Calculations & REGULATORY AGENCIES & Failure Modes

Accuracy, precision & resolution

Quantities can't be determined with absolute certainty. Measurement tools and systems have always sometolerance and disturbances that will introduce a degree of uncertainty. In addition, also the distinctiveness is a limiting factor.
The following terminology are often used in relation to the measurement uncertainty:
Accuracy: The error between the real and measured value.

Precision: The random spread of measured values around the average measured values.

Resolution: The smallest to be distinguished magnitude from the measured value.

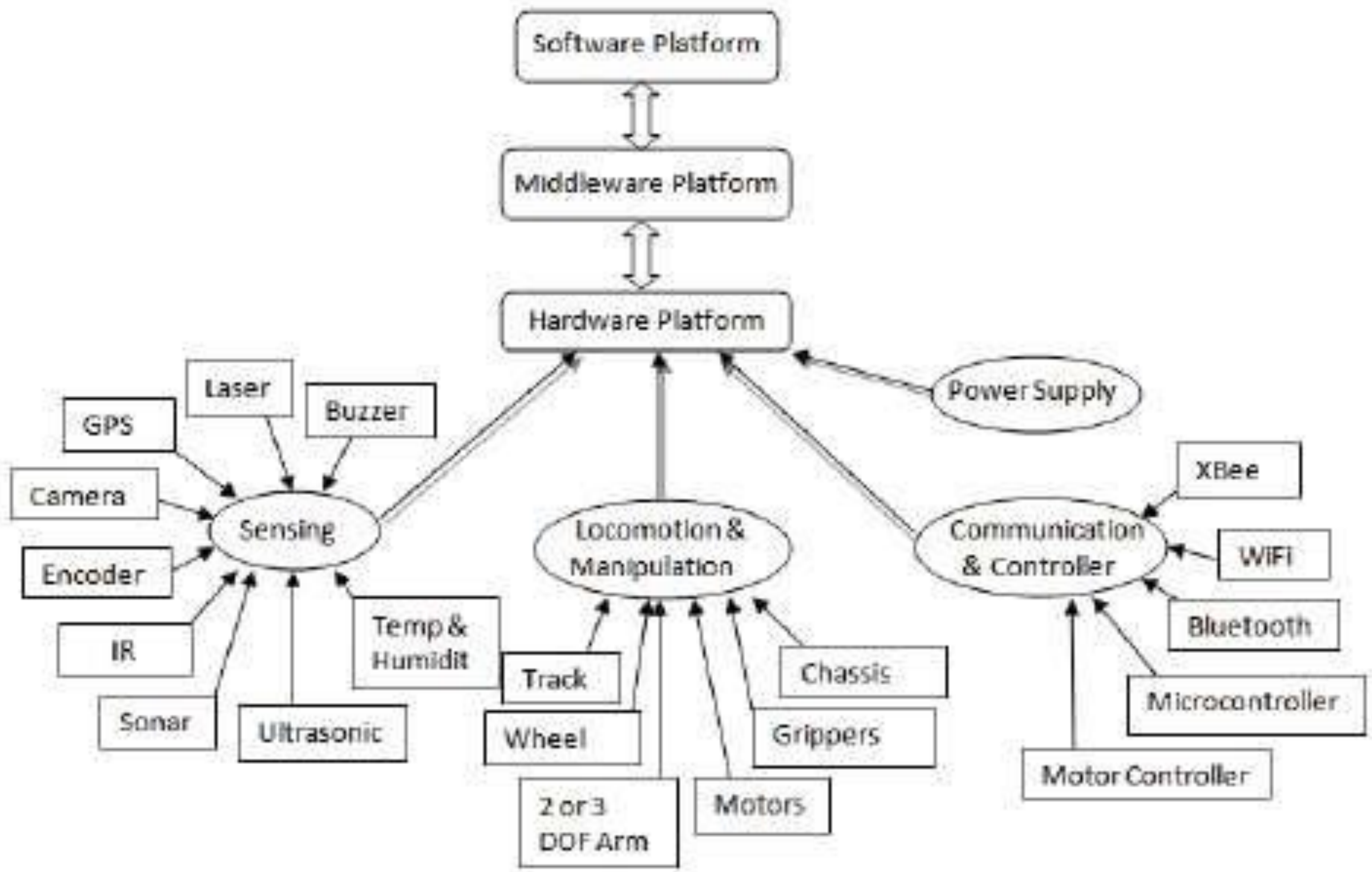
Table 1 Example conversion, on an 8-bit ADC								
Bit:	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Volts:	2.5	1.25	0.625	0.3125	0.156	0.078	0.039	0.0195
Output Value:	0	0	1	0	1	1	0	0

