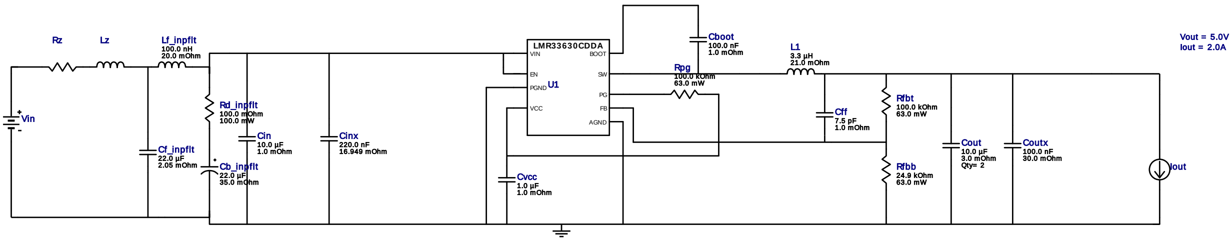
| | | |
|---|---|---|
| **TEXAS INSTRUMENTS** | VinMin = 18.0V<br>VinMax = 30.0V<br>Vout = 5.0V<br>Iout = 2.0A | Device = LMR33630CDDAR<br>Topology = Buck<br>Created = 2020-07-19 08:35:56.915<br>BOM Cost = $2.36<br>BOM Count = 17<br>Total Pd = 1.92W |

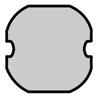
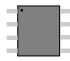
# WEBENCH ® Design Report

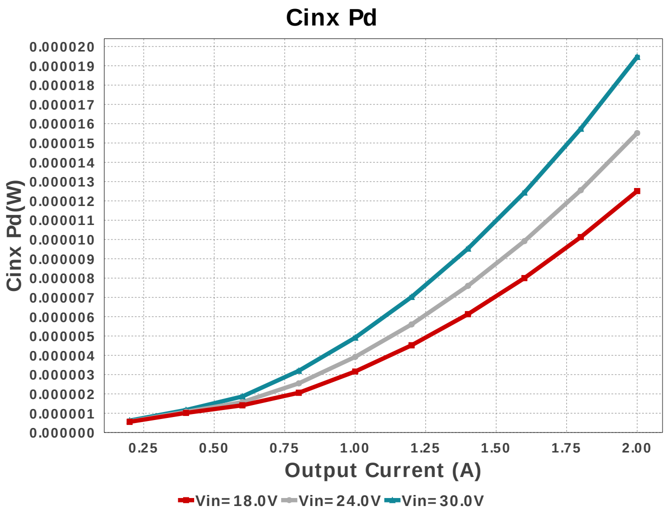
Design : 79 LMR33630CDDAR
LMR33630CDDAR 18V-30V to 5.00V @ 2A

