

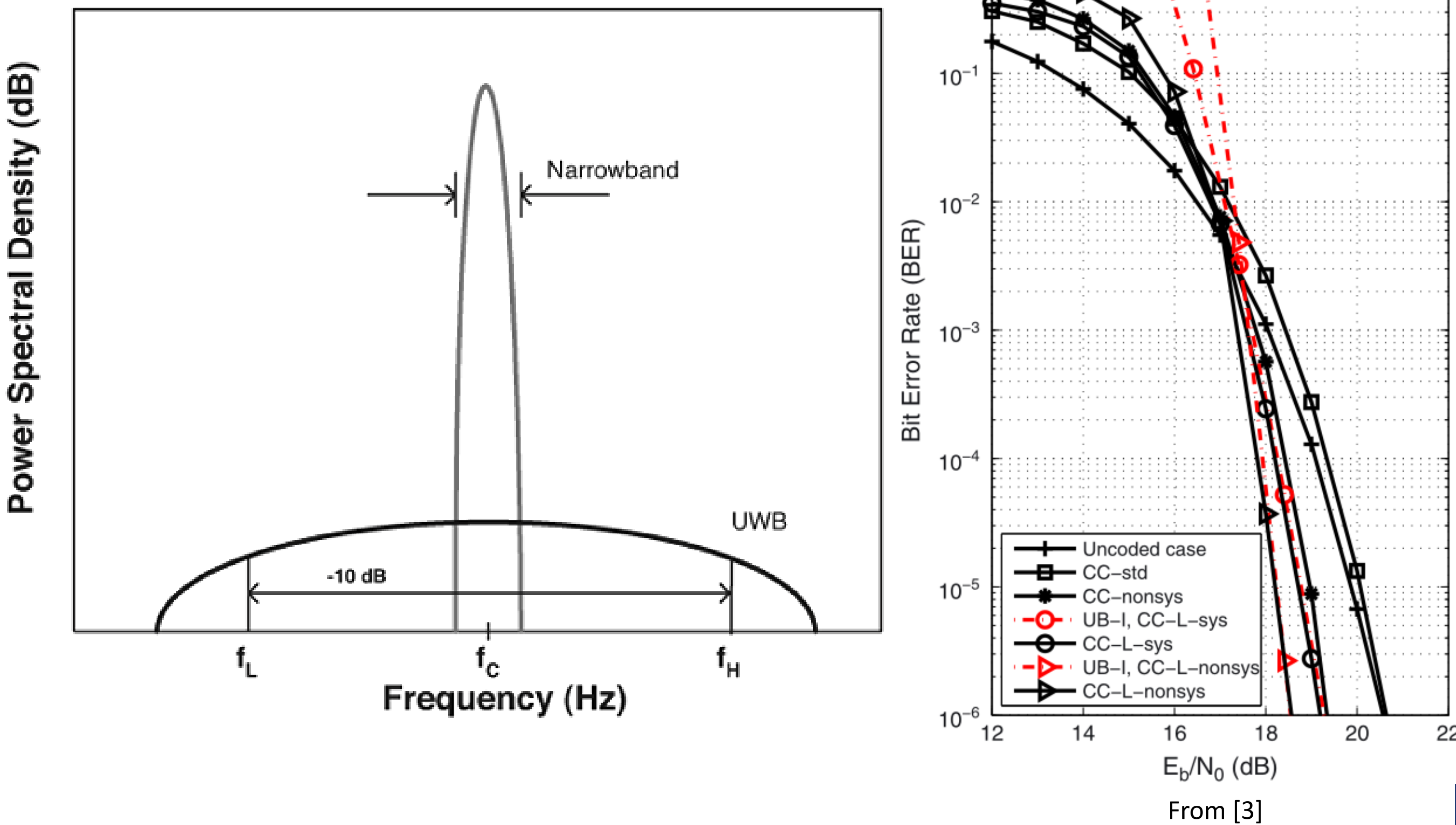
# Real-time Wireless Control via Ultra-Wideband (UWB) Communication

