



**MICROCHIP**

# **Power Monitoring for Connected Lighting Systems**

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**Microchip Technology Inc.**

- **Metrology Evolution**
- **Power-Monitoring Implementations**
  - System Characterization
  - Software
  - Hardware
    - Zero-Cal
  - Distributive Scheme
- **Power-Monitoring Examples & Uses**

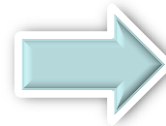
# Metrology Evolution

## Electric Utility Meters



- Strict/high-end requirements
- Government regulation
- Standards (e.g., IEC62053-21/22)
- High volume

## Power Monitoring



- Provides more granular data
- Dependent on connectivity
- Moving to utility-grade or revenue-grade accuracy

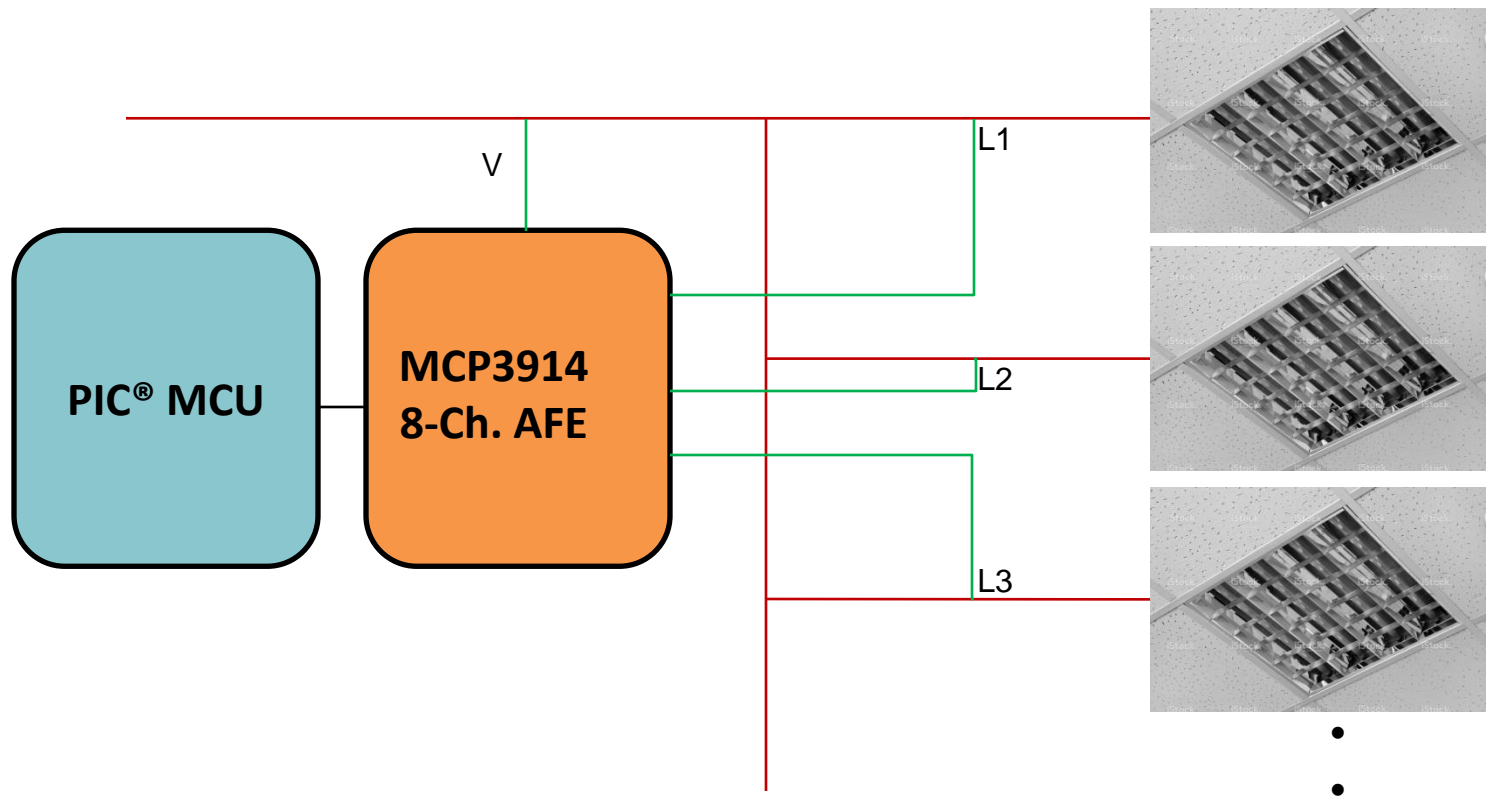


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**Power-Monitoring  
Implementations**