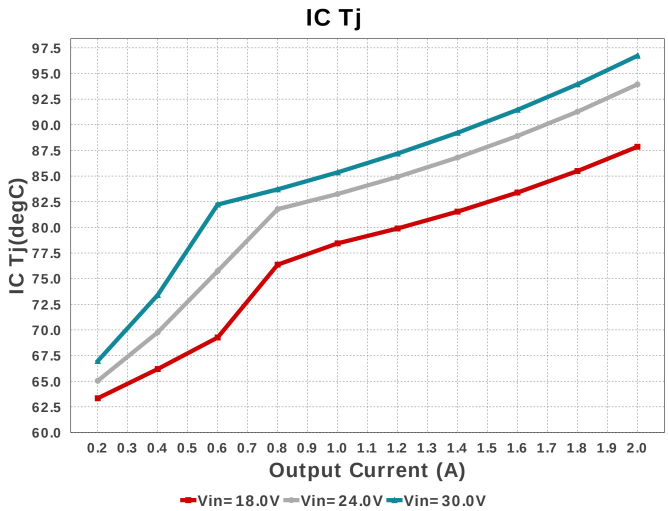


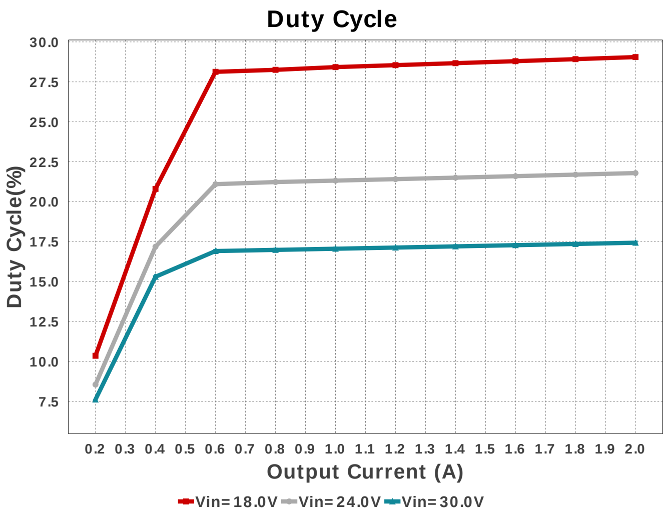

## Electrical BOM

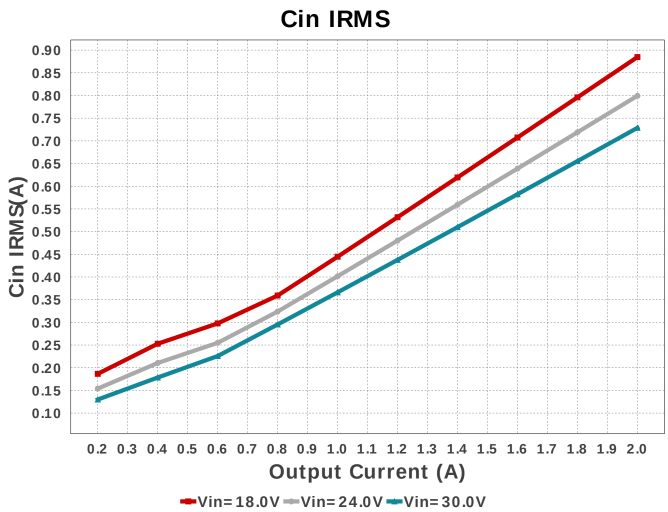
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| Cb_inpflt | Panasonic | 35SVPF22M<br>Series= SVPF | Cap= 22.0 uF<br>ESR= 35.0 mOhm<br>VDC= 35.0 V<br>IRMS= 2.6 A | 1 | $0.44 | CAPSMT_62_F61 74 $mm^2$ |
| Cboot | MuRata | GRM155R71C104KA88D<br>Series= X7R | Cap= 100.0 nF<br>ESR= 1.0 mOhm<br>VDC= 16.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 $mm^2$ |
| Cf_inpflt | TDK | C2012X5R1V226M125AC<br>Series= X5R | Cap= 22.0 uF<br>ESR= 2.05 mOhm<br>VDC= 35.0 V<br>IRMS= 4.5559 A | 1 | $0.33 | 0805 7 $mm^2$ |
| Cff | MuRata | GRM1555C1H7R5CA01D<br>Series= C0G/NP0 | Cap= 7.5 pF<br>ESR= 1.0 mOhm<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 $mm^2$ |
| Cff | MuRata | GRM1555C1H7R5CA01D<br>Series= C0G/NP0 | Cap= 7.5 pF<br>ESR= 1.0 mOhm<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 $mm^2$ |
| Cin | TDK | C3225X7R1H106M250AC<br>Series= X7R | Cap= 10.0 uF<br>ESR= 1.0 mOhm<br>VDC= 50.0 V<br>IRMS= 5.0 A | 1 | $0.28 | 1210 15 $mm^2$ |
| Cinx | TDK | C2012X7R1H224K125AA<br>Series= X7R | Cap= 220.0 nF<br>ESR= 16.949 mOhm<br>VDC= 50.0 V<br>IRMS= 1.5961 A | 1 | $0.03 | 0805 7 $mm^2$ |
| Cout | Kemet | C0805C106K8PACTU<br>Series= X5R | Cap= 10.0 uF<br>ESR= 3.0 mOhm<br>VDC= 10.0 V<br>IRMS= 11.43 A | 2 | $0.03 | 0805 7 $mm^2$ |
| Coutx | MuRata | GRM188R71E104KA01D<br>Series= X7R | Cap= 100.0 nF<br>ESR= 30.0 mOhm<br>VDC= 25.0 V<br>IRMS= 1.51 A | 1 | $0.01 | 0603 5 $mm^2$ |
| Cvcc | Kemet | C0603C105K8PACTU<br>Series= X5R | Cap= 1.0 uF<br>ESR= 1.0 mOhm<br>VDC= 10.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0603 5 $mm^2$ |

| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| L1 | Bourns | SRN8040-3R3Y | L= 3.3 µH<br>21.0 mOhm | 1 | $0.27 | <br>SRN8040 100 mm² |
| Lf_inpflt | TDK | NLCV32T-R10M-PFR | L= 100.0 nH<br>20.0 mOhm | 1 | $0.10 | <br>NLCV32 13 mm² |
| Rd_inpflt | Panasonic | ERJ-3RSFR10V<br>Series= ERJ-3R | Res= 100.0 mOhm<br>Power= 100.0 mW<br>Tolerance= 1.0% | 1 | $0.03 | 0603 5 mm² |
| Rfbb | Vishay-Dale | CRCW040224K9FKED<br>Series= CRCW..e3 | Res= 24.9 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| Rfbt | Vishay-Dale | CRCW0402100KFKED<br>Series= CRCW..e3 | Res= 100.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| Rpg | Vishay-Dale | CRCW0402100KFKED<br>Series= CRCW..e3 | Res= 100.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| U1 | Texas Instruments | LMR33630CDDAR | Switcher | 1 | $0.75 | <br>DDA0008J 55 mm² |

