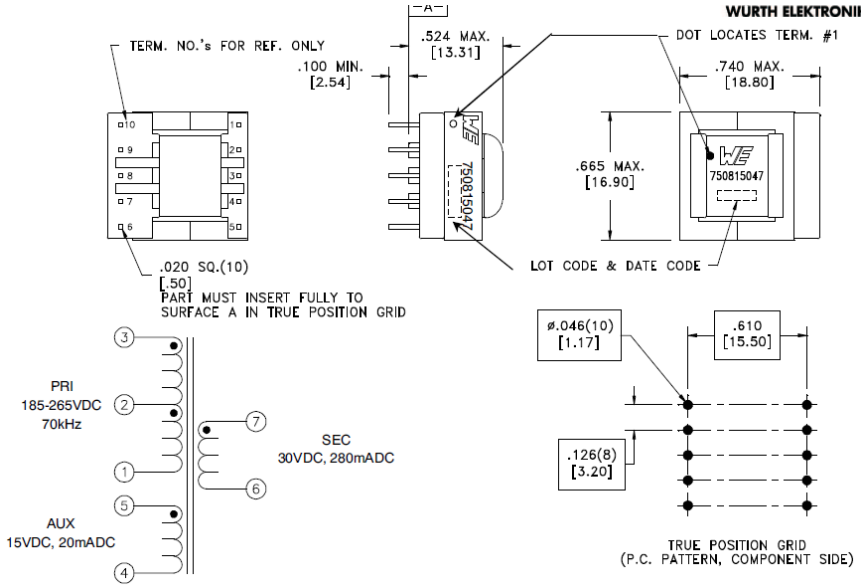
LM3447: Performance Analysis
(43 EVM Production Samples)

Lighting Power Products
Longmont Design Center

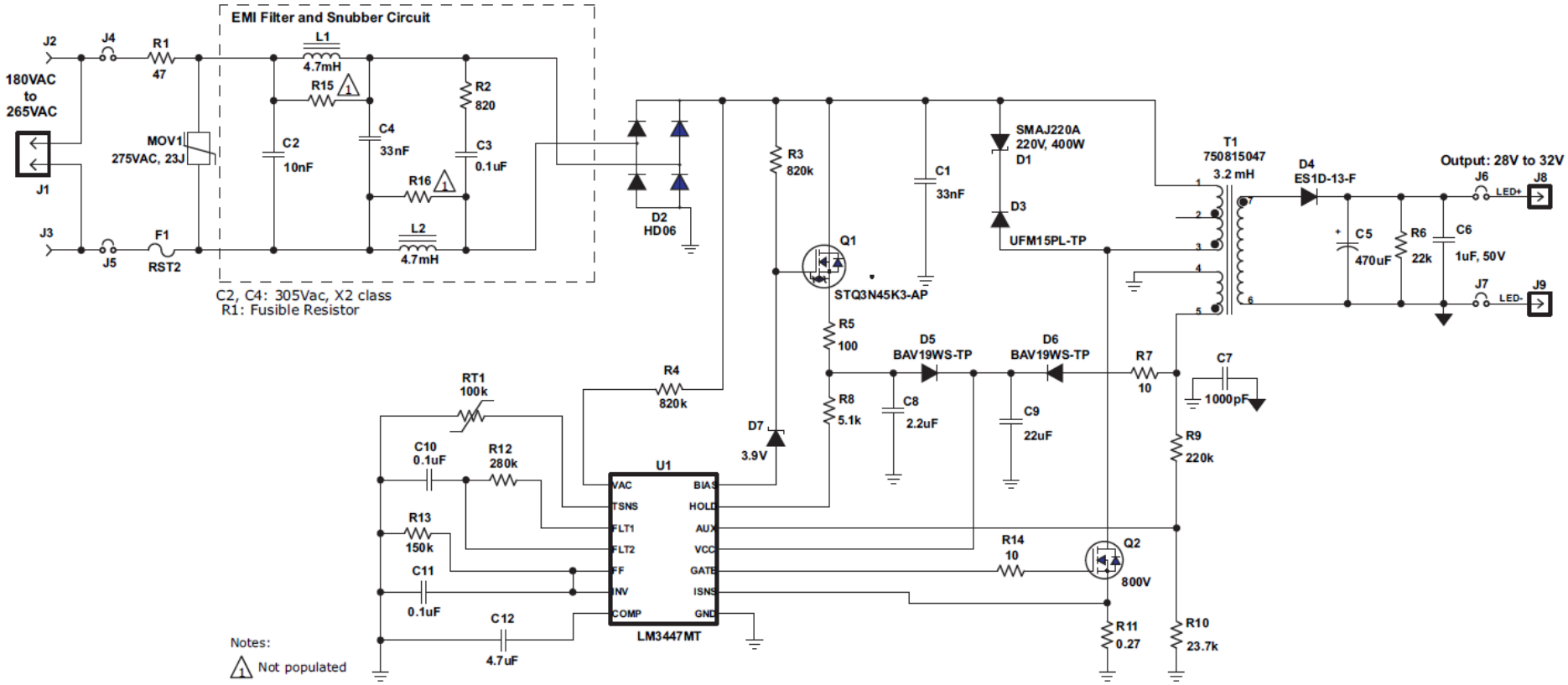
Design Example: LM3447-A19-230VEVM
(Online: http://www.ti.com/tool/lm3447-a19-230vevm)