Table 1 illustrates this point. Adding the voltages corresponding to each set bit in 0010 1100, we get:
.625 + .156 + .078 = .859 volts

Resolution can be improved by reducing the reference input. Changing that from 5V to 2.5V gives a resolution of2.5/256, or 9.7mV. However, the maximum voltage that can be measured is now **2.5V** instead of 5V.

Paper How to Calculate Power Needs:

https://www.edn.com/efficient-powering-of-a-robot-swarm/



Efficient powering of a robot swarm

Component	Rating	Operating Time (%)	Current Consumption * No of Components	Total
Ultrasonic Sensors (SRF02)	4 mA	70%	2.8 mA * 2	5.6 mA
Ultrasonic Sensors (URM V2)	20 mA	100%	20 mA*1	20 mA
IR Sensors (Sharp)	33 mA	50%	16.5 mA * 1	16.5 mA
Temp and Humidity sensor	4 mA	10%	0.4 mA *1	0.4 mA
Servos (HS 422)	120 mA	50%	60 mA * 4	240 mA
Wheel Drive Motors	160 mA	100%	160 mA * 1	160 mA
Microcontroller (PIC)	90 mA	100%	90 mA * 1	90 mA
Encoders	4 mA	100%	4 mA * 2	8 mA
Motor Controller	10 mA	100 %	10 mA * 1	10 mA
Miscellaneous	100 mA	100 %	100 mA * 1	100 mA
			Total	650.5 mA

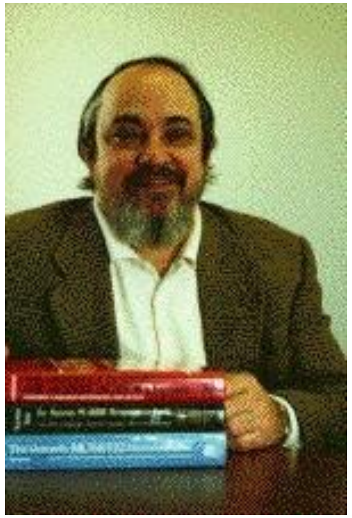
Presentation Electric Tankless Water Heaters