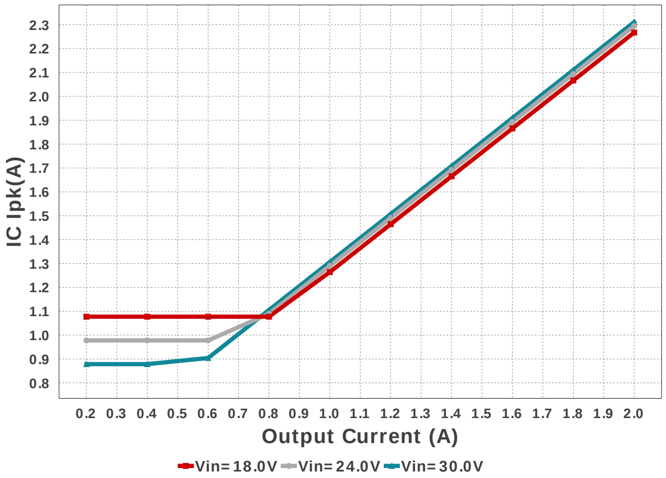


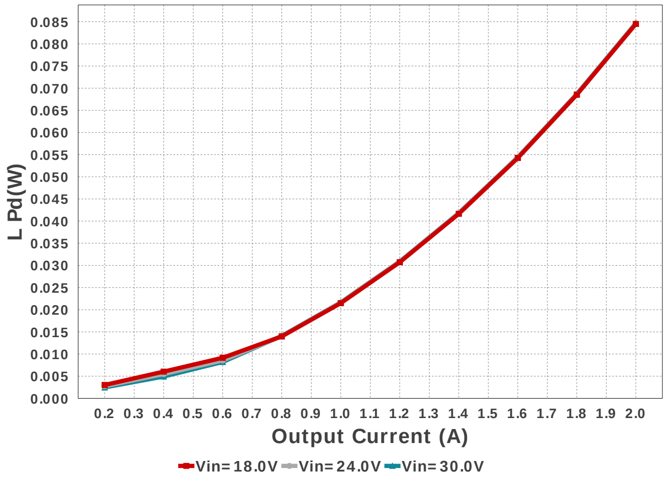



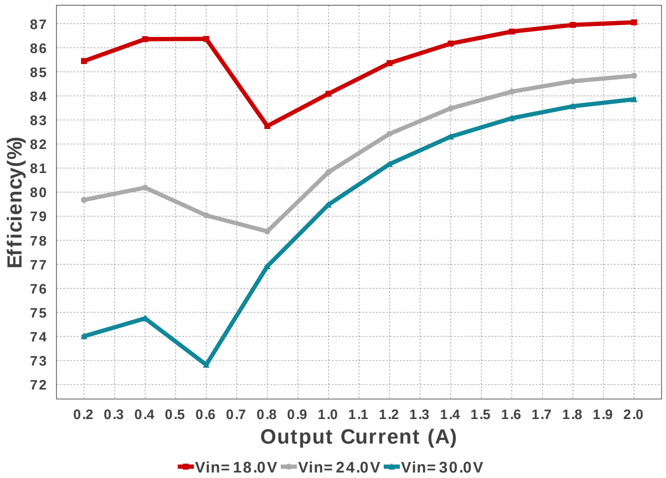
## IC Ipk



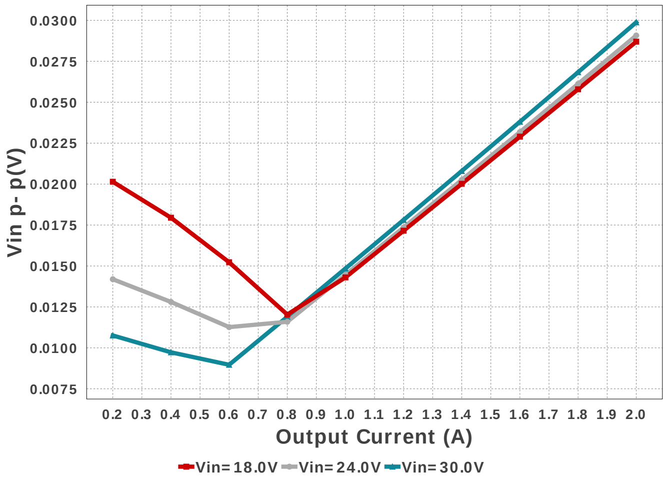

## L Pd



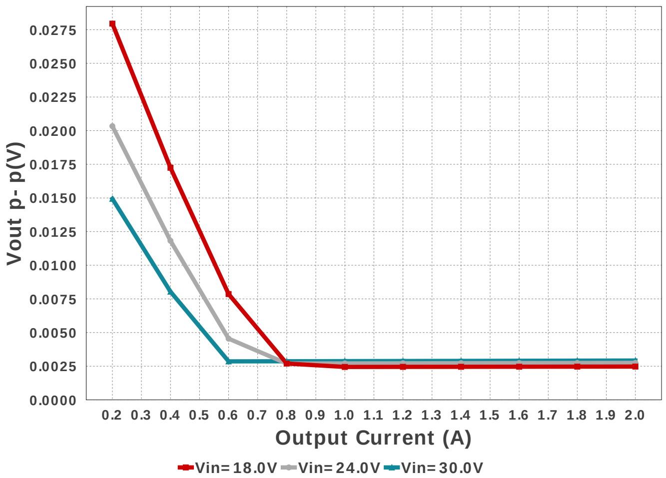

## Efficiency



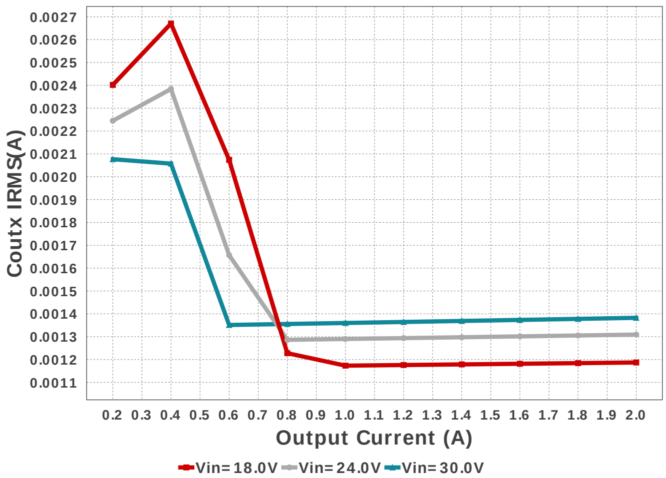

## Vin p- p

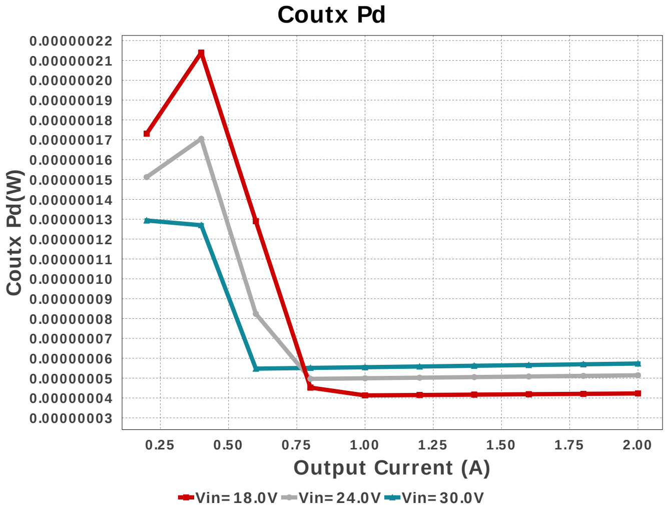


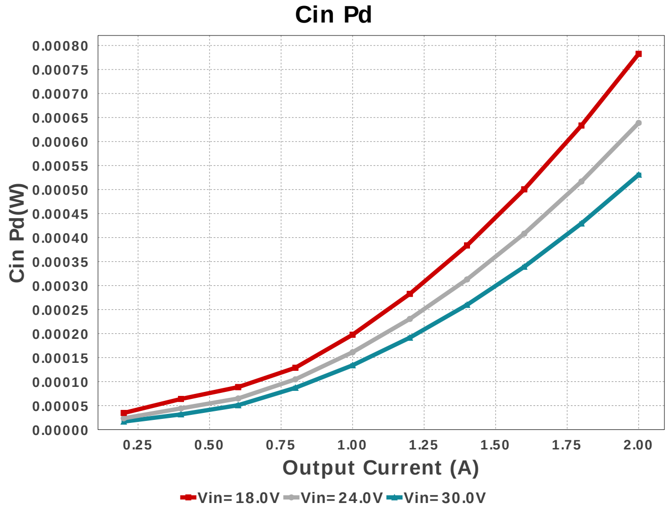

## Vout p- p

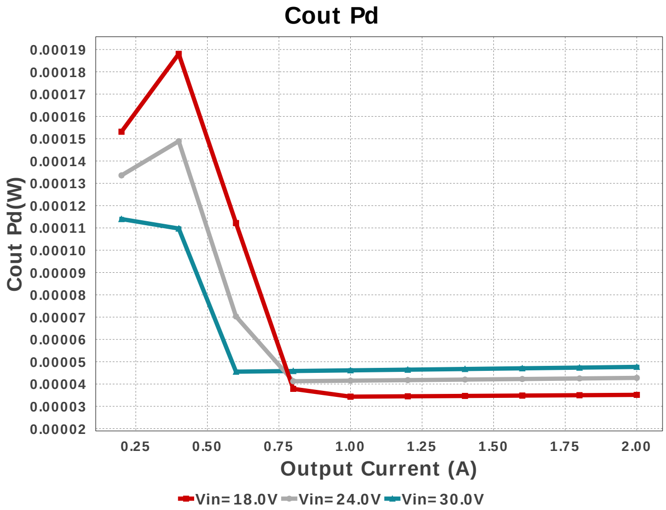


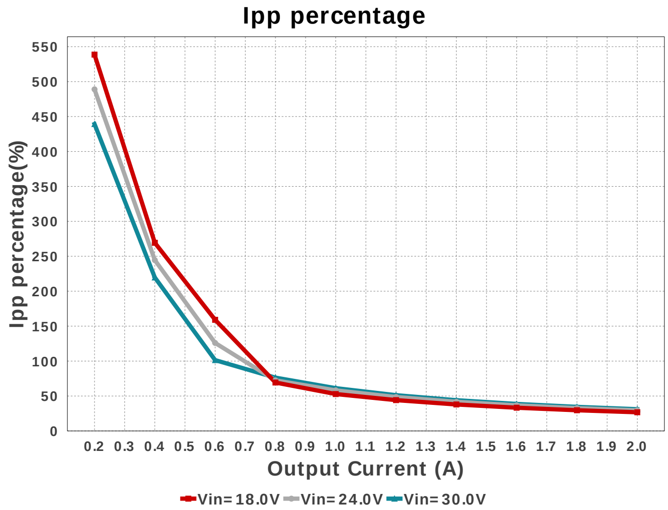

## Coutx IRMS

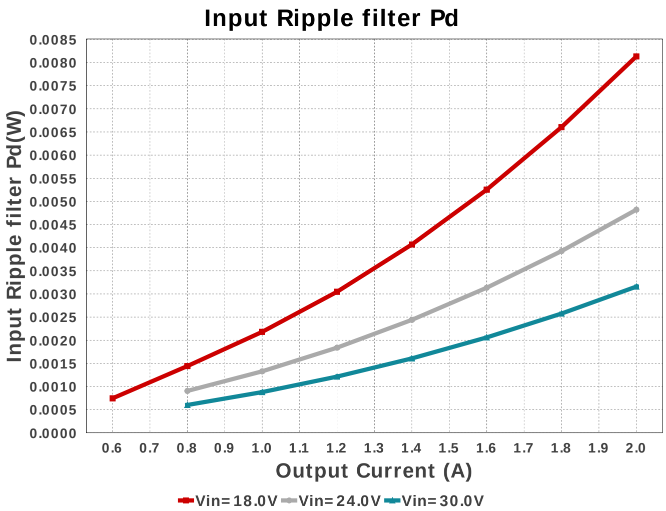


