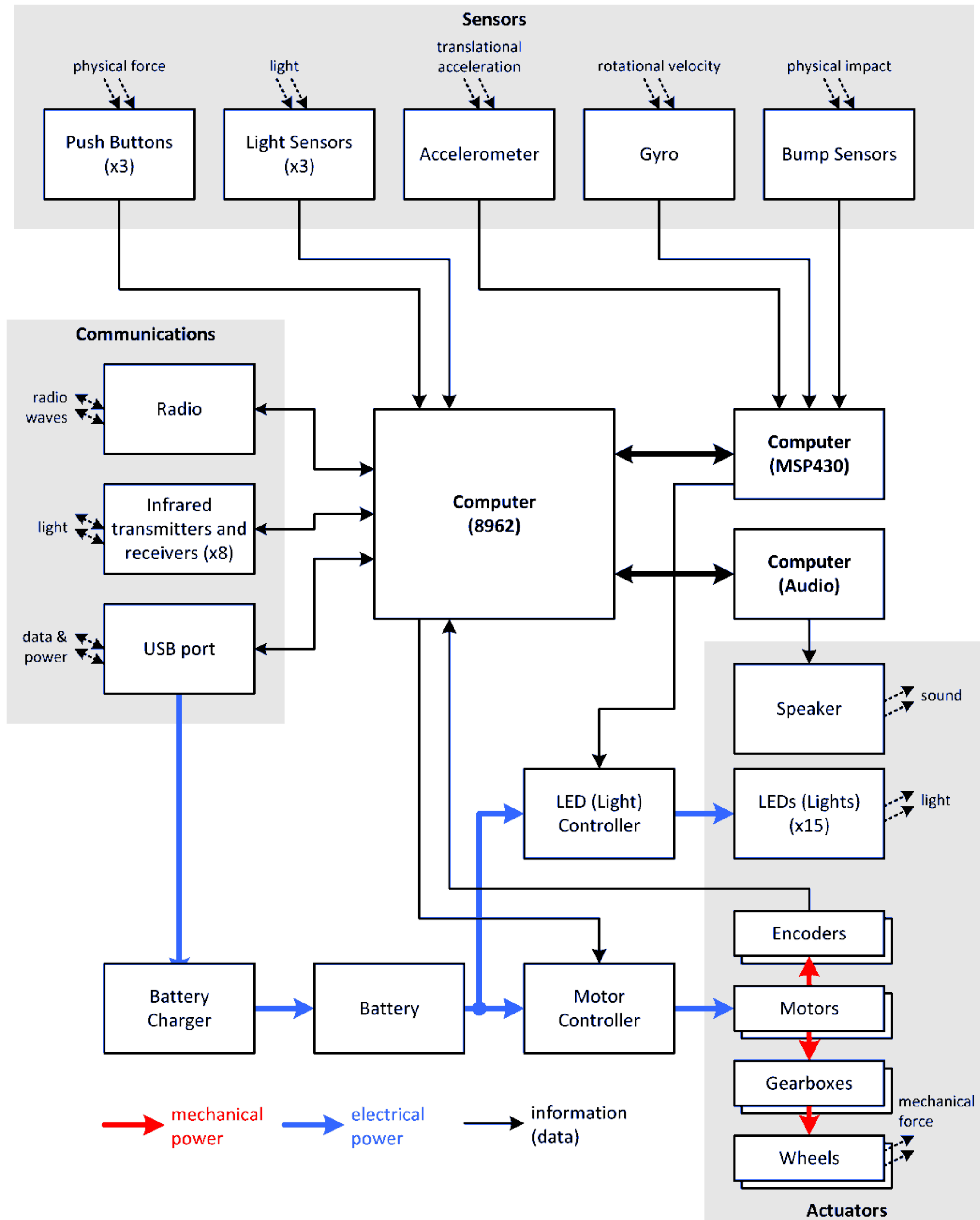
This sensor is called an *encoder*. Its block diagram is:



This is a simple block and a simple interface. How much complexity does this conceal?

rone v11

r-one Robot Block Diagram (v11)



