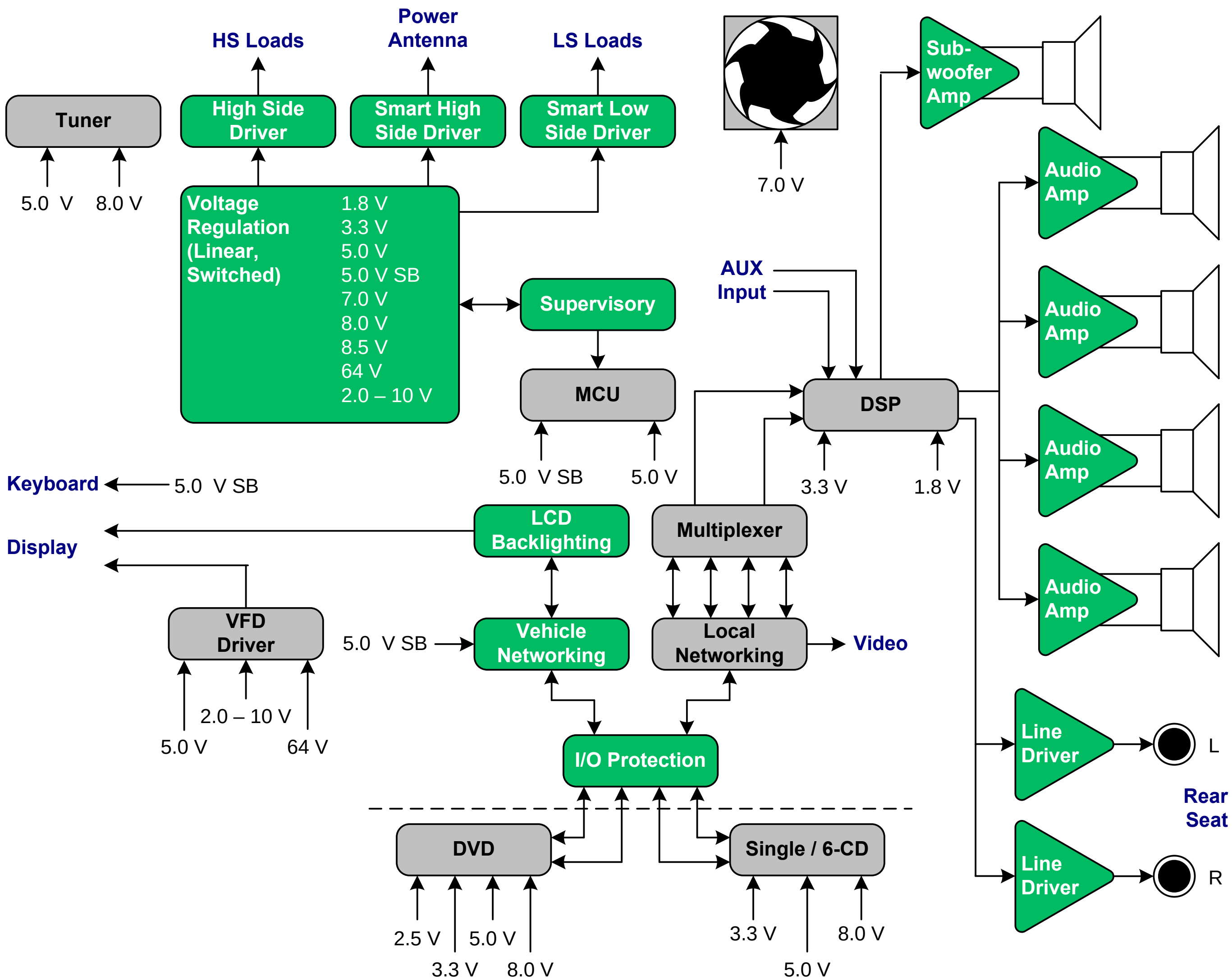
ON Semiconductor®

Automotive Infotainment Power

Agenda

- **Infotainment Overview**
- Regulation Options
- ON Semiconductor Solutions
- Example Applications
- System Power Architecture Design Examples

Automotive Infotainment System



Key Infotainment Features

- Many output voltages
- Low power stand-by, “always on” supplies
  - Low Iq LDOs (NCV861X)
- Higher power supplies during full operation
  - Switched-Mode Power Supplies (SMPS)
- Drive towards less power dissipation, higher efficiency
  - Necessitates more SMPS, upstream vs. downstream converters
- Drive towards more integration
  - System-basis devices (NCV885X)
- EMC of high importance

Infotainment Power Requirements

- Low current
  - Microcontrollers: 5.0 V, 3.3 V; 10’s to 100’s of milliamps of current
  - Sensors / transducers: tracking output; 10’s of milliamps of current
- Low voltage, higher current
  - DSPs: 3.3 V, 1.8 V, 1.2 V; amps of current
- Medium voltage, medium-higher current
  - DVD, CD, Tuner: 8.0 V; 100’s of milliamps to amps of current
  - Fans, blowers, motors: tracking output; amps of current
- Pre-regulation boosting, high current
  - “Start/stop”: 18.0 V; many amps of current
- High voltage
  - VFD: 64 V

Upstream vs. Downstream Converters

1. High power SMPS
2. Low power stand-by LDOs
3. Wide range, high input voltage
   – Battery
   – Load dump: Vin >= 45 V
   – Cold crank: Vin as low as 3-4 V
4. Expensive automotive-grade
   – NCV devices on PS5, I2T/I3T
5. Low-frequency SMPS
   – In design: NCV8901, 2 MHz

1. Inexpensive SMPS
2. Higher current LDOs, too
3. Narrow range, low input voltage
   – Upstream converter
   – Typically: tight, regulated input
4. Inexpensive “consumer”-grade
   – NCP conversions
5. High-frequency SMPS available
   – 2+ MHz, multiple outputs

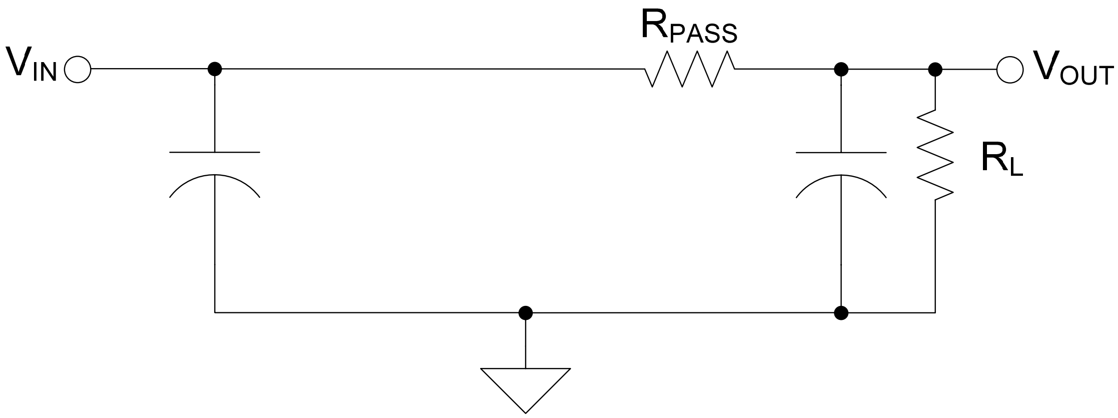
Agenda

- Infotainment Overview
- **Regulation Options**
- ON Semiconductor Solutions
- Example Applications
- System Power Architecture Design Examples

Regulation

- Purpose: maintain constant output
  - Keep constant over input and load operating points (dc)
  - Minimize variation during transient perturbations (ac)
- Most applications: voltage is regulated
  - Other applications: current is regulated, such as LED driving
- Output is fixed or tracking
  - Fixed: output fed back, compared to internal, fixed reference
  - Tracking: output fed back, compared to external/variable reference
    - Remote output buffering, control via digital/analog converter (DAC)

