Test Report: PMP21953
40-V Isolated Comparator-Based Power Supply Reference Design

Description

This reference design demonstrates a cost focused approach of an isolated power supplies with low current capability. The design consists of three options of three different topologies. All three design options are based on a high voltage comparator TLV1805-Q1 which works as a free-running oscillator and a driver. There is no control loop therefore the output voltage depends on the input voltage and load.

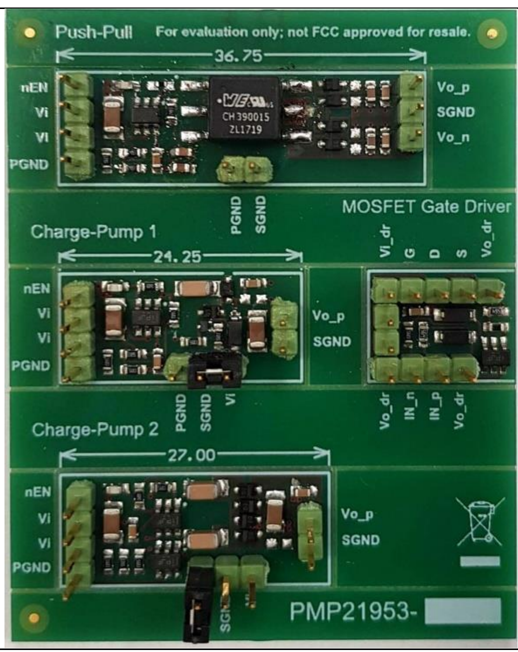
Designs are intended to be used in automotive applications for example:

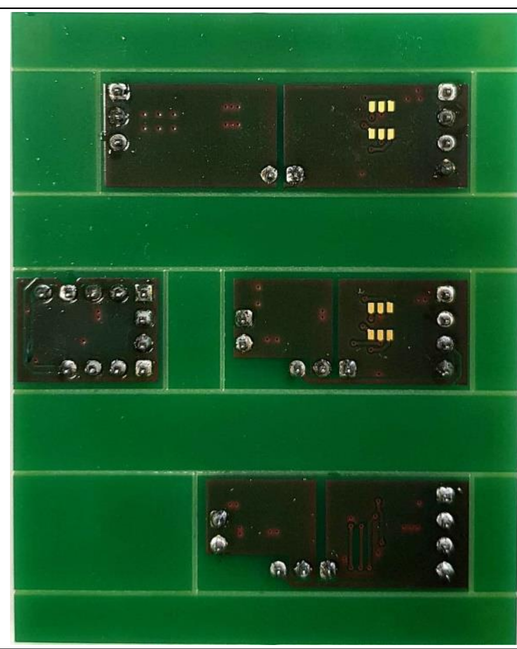
- Isolation amplifier supply for hot-side current sensing
- NFET reverse polarity protection charge pump
- Back-to-back NFET gate drive charge-pump (e.g. power disconnector)
- Small IGBT/SiC gate drive power supply

The features common to all three topologies:

- Automotive voltage input allows direct connection to car battery (Vin_max=40V)
- Easy customizable for various applications
- Low BOM cost
- Tiny PCB area

Additionally a simple output voltage limiter was designed single-ended charge-pump topology. Purpose of this is to statically drive a gate of a NFET while not exceeding VGS of the NFET even in case of higher input voltage. This replaces using just Zener diode. Use of this voltage limiter results in significant decrease of static current consumption because the oscillator gets disabled as soon as the output voltage reaches desired value. However this creates slow secondary voltage oscillations.