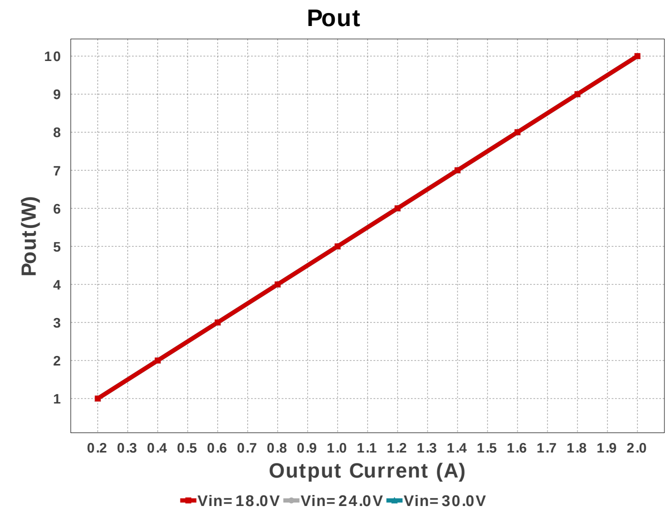

Coutx Pd
Coutx Pd(W)
Output Current (A)
Vin=18.0V Vin=24.0V Vin=30.0V


Cin Pd
Cin Pd(W)
Output Current (A)
Vin=18.0V Vin=24.0V Vin=30.0V

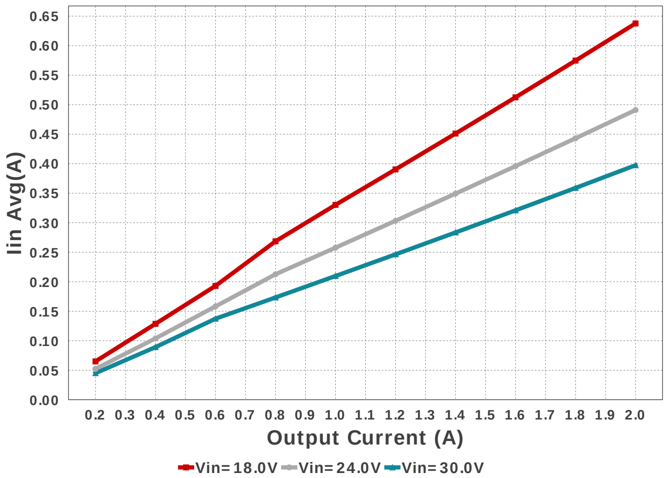

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=18.0V Vin=24.0V Vin=30.0V


Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=18.0V Vin=24.0V Vin=30.0V

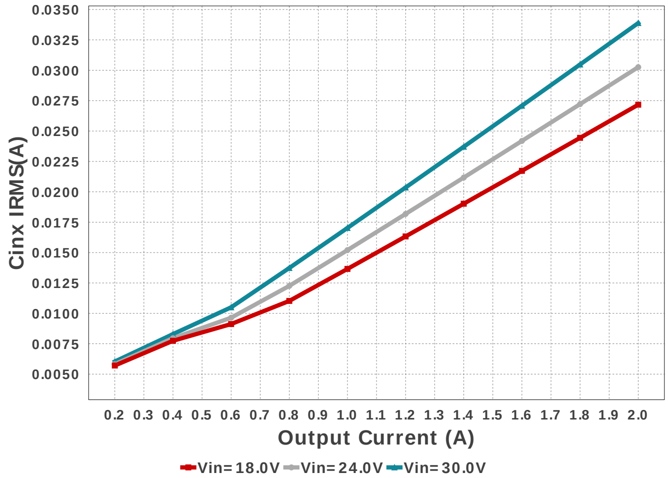

Input Ripple filter Pd
Input Ripple filter Pd(W)
Output Current (A)
Vin=18.0V Vin=24.0V Vin=30.0V