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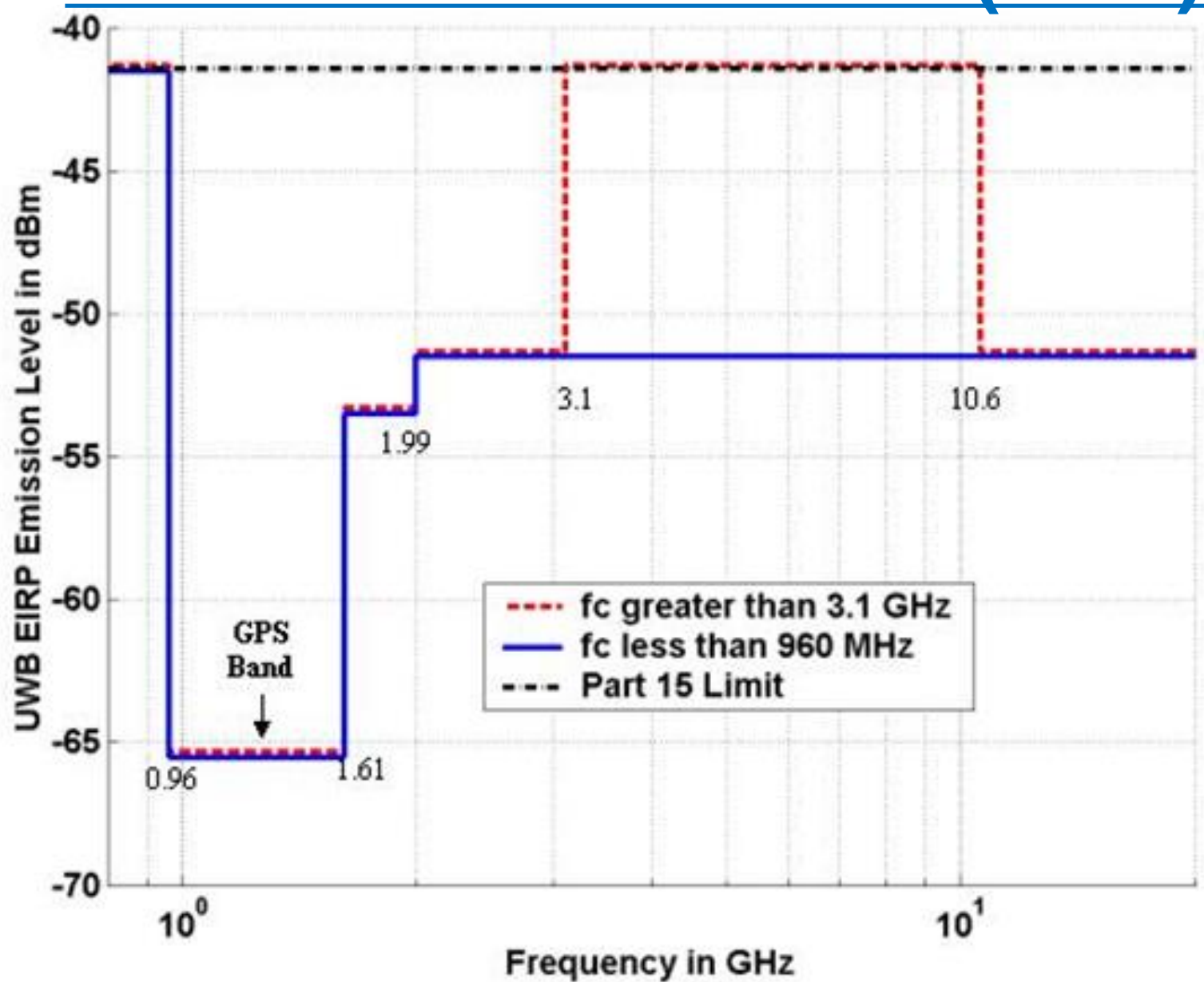
## Motivation

- Wireless control networks are becoming more common.
- Reliability of wireless networks for control is a concern, especially for safety-critical applications.
- Experience is that wired networks have “0 bit error rate”.
- UWB is potentially more reliable in the presence of noise and interference.