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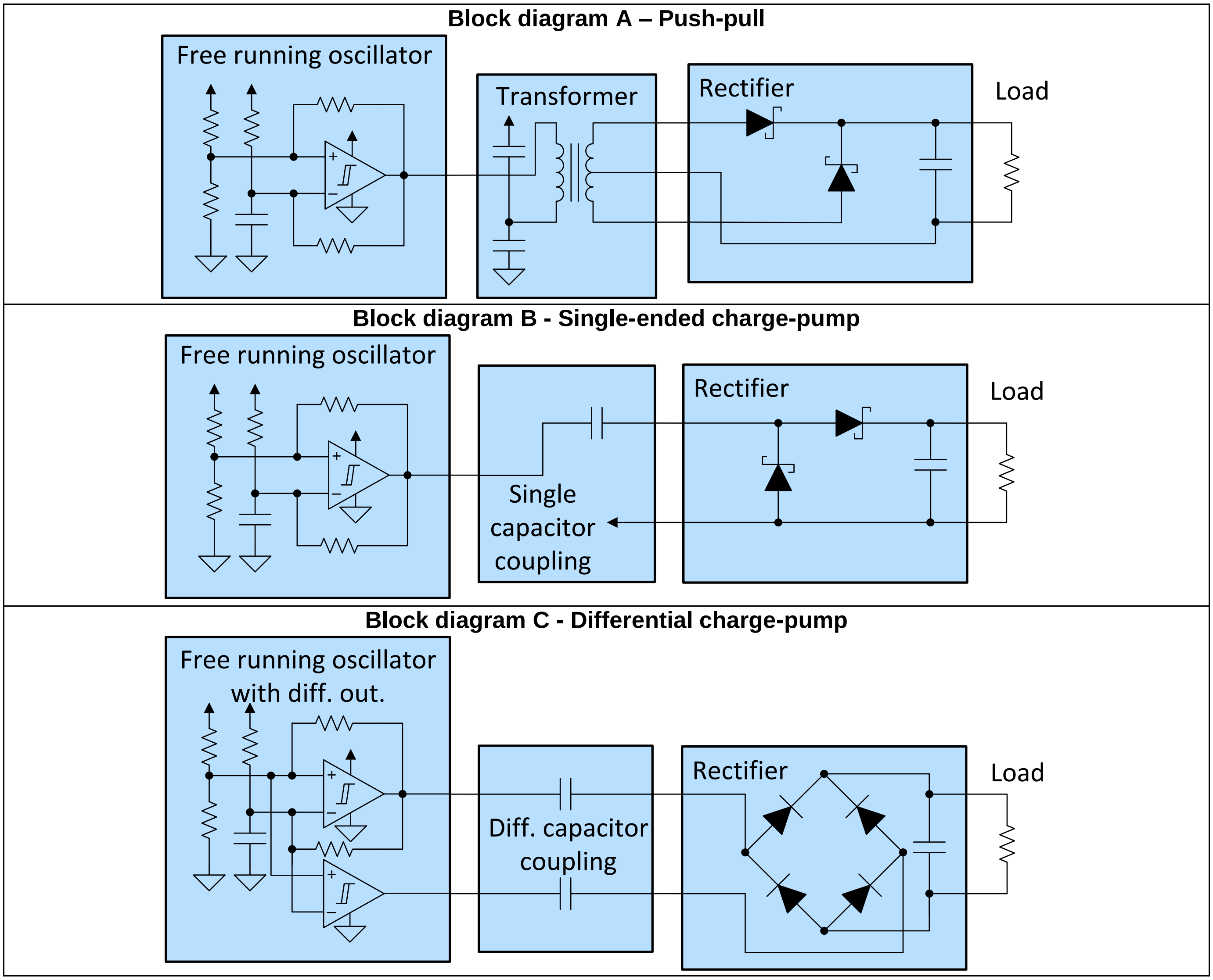

Block diagram A – Push-pull
Free running oscillator
Transformer
Rectifier
Load
Block diagram B - Single-ended charge-pump
Free running oscillator
Single
capacitor
coupling
Rectifier
Load
Block diagram C - Differential charge-pump
Free running oscillator
with diff. out.
Diff. capacitor
coupling
Rectifier
Load

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements – topology A (Push-Pull)

PARAMETER	SPECIFICATIONS
Input voltage	8..36VDC
Output voltage	4..18VDC
Output current	5..50mA

Table 2. Voltage and Current Requirements – topology B (Single-ended Charge-pump)

PARAMETER	SPECIFICATIONS
Input voltage	8..36VDC
Output voltage	8..36VDC
Output current	5..45mA

Table 3. Voltage and Current Requirements – topology C (Single-ended Charge-pump)

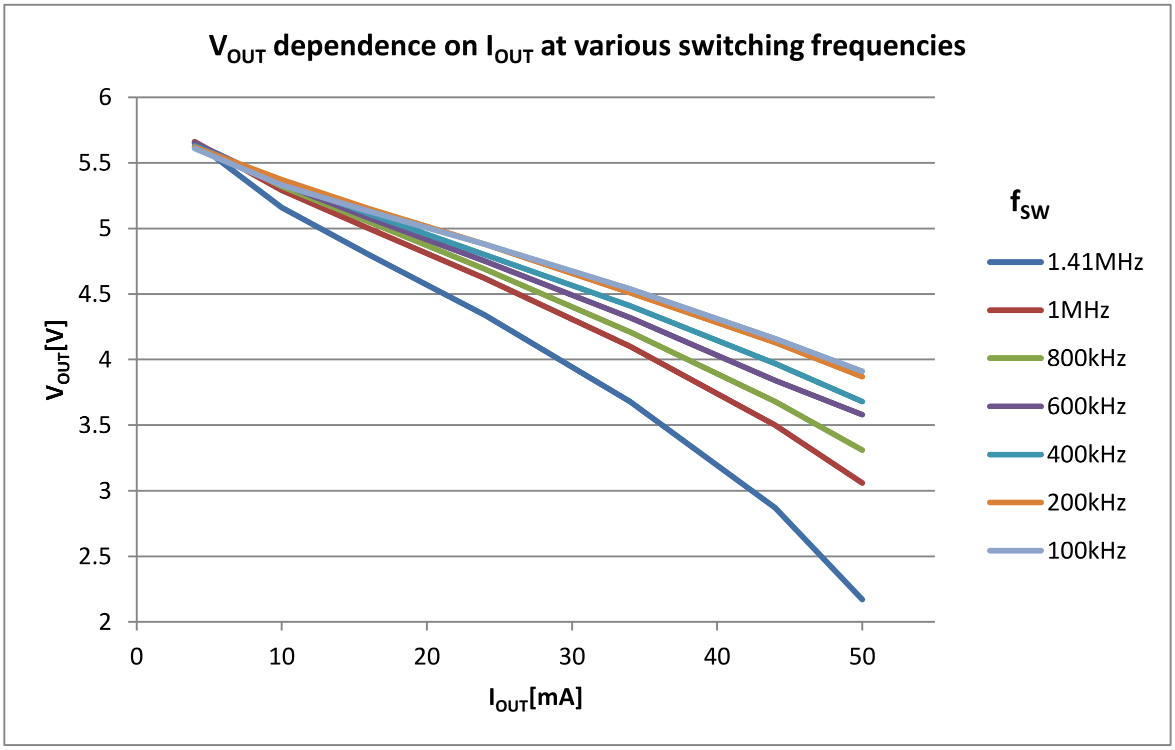
PARAMETER	SPECIFICATIONS
Input voltage	8..36VDC
Output voltage	8..36VDC
Output current	5..50mA

