Test Report: PMP40970

Multiple Output Isolated Driver Bias Supply Reference Design

Description

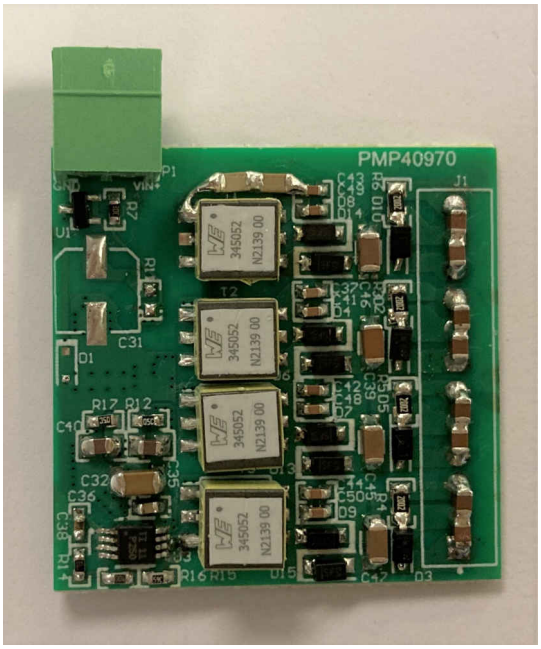
This isolated open-loop LLC transformer driver converter provides 4 rail outputs, each output has dual +18-V and –5-V outputs up to 0.5 W for traction inverter applications. The UCC25800-Q1 device is used here as the controller. The LLC topology allows the transformer to have significant leakage inductance, but a much smaller primary-secondary capacitance, which significantly reduces common-mode current injection through the bias transformer. This reference design offers a high level of integration and high efficiency in a compact form factor, it has passed CISPR 25 class 3 conducted EMI standard.

Features

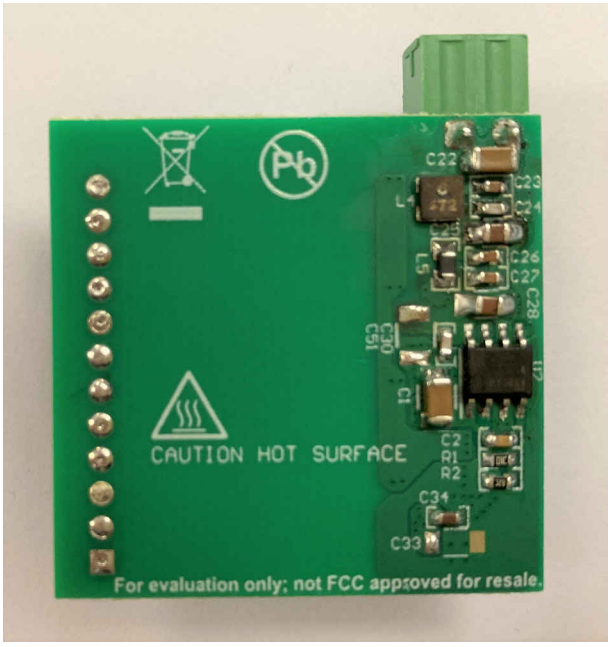
- Small open-loop solution size drives four rails
- Compact PCB size (36.7 mm × 36 mm)
- Passed CISPR 25 Class 3 conducted EMI standard

Applications

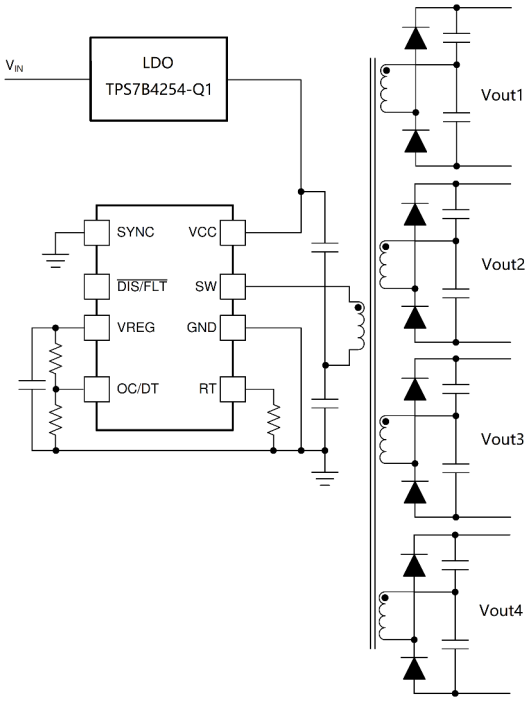
- On-board (OBC) and wireless charger
- IGBT and SiC gate transformer driver bias supply



Top of Board



Bottom of Board



Block Diagram

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

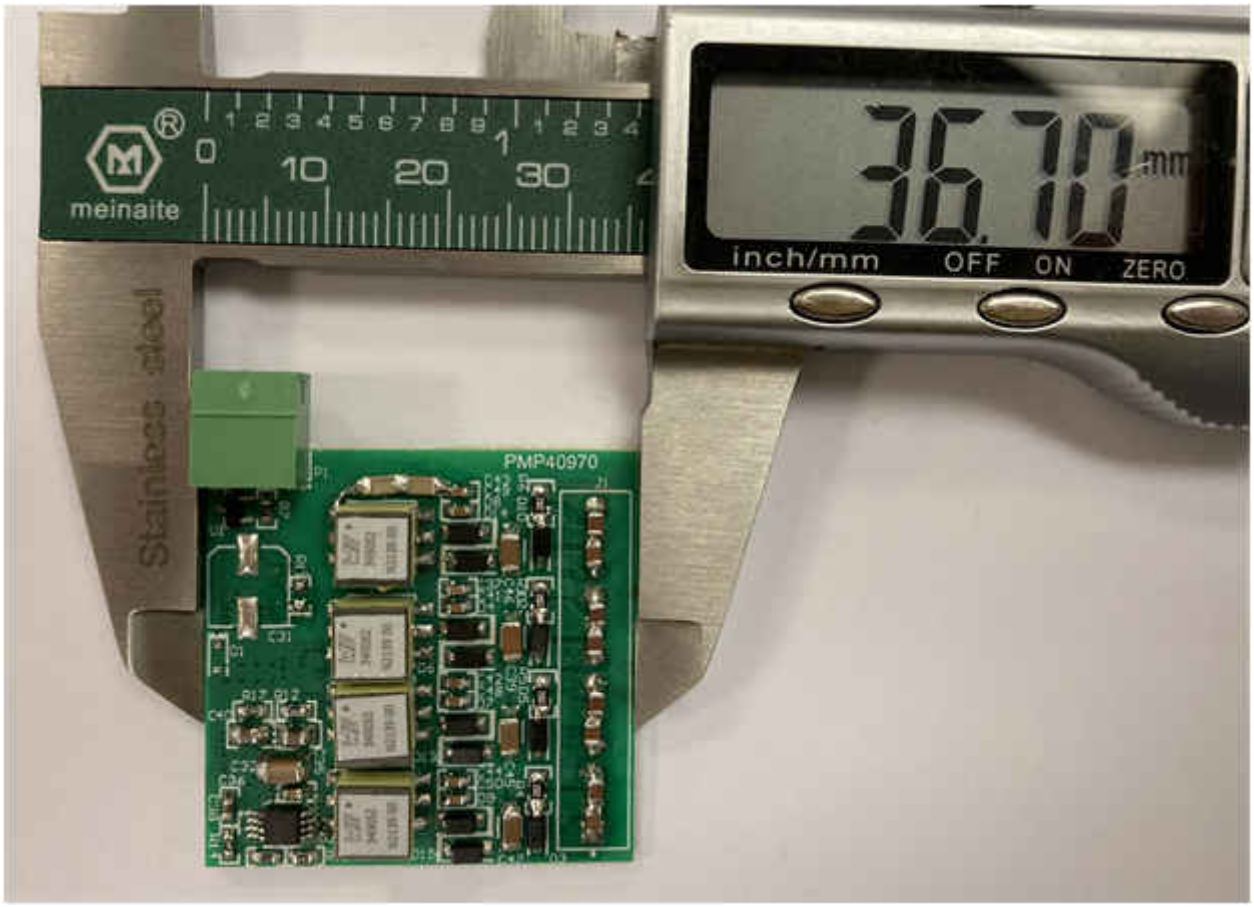
Parameter	Specifications
Input voltage range	24 V
Output voltage and current	4 × (18 V and –5 V, 22 mA), 2 W maximum
Nominal switching frequency	402 kHz
Isolation	Yes, 1500 VAC, 1 second
Topology	Open-loop LLC

1.2 Required Equipment

- Multimeter (current): Fluke 287C
- DC Source: Chroma 62012P-100-50
- E-Load: Chroma 63110 module
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke TiS65

1.3 Dimensions

The board dimensions are 36.7 mm (length) × 36 mm (width) × 9 mm (height). Ignore P1.