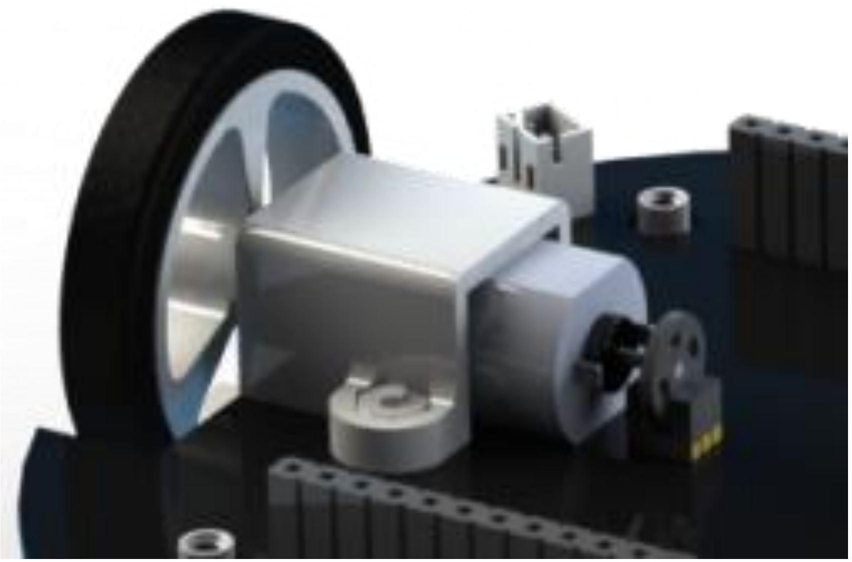
Motor Circuit Board

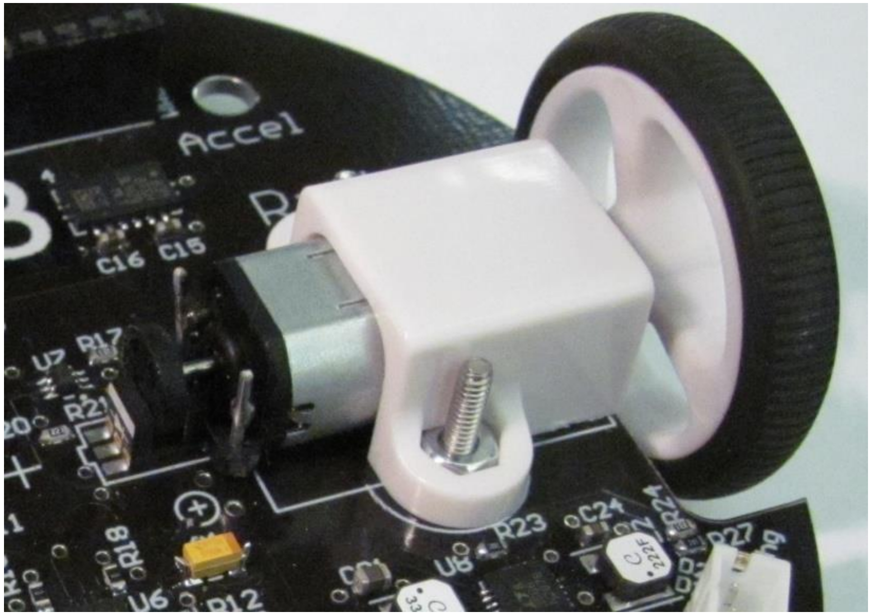
Start with commercial motors

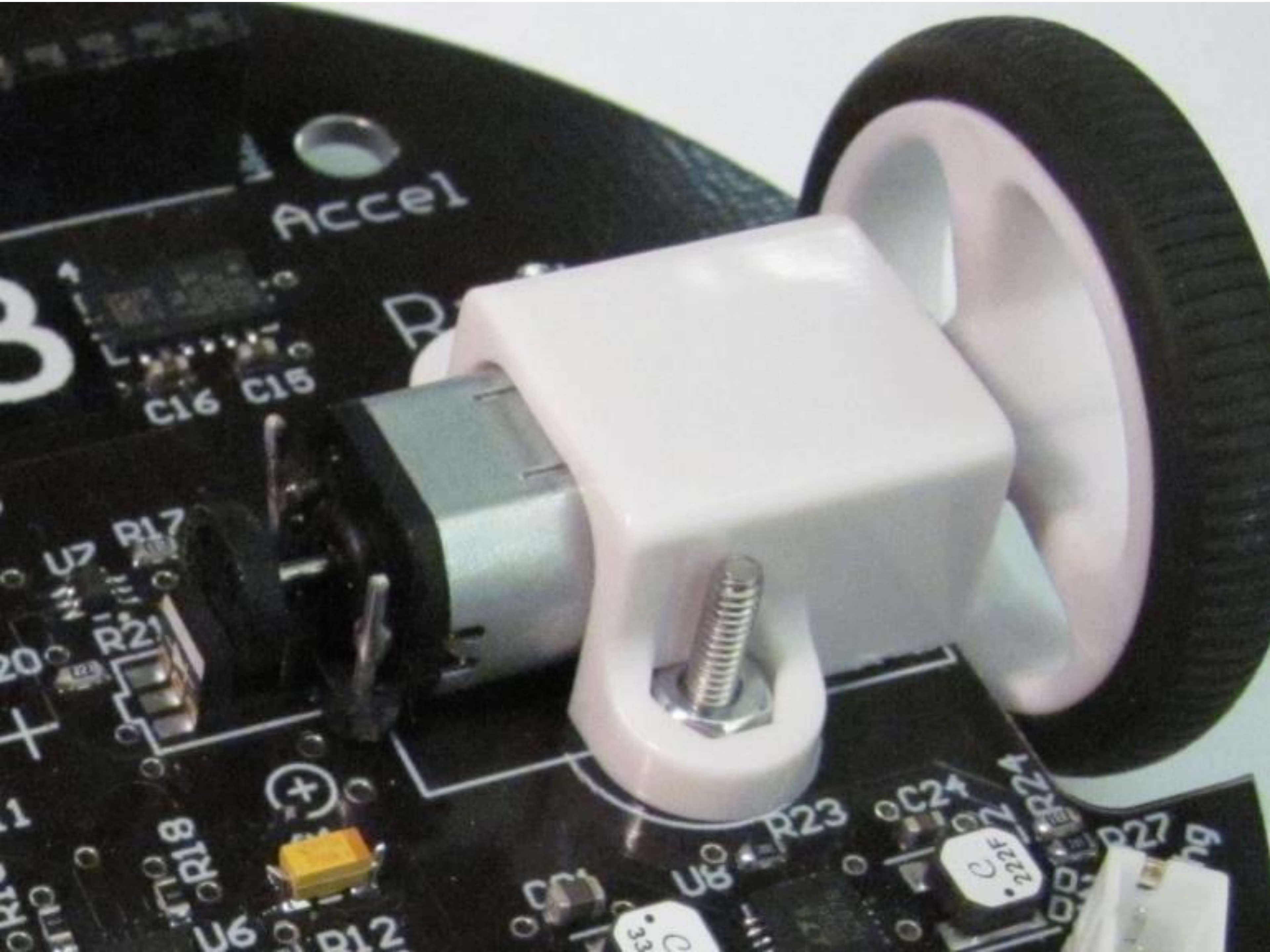
- Pololu micro-gearmotors with extended shafts