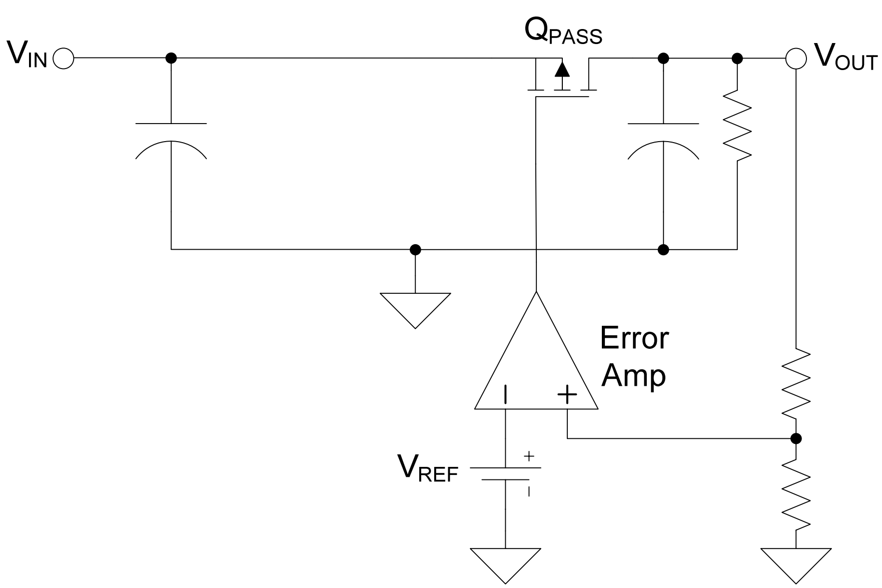
Linear Regulation



- **Concept:** Burn off excess voltage to regulate output voltage to value lower than input voltage
- Resistive divider, dropping $V_{IN} – V_{OUT}$ over R_{PASS}
- R_{PASS} must be adjusted for changes in V_{IN} and load (R_L)
- **Regulation:** Automatically adjust R_{PASS} based on feedback

LDO Realization

(Voltage-mode)

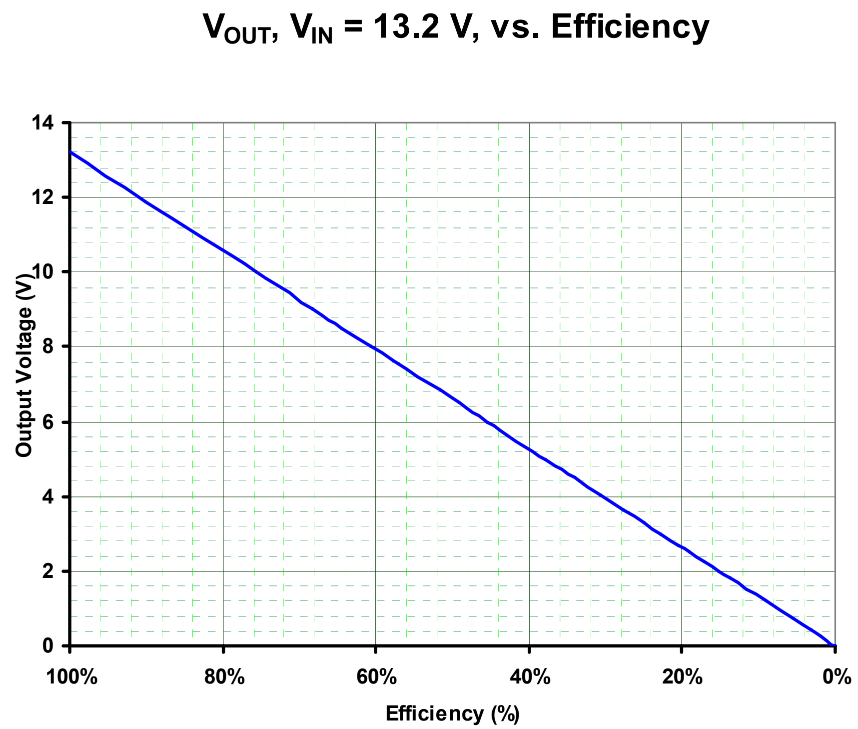


- Output voltage is fed back, compared to reference
  - Internally fixed or externally adjustable output
  - Tracking regulator: reference voltage is also adjustable
- Error amplifier adjusts pass transistor control signal
  - Pass transistor operates in linear/triode region
- Power dissipation:

  $(V_{IN}-V_{OUT})*I_{OUT}$

What's the Problem with LDOs?

- Efficiency is very low with high conversion ratios
- As current increases, power dissipation becomes very large
- Large heat sinking is required for many applications
- From 13.2 V to 5 V, even just 500 mA is 4.1 W!
- **If you're going to be dissipating over 2 watts, consider using a switcher!**



Switching: Who Needs It?

- High current demands
- Hot environments
- High voltage conversion ratio
- Voltage step-up or negative voltage generation
- Isolation
- Pre-regulation for down-stream LDOs (and other SMPS)
- **NCV8851 can go from 40 V to 5 V at 4 A with just 2.2 W of dissipation, spread out amongst the power stage and IC!**

Switcher "Hand-waving" Explanation

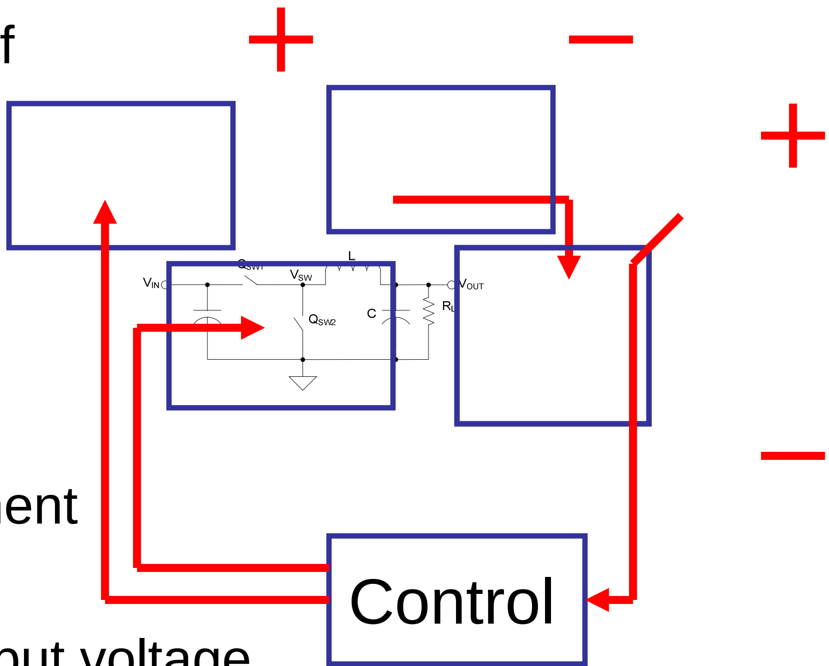
- **Concept:** Conservation of power from input to output to regulate output voltage (or current) to value lower, higher or equal to input voltage

- Switches some source fully-on/fully-off

- Source applies voltage to
  current storage element

- Current storage element supplies
  current into voltage storage element

- Voltage storage element provides output voltage



- **Regulation:** Feedback from output voltage controls switch(es)

Switcher Topologies Primer

- Buck
  - Steps voltage down
  - High-side gate driver
  - NCV8842/43, NCV8851, NCV8901

$$\frac{V_O}{V_{IN}} = D$$

- Boost
  - Steps voltage up
  - Low-side gate driver
  - NCV8871/72

$$\frac{V_O}{V_{IN}} = \frac{1}{1-D}$$

- Buck-Boost
  - Steps voltage up or down
  - Inverts sign (negative output)
  - Low-side gate driver

$$\frac{V_O}{V_{IN}} = -\frac{D}{1-D}$$

- Buck-Boost Derived Topologies
  - Non-inverting, isolation
  - Flyback (turns ratio), SEPIC
  - Low-side gate driver

$$\frac{V_O}{V_{IN}} = \frac{nD}{1-D}$$

Synchronous vs. Non-synchronous

- Primary, active, switch, Q_{SW1}:
  - Typically: MOSFETs
    - Low-side: NMOS
    - High-side: PMOS, NMOS
      - NMOS requires charge pump
  - BJTs also popular
  - IGBTs, SCRs, relays, tubes
    - Fundamentally same
    - Difference is in driving