Pout
Pout(W)
Output Current (A)
Vin=18.0V Vin=24.0V Vin=30.0V

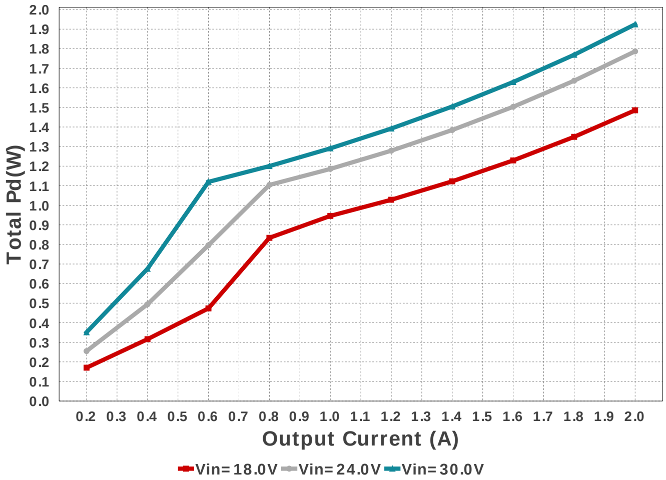
## Iin Avg



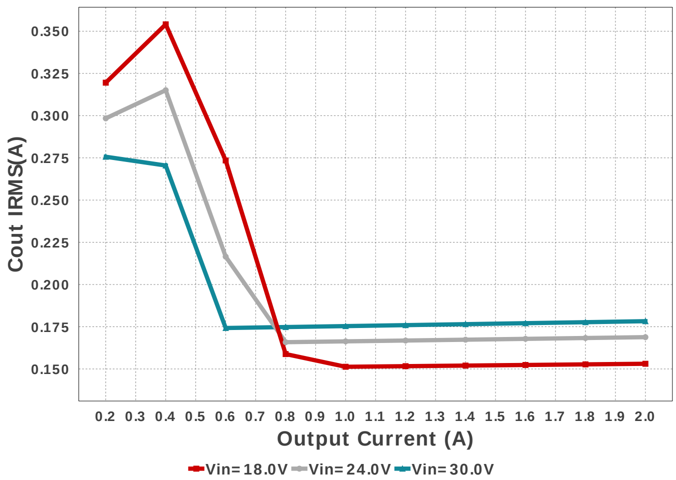

## Cinx IRMS



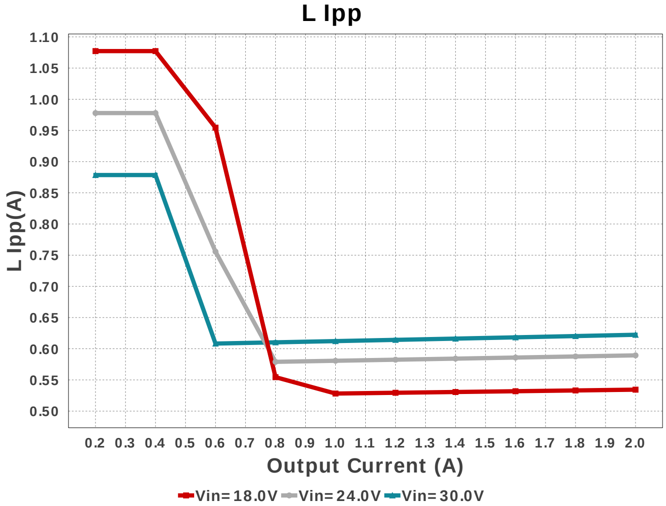

## Total Pd



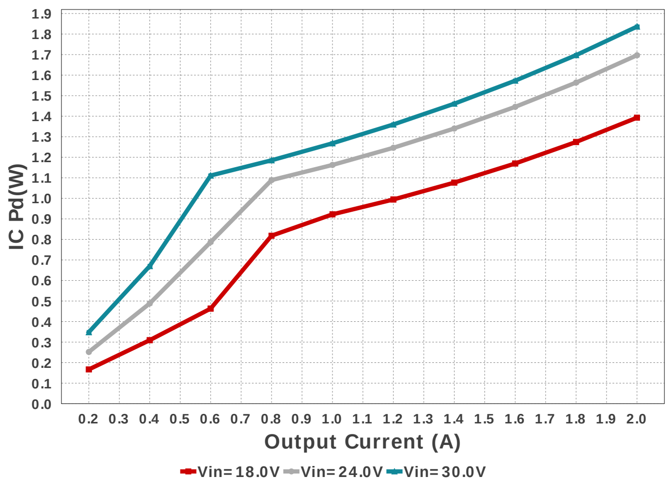

## Cout IRMS



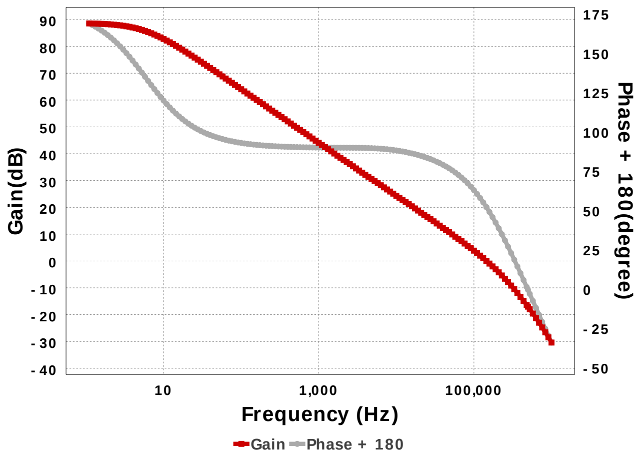

## L Ipp



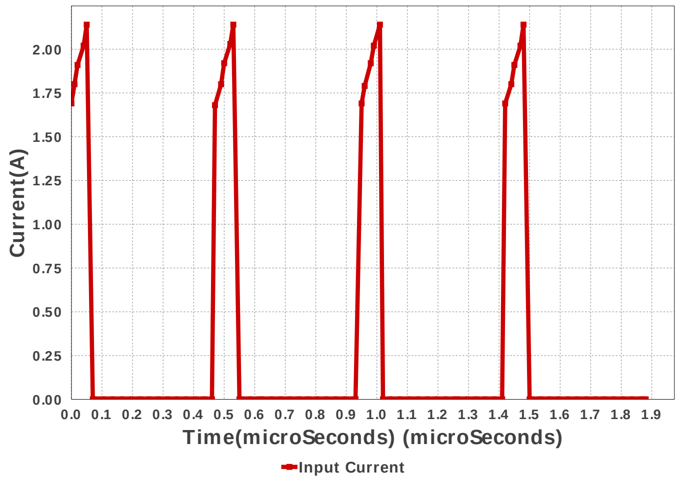

## IC Pd



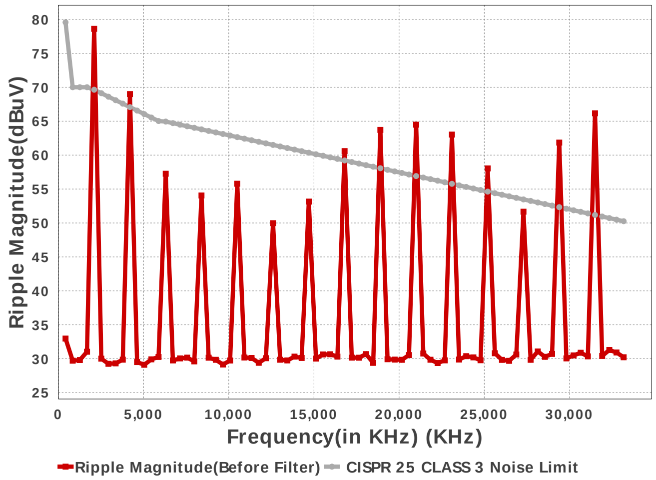
## Loop Response



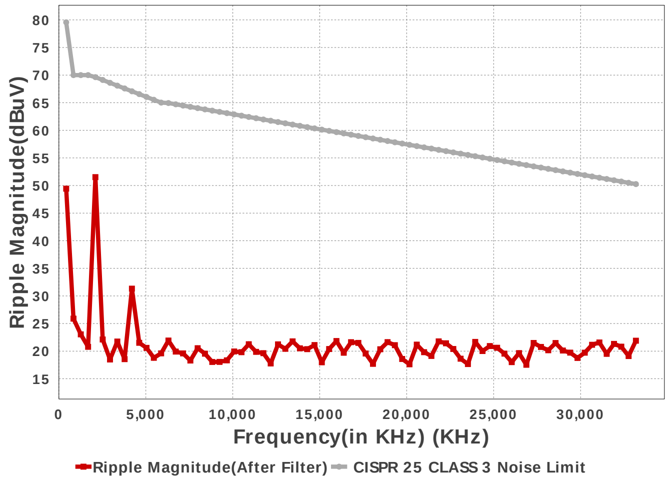

## Input Current



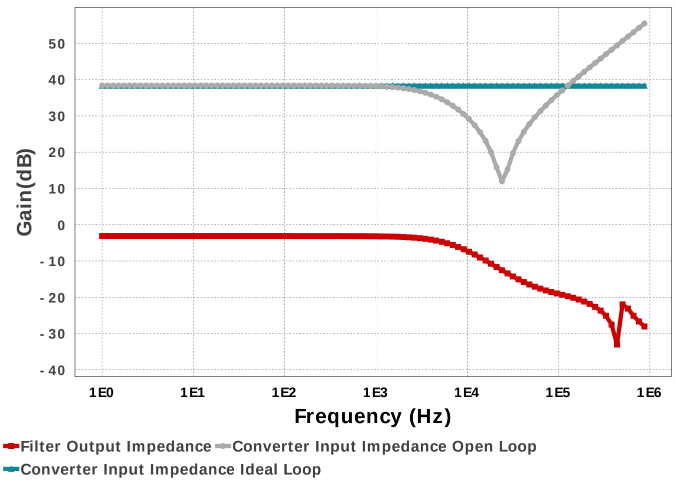

## Ripple Freq Spectrum(Before Filter)



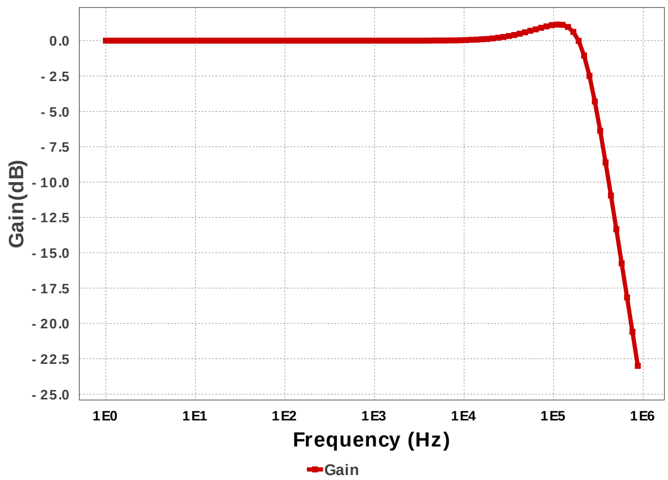

## Ripple Freq Spectrum(After Filter)

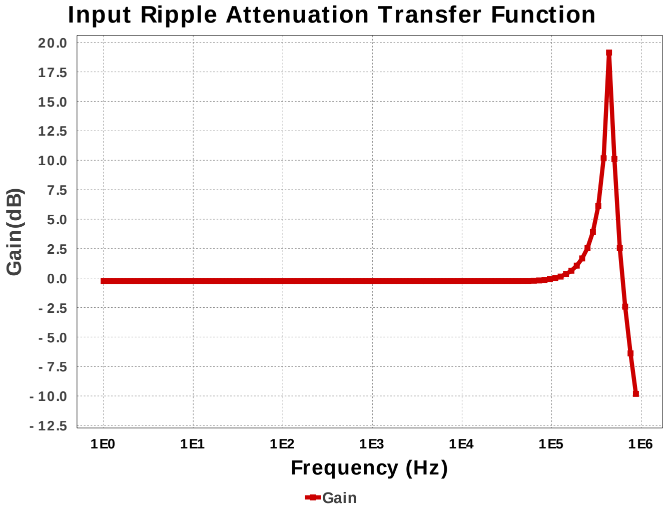


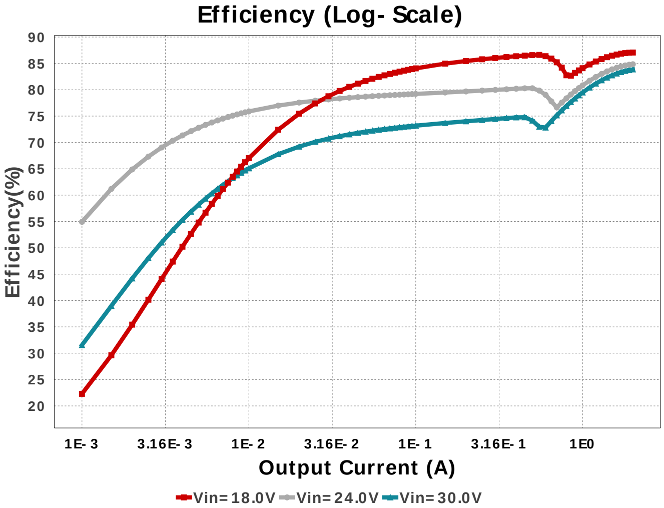

## Filter vs Converter Impedance Comparison




## Filter Forward Transfer Function






## Operating Values

| # | Name | Value | Category | Description |
|---|---|---|---|---|
| 1. | Cin IRMS | 728.604 mA | Capacitor | Input capacitor RMS ripple current |
| 2. | Cin Pd | 530.86 µW | Capacitor | Input capacitor power dissipation |
| 3. | Cinx IRMS | 33.884 mA | Capacitor | Bulk capacitor RMS ripple current |
| 4. | Cinx Pd | 19.459 µW | Capacitor | Bulk capacitor power dissipation |
| 5. | Cout IRMS | 178.286 mA | Capacitor | Output capacitor RMS ripple current |