THOMAS L. HARMAN, Ph.D

Seisco® Tankless Electric Water Heaters
And
The New SUPERCHARGER

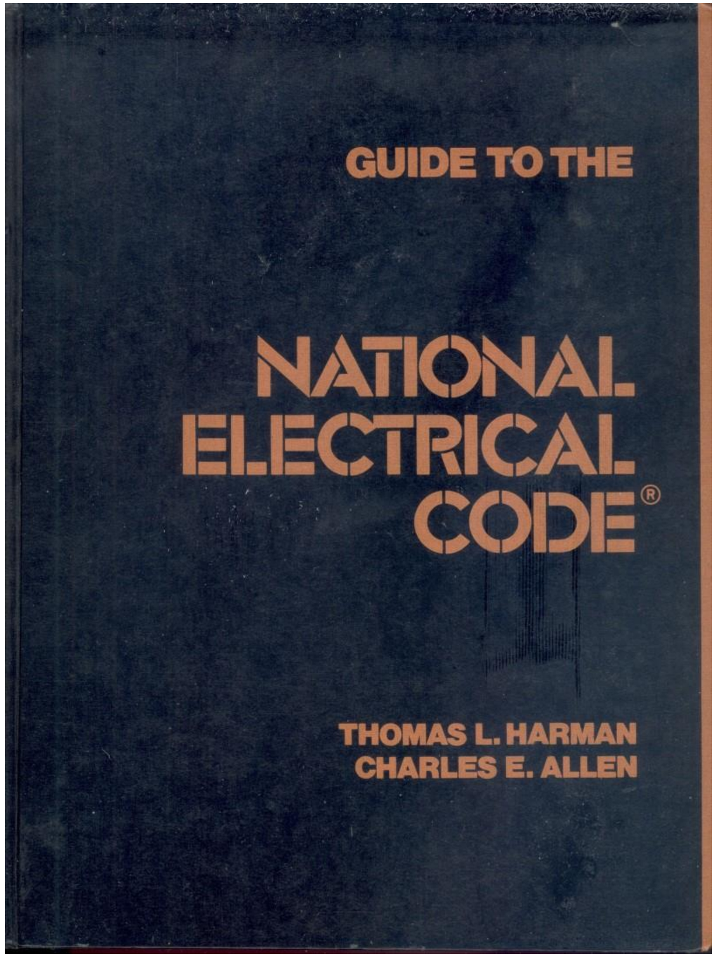
SEISCO

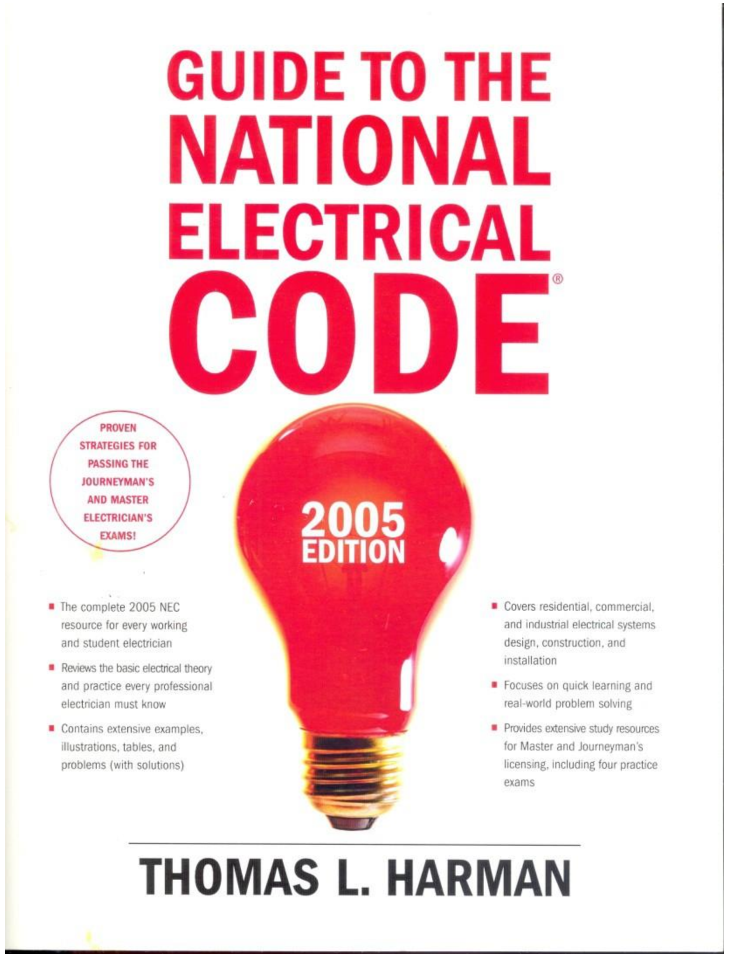
Thomas Harman

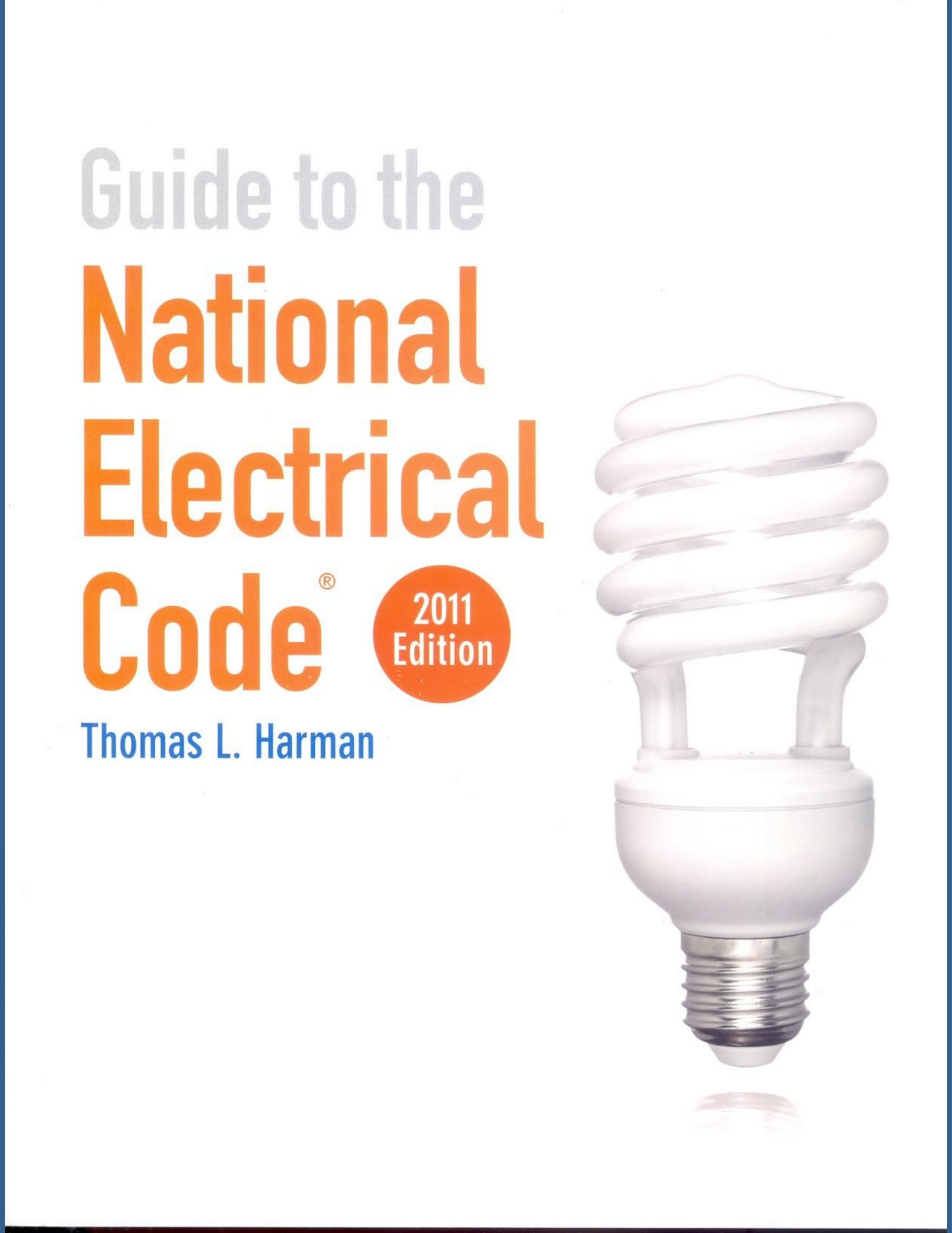


- PROFESSOR AND CHAIR OF ENGINEERING DIVISION
- ELECTRICAL ENGINEER
- MASTER ELECTRICIAN
- MEMBER NATIONAL ELECTRICAL CODE PANEL #2
- AUTHOR OF *GUIDE TO THE NATIONAL ELECTRICAL CODE* – 11TH
- CO-DESIGNER OF THE SEISCO PRODUCTS

Guide to the NEC 1979 ….