# Distributed Power-Monitoring Scheme

- A centralized power-monitoring unit can monitor multiple loads (i.e., lighting bays, room, floor)





# Distributed Power-Monitoring Scheme

- **Distribution Point**

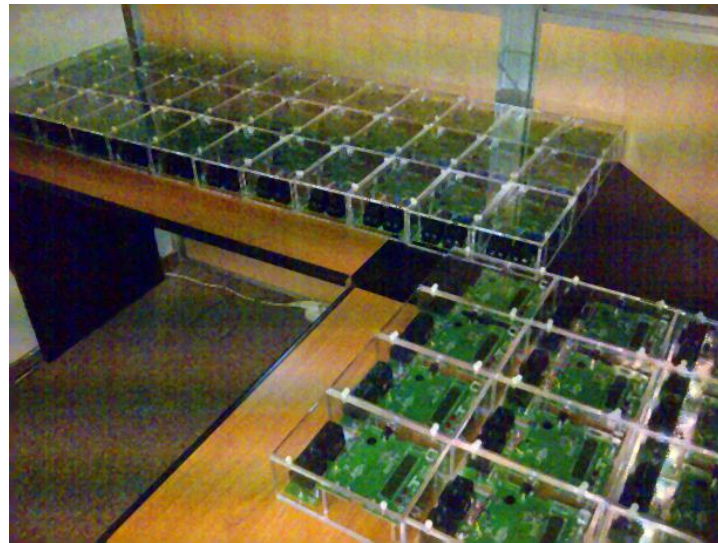
- AFE provides input up to 8-Ch.:  
1 voltage & up to 7 current loads
- Paired MCU does the calculations
- Implementation cost is thus divided among multiple units
- Less granularity

Characteristics	
Accuracy	0.1%
Hardware	<\$5.50 / 7
Software	Moderate
Calibration	1

# System Characterization

- **Characterize a set number of production units**
- **Estimate power usage based on current conditions**
  - Rough idea of power usage
  - Sensitive to changes in production

Characteristics	
Accuracy	10-20%
Hardware	No added hardware
Software	Low
Calibration	None



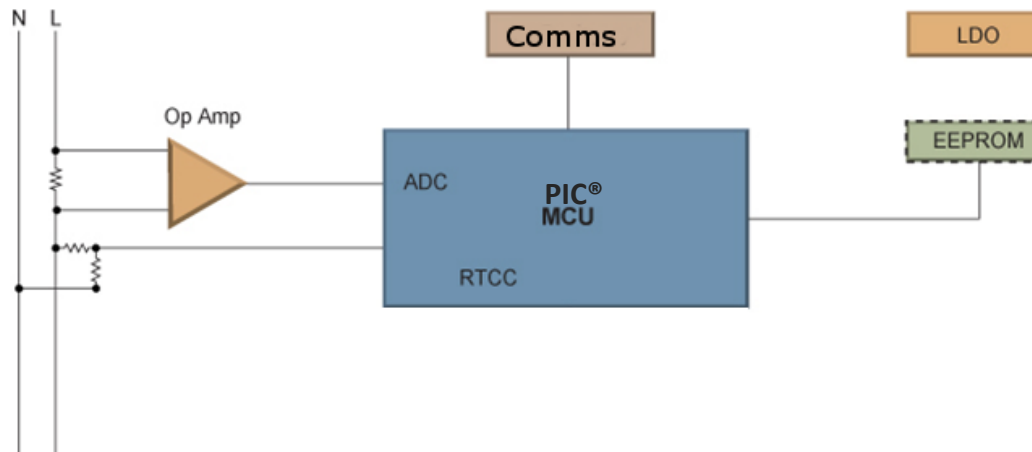
# Software Based

- **System microcontroller's ADC can be used for power measurement**

- Requires additional MCU resources
- Requires signal conditioning
- Provides good to moderate accuracy, dependent on the effort