- "Rectifier", $Q_{SW2:}$
  - Non-synchronous:
    - Passive rectification
      - Schottky diode
    - Lower efficiency at high load
    - Subject to DCM
    - Less complicated, single driver
  - Synchronous:
    - Active rectification
      - As primary switch
    - Higher efficiency at higher loads
    - No DCM
    - More complicated, dual, drivers
      - Avoid cross-conduction with non-overlap time

Switchers vs. LDOs for Automotive

1. Typically, poor efficiency at very light loads, otherwise very high efficiency
2. Minimal heat in package, less heat in pass devices
3. 10's of amps is fine
4. Regulate at double battery, load dump, without much dissipation
5. Have to be careful with layout, components, compensators
6. Expensive magnetics, components
7. EMI a significant problem
8. Theory of operation is much more complicated, customers may not be use to switchers yet

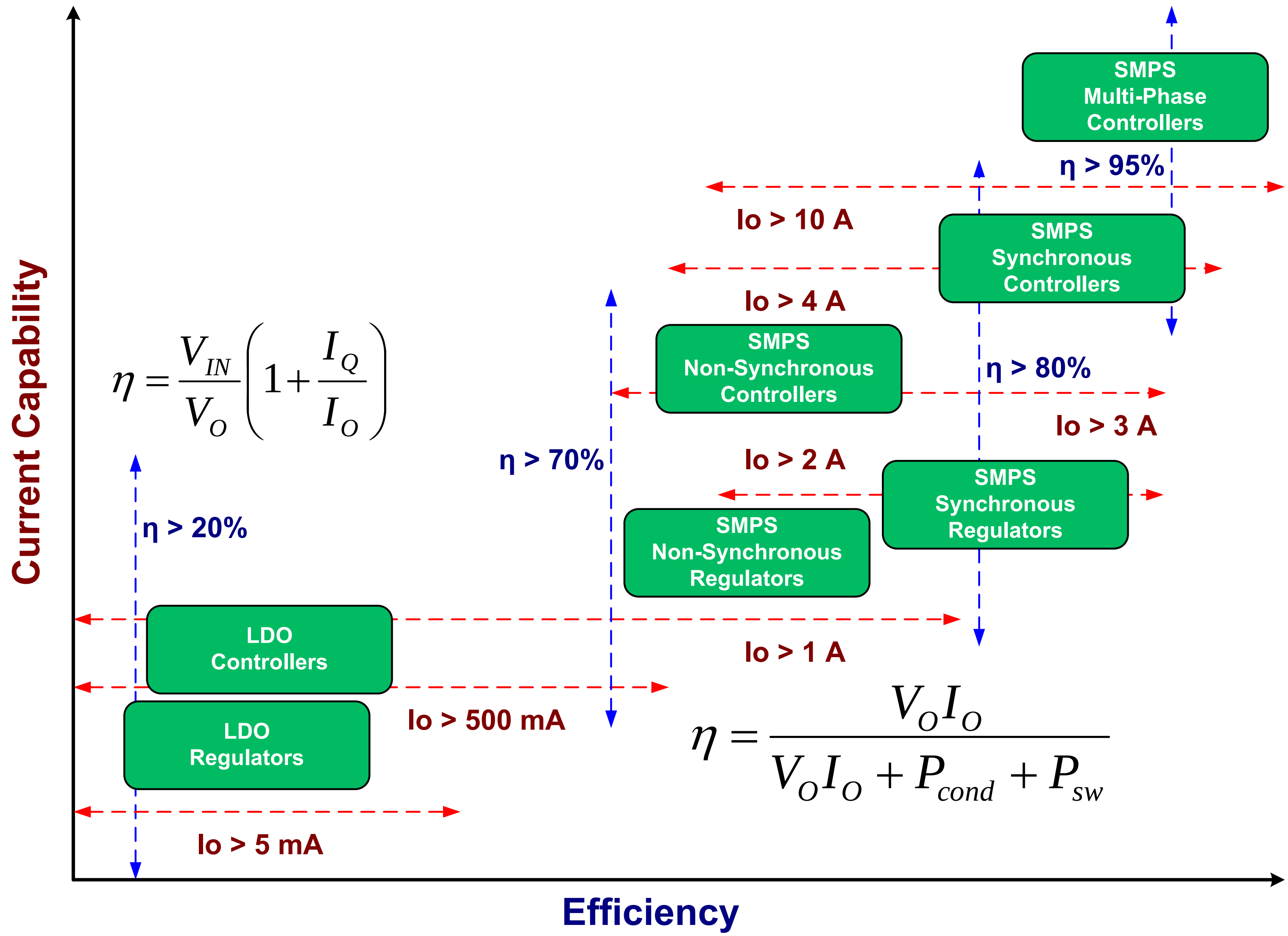
1. Low efficiency over most conditions, but better than switchers at very light loads
2. Lots of heat, potentially watts in pass device
3. ½ of an amp is pushing it
4. Even running off typical battery causes lots of dissipation
5. Drop-in product, typically "just works", regardless of layout, most components
6. Cheap!
7. EMI comparatively a non-issue
8. Theory of operation comparatively straight-forward, customers very acclimated to LDOs

Controllers vs. Regulators

1. External pass element(s) (FET, BJT)
2. Less compact, more expensive
3. Power dissipation limited by pass element package
4. More heatsinking options
5. Higher, flexible current capability
6. Wide-range of external pass elements
    - Not necessarily optimal
    - Application selection / tuning process

1. Internal pass element(s) (FET, BJT)
2. More compact, less expensive
3. Power dissipation limited by regulator package
4. Less heatsinking options
5. Lower, fixed current capability
6. Optimized for internal pass element

Comparison of Power Devices



$$\eta = \frac{V_{IN}}{V_O}\left(1 + \frac{I_Q}{I_O}\right)$$

$$\eta = \frac{V_O I_O}{V_O I_O + P_{cond} + P_{sw}}$$

Agenda

- Infotainment Overview
- Regulation Options
- **ON Semiconductor Solutions**
- Example Applications
- System Power Architecture Design Examples

LDO Device Solutions

Product	Description	Output	VO (V)	IO Typ (A)	VI Max (V)	VDO Typ (V)	Iq Typ (mA)
NCV1117	1 A, Adjustable, Low Dropout Voltage Regulator	Single	Adjustable	1	20	1.07	
NCV2931	100 mA, Adjustable, LDO with 60 V Load Dump Protection	Single	Adjustable	0.1	40	0.16	
NCV317	1.5 A, Adjustable Output 1.2 to 37 V, Voltage Regulator with ±4% Tolerance	Single	Adjustable	1.5	40	2.25	
NCV4264	3.3 / 5.0 V, 100 mA Low Quiescent Current Low Dropout Voltage Regulator	Single	3.3, 5.0	0.1	45	0.27	0.033
NCV4275	450 mA, 3.3 / 5.0 V, LDO w/Reset and Delay	Single	3.3, 5.0	0.45	45	0.25	0.15
NCV4279	150 mA, 5 V, LDO w/ Reset, Delay, Adjustable Reset and Early Warning	Single	5.0	0.15	45	0.25	0.19
NCV5504	Dual Output LDO	Dual	1.25 / 3.3	0.25	18	0.25	
NCV551	150 mA, CMOS Low Iq Low-Dropout Voltage Regulator	Single	1.4 - 5.0	0.15	12	0.17	0.004
NCV553	80 mA, 5.0 V CMOS Low Dropout Regulator with NOCAP™	Single	5.0	0.08	12	0.7	0.0028
NCV5663	Fast Response Adj 3A LDO Regulator with Enable, Qualified for Automotive	Single	Adjustable	3	9	1	
NCV662	100 mA, 1.5 V, CMOS Low Iq Low Dropout Voltage Regulator w/Enable	Single	1.5	0.1	6	0.68	0.0025
NCV7805	1 A, 5 V, ±2% Tolerance, Voltage Regulator	Single	5.0	1	35	2	
NCV8141	500 mA, 5 V, Linear Regulator with ENABLE, /RESET, and Watchdog	Single	5.0	0.5	60	1.25	
NCV8184	Micropower 70 mA Low Dropout Tracking Regulator/Line Driver	Single	Tracking	0.07	26	0.35	0.05
NCV8509	Sequenced Linear Dual Voltage Regulator	Dual	1.8 / 3.3, 2.5 / 5.0	0.1	50	0.6	0.125
NCV8518A	250 mA, 5 V LDO with Watchdog, Wake Up, Reset , Delay and Enable	Single	5.0	0.25	45	0.425	0.1
NCV8570	200 mA, Ultra-Low Noise, High PSSR, BiCMOS RF LDO Regulator	Single	1.8 - 3.3	0.2	5.5	0.7	0.07
NCV8664	3.3 / 5.0 V, 150 mA Very Low Quiescent Current LDO	Single	3.3, 5.0	0.15	45	0.315	0.021