1.2 Required Equipment

- Regulated bench power supply
- Oscilloscope
- Electronic load
- Multimeters

1.3 Considerations

Push-pull switching frequency considerations have been done in order to find the best efficiency. Optimal frequency balances the use of transformer at higher voltages and switching losses.
Load regulation graph (below) shows dependency of output voltage on load current for different various frequencies.
With regard to transformer saturation at highest input voltage compromise frequency of around 300kHz was selected.

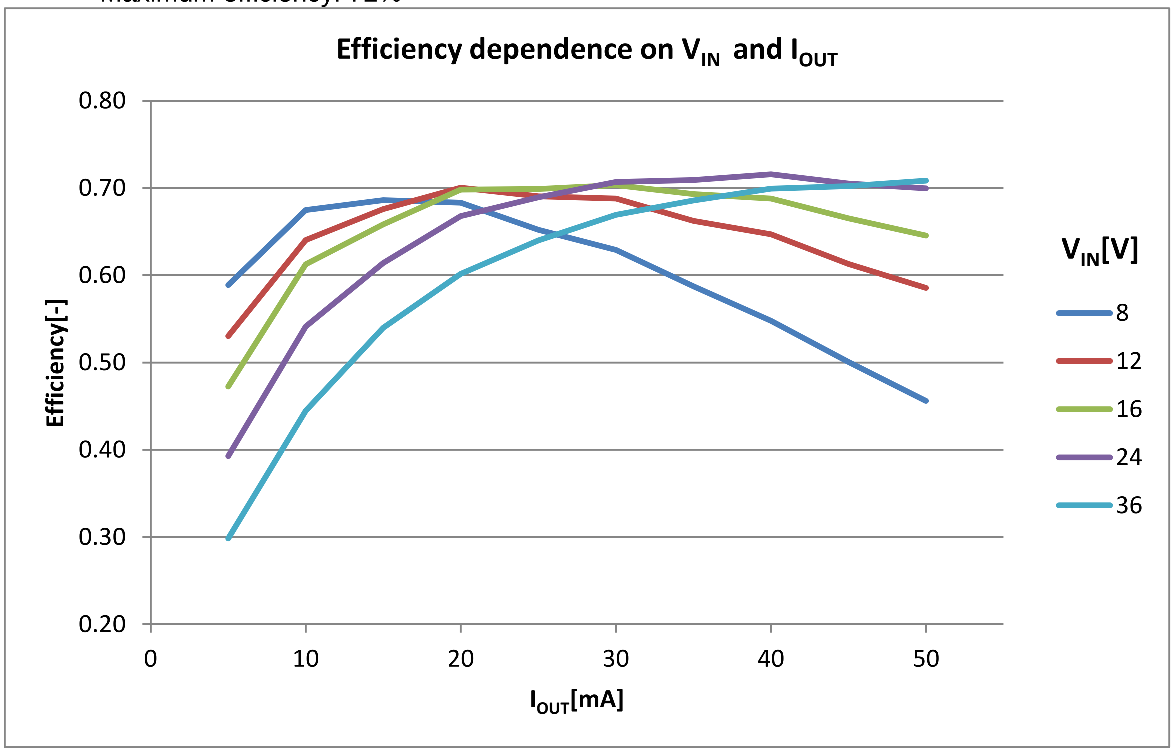


2 Testing and Results

2.1 Efficiency Graphs

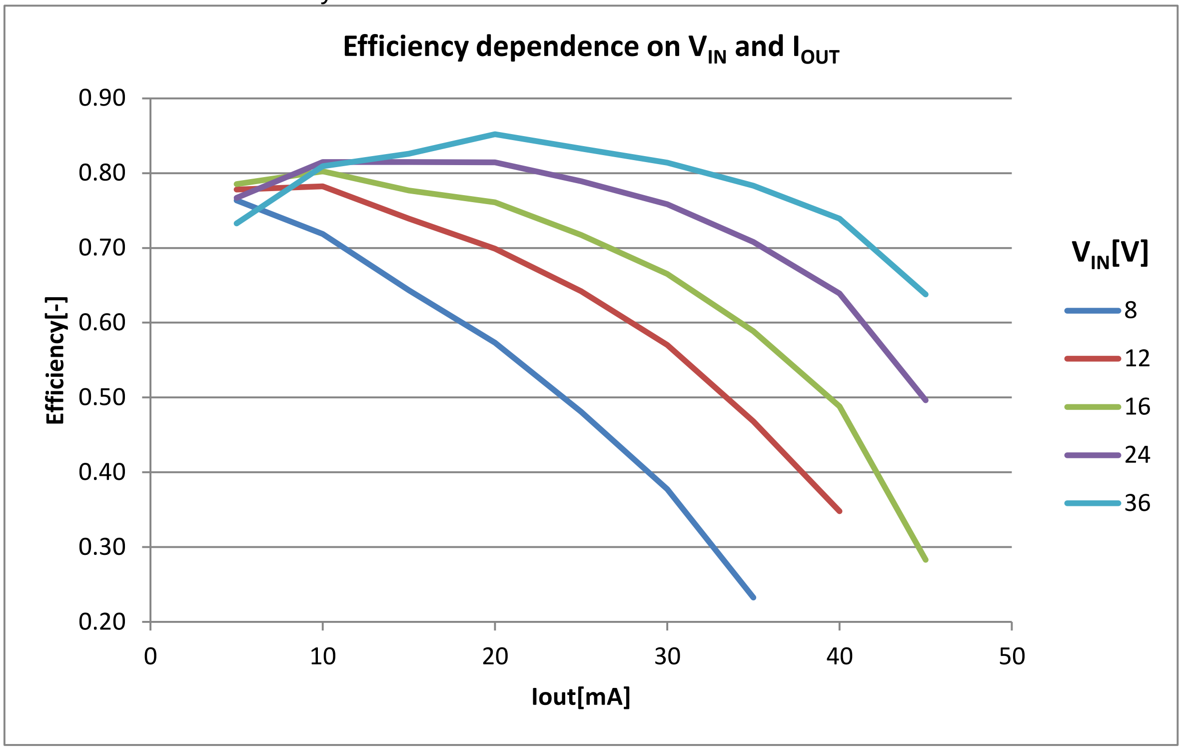
2.1.1 Topology A (Push-Pull)

- Iout between positive output and GND.
- Maximum efficiency: 72%



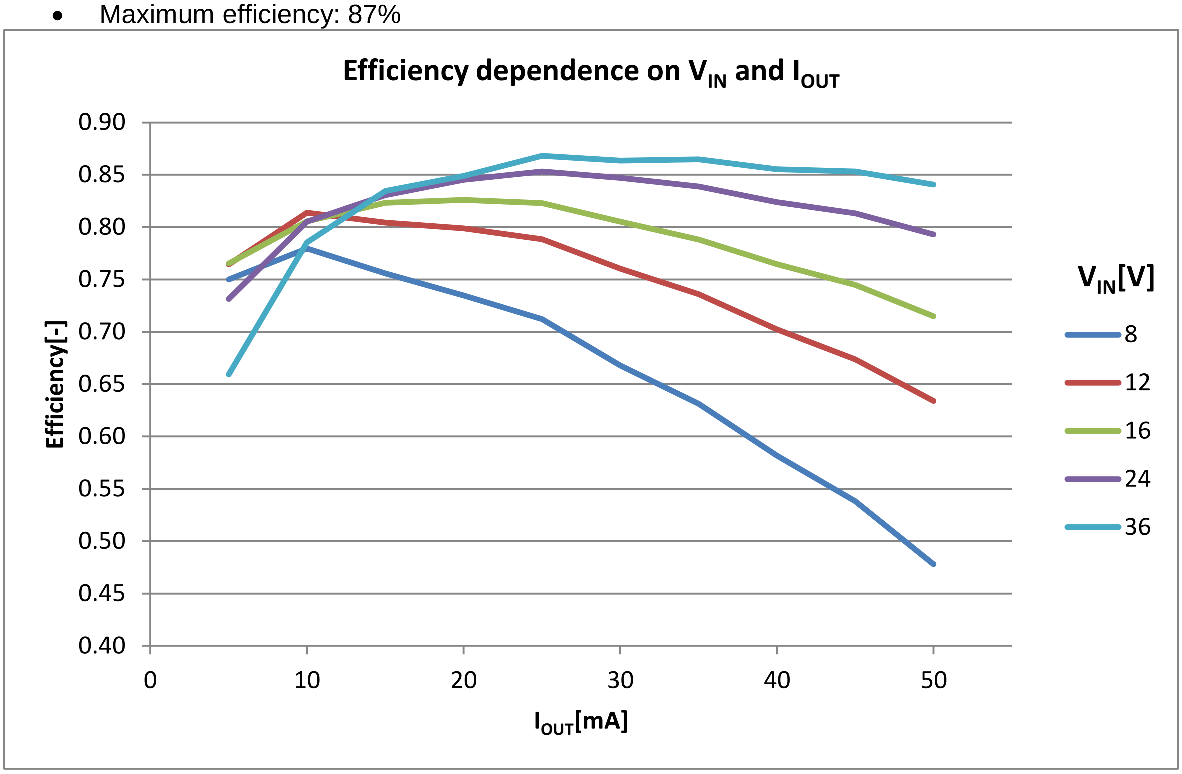
2.1.2 Topology B (Single-ended Charge-pump)