| 6. | Cout Pd | 47.679 µW | Capacitor | Output capacitor power dissipation |
| 7. | Coutx IRMS | 1.383 mA | Capacitor | Output capacitor_x RMS ripple current |
| 8. | Coutx Pd | 57.348 nW | Capacitor | Output capacitor_x power loss |
| 9. | Input Ripple Noise After input filter | 51.63 dBuV | EMI Noise | Input Ripple Noise after filter at switching frequency |
| 10. | Input Ripple Noise before input filter | 78.6 dBuV | EMI Noise | Input Ripple Noise before filter at switching frequency |
| 11. | Input Ripple filter Pd | 3.158 mW | EMI Noise | Input Ripple Filter Power Dissipation |
| 12. | Noise limits defined by CISPR Standards | 69.63 dBuV | EMI Noise | Noise limits for CLASS 3 of CISPR 25 standard |
| 13. | IC Ipk | 2.311 A | IC | Peak switch current in IC |
| 14. | IC Pd | 1.836 W | IC | IC power dissipation |
| 15. | IC Tj | 96.724 degC | IC | IC junction temperature |
| 16. | IC Tolerance | 15.0 mV | IC | IC Feedback Tolerance |
| 17. | ICThetaJA Effective | 20.0 degC/W | IC | Effective IC Junction-to-Ambient Thermal Resistance |
| 18. | Iin Avg | 397.39 mA | IC | Average input current |
| 19. | Ipp percentage | 31.12 % | Inductor | Inductor ripple current percentage (with respect to average inductor current) |
| 20. | L Ipp | 622.39 mA | Inductor | Peak-to-peak inductor ripple current |