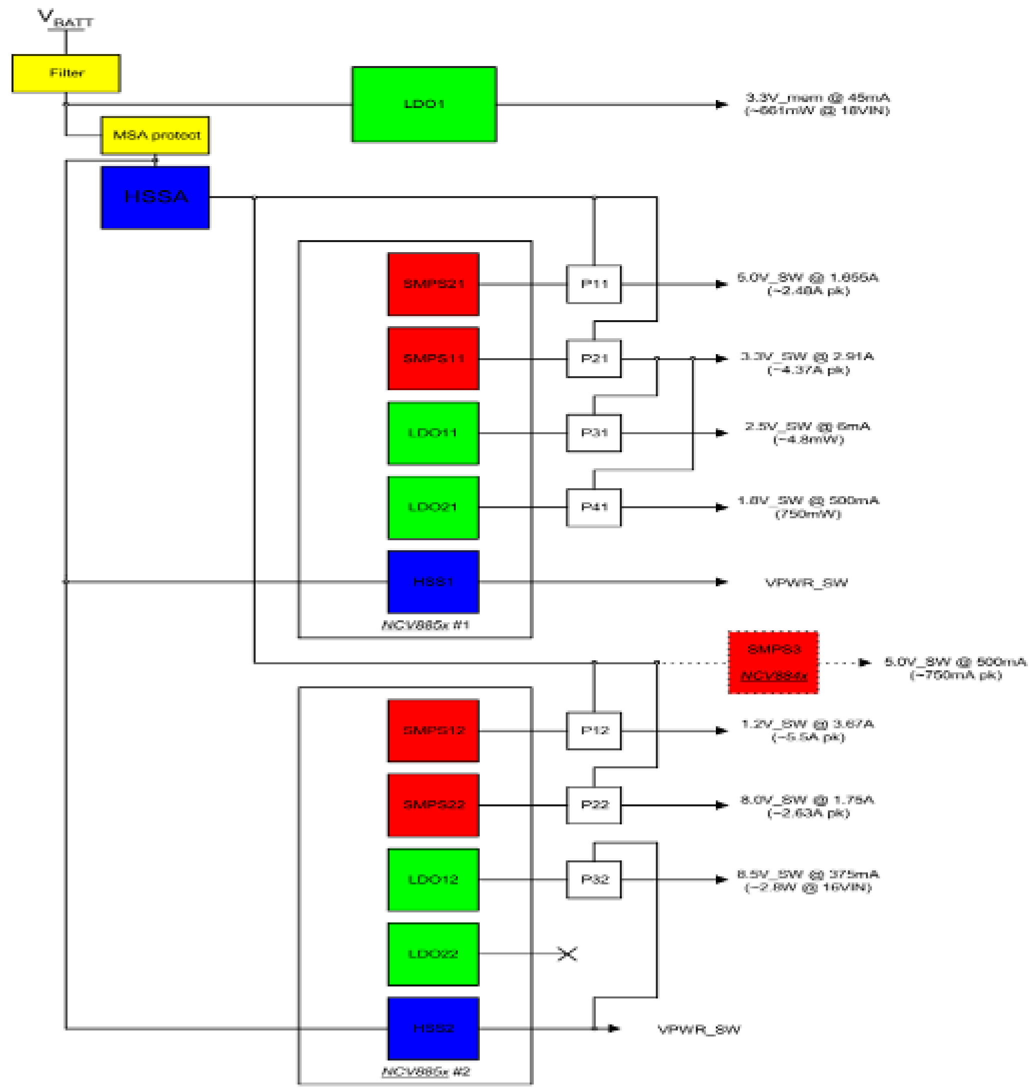
System Power Solutions

- **NCV885X**
  - SMPS Buck Controller
  - 2 A SMPS Buck Converter
  - 2 LDO Controllers
  - 2 A High-Side Switch
  - 170 kHz, 340 kHz options
  - Options with ROSC or SYNC
    - Up to 600 kHz
  - QFN32 6x6
- **NCV861X**
  - 3 LDO Outputs
    - Various voltage / current options
    - NCV8612
  - Automatic Switch-Over (ASO)
    - Decrease power dissipation
  - Ultra Low Iq < 50 µA
  - DFN20 6x5
- **NCV8881**
  - 1.5 A SMPS Buck Converter
  - 8.5 V / 40 mA, 5.0 V / 100 mA LDOs
  - ROSC and SYNC
    - Up to 600 kHz
  - Watchdog
  - SOIC-16EP

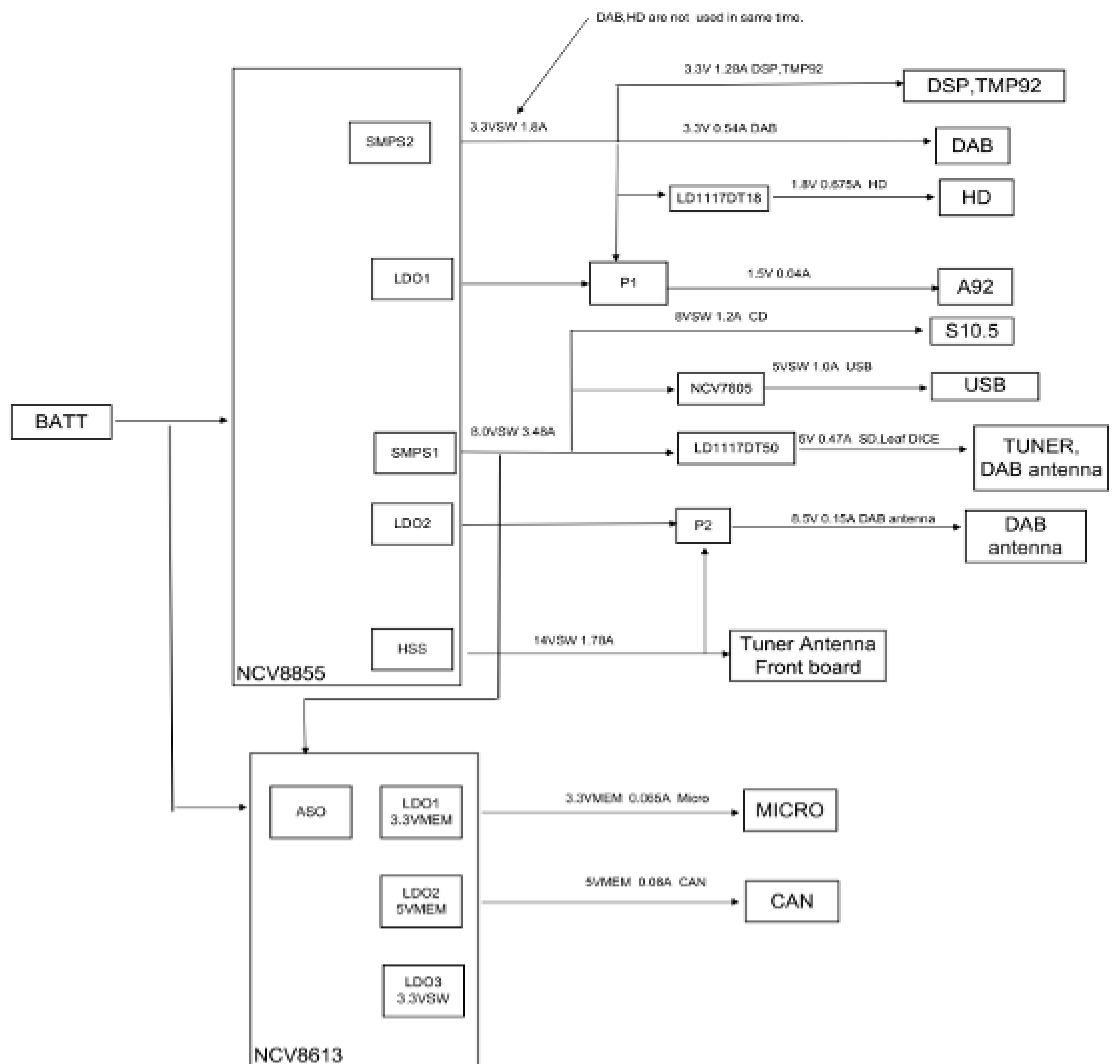
Agenda

- Infotainment Overview
- Regulation Options
- ON Semiconductor Solutions
- **Example Applications**
- System Power Architecture Design Examples