2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

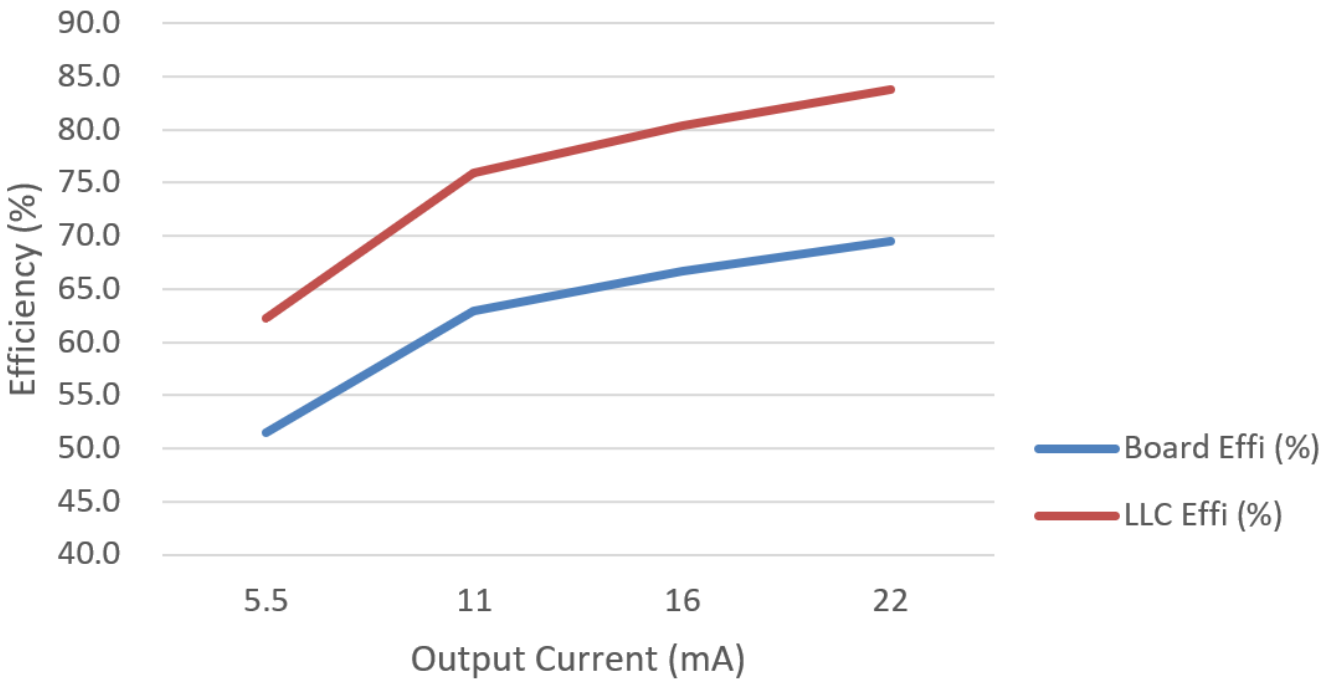


Figure 2-1. PMP40970 Efficiency Graph

2.2 Efficiency Data

Vin (V)	Iin (mA)	Vo_LDO (V)	Vo1 (V)	Io1 (mA)	Vo2 (V)	Io2 (mA)	Vo3 (V)	Io3 (mA)	Vo4 (V)	Io4 (mA)	Effi (%)	Effi (%) LLC
23.987	16.73	19.880	23.85	0.0	23.858	0.0	24.150	0.0	23.891	0.0		
24.051	42.01	19.884	23.35	5.8	23.286	5.4	23.618	5.4	23.383	5.6	51.4	62.2
24.012	69.32	19.880	23.14	12.0	23.170	11.4	23.384	11.1	23.18	10.6	62.9	76.0
23.978	91.92	19.880	22.99	16.2	23.020	16.0	23.230	16.0	23.023	15.5	66.7	80.4
23.934	122.42	19.881	22.80	22.4	22.830	21.9	23.044	22.0	22.828	22.8	69.6	83.7

2.3 Load Regulation

Table 2-1. Vo1 Load Regulation

Vin (V)	Vo1_18V (V)	Io1_18V (mA)	Vo1_–5V (V)	Io1_–5V (mA)
24	18.865	0.0	–4.906	0.0
24	18.164	5.8	–5.063	5.5
24	18.096	10.3	–5.031	10.3
24	18.060	15.0	–4.984	14.9
24	17.895	22.4	–5.023	22.5

Table 2-2. Vo2 Load Regulation

Vin (V)	Vo2_18V (V)	Io2_18V (mA)	Vo2_–5V (V)	Io2_–5V (mA)
24	18.965	0.0	–4.936	0.0
24	18.471	5.4	–4.924	5.0
24	18.235	11.4	–4.928	11.0
24	18.046	16.1	–5.012	15.0
24	17.945	22.0	–5.012	21.0

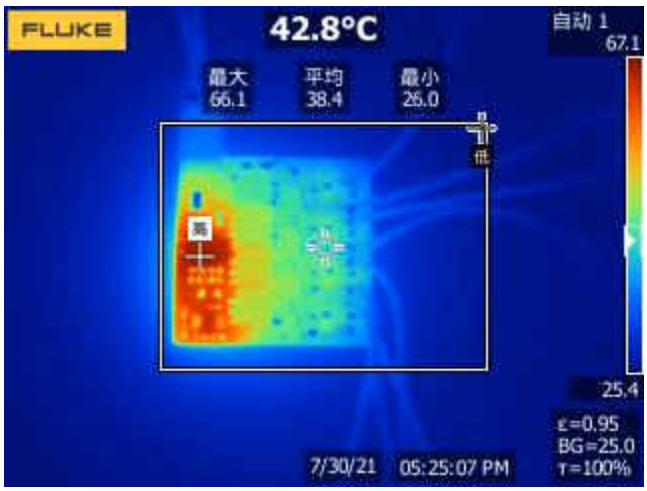
Table 2-3. Vo3 Load Regulation

Vin (V)	Vo3_18V (V)	Io3_18V (mA)	Vo3_–5V (V)	Io3_–5V (mA)
24	19.246	0.0	–4.918	0.0
24	18.715	5.4	–4.910	5.0
24	18.523	11.5	–4.912	11.0
24	18.253	16.1	–5.012	15.0
24	18.146	22.0	–5.008	21.0

Table 2-4. Vo4 Load Regulation

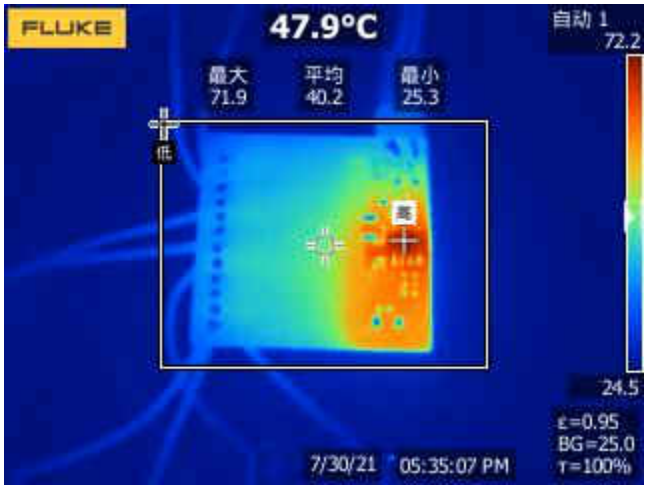
Vin (V)	Vo4_18V (V)	Io4_18V (mA)	Vo4_–5V (V)	Io4_–5V (mA)
24	18.981	0.0	–4.932	0.0
24	18.360	5.5	–4.926	5.0
24	18.194	11.5	–4.942	11.0
24	18.018	16.1	–5.032	15.0
24	17.930	22.0	–5.032	21.0

2.4 Thermal Images



V_{IN} = 24 V, 22 mA for each rail; ambient temperature = 25°C

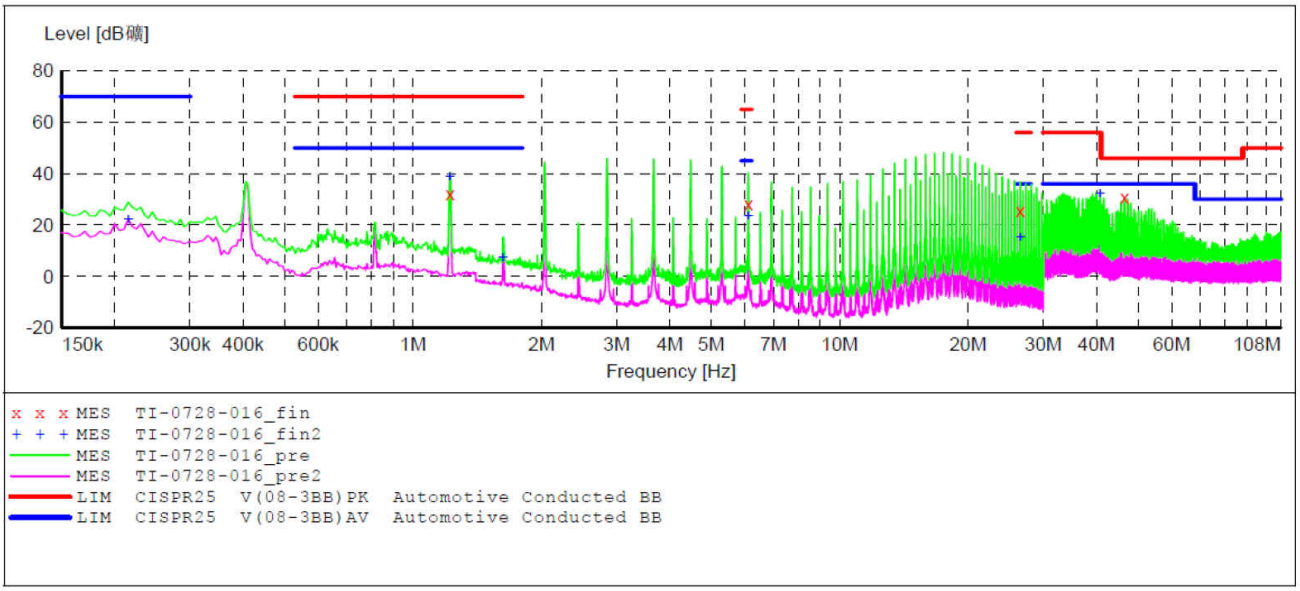
Figure 2-2. Top Layer Thermal



V_{IN} = 24 V, 22 mA for each rail; ambient temperature = 25°C; highest temperature point: LDO 72.2°C

Figure 2-3. Bottom Layer Thermal

2.5 EMI



MEASUREMENT RESULT: "TI-0728-016_fin"

2021-7-28 05:12下午

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
1.220000	32.10	0.2	70	37.9	PK	N	GND
6.105000	28.10	0.2	65	36.9	PK	N	GND
26.475000	25.70	1.3	56	30.3	PK	N	GND
46.450000	30.70	1.7	46	15.3	PK	N	GND