Very inexpensive quadrature encoders

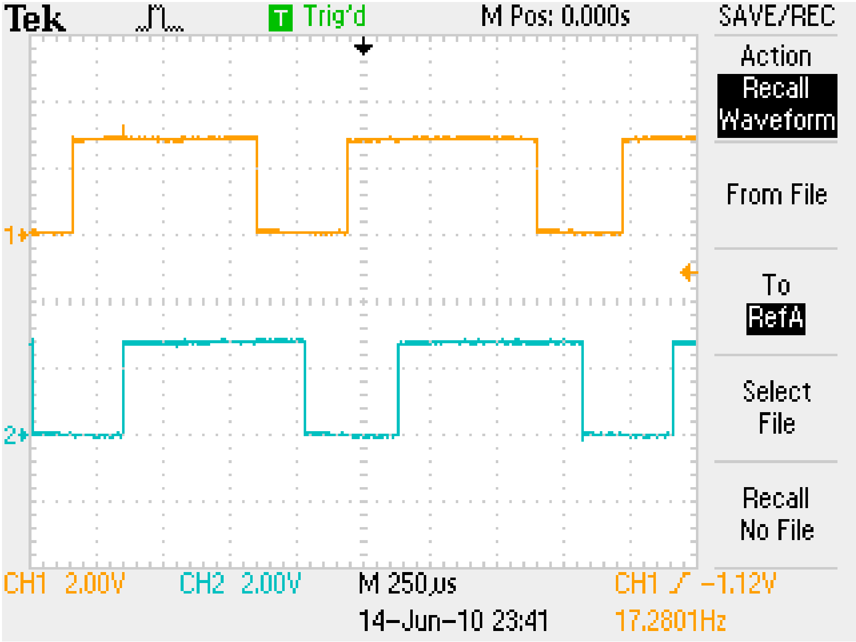
- Composed of a plastic wheel and a photointerupter
- 0.0625 mm/tick resolution
- Cost around $5 each