Guide to the
National
Electrical
Code®
2011
Edition
Thomas L. Harman

Seisco Tankless Electric Water Heaters

Residential Whole-House Water Heating Models ("RA")

Outside View

Inside View

SEISCO Model	Max. Power Rating (KW)	Voltage Rating (VAC)	Btu Rating	Number of Circuits Required (Two-Wire)	Maximum Temperature Rise At 3 gpm
RA-28	28	220/240	95,560	2	63° F
RA-22	22	220/240	75,080	2	50° F
RA-18	18	220/240	61,430	2	41° F

Note: The National Electric Code requires that branch circuits and breakers supplying the Water Heater to be Sized at 100% of the Water Heater's maximum amperage rating.

Electrical Load Calculations — FLORIDA EXAMPLE

150A or 200A PANEL AND DISCONNECT SWITCH

1,779 Sq. Ft. at 3 VA per Sq. Ft.	=	5,337	VA
2 ea. Appliance Circuits at 1,500 VA Ea.	=	3,000	VA
Refrigerator	=	500	VA
Dish Washer	=	1,500	VA
Clothes Washer	=	1,500	VA
Clothes Dryer		5,000	VA
Range	=	5,000	VA
Tankless Water Heater	=	28,000	VA
Sub-Total	=	49,837	VA
1 st 10,000 VA at 100%		10,000	VA
Remainder (39,837 VA) at 40%		15,935	VA
Sub-Total		25,935	VA
A/C # 1 at 100%		6,000	VA

TOTAL DEMAND LOAD AT RESIDENCE **31,935 / 230 V = 139 A**

150A or 200A PANEL AND DISCONNECT SWITCH

2,200 Sq. Ft. at 3 VA per Sq. Ft.	=	6,600	VA
2 ea. Appliance Circuits at 1,500 VA Ea.	=	3,000	VA
Refrigerator	=	500	VA
Dish Washer	=	1,500	VA
Clothes Washer	=	1,500	VA
Clothes Dryer		5,000	VA
Range	=	5,000	VA
Tankless Water Heater	=	28,000	VA
Sub-Total	=	51,100	VA
1 st 10,000 VA at 100%		10,000	VA
Remainder (41,100 VA) at 40%		16,440	VA
Sub-Total		26,440	VA
A/C # 1 at 100%		6,000	VA

TOTAL DEMAND LOAD AT RESIDENCE **32,440 / 230 V = 141 A**

150A or 200A PANEL AND DISCONNECT SWITCH

1,783 Sq. Ft. at 3 VA per Sq. Ft.	=	5,349	VA
2 ea. Appliance Circuits at 1,500 VA Ea.	=	3,000	VA
Refrigerator	=	500	VA
Dish Washer	=	1,500	VA
Clothes Washer	=	1,500	VA
Clothes Dryer		5,000	VA
Range	=	5,000	VA
Tankless Water Heater	=	28,000	VA
Sub-Total	=	49,849	VA
1 st 10,000 VA at 100%		10,000	VA

200A PANEL AND DISCONNECT SWITCH

2,376 Sq. Ft. at 3 VA per Sq. Ft.	=	7,128	VA
2 ea. Appliance Circuits at 1,500 VA Ea.	=	3,000	VA
Refrigerator	=	500	VA
Dish Washer	=	1,500	VA
Clothes Washer	=	1,500	VA
Clothes Dryer		5,000	VA
Range	=	5,000	VA
Tankless Water Heater	=	28,000	VA
Sub-Total	=	51,628	VA
1 st 10,000 VA at 100%		10,000	VA

(12) **United States Patent**
Seitz et al.

(10) **Patent No.: US 10,024,571 B2**
(45) **Date of Patent: Jul. 17, 2018**

(54) **TANKLESS WATER HEATER**

(71) Applicant: **David E. Seitz**, San Antonio, TX (US)

(72) Inventors: **David E. Seitz**, San Antonio, TX (US); **James Dabney**, Houston, TX (US); **Louis Everett**, El Paso, TX (US); **Thomas L. Harman**, Houston, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/845,039**

(22) Filed: **Dec. 18, 2017**

(65) **Prior Publication Data**

US 2018/0106497 A1 Apr. 19, 2018

Related U.S. Application Data

(63) Continuation of application No. 15/412,816, filed on Jan. 23, 2017, now Pat. No. 9,874,373, which is a

(Continued)

392/447–449, 451, 453, 465, 485, 486, 392/488, 490, 492; 237/2 A

See application file for complete search history.