	Typ	Units
Input Voltage	230	V_{RMS}
Output Voltage	30	V
LED Current	275	mA
Output Power	8.25	W
Input Power	10.1	W
Efficiency	82	%
Power Factor	0.95	

- EVM production lot = 150
- Sampled size = 43
- Random sampling
- LM3447MT – Tape & Reel
- Xfmr – 750815047
  Wurth Electronics China

Schematic: LM3447-A19-230VEVM



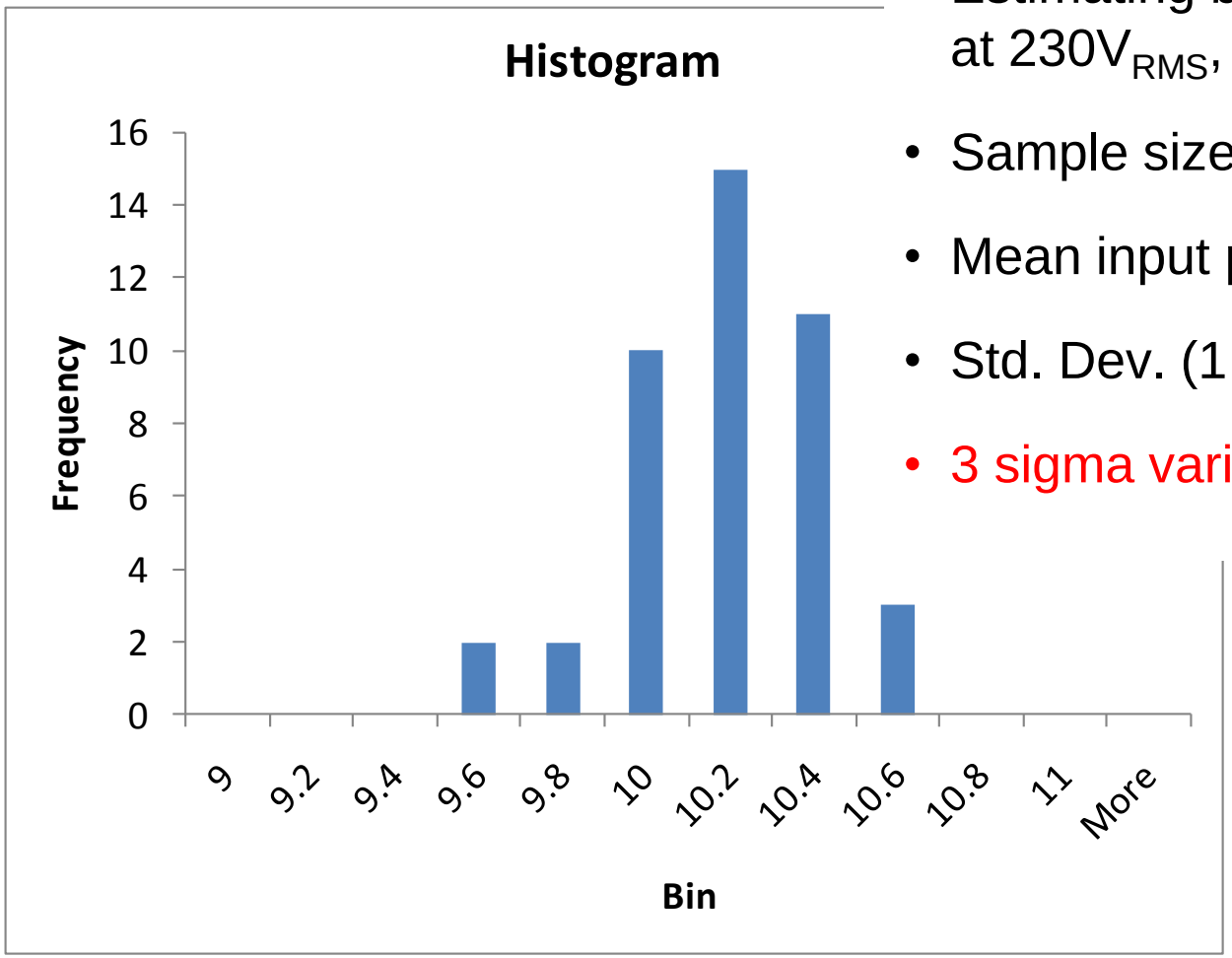
LM3447: Theoretical Analysis (1)

$$P_{IN} = \frac{\pi}{4} \frac{G_{FF}^2 V_{REF}^2}{L_M f_S} \left(\frac{R_{AC}}{R_{FF}} \right)^2$$