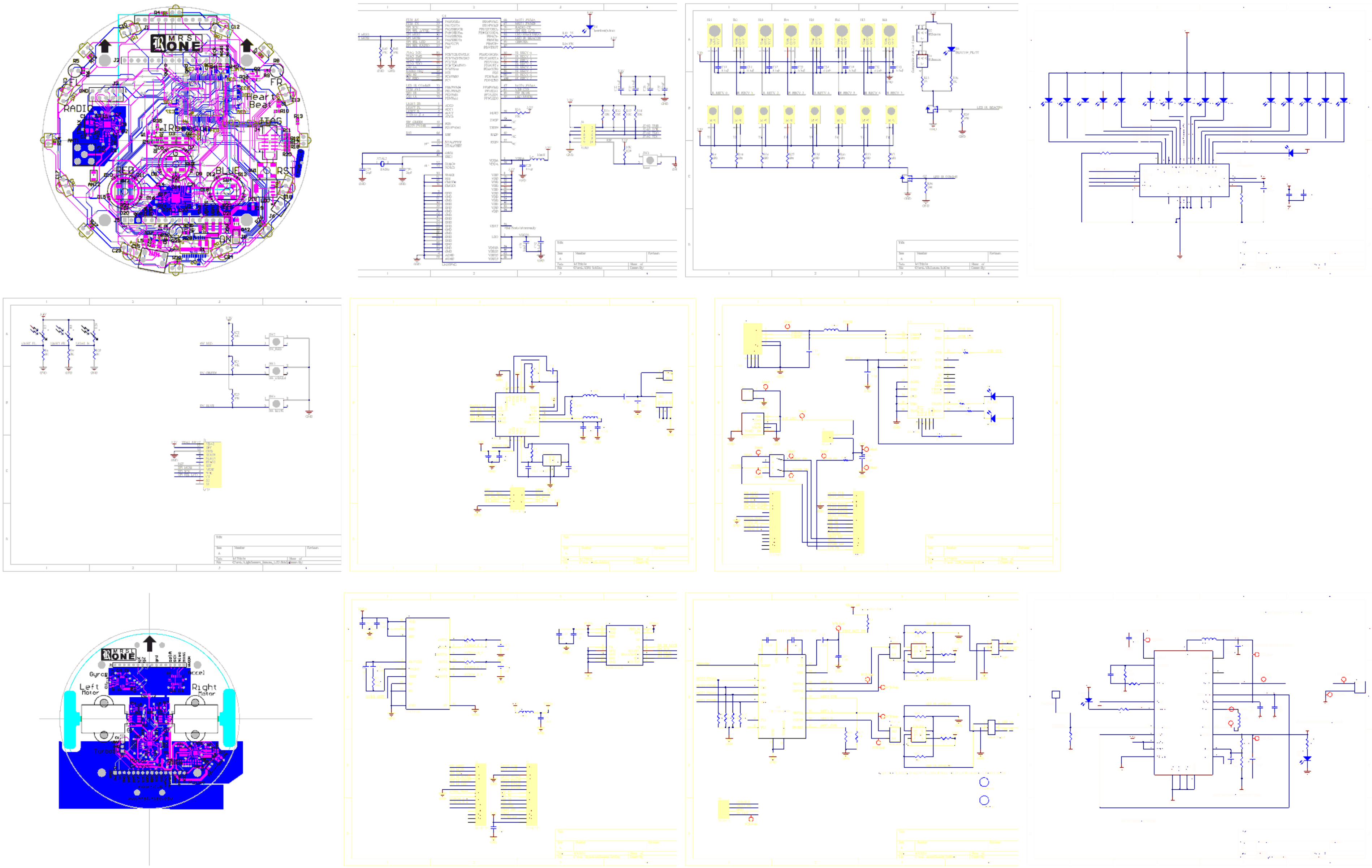



Accel
C16
C15
R17
U7
R21
R18
R23
C24
R24
R27
U6
R12