| 21. | L Pd | 84.678 mW | Inductor | Inductor power dissipation |
| 22. | Cin Pd | 530.86 µW | Power | Input capacitor power dissipation |
| 23. | Cinx Pd | 19.459 µW | Power | Bulk capacitor power dissipation |
| 24. | Cout Pd | 47.679 µW | Power | Output capacitor power dissipation |
| 25. | Coutx Pd | 57.348 nW | Power | Output capacitor_x power loss |
| 26. | IC Pd | 1.836 W | Power | IC power dissipation |
| 27. | Input Ripple filter Pd | 3.158 mW | Power | Input Ripple Filter Power Dissipation |
| 28. | L Pd | 84.678 mW | Power | Inductor power dissipation |
| 29. | Total Pd | 1.924 W | Power | Total Power Dissipation |
| 30. | BOM Count | 17 | System Information | Total Design BOM count |
| 31. | Cross Freq | 145.199 kHz | System Information | Bode plot crossover frequency |
| 32. | Duty Cycle | 17.433 % | System Information | Duty cycle |
| 33. | Efficiency | 83.859 % | System Information | Steady state efficiency |
| 34. | FootPrint | 313.0 $mm^2$ | System Information | Total Foot Print Area of BOM components |
| 35. | Frequency | 2.1 MHz | System Information | Switching frequency |
| 36. | Gain Marg | -17.025 dB | System Information | Bode Plot Gain Margin |
| 37. | Iout | 2.0 A | System Information | Iout operating point |
| 38. | Low Freq Gain | 88.564 dB | System Information | Gain at 1Hz |