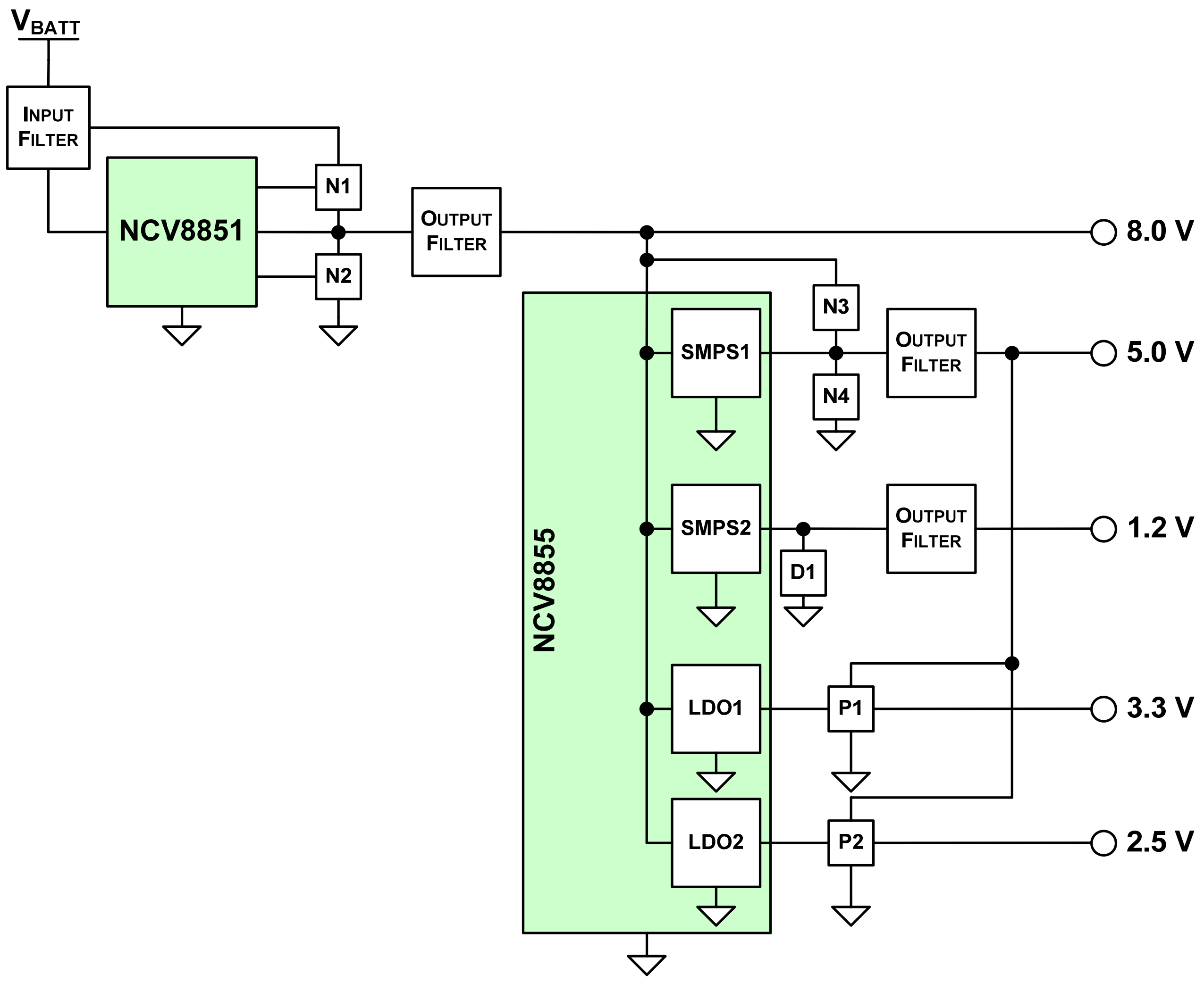
Many-Output NCV885X Application



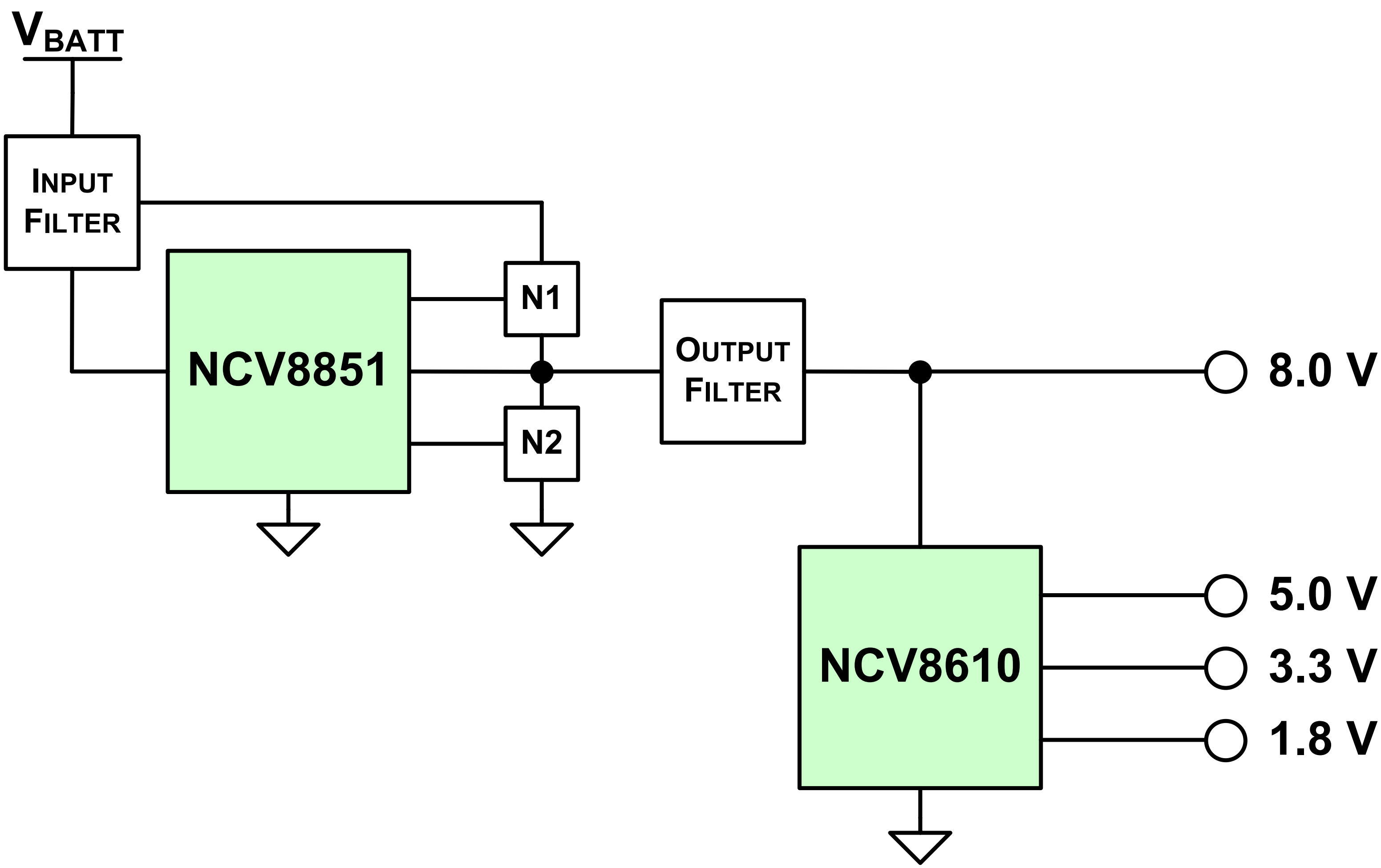
NCV885X / NCV861X Application



5-Output NCV8851/NCV8855



4-Output NCV8851/NCV8610



Agenda

- Infotainment Overview
- Regulation Options
- ON Semiconductor Solutions
- Example Applications
- **System Power Architecture Design Examples**