- P_{IN} – *Input power*
- L_M – *Primary side magnetizing inductance*
- f_s – *Switching frequency*
- G_{FF} – *Internal gain*
- V_{REF} – *Internal reference*
- R_{AC} – *AC sense resistor (R4)*
- R_{FF} – *Feedforward resistor (R13)*

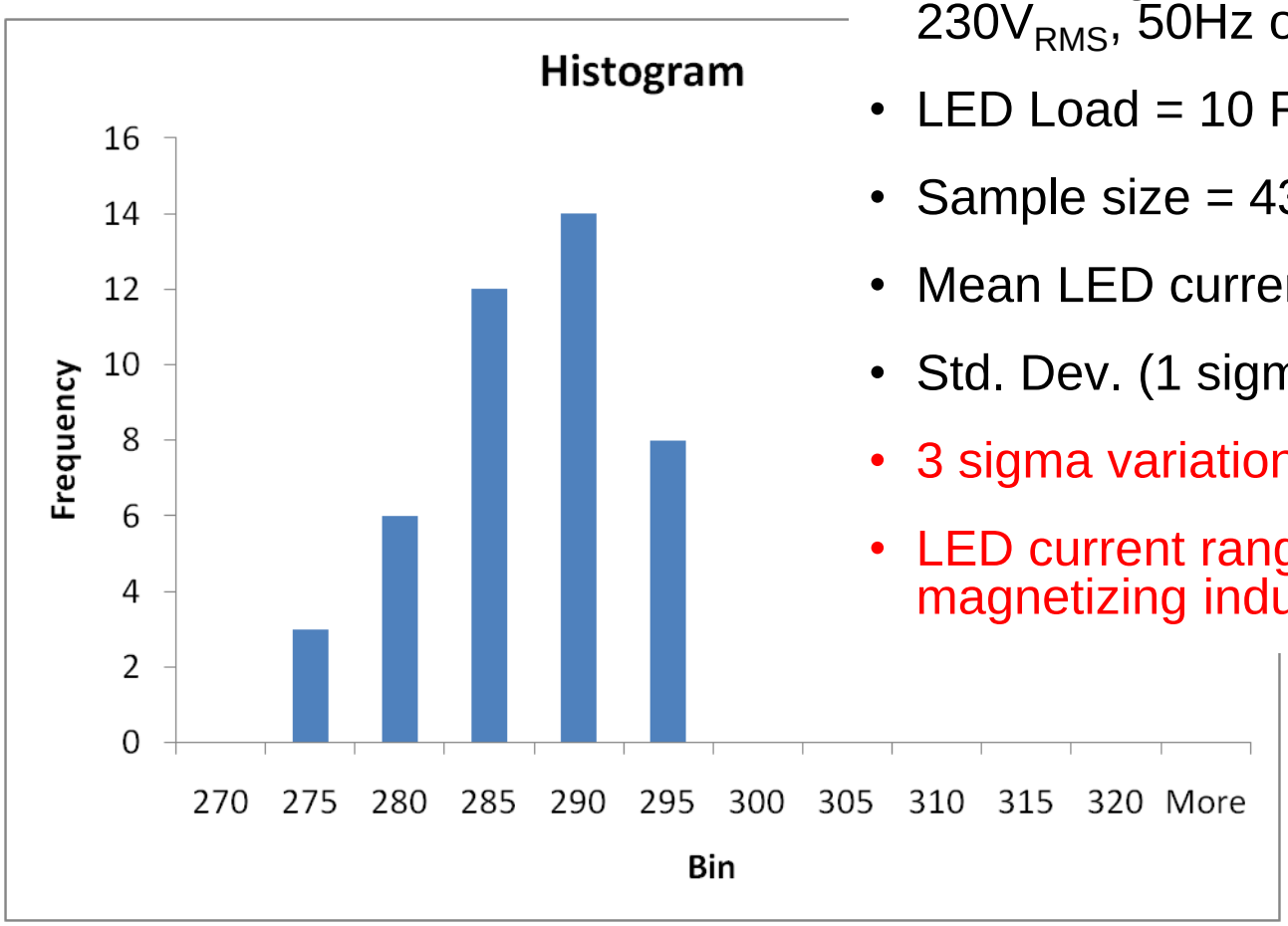
- Input power is function of external components
- Impact of magnetizing inductance: L_M
  - Inversely proportionality
  - Manufacturing spec < ±10%
  - Based on air-gap tolerance (independent of Ferrite material)
- External resistors (ratio)
  - R_{AC} & R_{FF} with ±1% tolerance
- Internal IC parameters trimmed and tested to industry standards

Input Power Variation (Production Run)