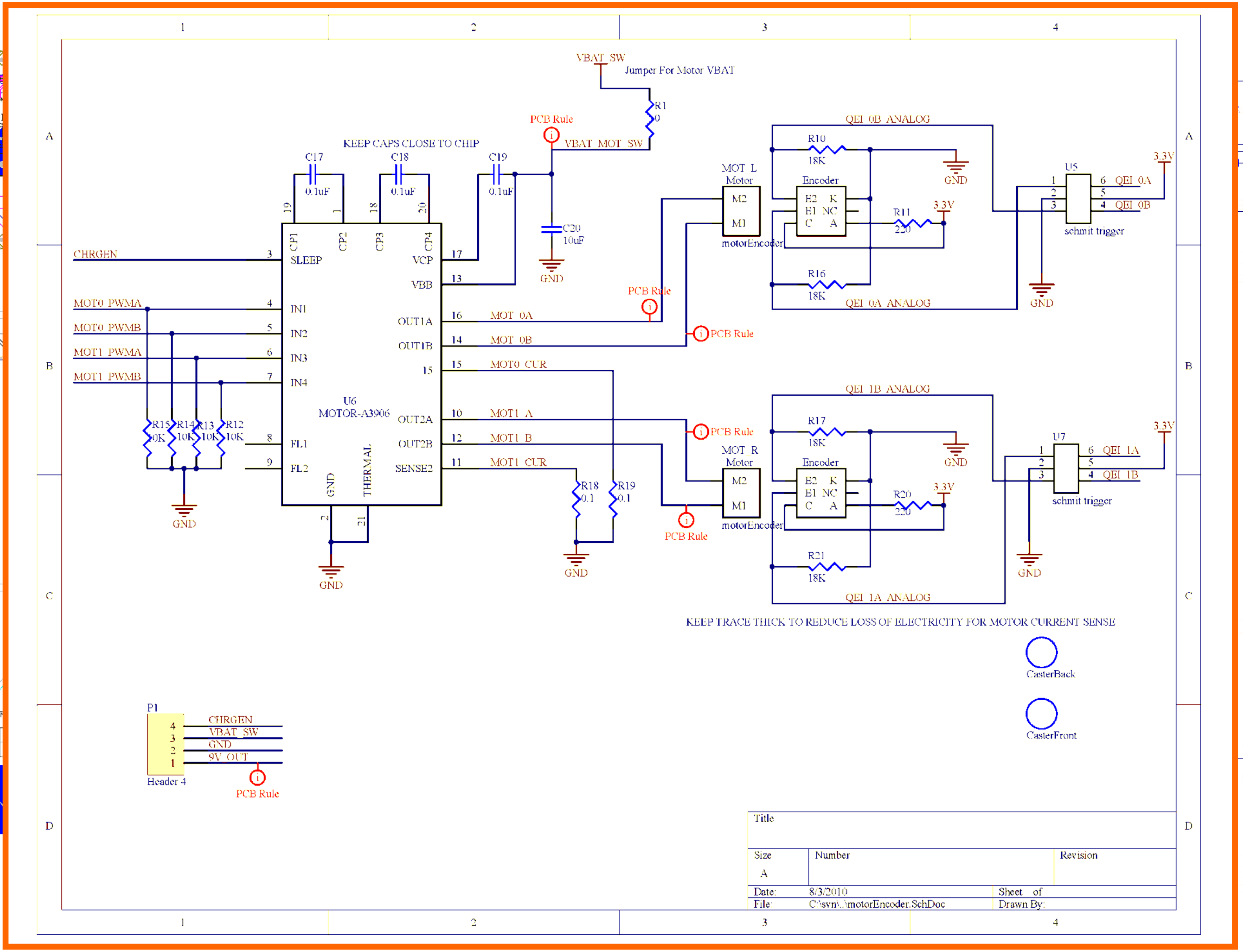
Encoder Wheel



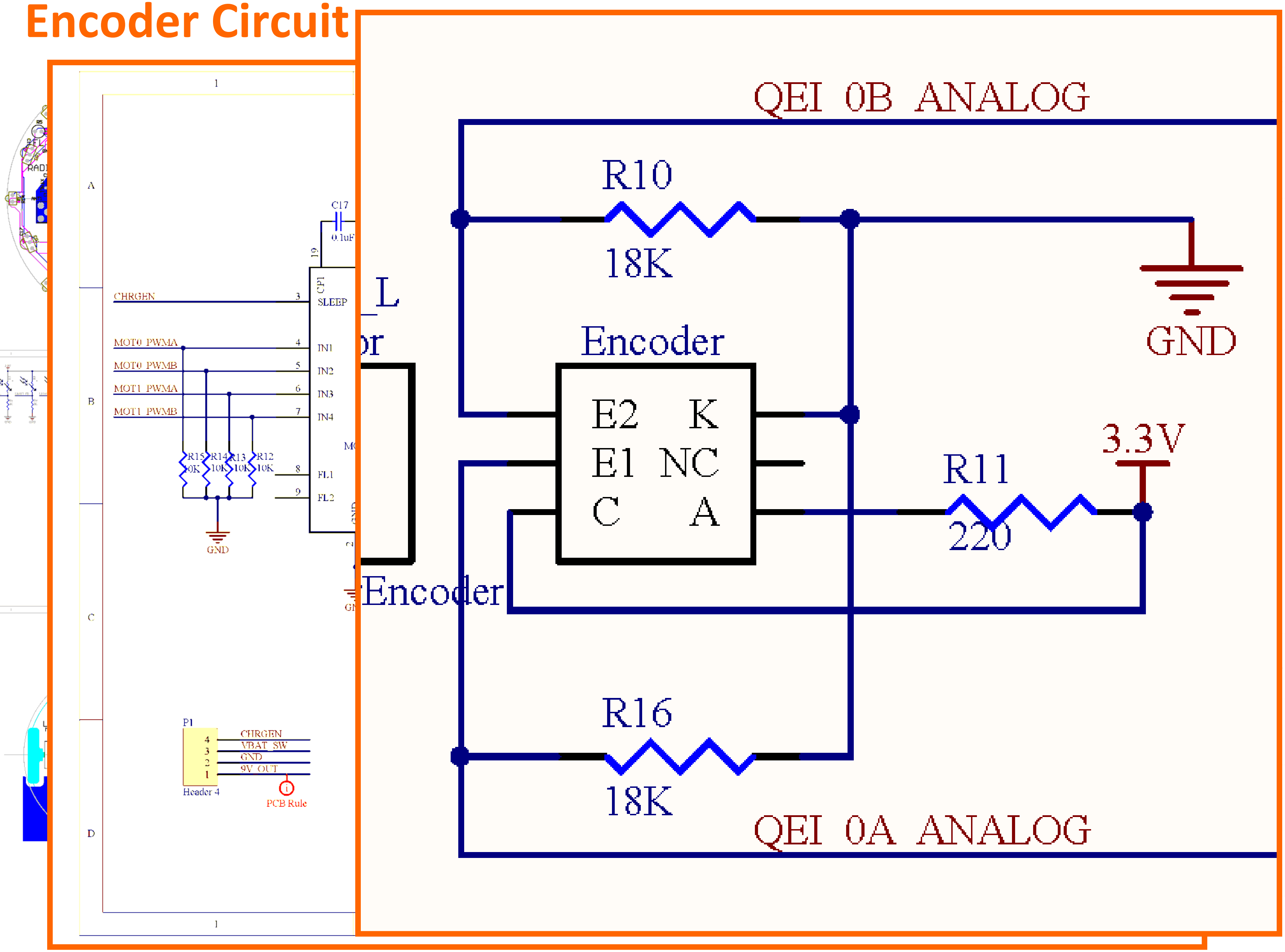
Full Schematics:



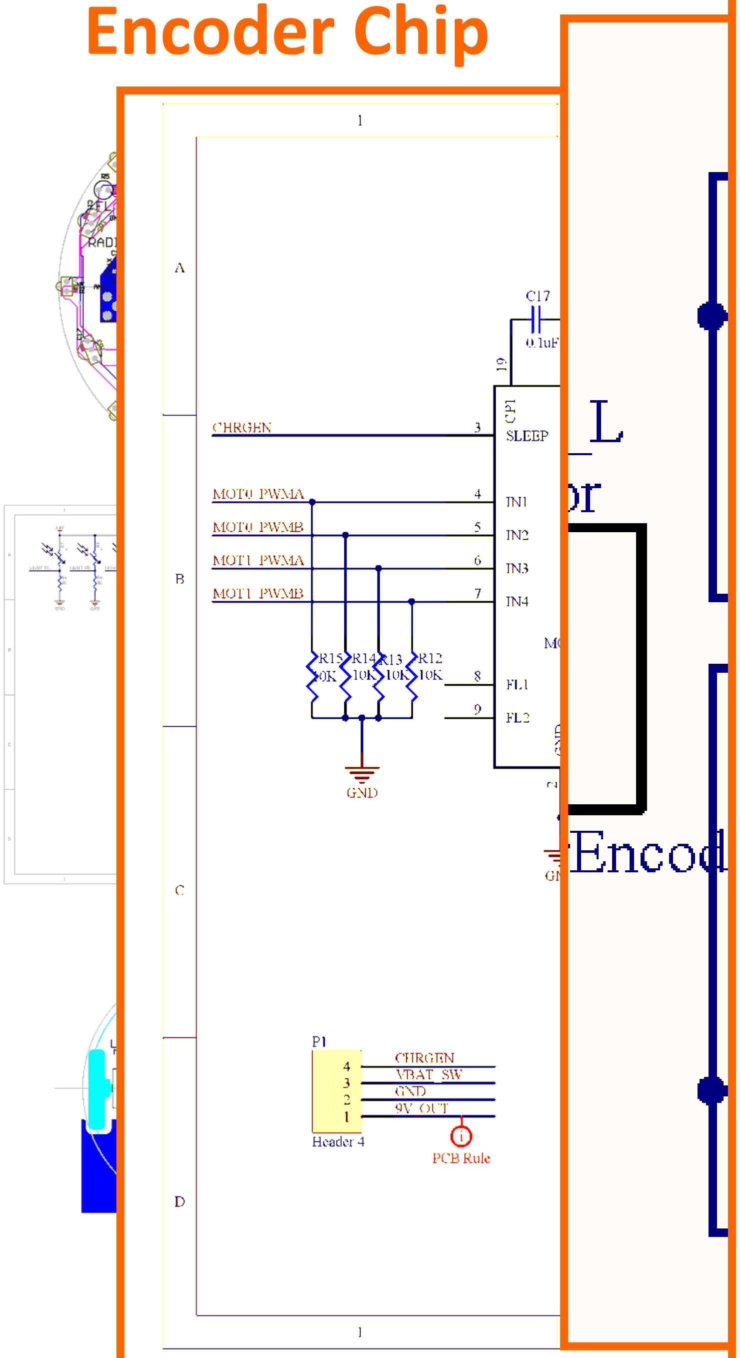
Motors and Encoders Schematic Page

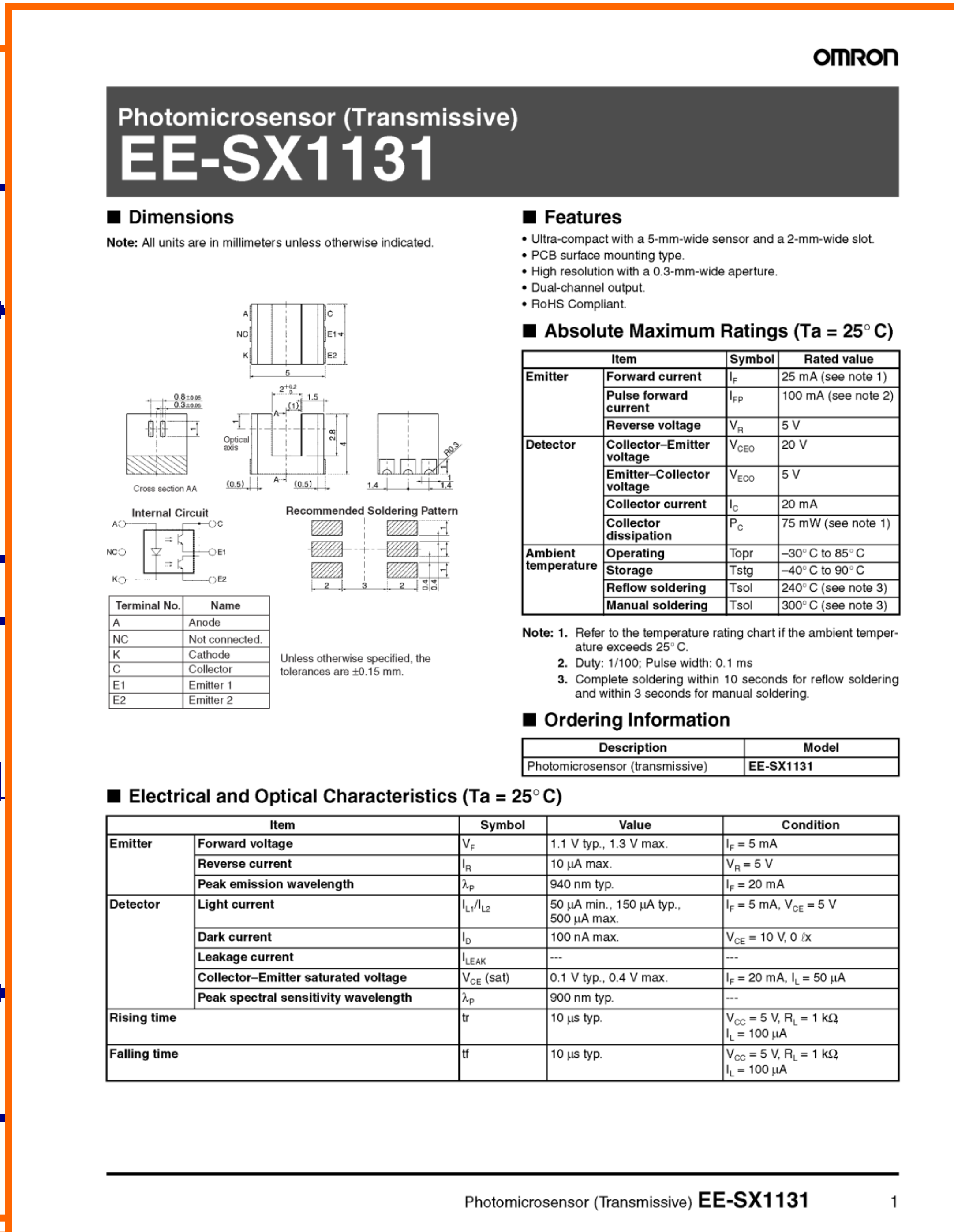


Encoder Circuit



Encoder Chip





OMRON

Photomicrosensor (Transmissive)
EE-SX1131

■ Dimensions

Note: All units are in millimeters unless otherwise indicated.

Cross section AA

Internal Circuit

Recommended Soldering Pattern

Terminal No.	Name
A	Anode
NC	Not connected.
K	Cathode
C	Collector
E1	Emitter 1
E2	Emitter 2

Unless otherwise specified, the tolerances are ±0.15 mm.

■ Features

- Ultra-compact with a 5-mm-wide sensor and a 2-mm-wide slot.
- PCB surface mounting type.
- High resolution with a 0.3-mm-wide aperture.
- Dual-channel output.
- RoHS Compliant.

■ Absolute Maximum Ratings (Ta = 25° C)

Item		Symbol	Rated value
Emitter	Forward current	I_F	25 mA (see note 1)
	Pulse forward current	I_{FP}	100 mA (see note 2)
	Reverse voltage	V_R	5 V
Detector	Collector–Emitter voltage	V_{CEO}	20 V
	Emitter–Collector voltage	V_{ECO}	5 V
	Collector current	I_C	20 mA
	Collector dissipation	P_C	75 mW (see note 1)
Ambient temperature	Operating	Topr	–30° C to 85° C
	Storage	Tstg	–40° C to 90° C
	Reflow soldering	Tsol	240° C (see note 3)
	Manual soldering	Tsol	300° C (see note 3)

Note: 1. Refer to the temperature rating chart if the ambient temperature exceeds 25° C.