MEASUREMENT RESULT: "TI-0728-016_fin2"

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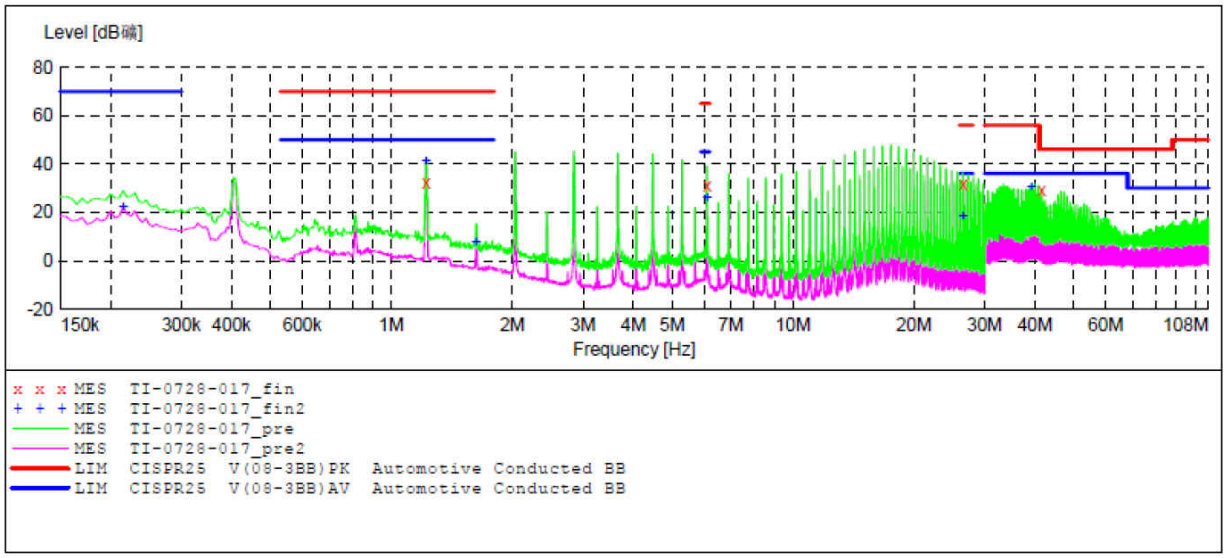
Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
0.215000	22.00	0.1	70	48.0	AV	N	GND
1.220000	38.50	0.2	50	11.5	AV	N	GND
1.625000	7.20	0.2	50	42.8	AV	N	GND
6.105000	23.40	0.2	45	21.6	AV	N	GND
26.475000	15.20	1.3	36	20.8	AV	N	GND
40.750000	32.10	1.5	36	3.9	AV	N	GND

Figure 2-4. DC+ Conducted EMI Test Result for CISPR 25 Class 3 Standard



MEASUREMENT RESULT: "TI-0728-017_fin"

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Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
1.220000	32.10	0.2	70	37.9	PK	N	GND
6.105000	30.80	0.2	65	34.2	PK	N	GND
26.475000	31.50	1.3	56	24.5	PK	N	GND
41.550000	28.90	1.5	46	17.1	PK	N	GND

MEASUREMENT RESULT: "TI-0728-017_fin2"

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Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
0.215000	22.40	0.1	70	47.6	AV	N	GND
1.220000	41.00	0.2	50	9.0	AV	N	GND
1.625000	7.60	0.2	50	42.4	AV	N	GND
6.105000	26.00	0.2	45	19.0	AV	N	GND
26.475000	18.40	1.3	36	17.6	AV	N	GND
39.100000	30.30	1.5	36	5.7	AV	N	GND