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Primary Examiner — Michael Laflame, Jr.

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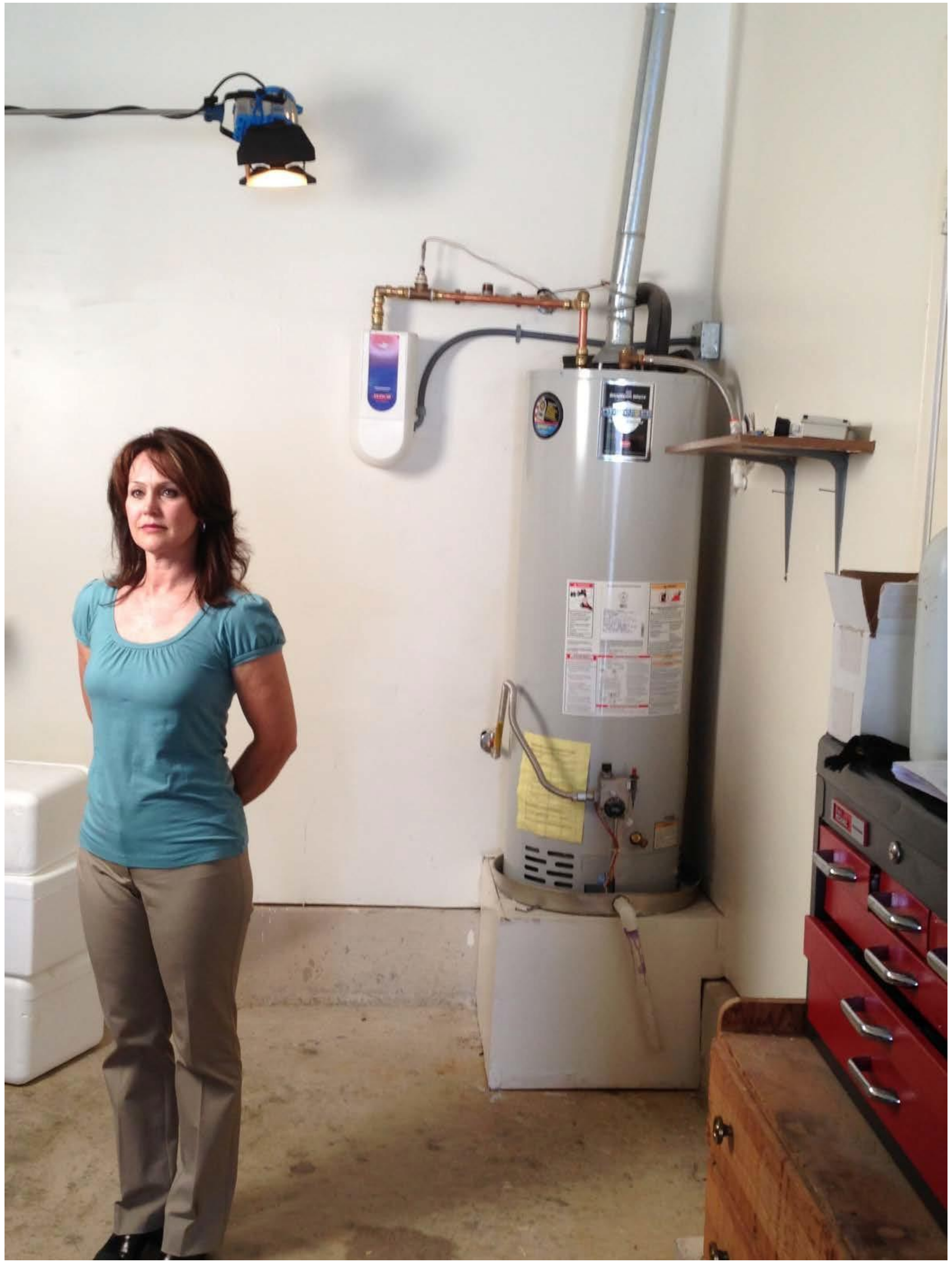