2. Duty: 1/100; Pulse width: 0.1 ms

3. Complete soldering within 10 seconds for reflow soldering and within 3 seconds for manual soldering.

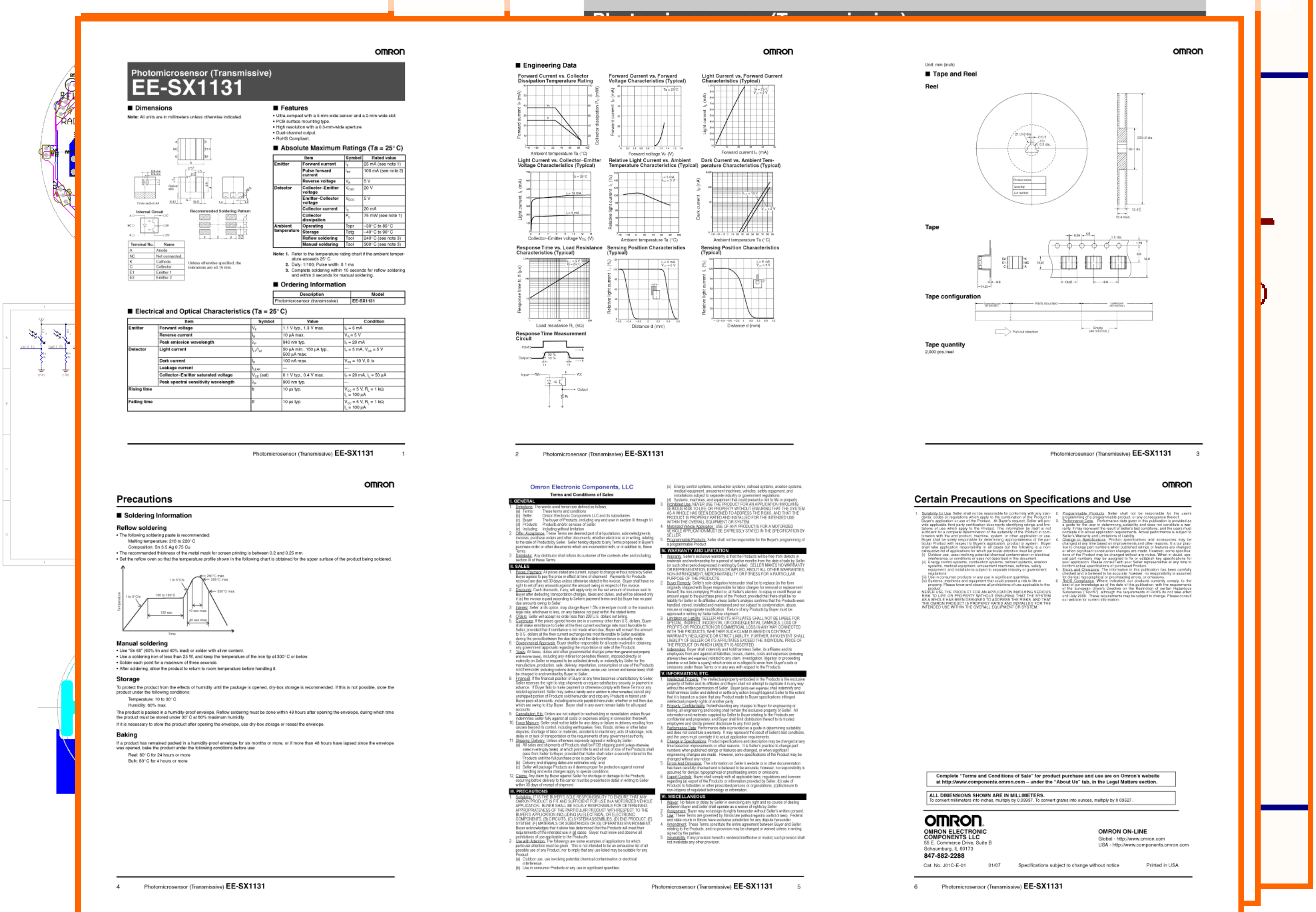
■ Ordering Information

Description	Model
Photomicrosensor (transmissive)	EE-SX1131

■ Electrical and Optical Characteristics (Ta = 25° C)

Item		Symbol	Value	Condition
Emitter	Forward voltage	V_F	1.1 V typ., 1.3 V max.	I_F = 5 mA
	Reverse current	I_R	10 µA max.	V_R = 5 V
	Peak emission wavelength	λ_P	940 nm typ.	I_F = 20 mA
Detector	Light current	I_{L1}/I_{L2}	50 µA min., 150 µA typ., 500 µA max.	I_F = 5 mA, V_{CE} = 5 V
	Dark current	I_D	100 nA max.	V_{CE} = 10 V, 0 ℓx
	Leakage current	I_{LEAK}	---	---
	Collector–Emitter saturated voltage	V_{CE} (sat)	0.1 V typ., 0.4 V max.	I_F = 20 mA, I_L = 50 µA
	Peak spectral sensitivity wavelength	λ_P	900 nm typ.	---
Rising time		tr	10 µs typ.	V_{CC} = 5 V, R_L = 1 kΩ, I_L = 100 µA
Falling time		tf	10 µs typ.	V_{CC} = 5 V, R_L = 1 kΩ, I_L = 100 µA

Encoder Chip, complete



Encoder block diagram

motor rotations → **sensor: encoder** → information