Figure 2-5. DC– Conducted EMI Test Result for CISPR 25 Class 3 Standard

3 Waveforms

3.1 Switch-Node Voltage

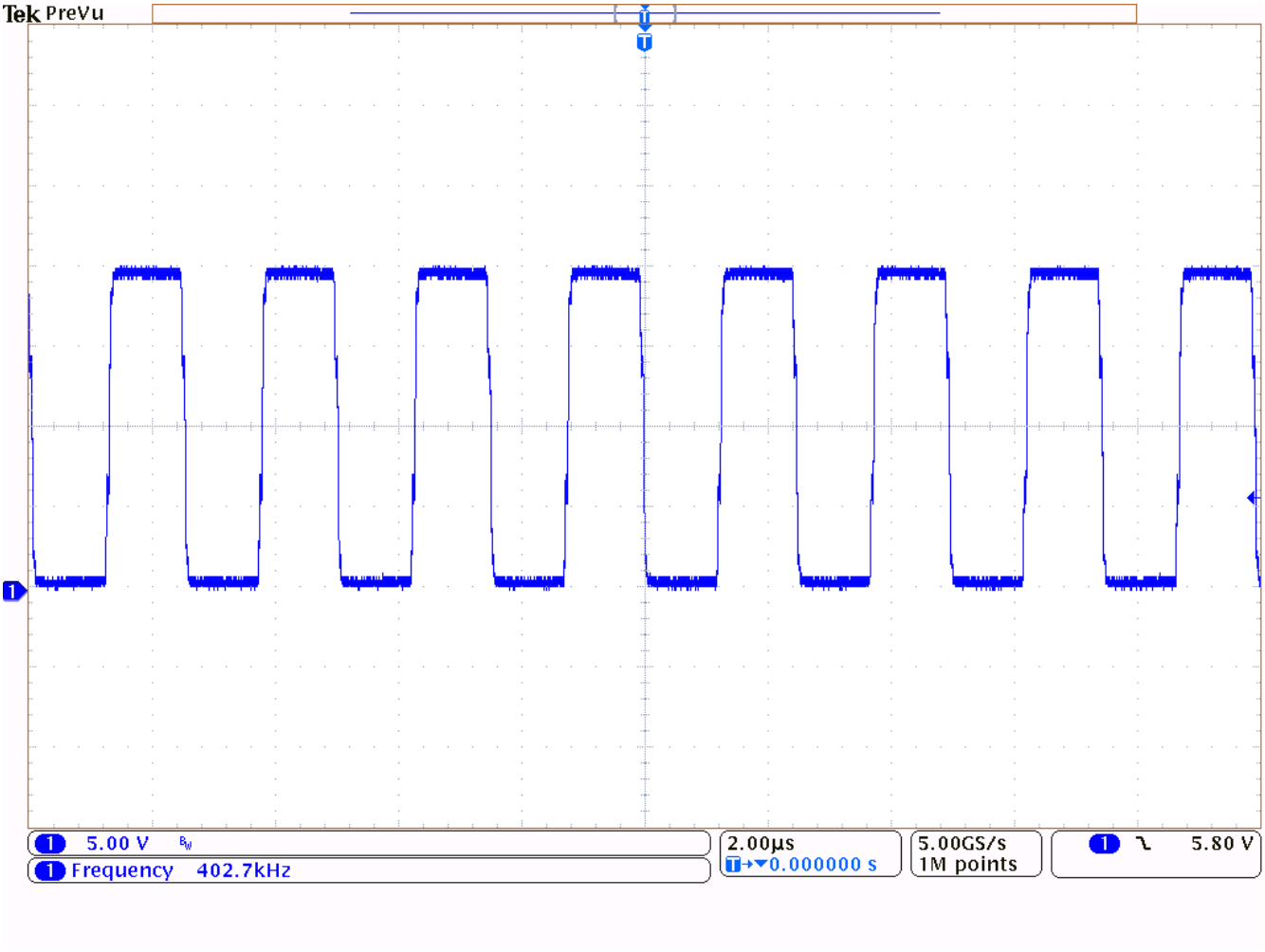


Figure 3-1. Switch-Node Voltage, No Load

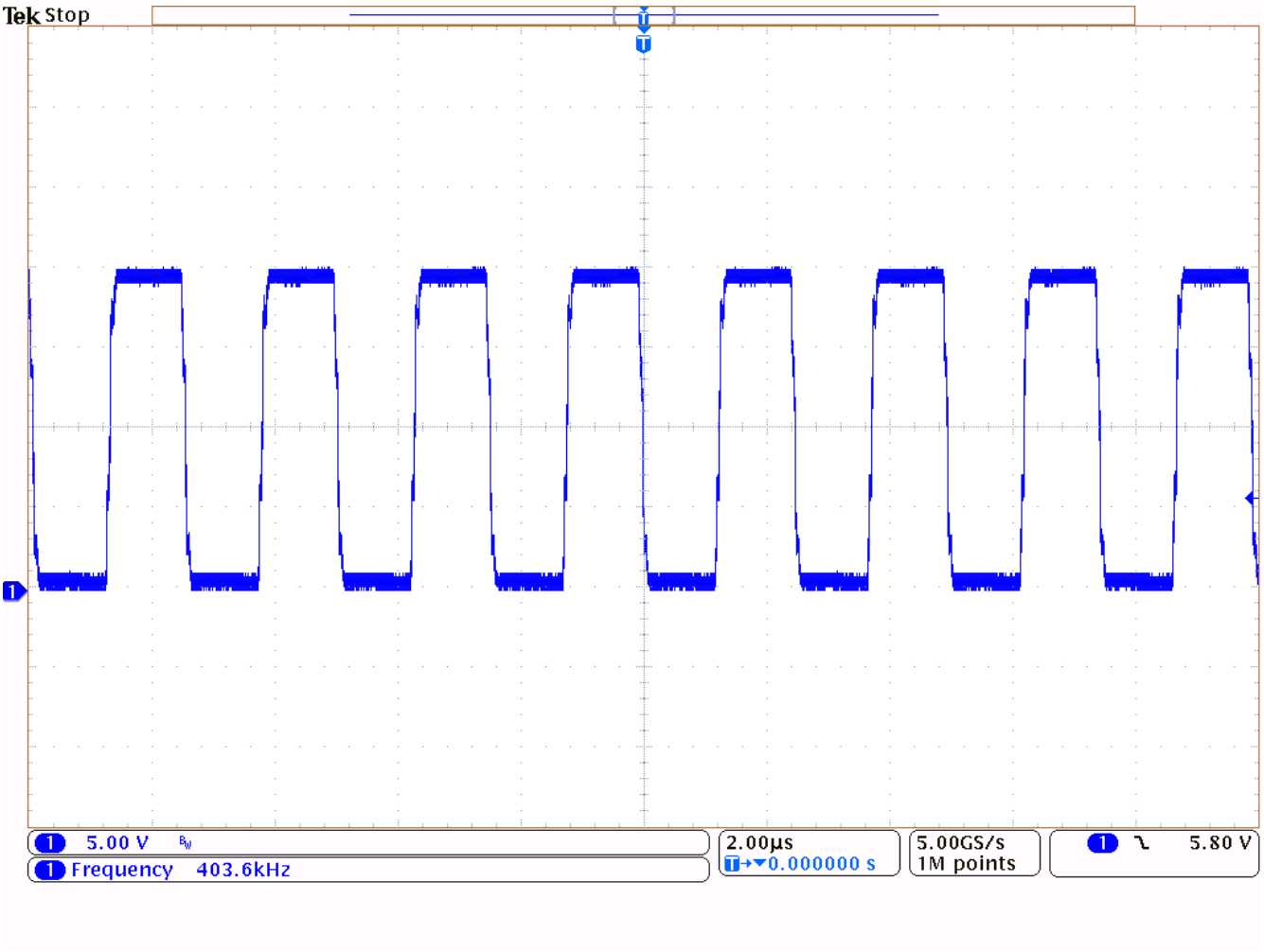


Figure 3-2. Switch-Node Voltage, 22-mA Load for Each Rail