## Characteristics

Accuracy	1% to 5%
Hardware	<\$0.80
Software	Complex
Calibration	1 to 2 point



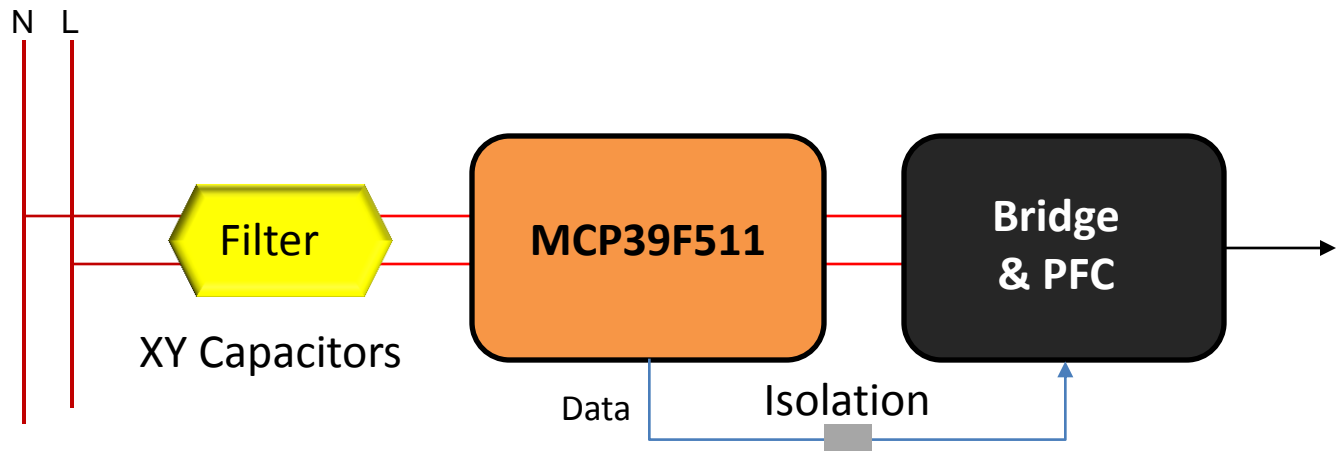


# Hardware Based

- **Dedicated power-monitoring IC**

- Provides all power calculations
- Event monitoring
- Best accuracy
- Zero-cal can significantly reduce production cost

Characteristics	
Accuracy	0.1% to 2%
Hardware	<\$1.40
Software	Low
Calibration	1 to None



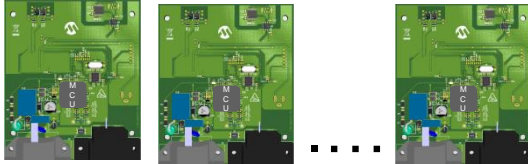
# What a Power-Monitor IC Offers

- **Revenue-Grade Accuracy**
  - Active, reactive and apparent power
  - Active and reactive energy accumulation
  - True RMS current, RMS voltage
  - Line frequency, power factor
  - Zero crossing detection pin
  - Event monitoring



# Zero Calibration

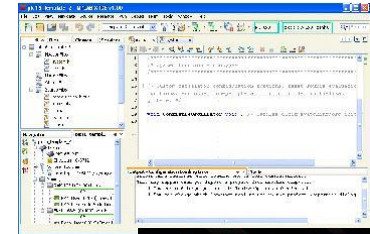
1 X pre-production units built and calibration data recorded



2 Determine **mean** values then Cal values

Sales Targets for Global Electronics	
1	Total International Quota
2	2002 Germany 10000
3	2002 United States 20000
4	2002 Australia 3000
5	2002 Canada 5000
6	2002 Hong Kong 4000
7	2002 Japan 8000
8	2002 Korea 3000
9	2002 United Kingdom 4000
10	2002 France 7000
11	2002 Singapore 2000
12	2002 Spain 2000
13	2002 Germany 10000
14	2002 United States 20000
15	2002 Australia 3000
16	2002 Canada 5000
17	2002 Hong Kong 4000
18	2002 Japan 8000
19	2002 Korea 3000
20	2002 United Kingdom 4000
21	2002 France 7000
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23	2002 Spain 2000
24	2002 Germany 10000
25	2002 United States 20000
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31	2002 United Kingdom 4000
32	2002 France 7000
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34	2002 Spain 2000
35	2002 Germany 10000
36	2002 United States 20000
37	2002 Australia 3000
38	2002 Canada 5000
39	2002 Hong Kong 4000
40	2002 Japan 8000
41	2002 Korea 3000
42	2002 United Kingdom 4000
43	2002 France 7000
44	2002 Singapore 2000
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49	2002 Canada 5000
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92	2002 Australia 3000
93	2002 Canada 5000
94	2002 Hong Kong 4000
95	2002 Japan 8000
96	2002 Korea 3000
97	2002 United Kingdom 4000
98	2002 France 7000
99	2002 Singapore 2000
100	2002 Spain 2000