- Maximum efficiency: 85%



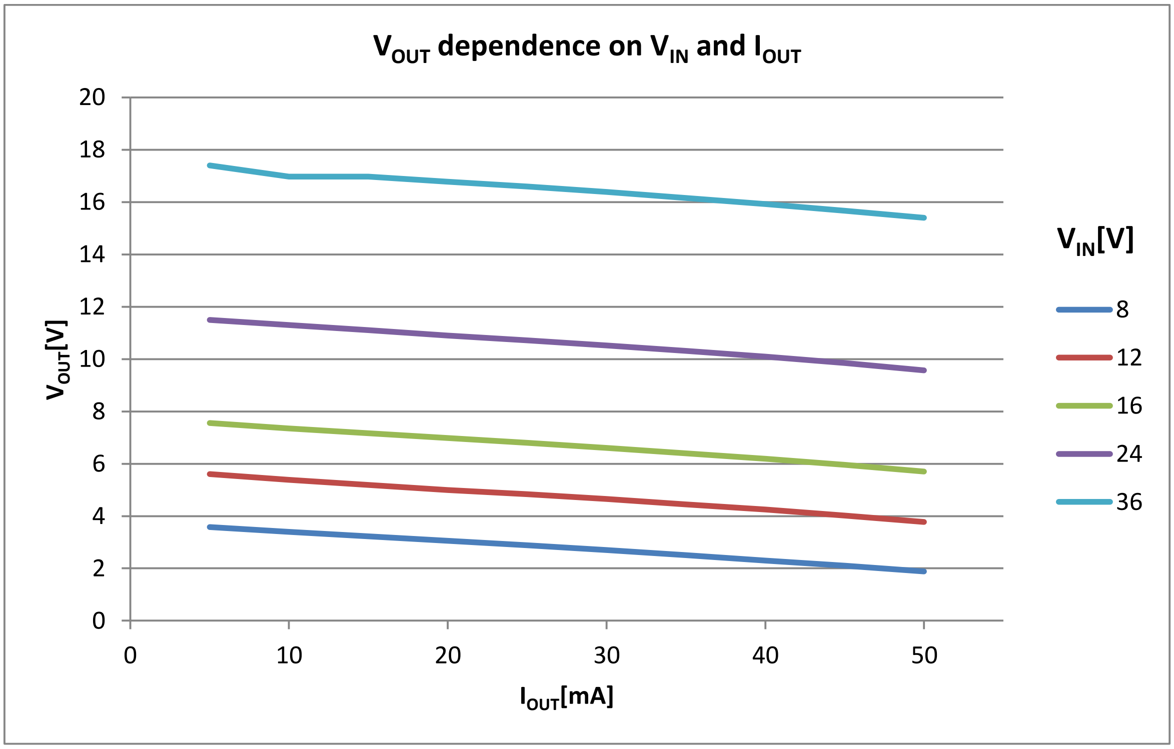
2.1.3 Topology C (Differential Charge-pump)

