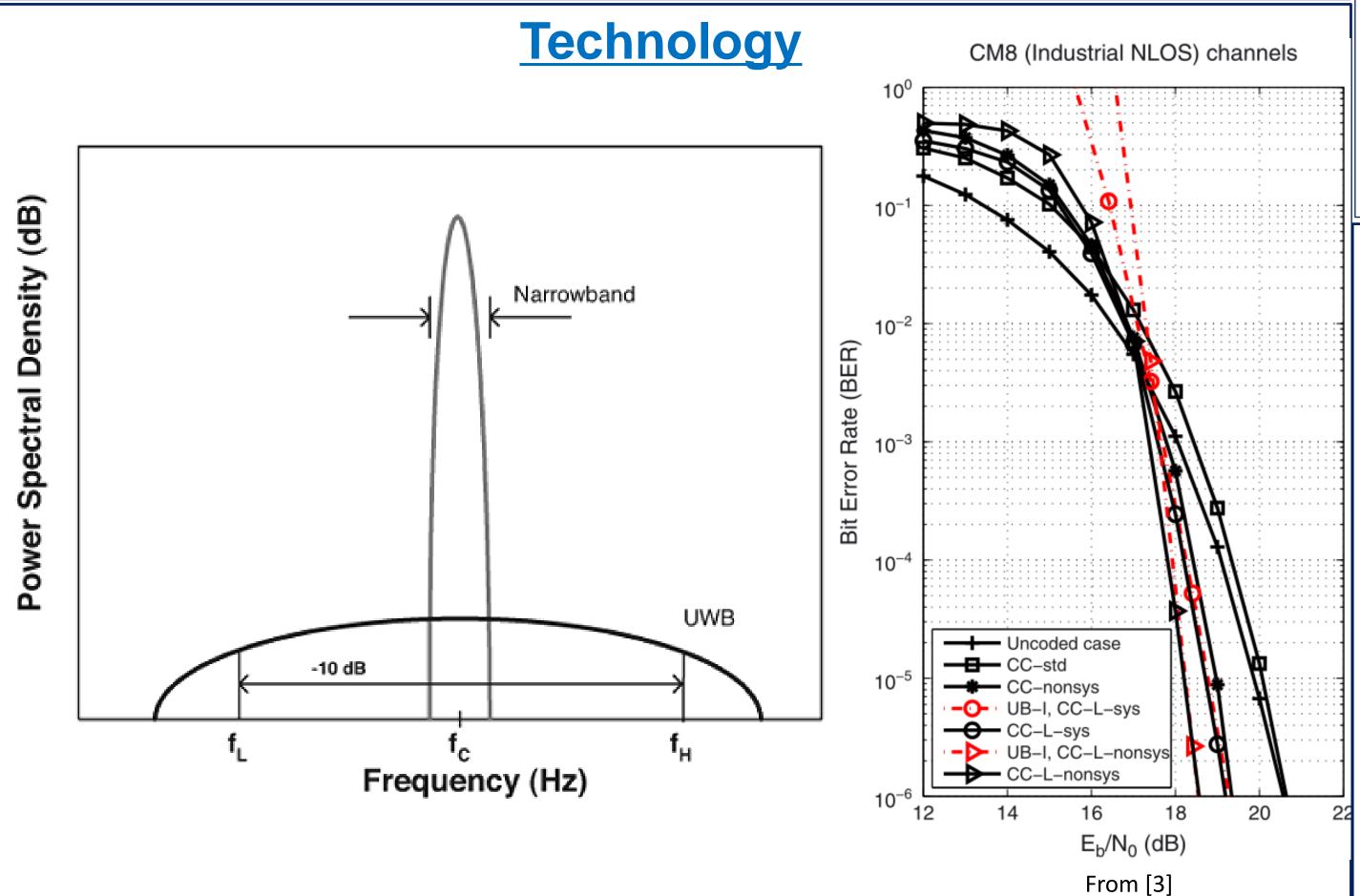
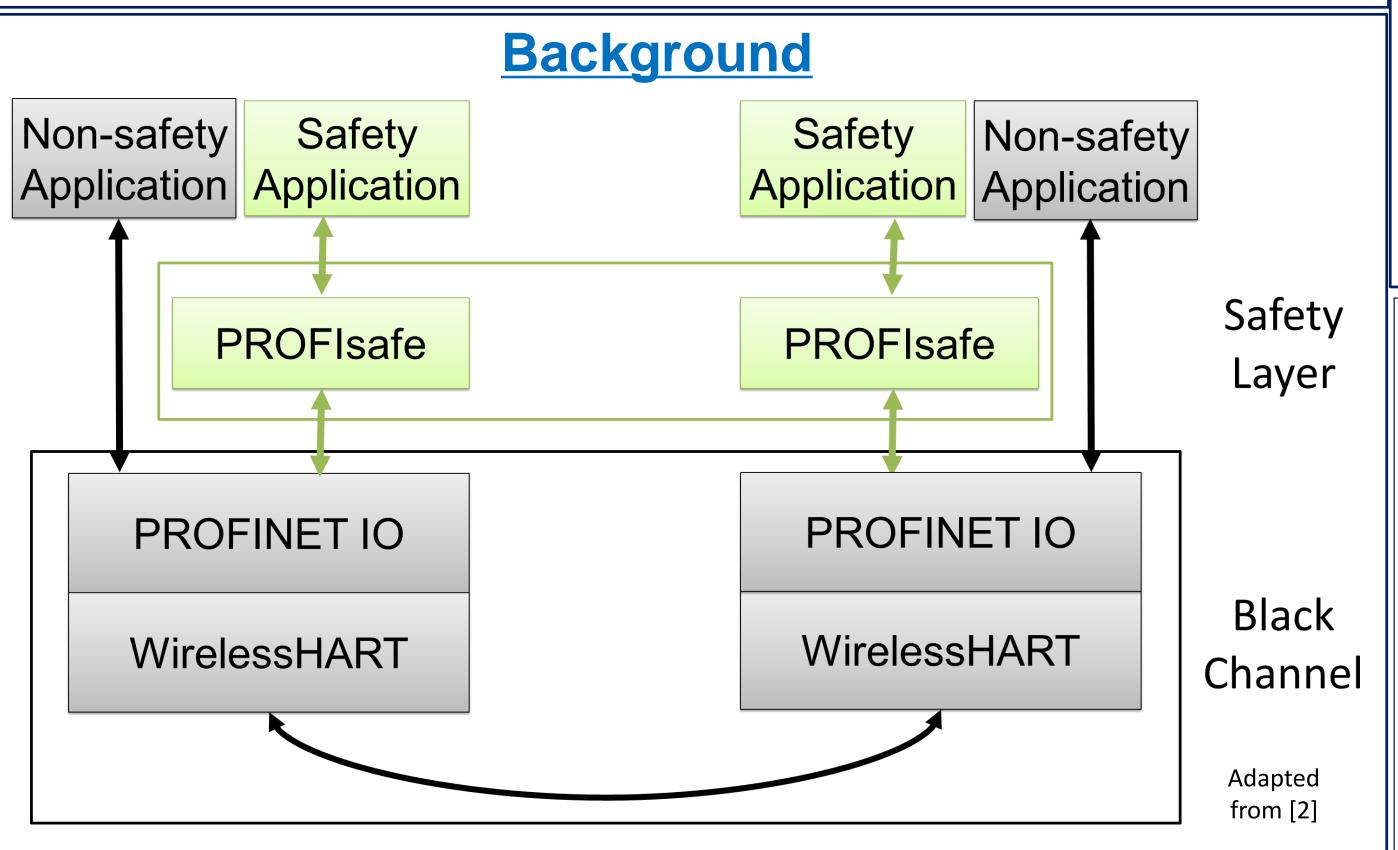
Real-time Wireless Control via Ultra-Wideband (UWB) Communication