System Power Architecture Considerations

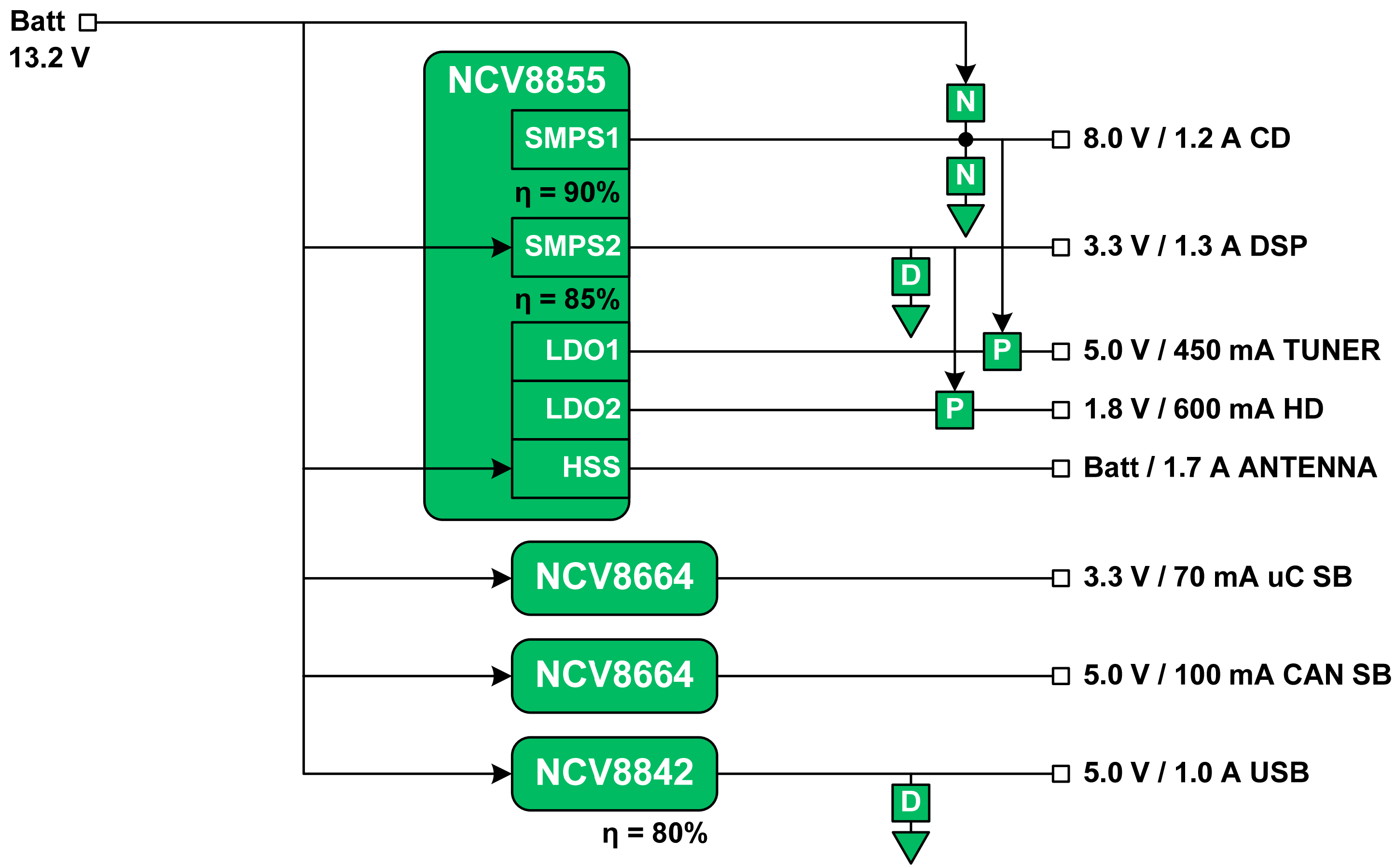
1. Customer voltage / current requirements
   - Standby / Quiescent current
2. Cost!
3. Efficiency / power dissipation
4. Integration / size
5. EMC requirements

Example: System Power Requirements

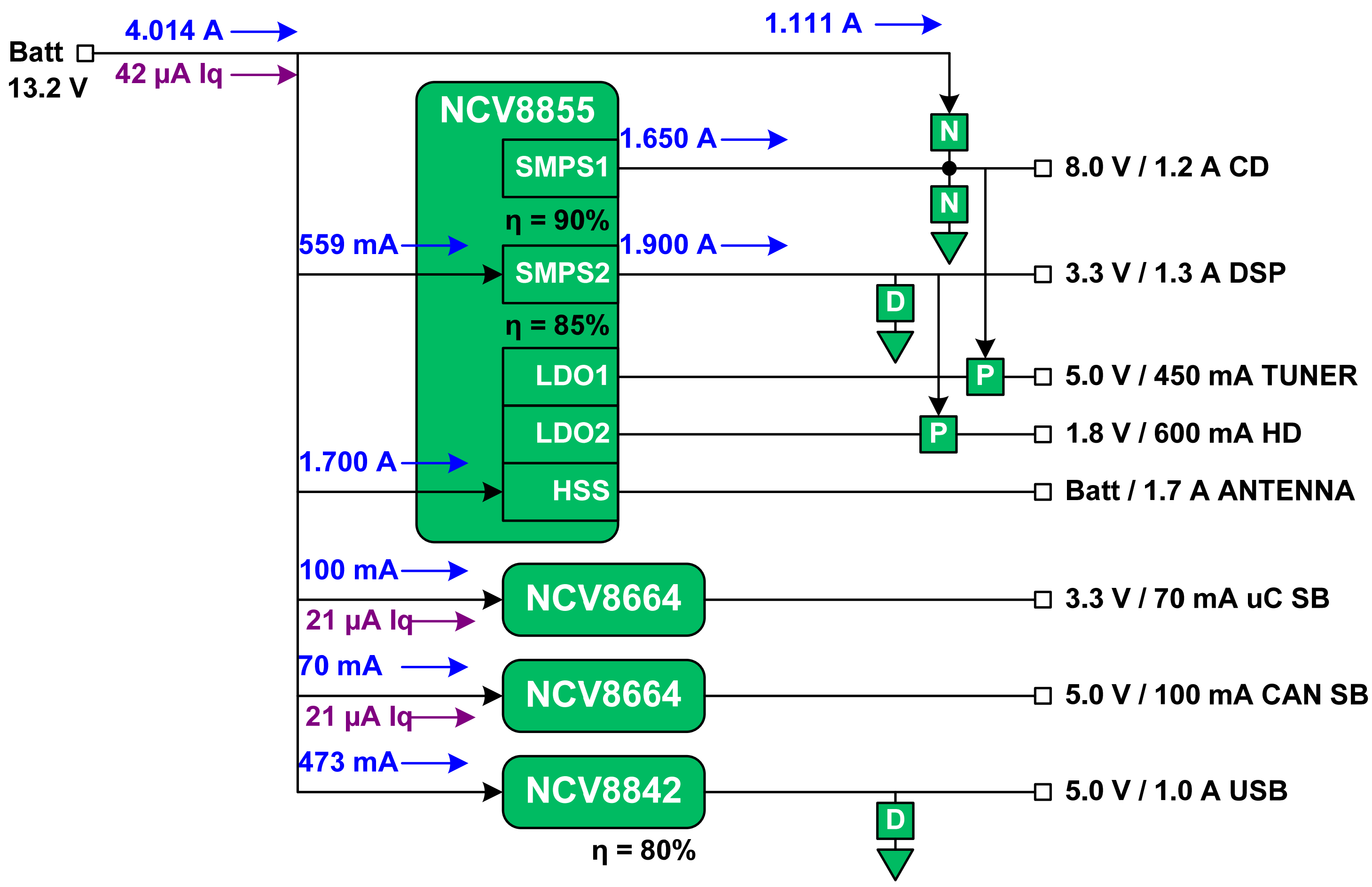
- Vbatt / 1.7 A Antenna
- 8.0 V / 1.2 A CD
- 5.0 V / 1 A USB
- 5.0 V / 500 mA Tuner
- 5.0 V / 100 mA CAN SB
- 3.3 V / 1.3 A DSP
- 3.3 V / 70 mA µC SB
- 1.8 V / 600 mA HD