- Maximum efficiency: 87%

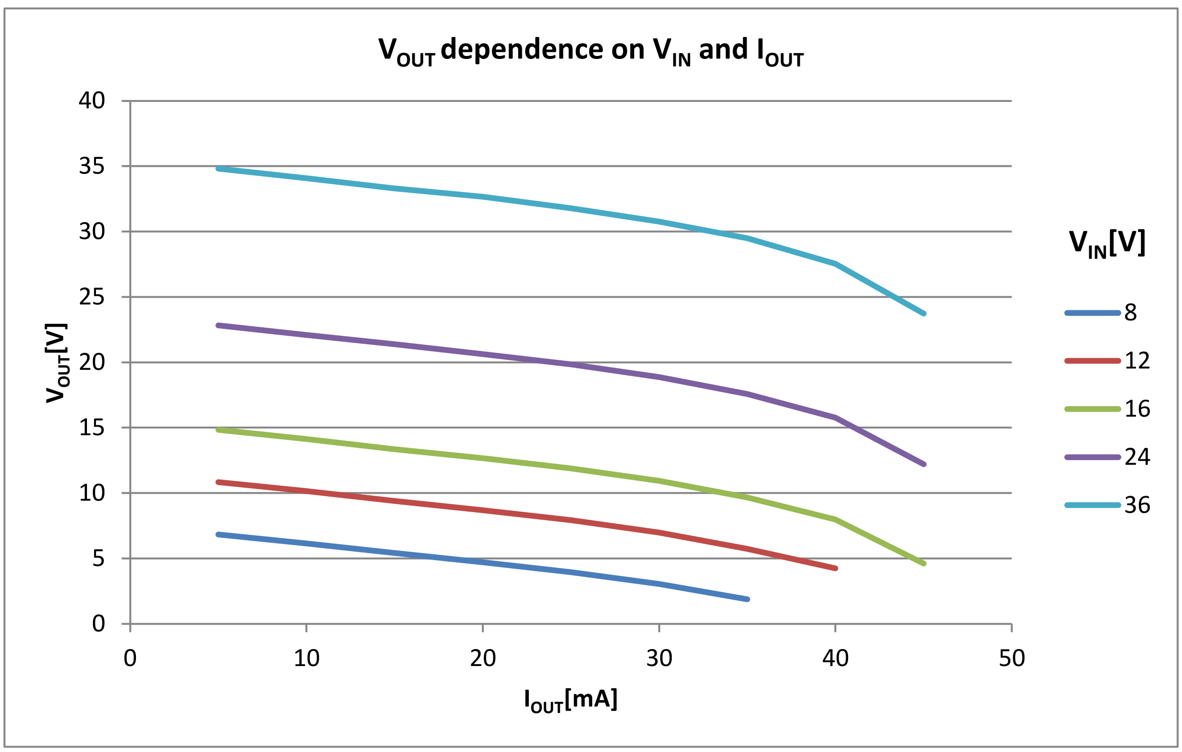


2.2 Load regulation Graphs

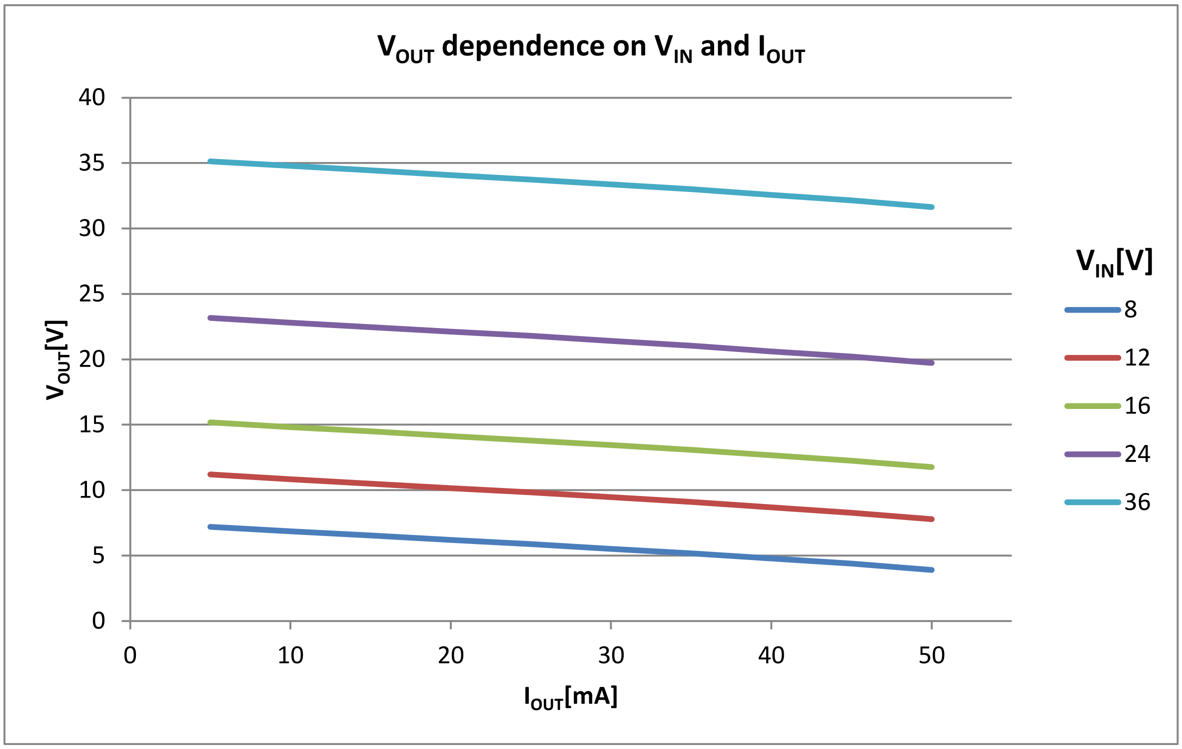
2.2.1 Topology A (Push-Pull)