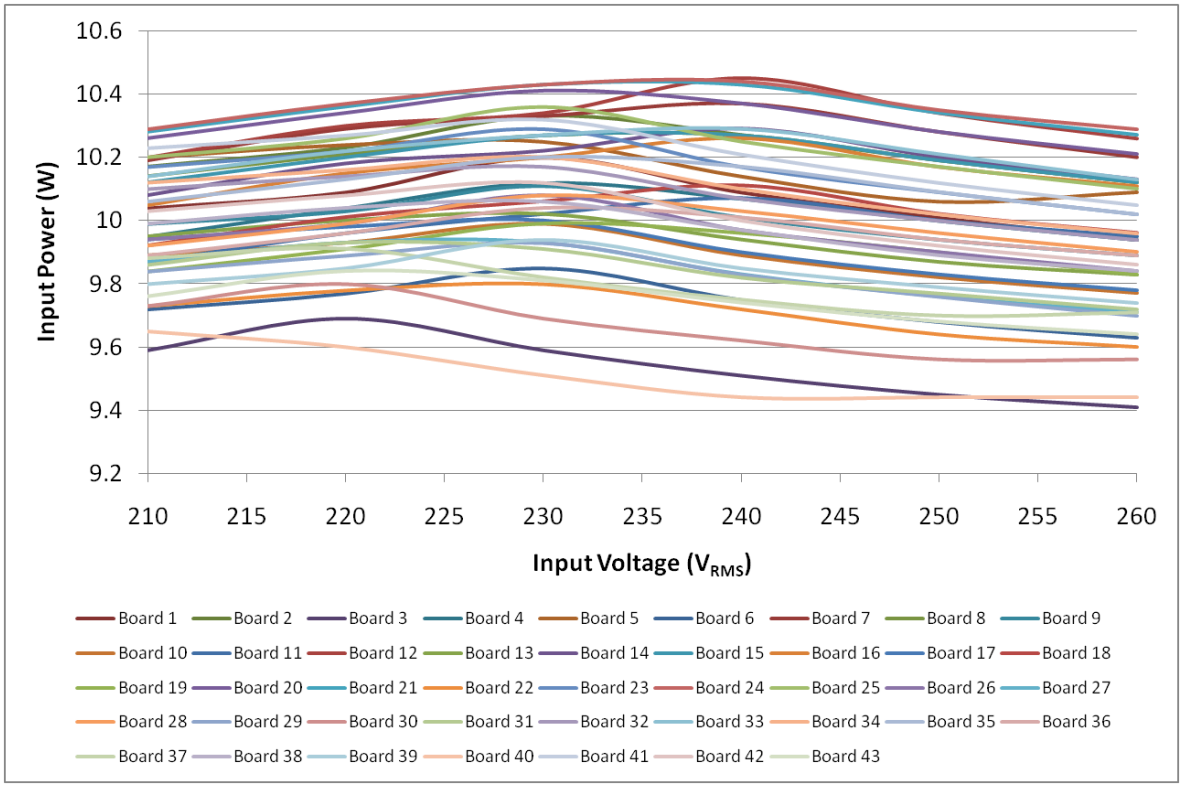
- Estimating board-to-board variations at 230V_{RMS}, 50Hz operating point
- Sample size = 43 boards
- Mean input power = 10.1W
- Std. Dev. (1 sigma) = 221mW
- 3 sigma variation= ±6.6%