3.2 Output Voltage Ripple

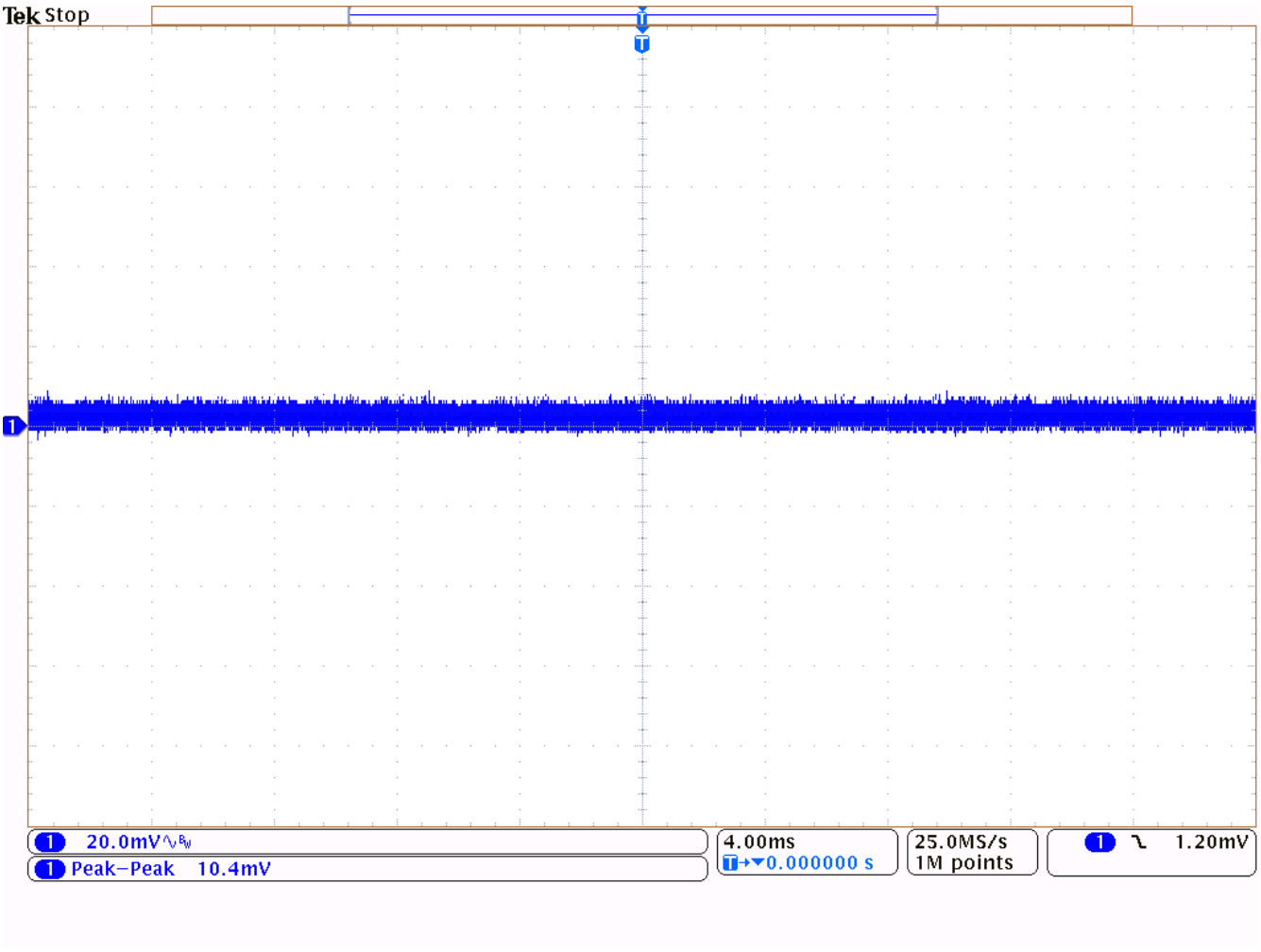


Figure 3-3. Vo1 18-V Output Ripple Voltage, No Load

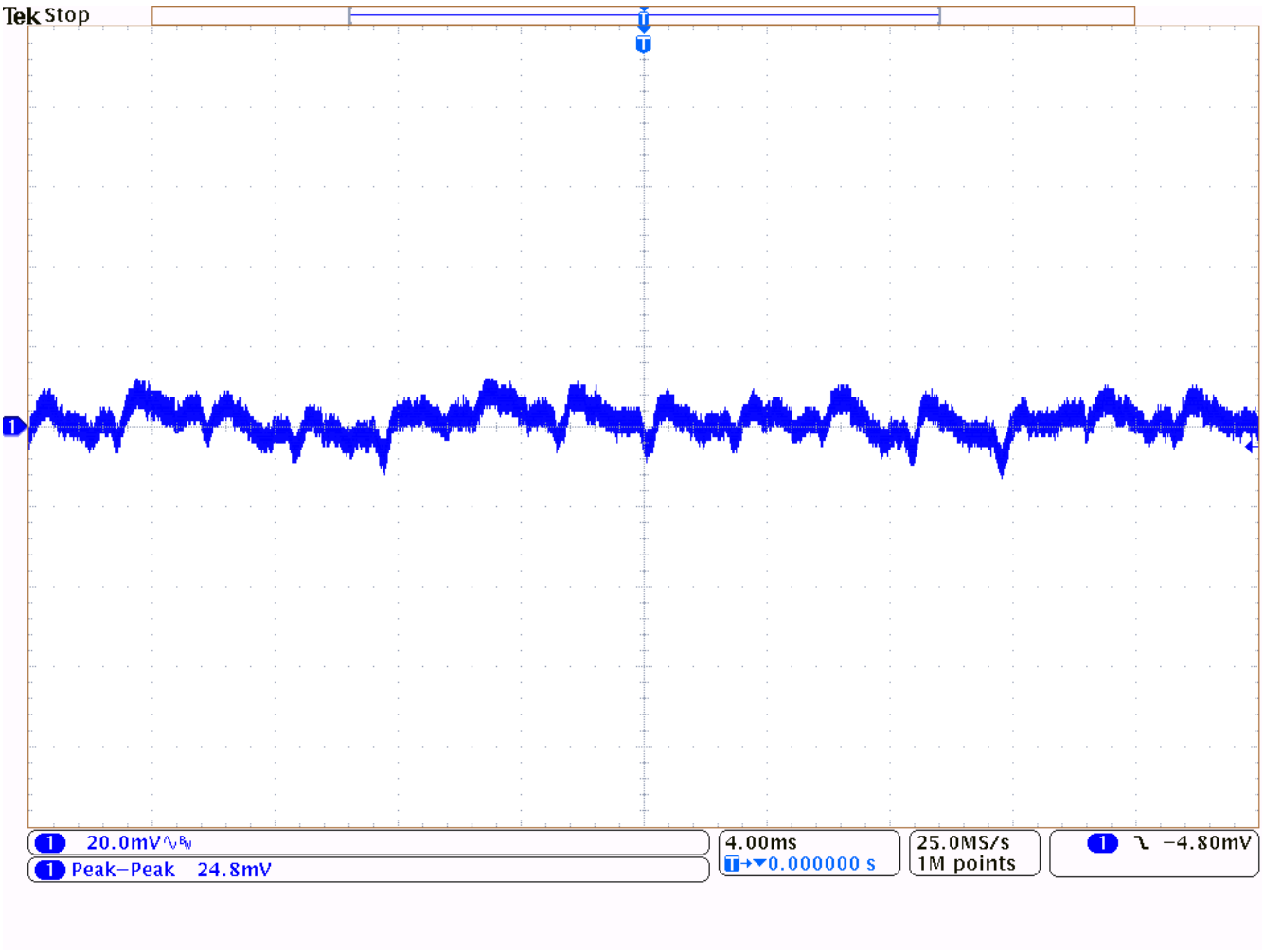


Figure 3-4. Vo1 18-V Output Ripple Voltage, Io = 11 mA

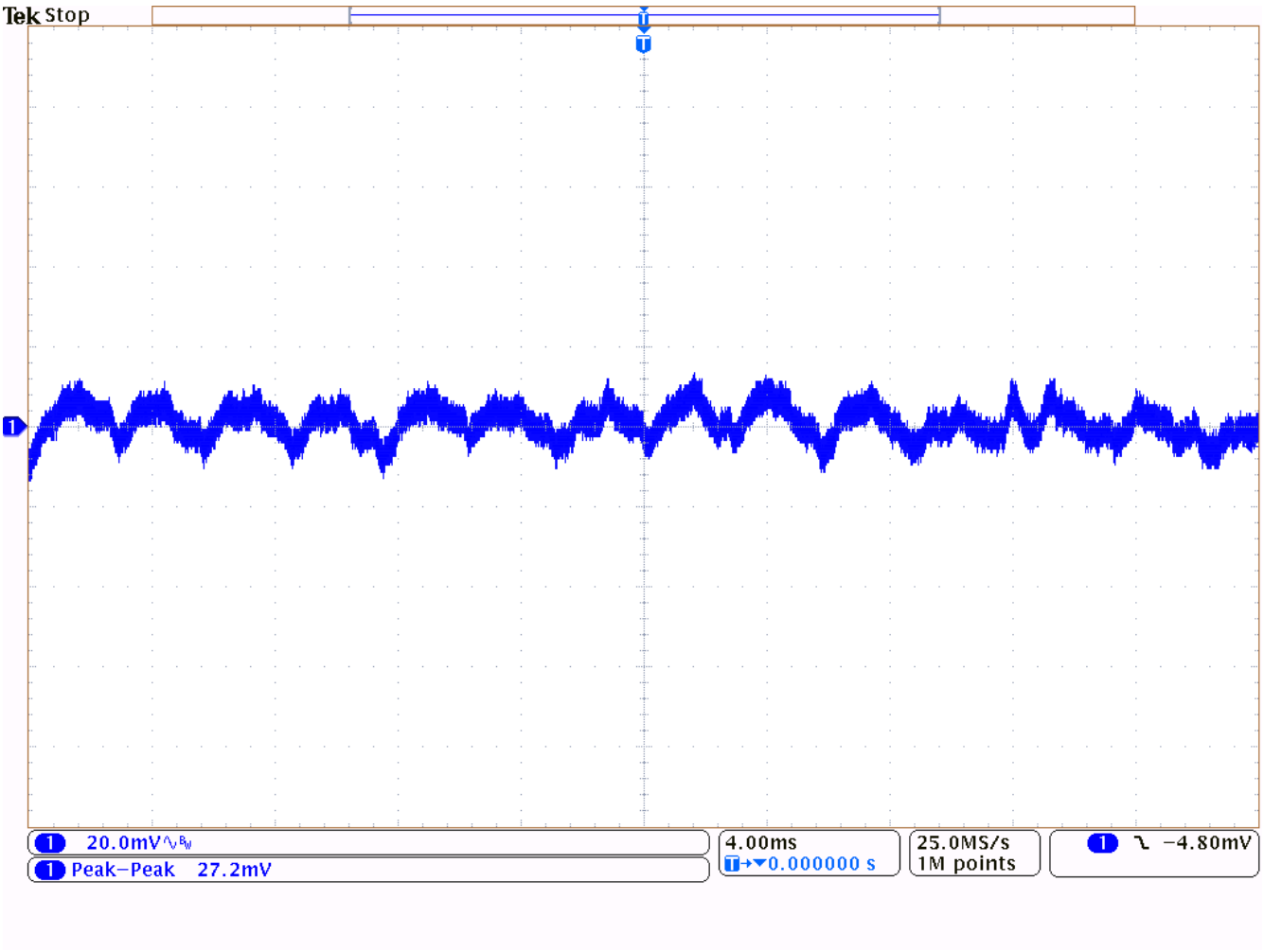


Figure 3-5. Vo1 18-V Output Ripple Voltage, Io = 22 mA