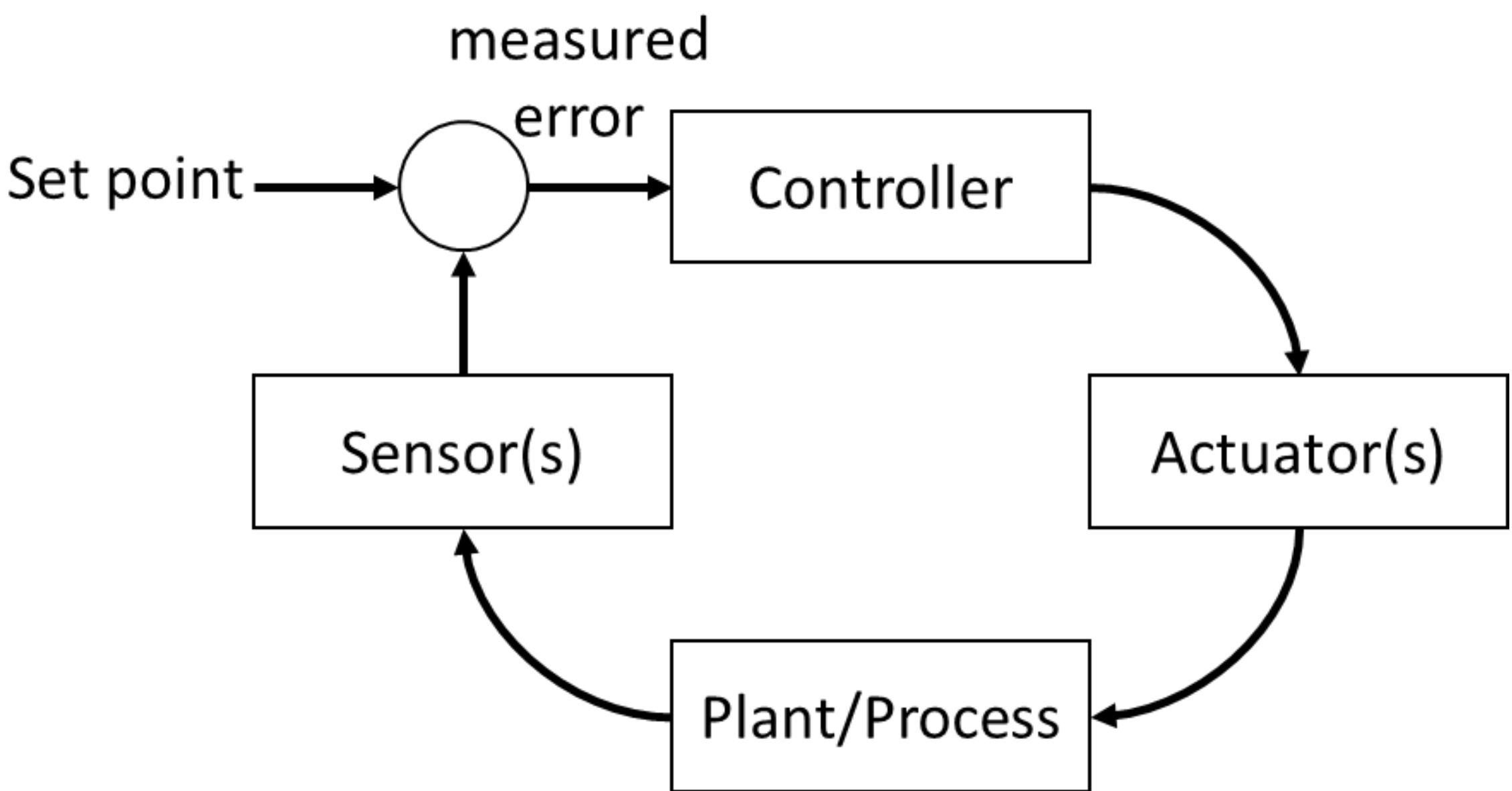
## Technology



## UWB Emission Limits (FCC)



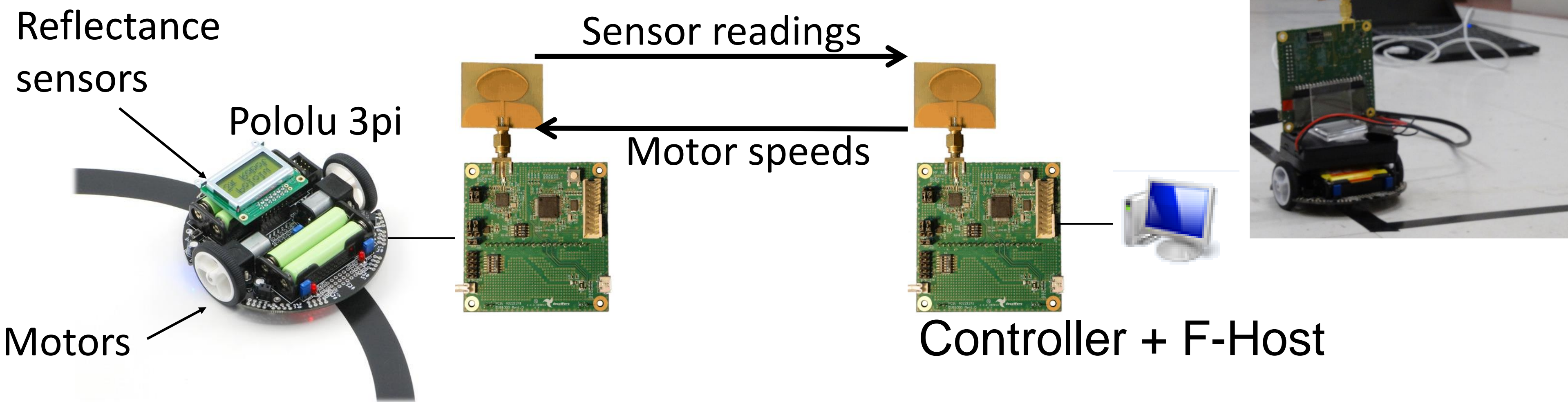
## Closed Control Loops



## Real-Time Evaluation System

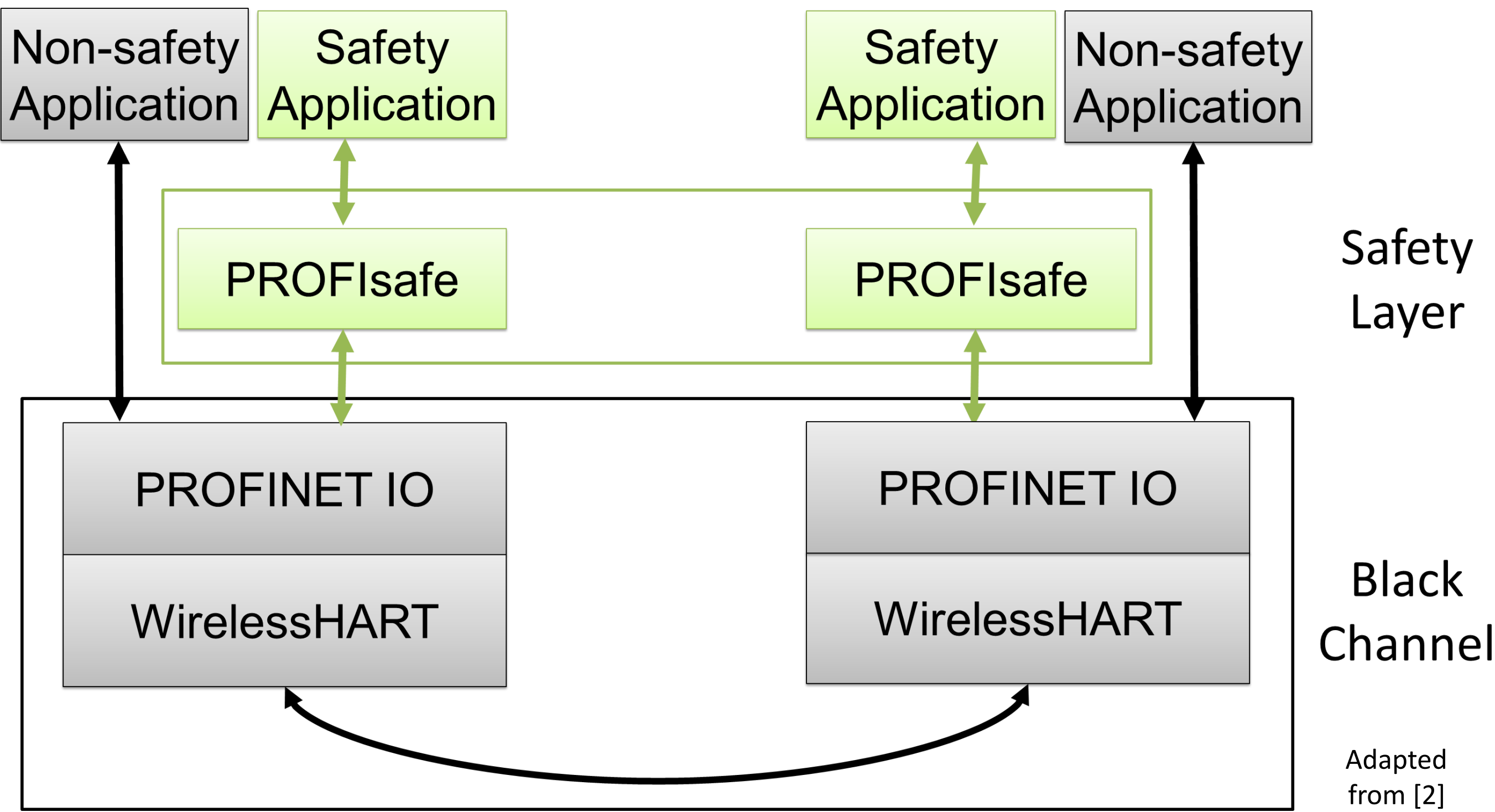
DecaWave EVK100 evaluation kit.  
IEEE 802.15.4-2011 compliant

Communication speed up to 6.8 Mbps  
Range : up to 290 m



- Pololu 3pi transmits reflectance sensor readings to controller via UWB
- The controller calculates new wheel speeds to keep the 3pi on the line
- The controller transmits the new wheel speeds to the 3pi via UWB.