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Motivation

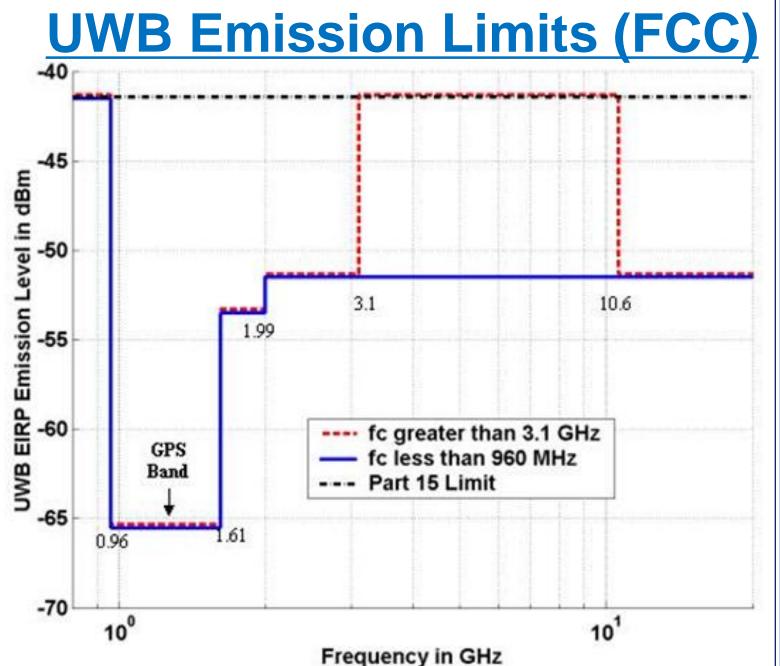
- Wireless control networks are becoming more common.
- Reliability of wireless networks for control is a concern, especially for safety-critical applications.
- Experience is that wired networks have "0 bit error rate".
- UWB is potentially more reliable in the presence of noise and interference.