- Protected connection to battery
- Standby HS-CAN IVN (CAN SB)
- Standby microcontroller (µC SB)
- 50 µA max quiescent current (Iq)

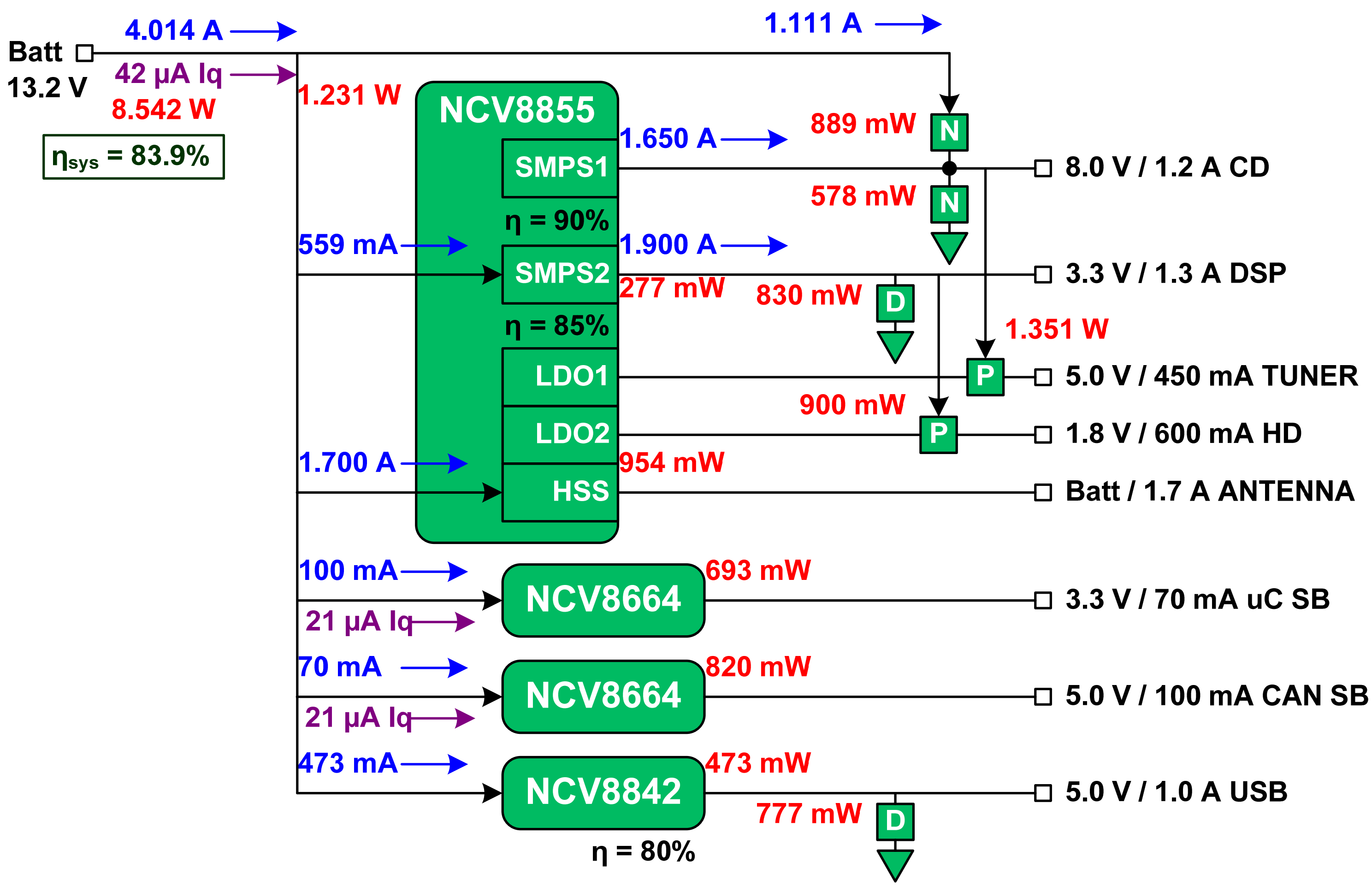
Example: System Power Architecture #1



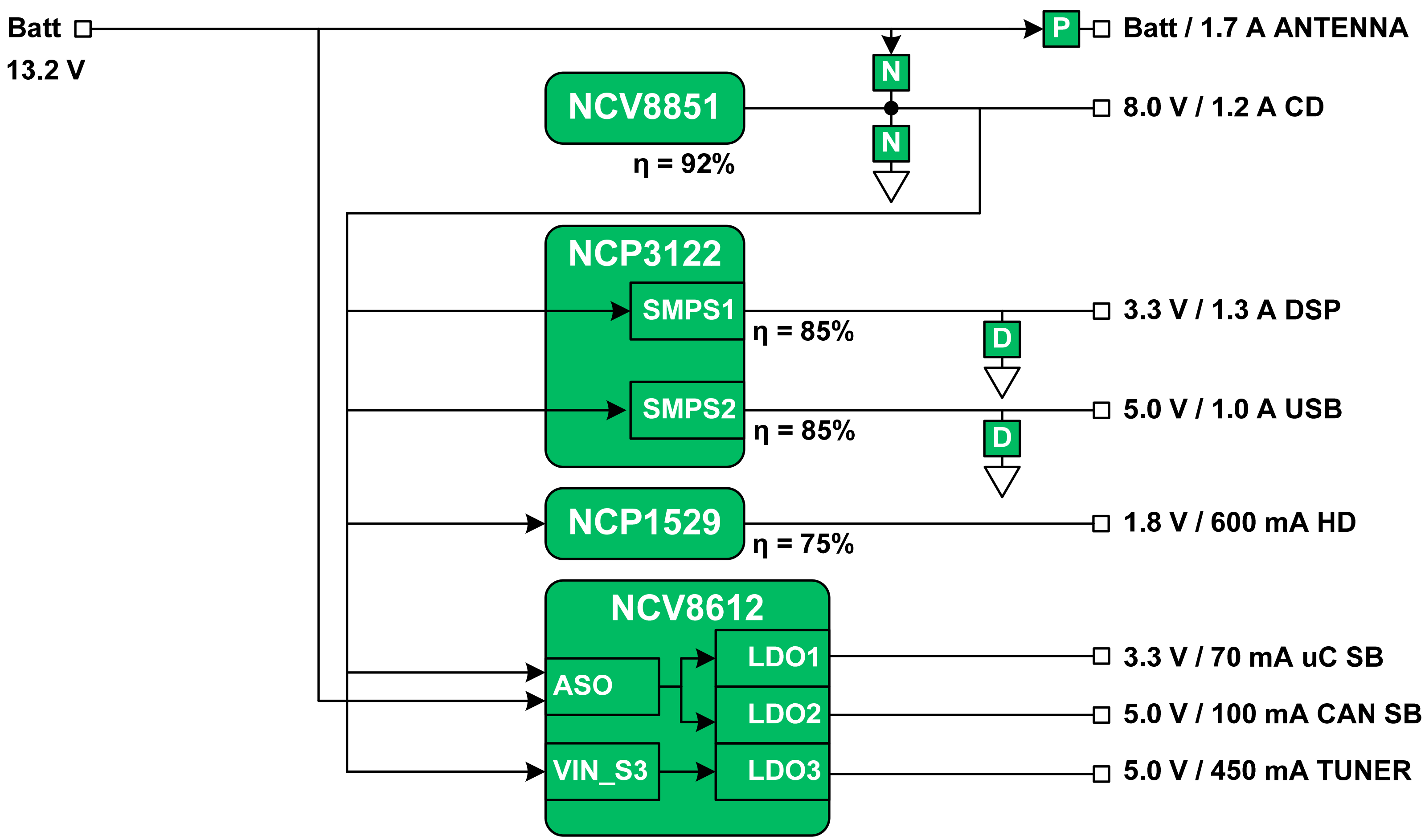
Example: System Power Architecture #1



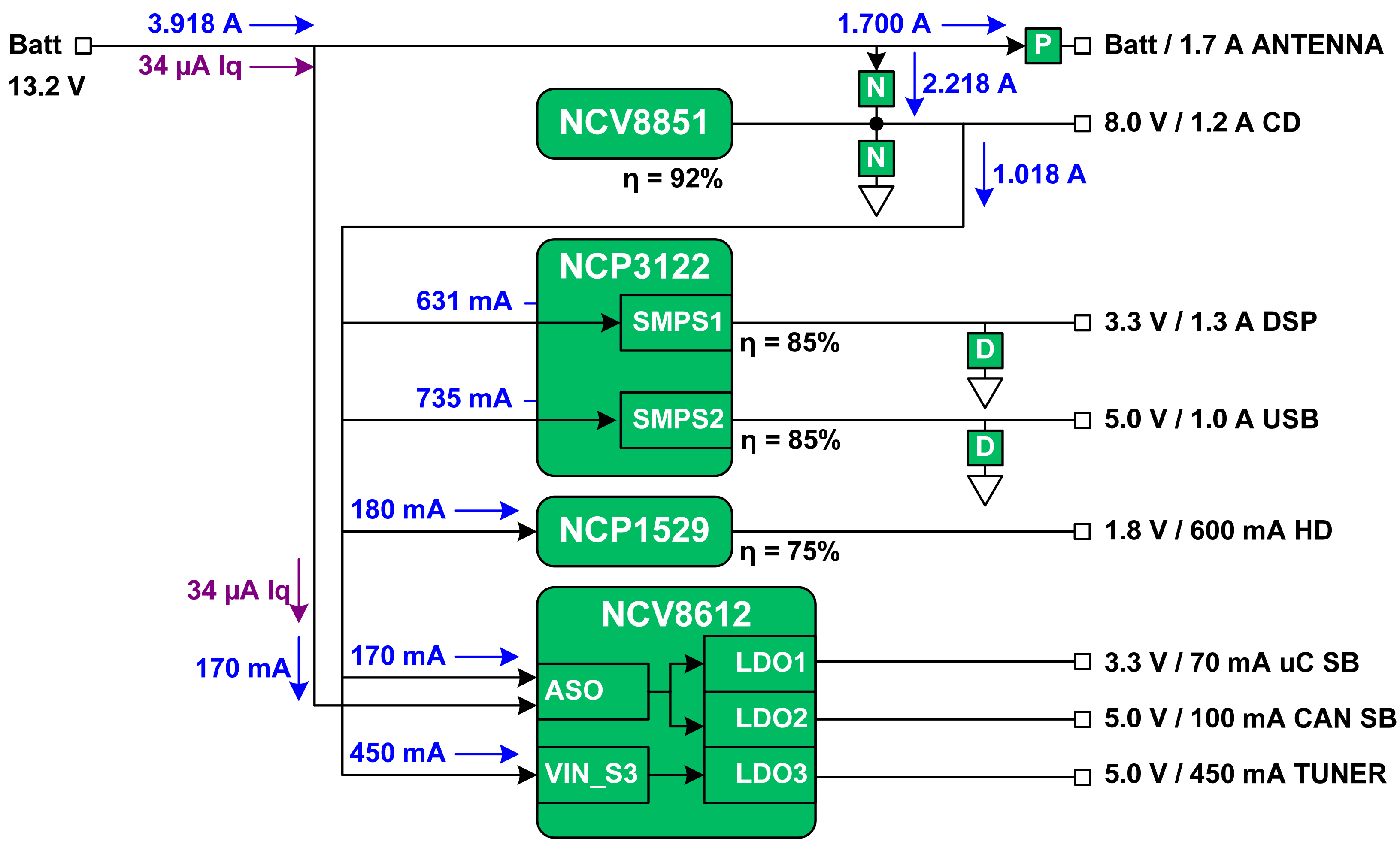
Example: System Power Architecture #1