- BER can be measured by counting the number of incorrect bits per packet

## Background



- PROFIsafe can share communication medium with non-safety functions.
- In the “black channel” model the safety layer implements mechanisms to detect and mitigate errors from the black channel (e.g. data corruption).
- The bit error rate (BER) of the black channel affects the target SIL of the safety layer.
- BER can be estimated from the packet error rate.

## IEC 61508 Safety Integrity Level (SIL)

SIL	Probability of dangerous failure per hour (PFH)	Probability of dangerous failure on demand (PFD)
1	$\geq 10^{-6}$ to $< 10^{-5}$	$\geq 10^{-2}$ to $< 10^{-1}$
2	$\geq 10^{-7}$ to $< 10^{-6}$	$\geq 10^{-3}$ to $< 10^{-2}$
3	$\geq 10^{-8}$ to $< 10^{-7}$	$\geq 10^{-4}$ to $< 10^{-3}$
4	$\geq 10^{-9}$ to $< 10^{-8}$	$\geq 10^{-5}$ to $< 10^{-4}$

## Objectives

- What is the reliability of UWB for real-time industrial communications?
- How can IEEE 802.15.4 UWB be used in real-time industrial control networks?
- How can IEEE 802.15.4 UWB be used as the “black channel” with safety protocols such as PROFIsafe?
- What is the relationship between UWB BER and IEC 61508 SIL?