2.2.2 Topology B (Single-ended Charge-pump)



2.2.3 Topology C (Differential Charge-pump)

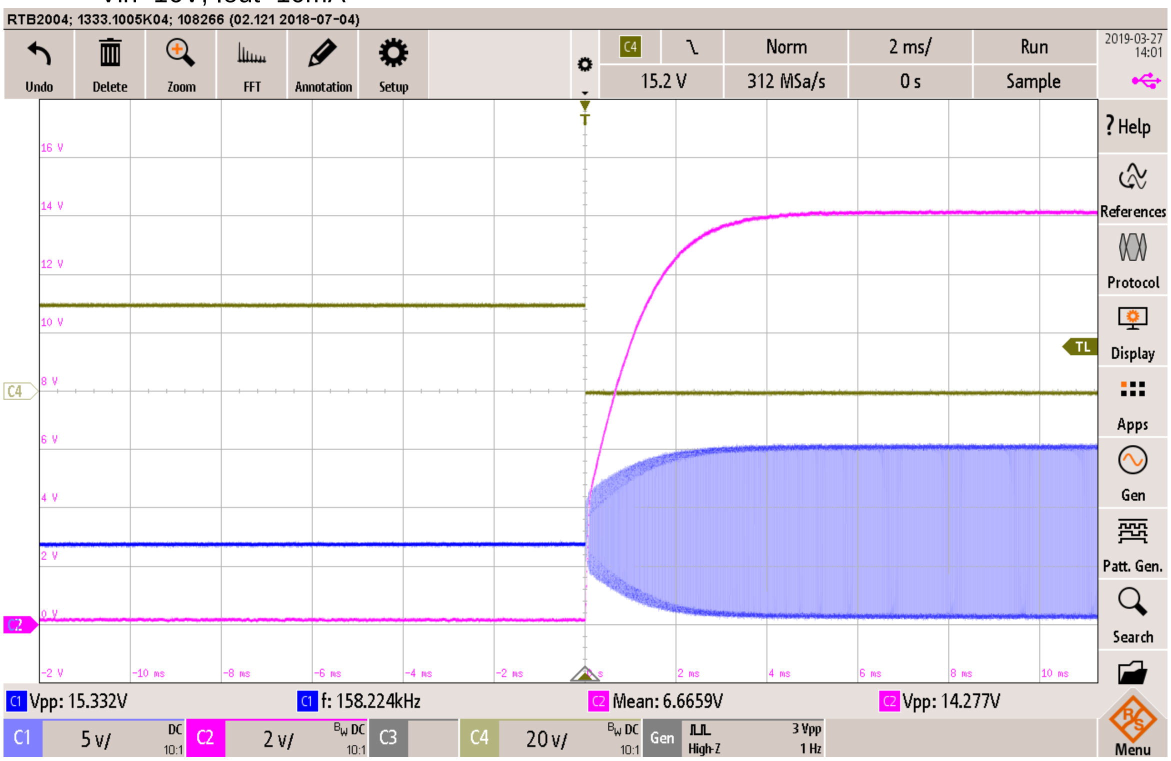


3 Waveforms

3.1 Start-up Sequence

3.1.1 Topology B (Single-ended Charge-pump), output voltage limiter not populated

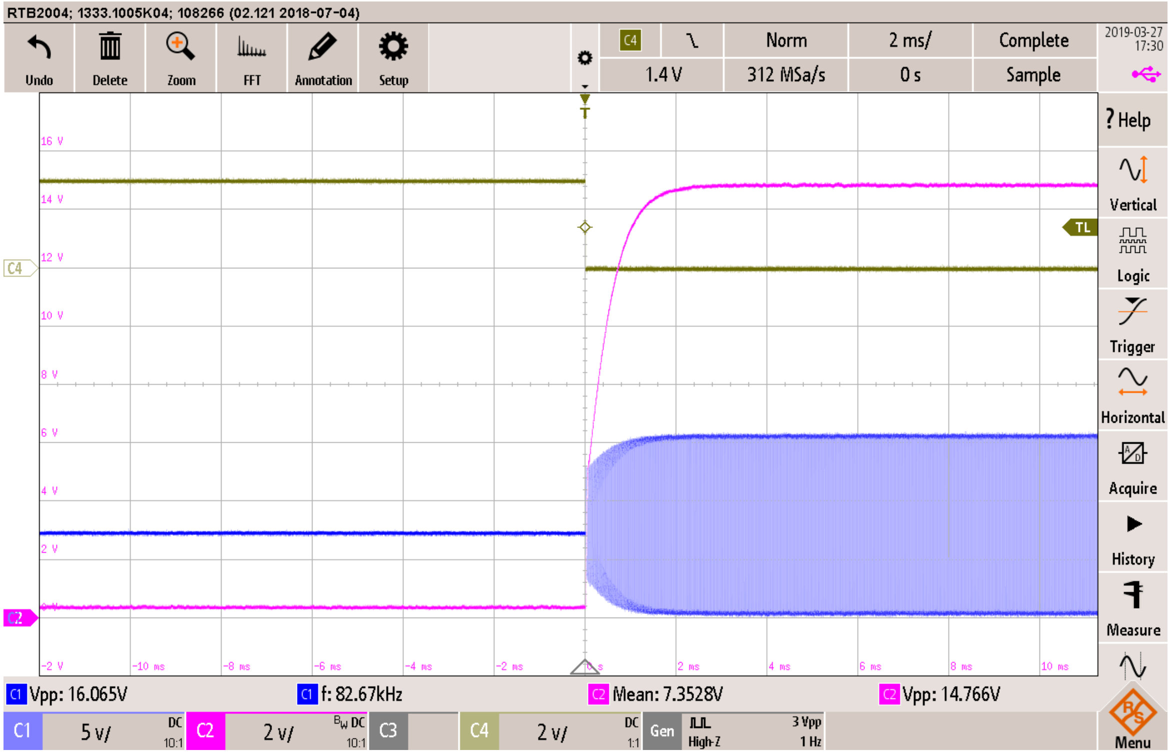
- Vin=16V, Iout=10mA