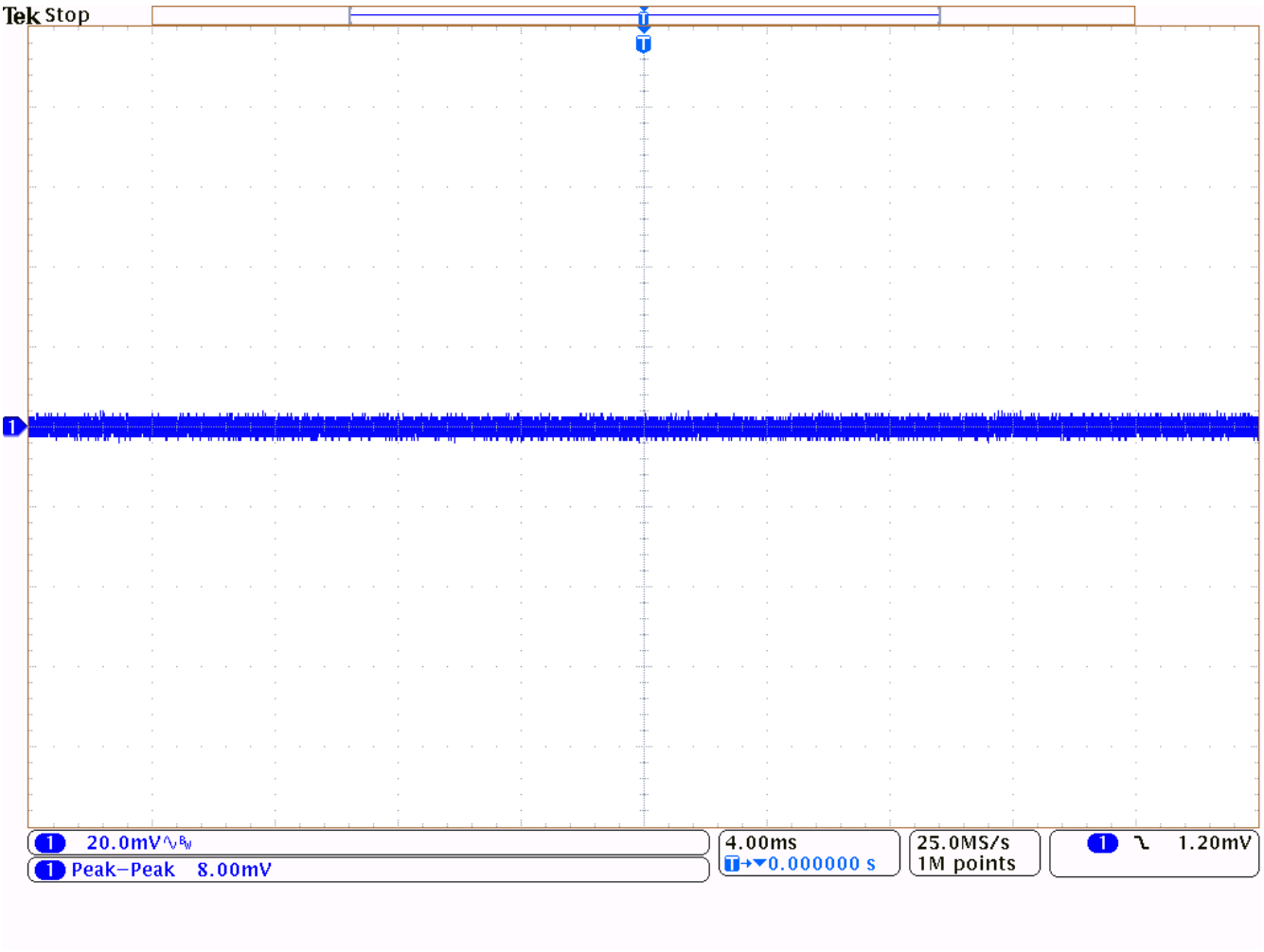


Figure 3-6. Vo1 –5-V Output Ripple Voltage, No Load

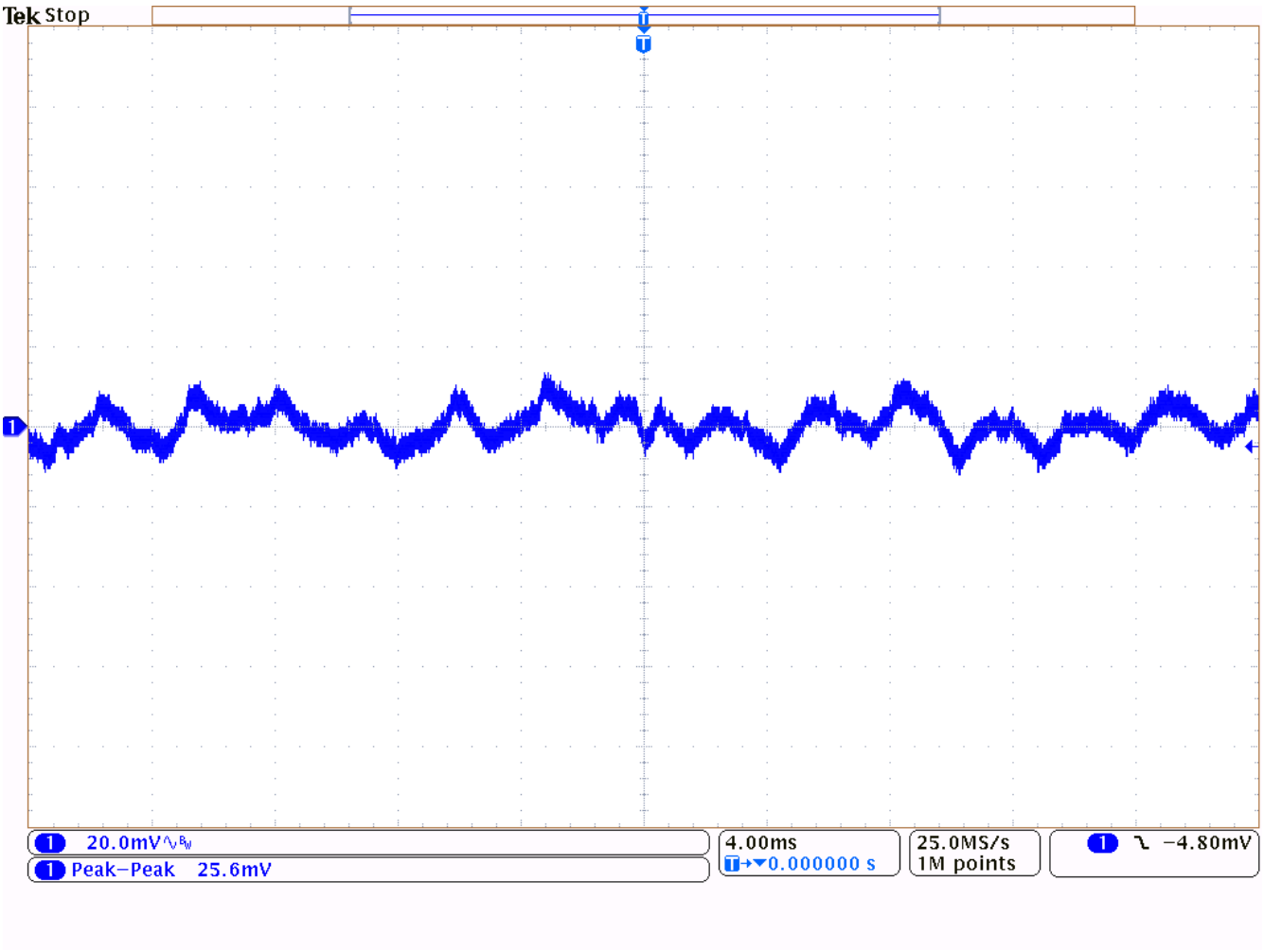


Figure 3-7. Vo1 –5-V Output Ripple Voltage, Io = 11 mA

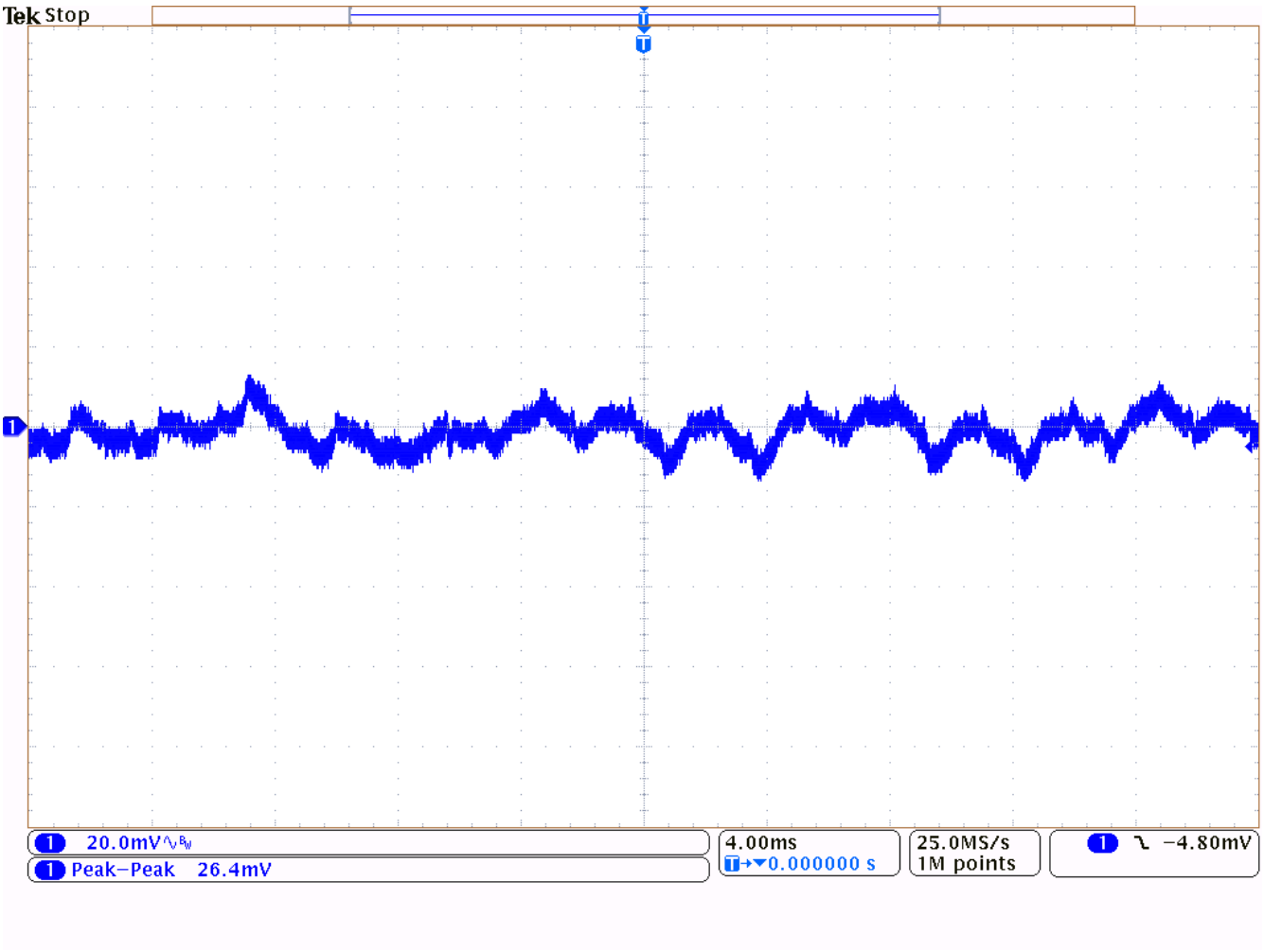


Figure 3-8. Vo1 –5-V Output Ripple Voltage, Io = 22 mA