| # | Name | Value | Category | Description |
|---|---|---|---|---|
| 39. | Mode | CCM | System Information | Conduction Mode |
| 40. | Phase Marg | 52.455 deg | System Information | Bode Plot Phase Margin |
| 41. | Pout | 10.0 W | System Information | Total output power |
| 42. | Total BOM | $2.36 | System Information | Total BOM Cost |
| 43. | Vin | 30.0 V | System Information | Vin operating point |
| 44. | Vin p-p | 29.878 mV | System Information | Peak-to-peak input voltage |
| 45. | Vout | 5.0 V | System Information | Operational Output Voltage |
| 46. | Vout Actual | 5.016 V | System Information | Vout Actual calculated based on selected voltage divider resistors |
| 47. | Vout Tolerance | 3.142 % | System Information | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |
| 48. | Vout p-p | 2.922 mV | System Information | Peak-to-peak output ripple voltage |

## Design Inputs

| Name | Value | Description |
|---|---|---|
| Iout | 2.0 | Maximum Output Current |
| VinMax | 30.0 | Maximum input voltage |
| VinMin | 18.0 | Minimum input voltage |
| Vout | 5.0 | Output Voltage |
| base_pn | LMR33630C-SOIC | Base Product Number |
| source | DC | Input Source Type |
| Ta | 60.0 | Ambient temperature |

# WEBENCH® Assembly

## Component Testing

Some published data on components in datasheets such as Capacitor ESR and Inductor DC resistance is based on conservative values that will guarantee that the components always exceed the specification. For design purposes it is usually better to work with typical values. Since this data is not always available it is a good practice to measure the Capacitance and ESR values of Cin and Cout, and the inductance and DC resistance of L1 before assembly of the board. Any large discrepancies in values should be electrically simulated in WEBENCH to check for instabilities and thermally simulated in WebTHERM to make sure critical temperatures are not exceeded.

## Soldering Component to Board

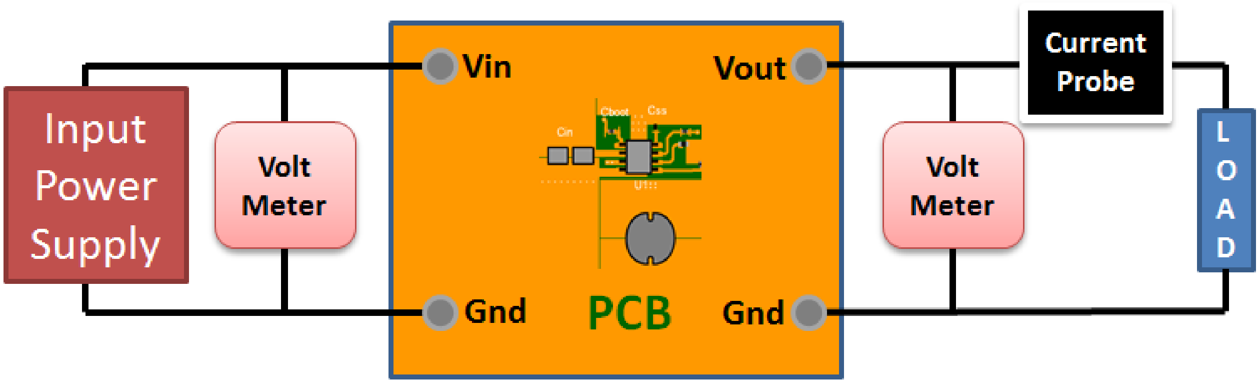
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab town to the board place the iron down on the board while resting against the tab, heating both surfaces simultaneously. Apply light pressure to the top of the plastic case until the solder flows around the part and the part is flush with the PCB. If the solder is not flowing around the board you may need a higher wattage iron (generally 25W to 30W is enough).

## Initial Startup of Circuit

It is best to initially power up the board by setting the input supply voltage to the lowest operating input voltage 18.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

## Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout and the load. The load must be able to handle at least rated output power + 50% ( 7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.




## Design Assistance

1. Master key : D92E1EB0221A07D6[v1]

2. **LMR33630C-SOIC** Product Folder : http://www.ti.com/product/LMR33630 : contains the data sheet and other resources.

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