LED Current Variation



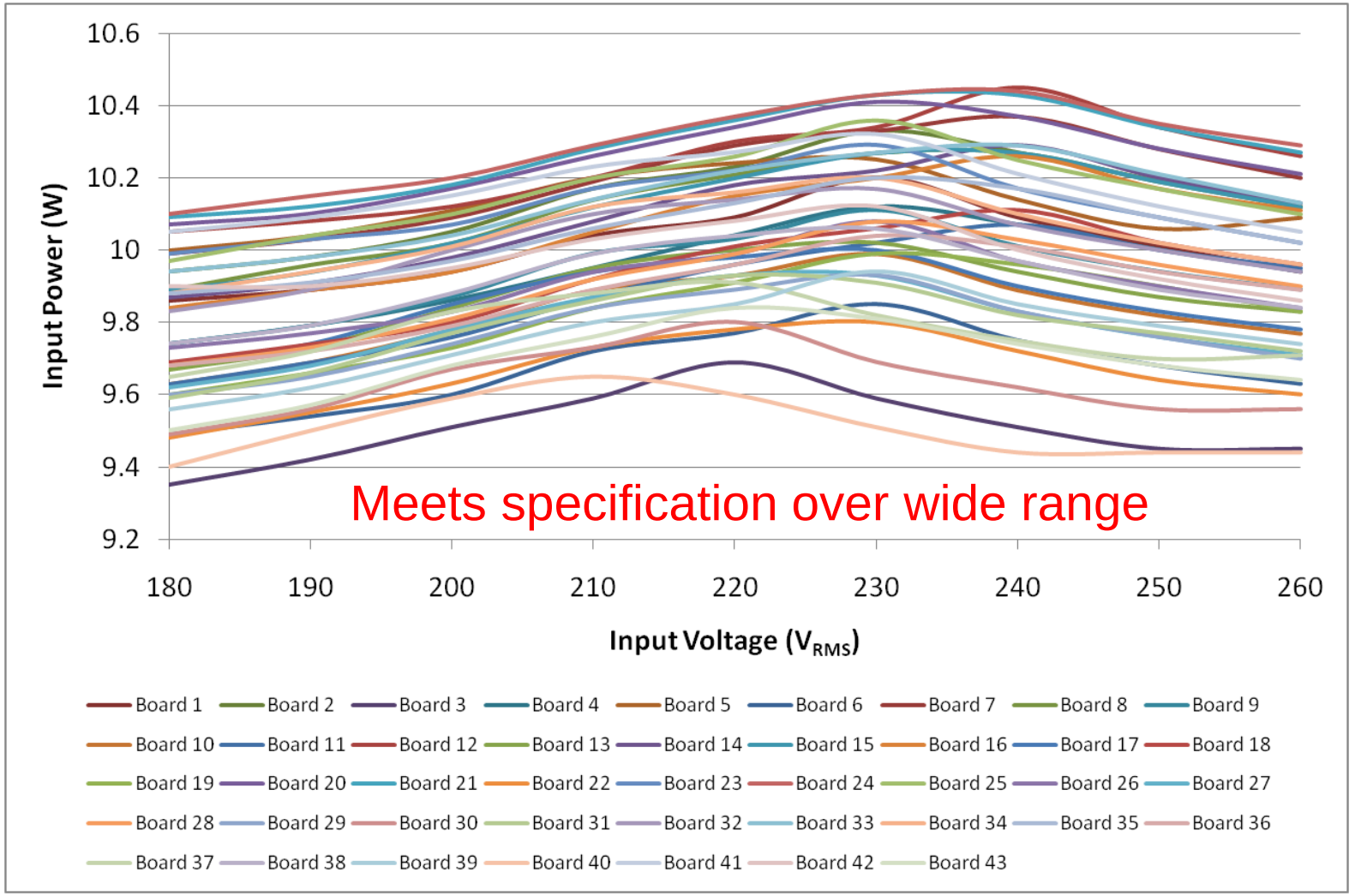
- Estimating board-to-board variations at $230V_{RMS}$, 50Hz operating point
- LED Load = 10 Rebel LEDs
- Sample size = 43 boards
- Mean LED current = 284mA
- Std. Dev. (1 sigma) = 5.86mA
- 3 sigma variation= ±6.19%
- LED current range depends on magnetizing inductance variation

Input Power vs. Input Voltage (210V to 260V)