C1: Switch node, C2: Vout, C4: enable signal

3.1.2 Topology C (Single-ended Charge-pump)

- Vin=16V, Iout=10mA

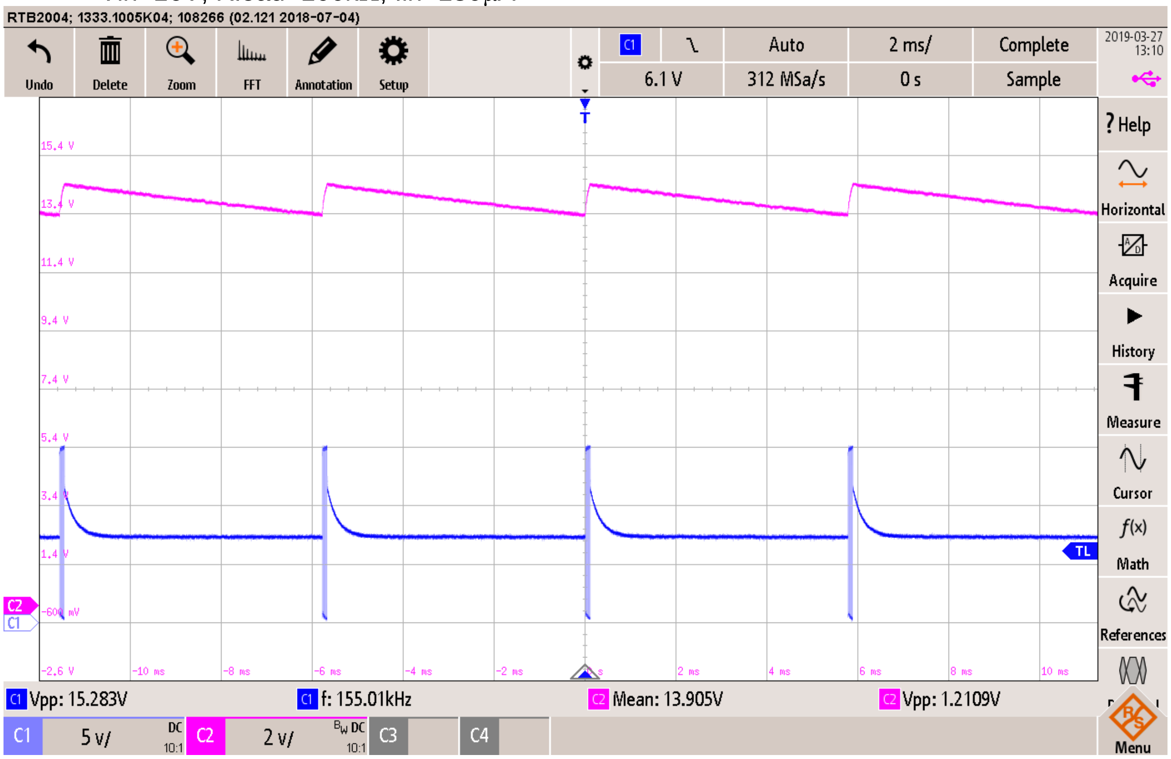


C1: Switch node, C2: Vout, C4: enable signal

3.2 *Other*

3.2.1 Topology B (Single-ended Charge-pump) output voltage limiter populated

- Vin=16V, Rload=100kΩ, Iin=180µA



C1: Switch node, C2: Vout