3 Cal values incorporated into application code Or QTP part #

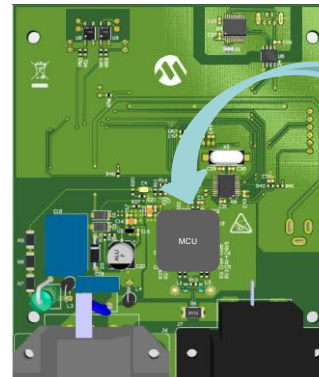


5 Ship to your customers



pe0064162 [RF] © www.viewphoto.com

4 Program application software into MCU  
 A) In-circuit  
 B) Pre-programmed by Microchip (QTP)





# Example Zero Cal.

## Set-up: 1% shunt, 1% voltage divider, internal oscillator

UNIT #	VOLTAGE	CURRENT	POWER	FREQUENCY	% Error - Voltage	% Error - Current	% Error - Power	% Error - Frequency
800	220.1	5.0187	1107.76	50.28	0.04545	0.374	0.705454545	0.56
801	220.1	4.9691	1097.03	49.824	0.04545	-0.618	-0.27	-0.352
802	220.7	5.0185	1110.8	49.86	0.31818	0.37	0.981818182	-0.28
803	219.9	4.9493	1091.59	49.772	-0.04545	-1.014	-0.764545455	-0.456
804	219.7	4.9811	1097.31	50	-0.13636	-0.378	-0.244545455	0
805	220.1	5.0278	1110.03	49.964	0.04545	0.556	0.911818182	-0.072
806	219.6	4.9405	1088.32	49.894	-0.18182	-1.19	-1.061818182	-0.212
807	219.9	4.9594	1093.91	49.876	-0.04545	-0.812	-0.553636364	-0.248
808	219.7	5.0359	1109.59	49.93	-0.13636	0.718	0.871818182	-0.14
809	219.6	4.9602	1092.46	49.93	-0.18182	-0.796	-0.685454545	-0.14
811	220.1	5.0359	1093.91	49.876	0.04545	0.718	-0.553636364	-0.248
813	219.4	5.0005	1100.32	49.93	-0.27273	0.01	0.029090909	-0.14
815	219.8	4.9853	1099.1	50.07	-0.09091	-0.294	-0.081818182	0.14
817	218.6	4.9339	1081.59	49.548	-0.63636	-1.322	-1.673636364	-0.904
819	219.8	4.9981	1102.02	49.912	-0.09091	-0.038	0.183636364	-0.176
821	220.8	4.9969	1106.59	49.756	0.36364	-0.062	0.599090909	-0.488
823	219.9	4.9867	1100.01	49.964	-0.04545	-0.266	0.000909091	-0.072
				Min	-0.68182	-1.76200	-1.67364	-0.90400
				Max	0.72727	0.86000	1.12273	0.56000
				Average	0.00423	-0.43953	-0.17571	-0.15433

**Results: <2% on 50 units, potentially <1.5% if optimized**

# Tradeoff Comparison

Characteristic	Distributed	System Characterization	Software Based	Hardware Based
Accuracy	0.1%	10% to 20%	1% to 5%	0.1% to 2%
Granularity	Medium	Low	High	High
Hardware	<\$5.50 / 7	None	<\$0.80	<\$1.40
Software	Moderate	Low	Complex	Low
Calibration	1	None	1 to 2	1 to None



**MICROCHIP**

**Power-Monitoring Examples &  
Uses**

# LED Lighting

- **Energy reporting for intelligent lighting systems, calculating energy costs and system optimization**
- **Integrated DALI protocol into our Power-Monitoring IC**



# Commercial Ovens

- **Precision heating to cook rapidly and consistently over thousands of cycles**
- **Allows them to adjust as power conditions change and as equipment ages**





# HVAC OEMs

- **Provide end users with power-usage data to enable informed decisions**
- **Also, to prove their efficiency because competitors would lie!**



# Server Power Supplies

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- **Very fast voltage sag indication is needed to switch server loads**
- **Need high-accuracy monitoring, even at low-load conditions**



# Smart Plugs

- **Smart plugs specifically designed to monitor coffee machines**
- **By power/current profile, they can determine cup size, coffee style, etc.**



# Conclusions

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- **Power-monitoring technology has become accessible**
- **Energy reporting and connectivity are key to intelligent lighting systems**
- **There are uses for power monitoring outside of reporting**