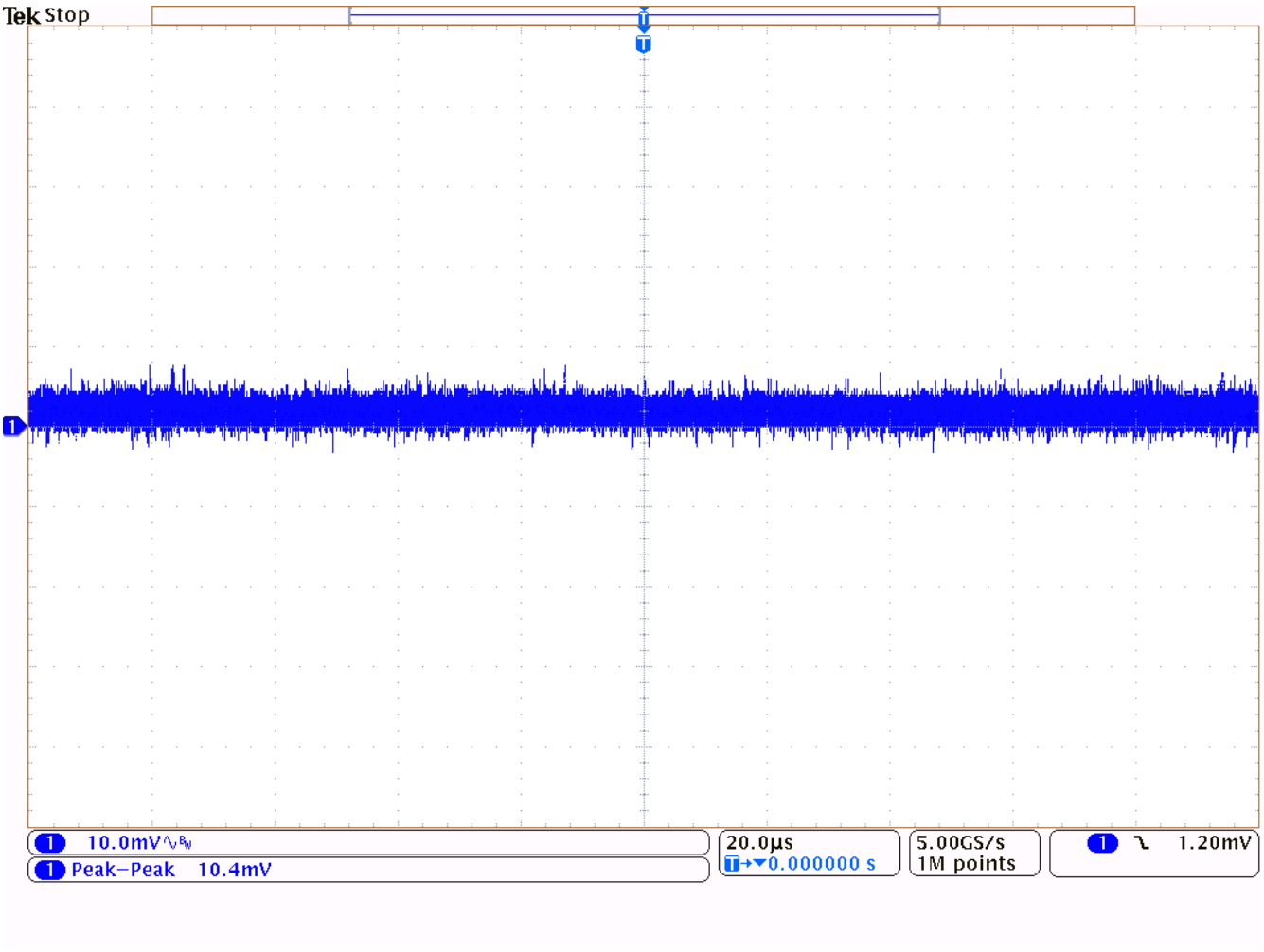


Figure 3-9. Vo1 23-V Output Ripple Voltage, No Load

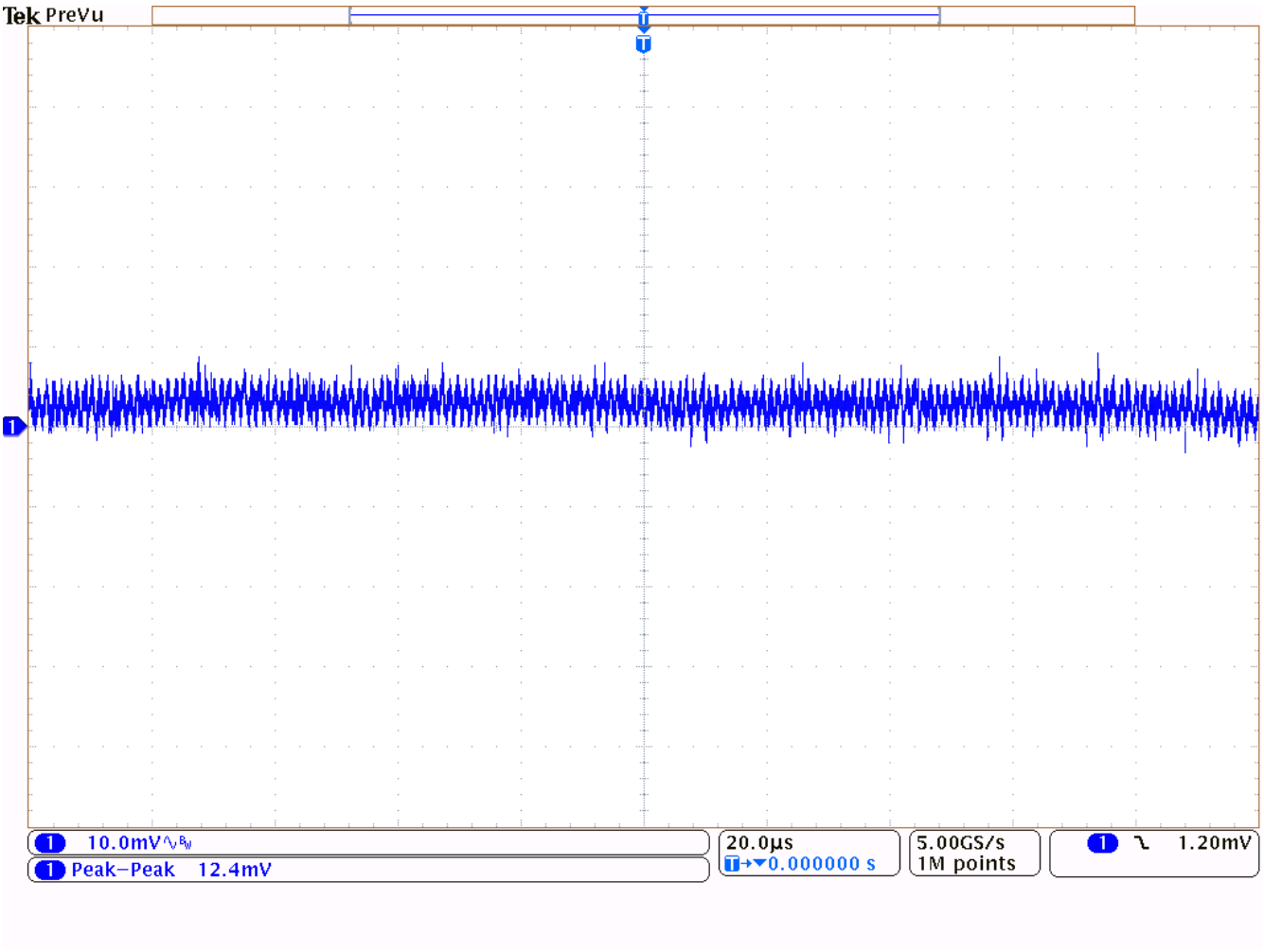


Figure 3-10. Vo1 23-V Output Ripple Voltage, Io = 11 mA

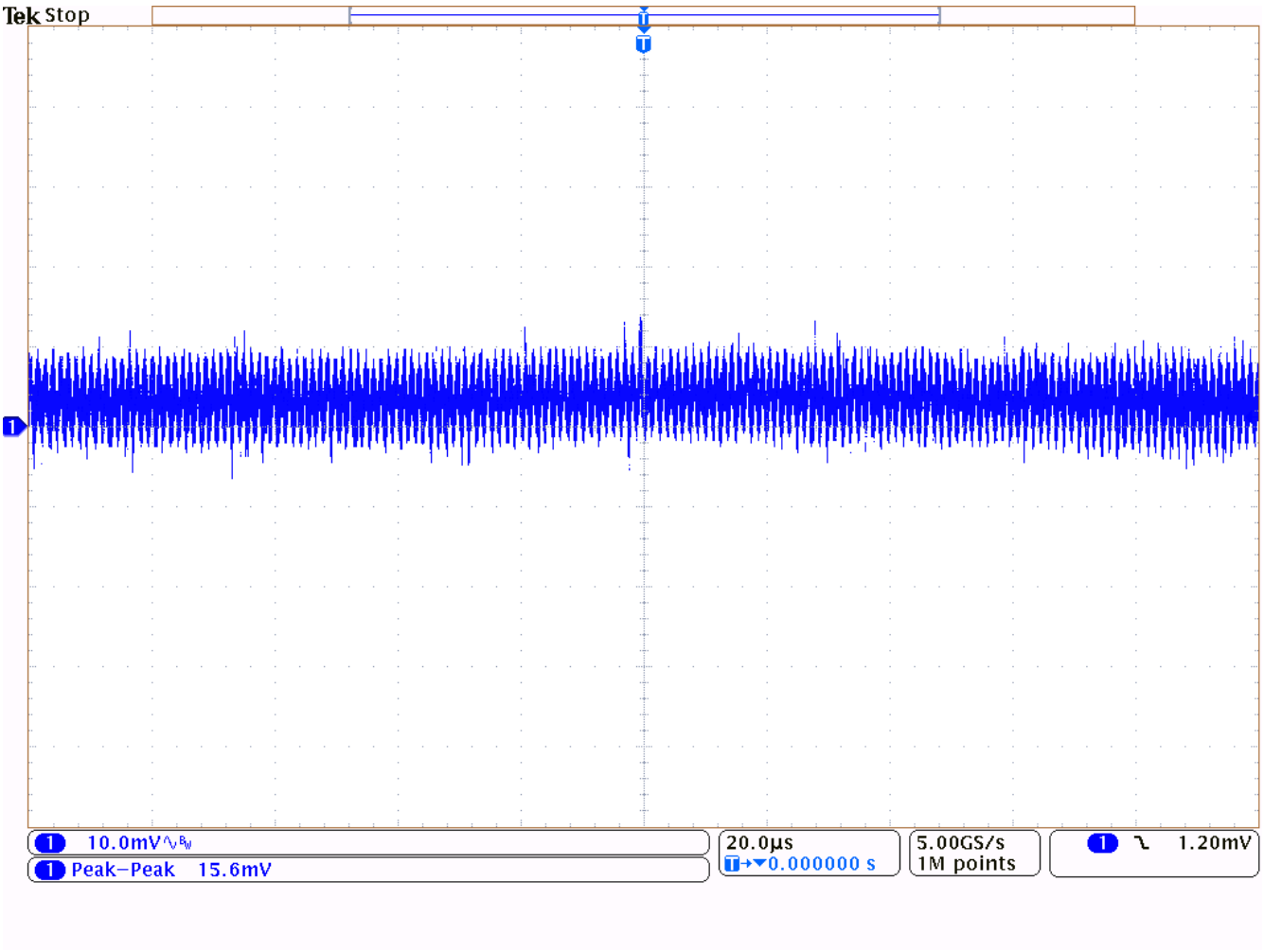
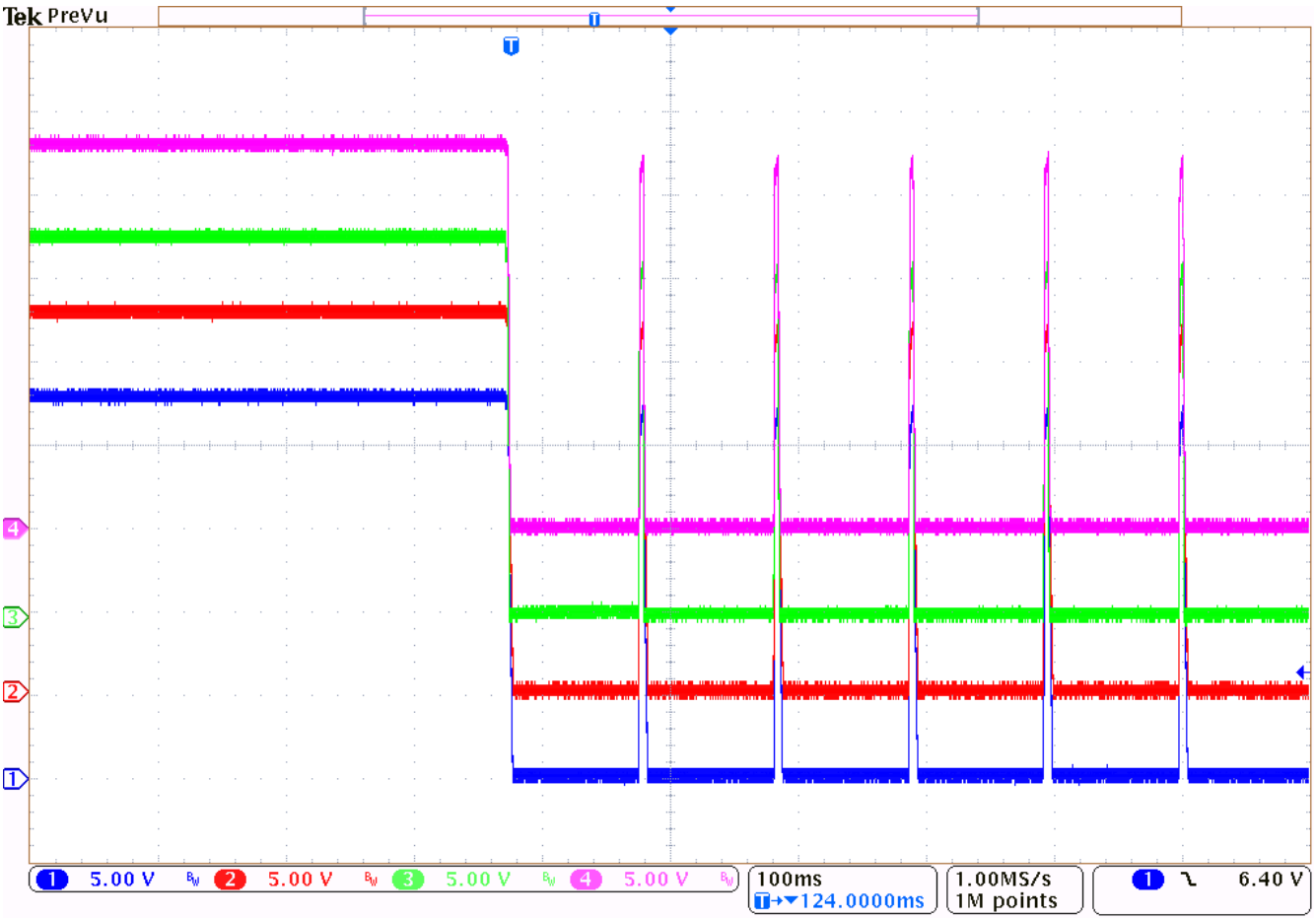