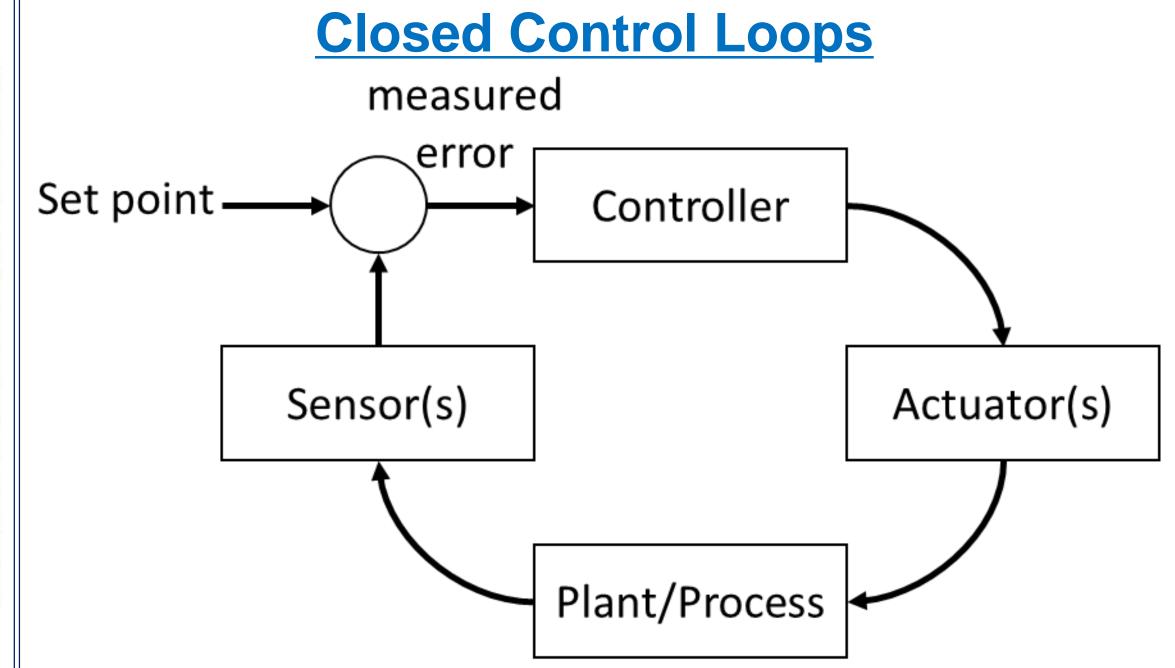




- PROFIsafe can share communication medium with non-safety functions.
- In the "black channel" model the safety layer implements mechanisms to detect and mitigate errors from the black channel (e.g. data corruption).
- The bit error rate (BER) of the black channel affects the target SIL of the safety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

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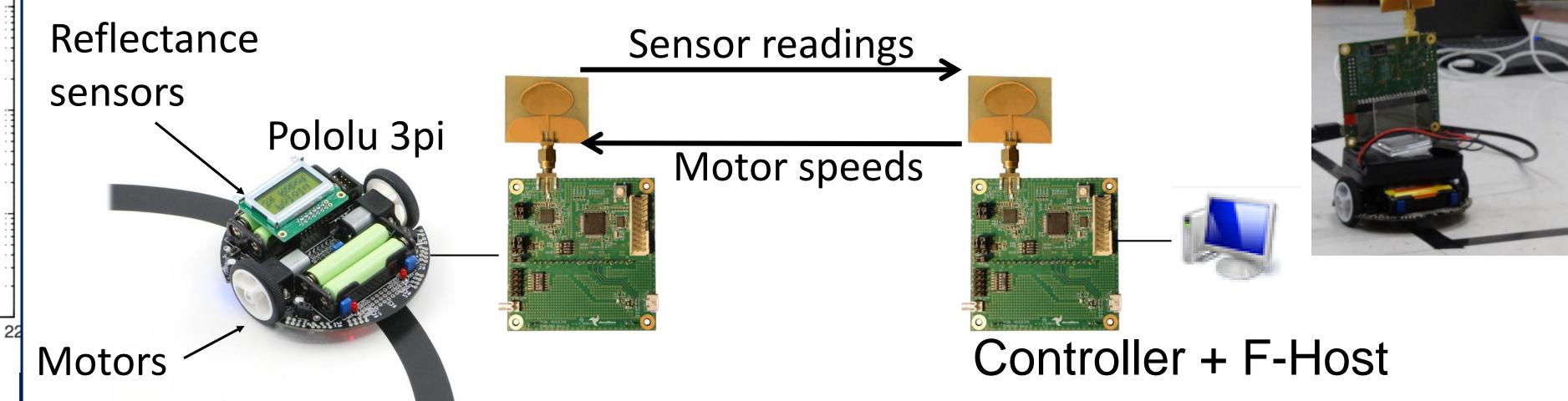


Real-Time Evaluation System

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

IEC 61508 Safety Integrity Level (SIL)

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

Objectives

- 1. What is the reliability of UWB for real-time industrial communications?
- 2. How can IEEE 802.15.4 UWB be used in real-time industrial control networks?
- 3. How can IEEE 802.15.4 UWB be used as the "black channel" with safety protocols such as PROFIsafe?
- 4. What is the relationship between UWB BER and IEC 61508 SIL?
- [1] IEEE Standard for Local and metropolitan area networks--Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)," in IEEE Std 802.15.4-2011, Sept. 5 2011
- [2] J. Åkerberg, M. Gidlund, F. Reichenbach and M. Björkman, "Measurements on an industrial wireless HART network supporting PROFIsafe: A case study," Emerging Technologies & Factory Automation (ETFA), 2011
- [3] Zhonghua Liang, Xiaodai Dong, T. Aaron Gulliver and Xuewen Liao, "Performance of transmitted reference pulse cluster ultra-wideband systems with forward error correction", Int. J. Commun. Syst. 2014; 27:265–276