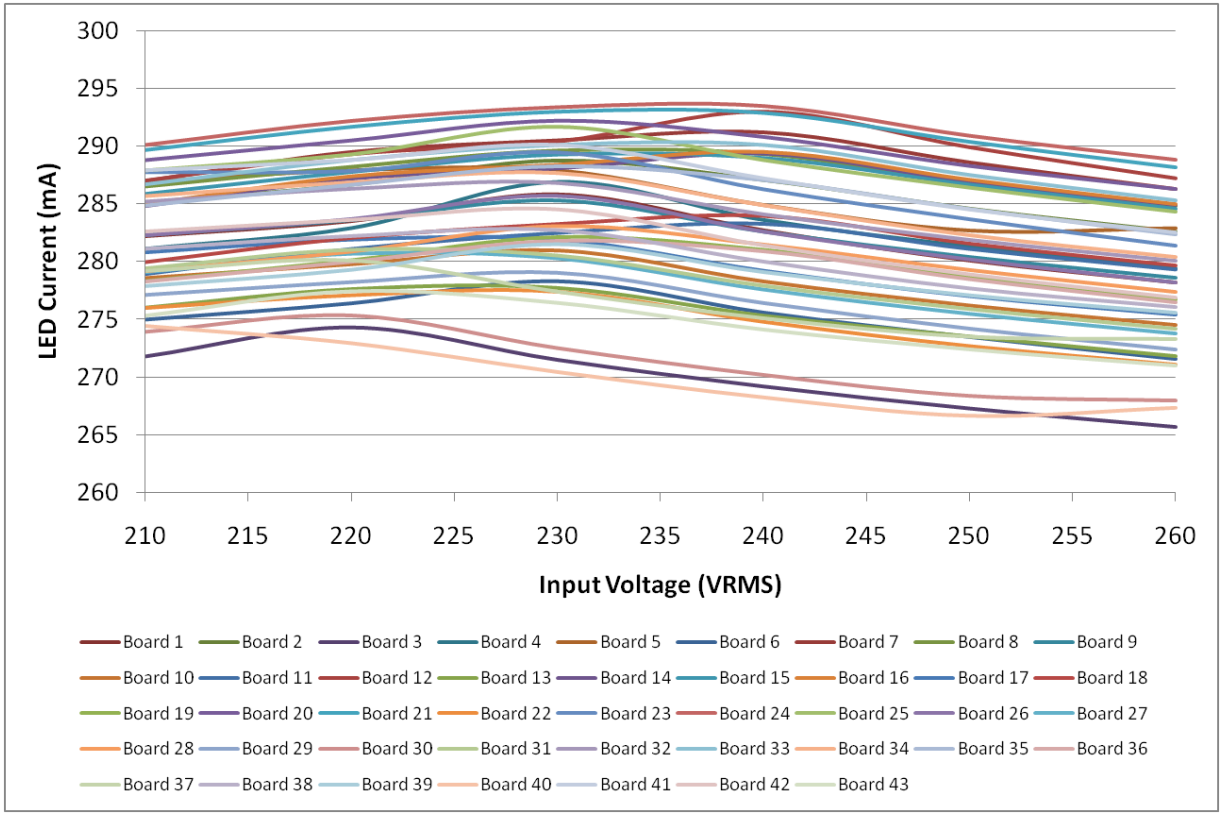


- Input power range for sample size of 43 boards ($210V_{RMS}$ to $260V_{RMS}$)
  - Min = 9.44W (−5.7%)
  - Max = 10.45W (+4.4%)
  - Average = 10.01W
- Input power deviation at any given voltage < ±7.5% (3 sigma)

Input Power vs. Input Voltage: Extended Range (180V to 260V)