TERESA GARRETT

YOUR NEW HOME

A Guide to United States Electrical and Electronic Equipment Compliance Requirements

NIST

Agency	Scope
Consumer Product Safety Commission (CPSC)	Children's products, hazardous substances, labeling of hazardous products, consumer product safety
Customs and Border Protection (CBP)	Country of origin for most imported products
Department of Energy (DOE)	Energy efficiency
Environmental Protection Agency (EPA)	Toxic substances, Energy Star
Federal Communication Commission (FCC)	Radio frequency and digital devices
Food and Drug Administration (FDA)	Food contact substances, medical products and devices
Federal Trade Commission (FTC)	Labeling, EnergyGuide standards, environmental claims
Occupational Safety and Health Administration (OSHA)	Occupational safety, nationally recognized testing program

Underwriters Laboratories Inc.

Standard for Safety

Software in Programmable Components

3.1 A risk analysis shall be conducted to determine:

a) **The set of risks**; and

b) **That the software addresses the identified risks.**

3.2 The risk analysis shall be based on the safety requirements for the programmable component.

3.3 An analysis shall be conducted to identify the critical, non-critical, and supervisory sections of the software.

3.4 An analysis shall be conducted **to identify states or transitions that are capable of resulting in a risk.**

6.1 A fault in the software shall not initiate an event that results in a risk.

6.2 The software shall maintain an RA state upon detection of a condition that is capable of resulting in a risk as identified in Section 3, Risk Analysis.
6.3 Detection of a failure in the software during the intended operation of the product shall be handled in a manner that is in accordance with the product safety requirements.

8 Measures To Address Microelectronic Hardware Failure Modes Page

8.1 Means shall be employed to address all microelectronic hardware failure modes identified by Section 3, Risk Analysis. Appendix A contains examples of acceptable measures for microelectronic hardware.

8.2 **Physical failures of the following microelectronic hardware shall be considered:**
a) CPU registers, instruction decoding and execution, program counter, addressing and data paths;
b) Interrupt handling and execution;
c) Clock;
d) Non-volatile and volatile memory and memory addressing;
e) Internal data path and data addressing;
f) External communication and data, addressing, and timing;
g) Input/output devices such as analog I/O, D/A and A/D converters, and analog multiplexers;
h) Monitoring devices and comparitors; and
i) Application-Specific Integrated Circuits (ASICs), Gate Array Logics (GALs), Programmable Logic Arrays (PLAs), and Programmable Gate Arrays (PGAs) hardware.

12.2 Software plan Page 23

12.2.1 **A software plan shall be documented**, which describes the software development activities.
12.2.2 The software plan shall include a description of the software design methodology, development rationale, any metrics to be collected, applicable standards and the engineering methods/techniques employed, and an itemized list of all documents produced throughout the software process.