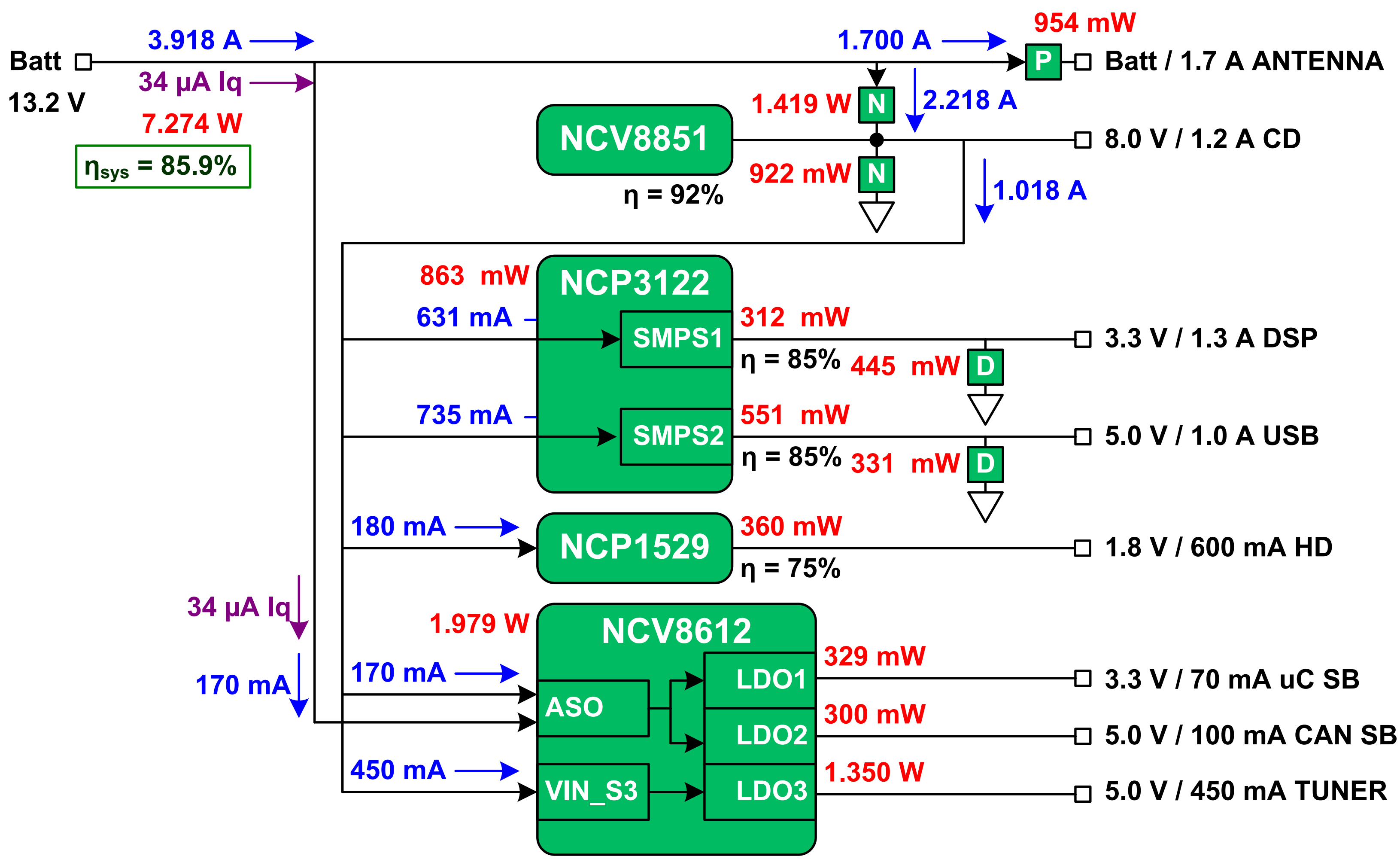
Example: System Power Architecture #2



Example: System Power Architecture #2



Example: System Power Architecture #2



For More Information

- View the extensive portfolio of power management products from ON Semiconductor at www.onsemi.com

- View reference designs, design notes, and other material supporting automotive applications at www.onsemi.com/automotive