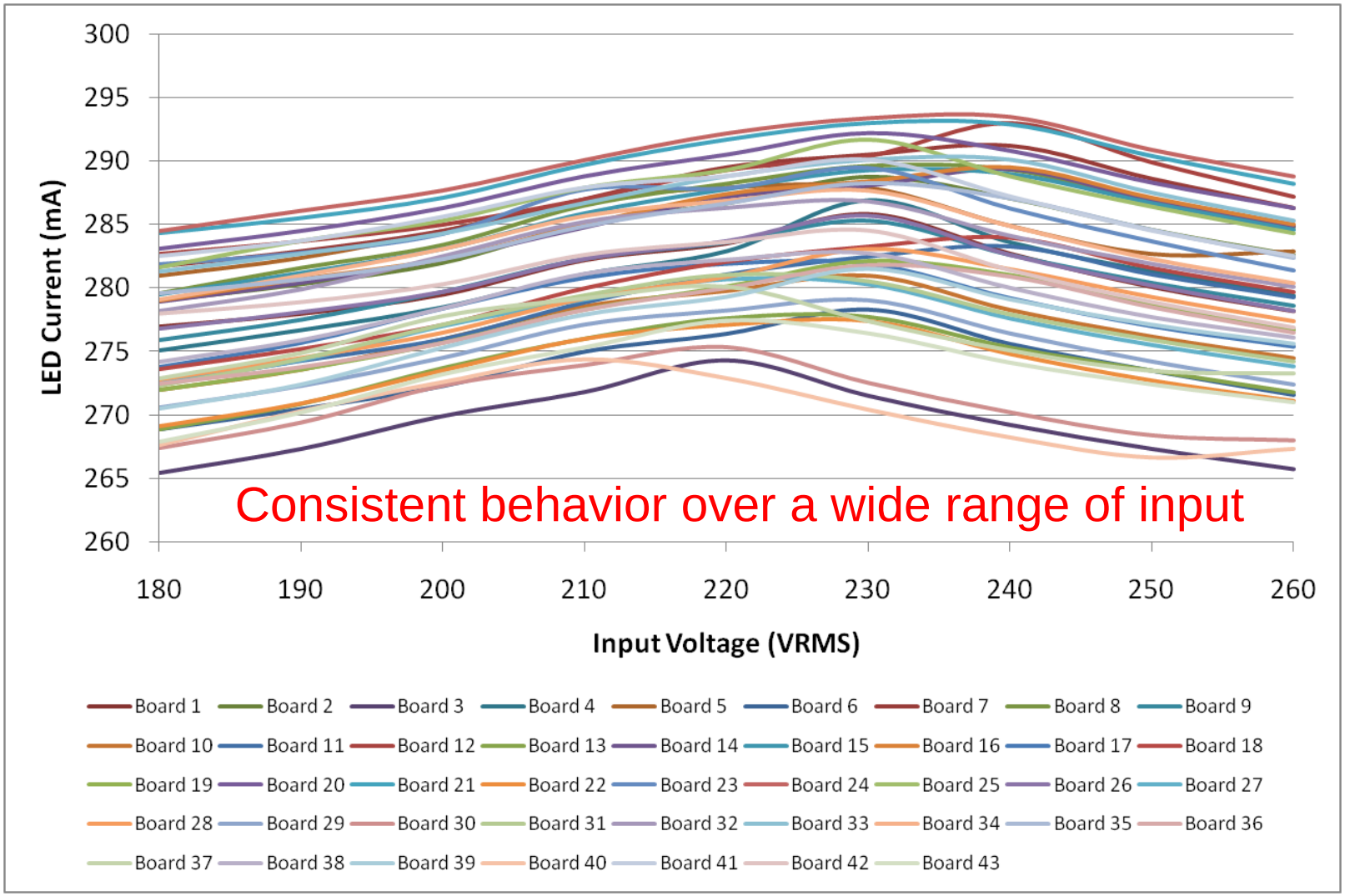


LED Current vs. Input Voltage

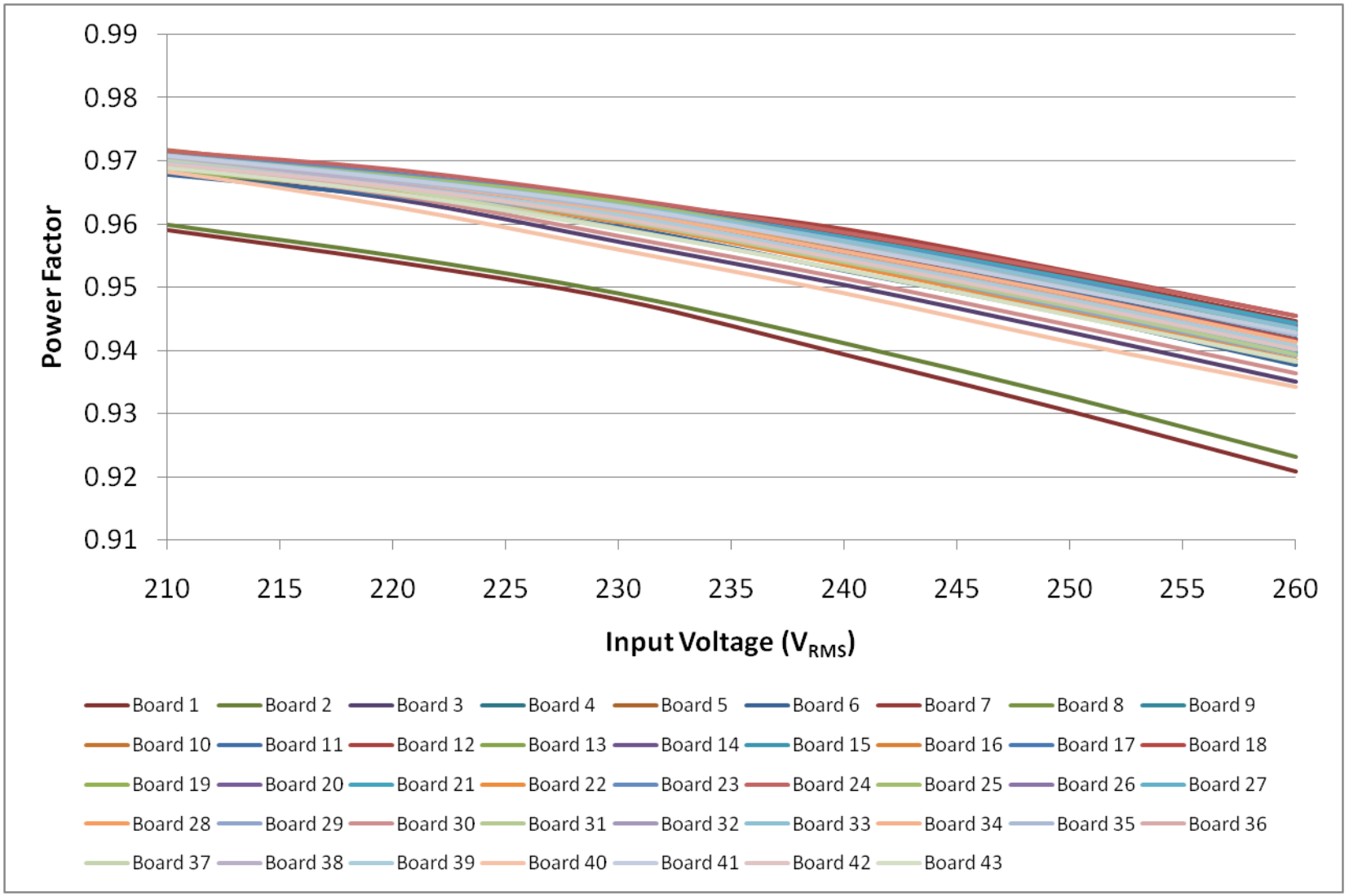


- LED current range for sample size of 43 boards ($210V_{RMS}$ to $260V_{RMS}$)
  - Min = 265.7mA(-5.74%)
  - Max = 293.5mA (+4.12%)
  - Average = 282mA
- LED current deviation at any given voltage < ±7% (3 sigma)