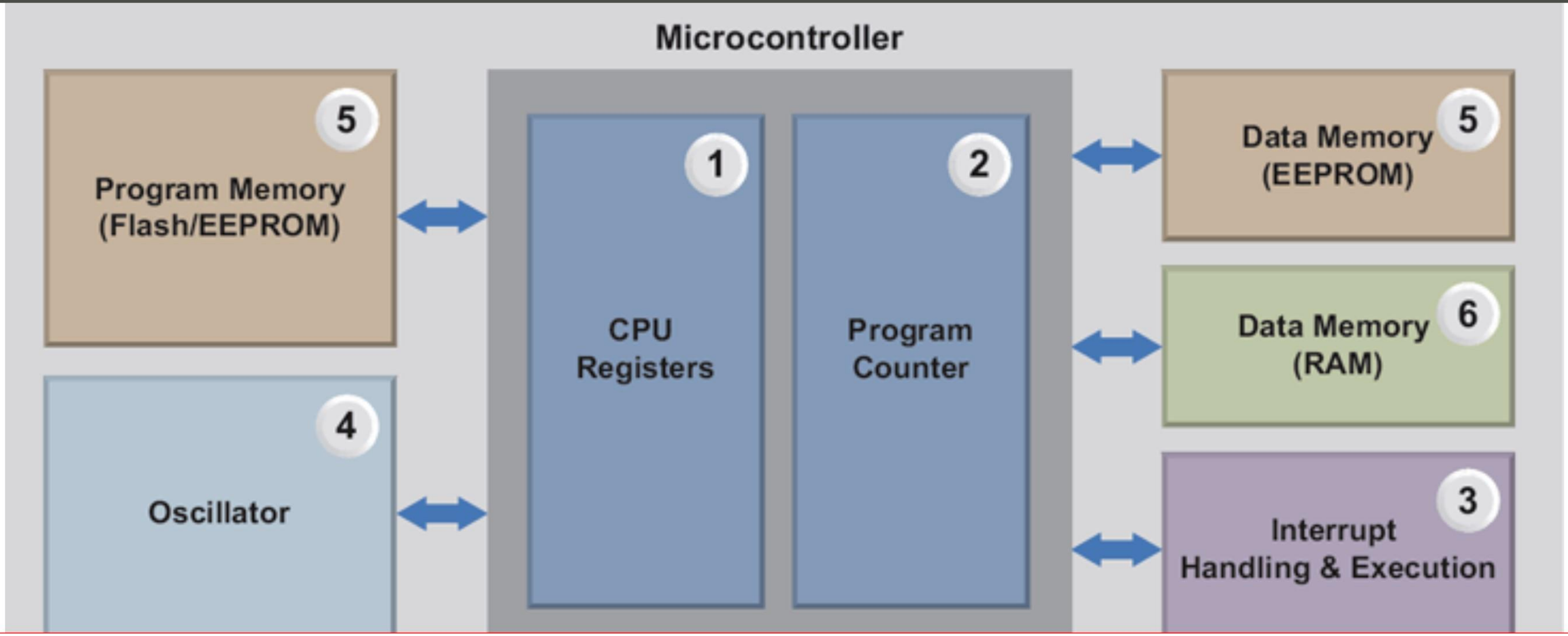
IEC 60730 Safety Standard for Household Appliances

The IEC 60730 standard classifies appliance software into three categories:

- **Class A** - Control functions that are **not intended to be relied upon for the equipment's safety** such as humidity controls, lighting controls, timers, and switches.
- **Class B** - Control functions that are intended to prevent unsafe operation of the controlled equipment such as thermal cut-offs and door locks for laundry machines.
- **Class C** - **Control functions that are intended to prevent special hazards. Examples are automatic burner controls and thermal cut-outs for closed, unvented water heater systems.**

CPU registers can be monitored by using a periodic test routine that writes a 0xAA pattern followed by a 0x55 pattern to verify no register bits are stuck at a 1 or 0 state.

A CPU program counter can be similarly tested with a 0x55/0xAA pattern by placing small routines at addresses 0x5555.. and 0xAAA.. that have return from subroutine instructions (RTS). The CPU should execute these routines and then examine the contents in the stack pointer



We have developed a library of low-level software routines and hardware peripherals that simplify meeting IEC 60730 requirements for class B safety.

Components Covered by the Class B Safety Software Library

1	CPU Registers	Stuck
2	Program Counter	Stuck
3	Interrupt handling and execution	No interrupts or too many interrupts
4	Clock Frequency	Clock failure or incorrect frequency

Embedded Control Systems Design/Failure modes and prevention

https://en.wikibooks.org/wiki/Embedded_Control_Systems_Design/Failure_modes_and_prevention

Some examples of hardware failure modes:

- Electrical failure: short-circuiting, too high voltage/current
- Mechanical failure: jamming of a valve
- Temperature effects: deformation of components
- Material failure: corrosion

Some examples of software failure causes are:

- Deadlock: two or more processes are each waiting for the other to finish, so none of the processes ever finish.
- Resource starvation: a process doesn't get the resources it needs, so it can never finish.
- Too small memory
- Noise
- Shared interfaces with other systems

Some examples of hardware failure causes:

- Hostile environments: any factor which prevents a system from functioning correctly.
- Badly calibrated sensors
- Choosing the wrong dimensions
- Manufacturing/assembly process deficiencies