LED Current vs. Input Voltage: Extended Range (180V to 260V)



Power Factor vs. Input Voltage

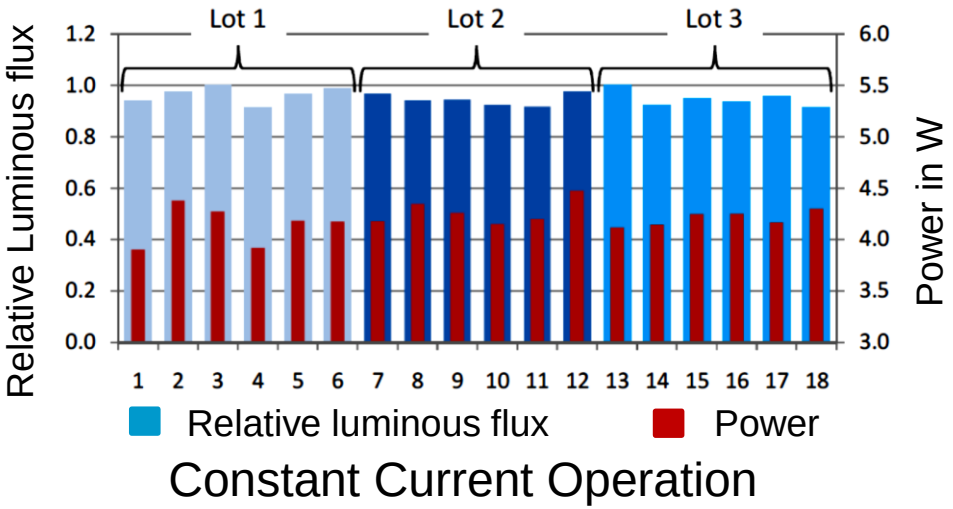


Summary

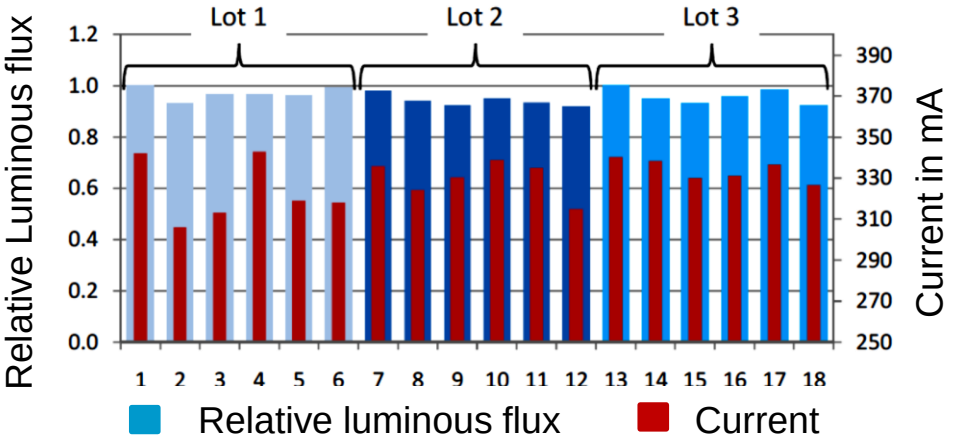
- Input power and LED current dependent on
  - Magnetizing inductance (L_M)
  - External resistors (R_{AC}, R_{FF})
  - Internal IC parameters (G_{FF}, V_{REF}, f_S)*
- Theoretical analysis can be performed based on mathematical relation derived DCM Flyback PFC converter
- Experimental analysis performed for LM3447-A19-230VEVM using a sample size of 43 boards and 10 series connected Luxeon Rebel LED load board
  - Input power variation at $230V_{RMS}$, 50Hz = ±6.6% (3 sigma)
  - LED current variation at $230V_{RMS}$, 50Hz = ±6.19% (3 sigma)
  - Input power variation at any voltage between 210-260V < ±7.5% (3 sigma)
  - LED current variation at any voltage between 210-260V < ±7% (3 sigma)
- Input power variation is within the desired specification over input range (3 sigma)
- LED current variation is close to the desired specification over input range (3 sigma)
- Expecting lower luminous flux variation over different LED bins, operating temperature and life time using power regulation approach
- Improved LED current matching can be achieved by reducing magnetizing inductance variation during manufacturing

* Contact TI for more information

Discussion: Comparing Power Regulation with Current Regulation Control



Constant Current Operation



Constant Power Operation

- Measured experimental data for 18 CREE MC-E LEDs
- Constant current (350 mA) operation
  - Maximum luminous flux difference of 8.5%
- Constant power (4 W) operation
  - Maximum luminous flux difference of 6.7%
- Power regulation approach is suggested to be better than current regulation when considering LED manufacturing variations

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