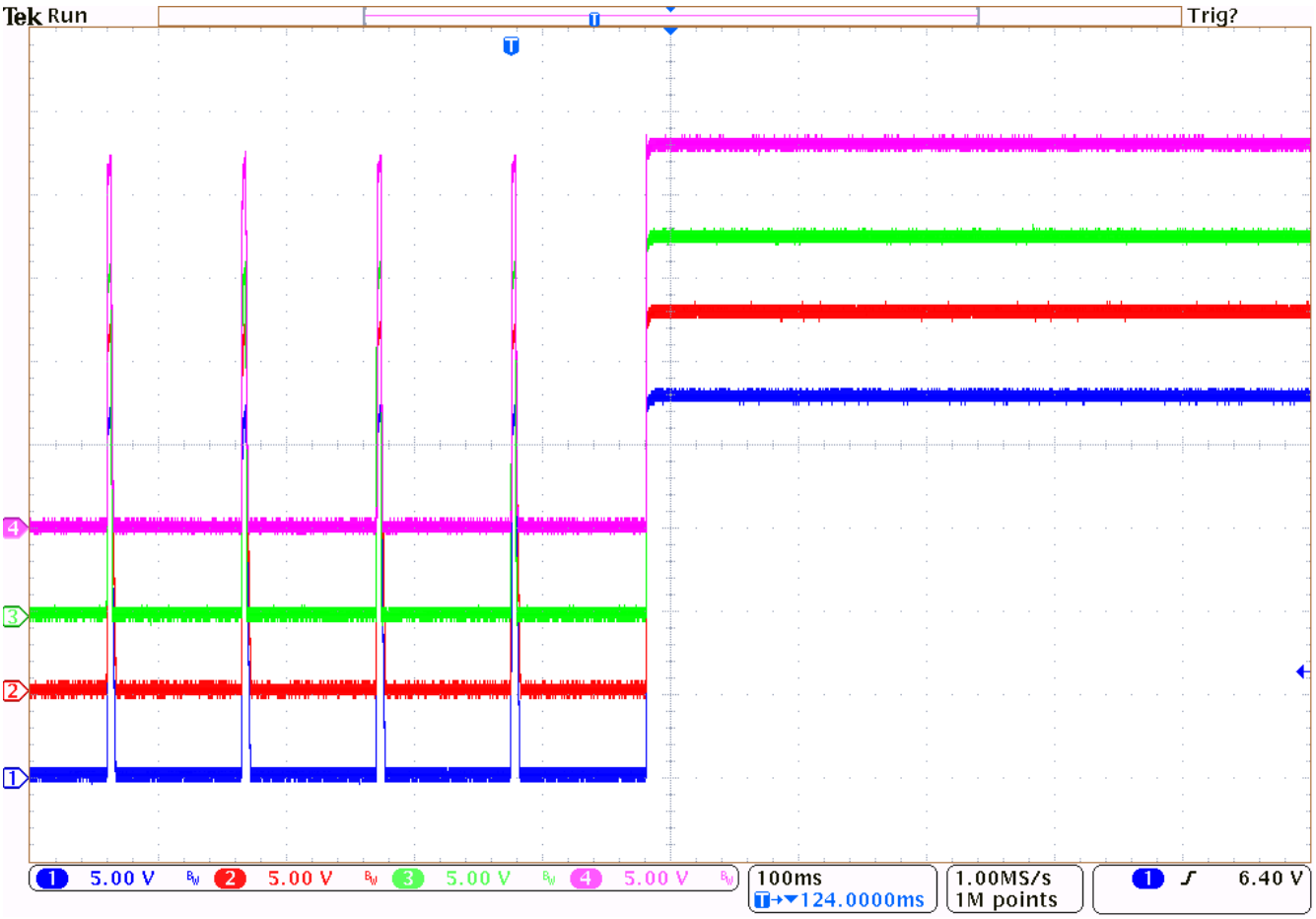
Figure 3-11. Vo1 23-V Output Ripple Voltage, Io = 22 mA

3.3 Overcurrent Protection



Vo4 output current from 22 mA to 100 mA
CH1: Vo1 output voltage
CH2: Vo2 output voltage
CH3: Vo3 output voltage
CH4: Vo4 output voltage

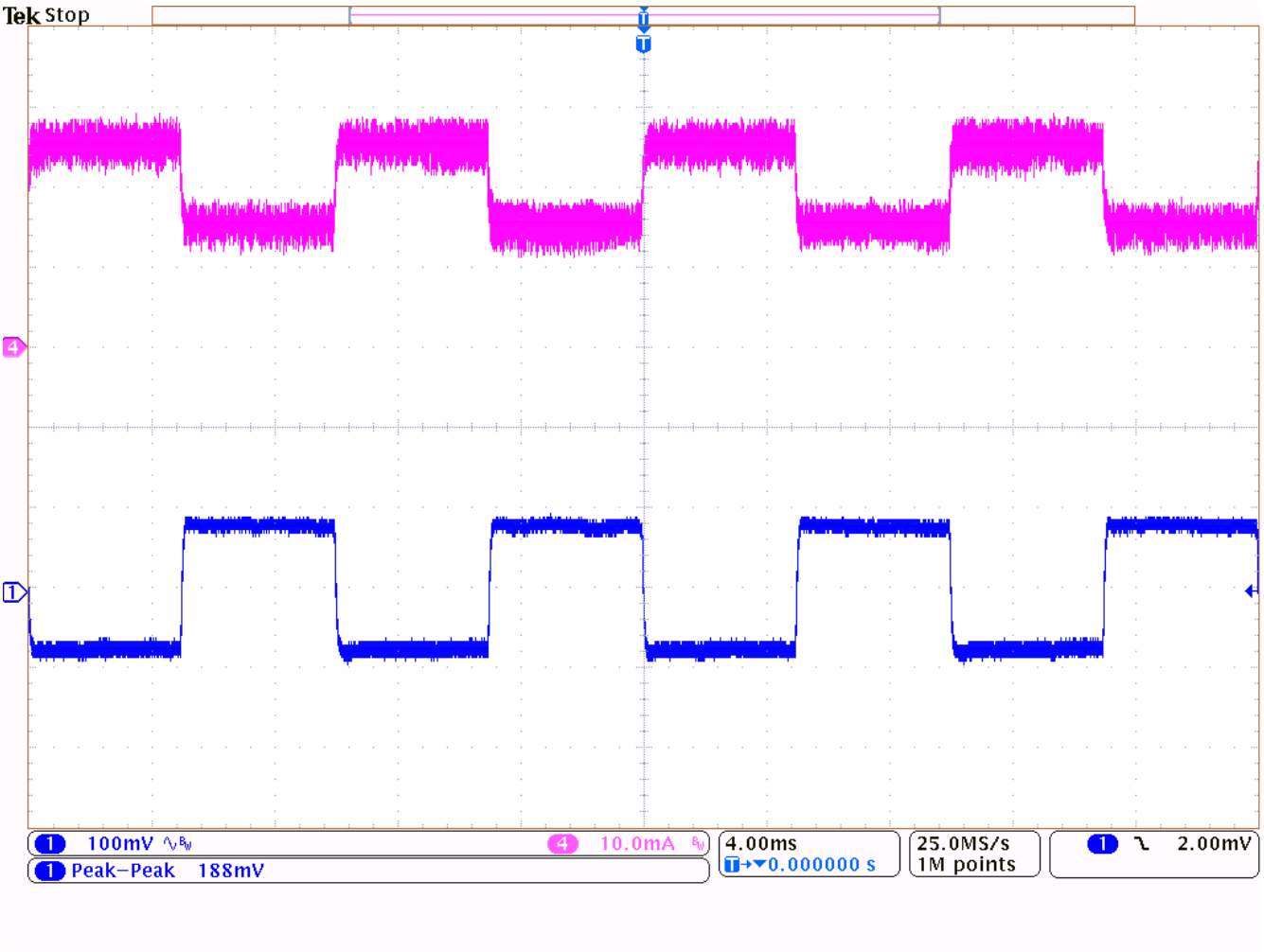
Figure 3-12. Output Overcurrent Protection



Vo4 output current from 22 mA to 100 mA
CH1: Vo1 output voltage
CH2: Vo2 output voltage
CH3: Vo3 output voltage
CH4: Vo4 output voltage

Figure 3-13. Output Overcurrent Protection Recovery

3.4 Load Transients



Ch1: output voltage, AC coupled
Ch4: output current, repetitive change between 50% (11 mA) and 100% (22 mA)

Figure 3-14. Vo1 Load Transient Response, Vo = 23 V

3.5 Start-Up Sequence

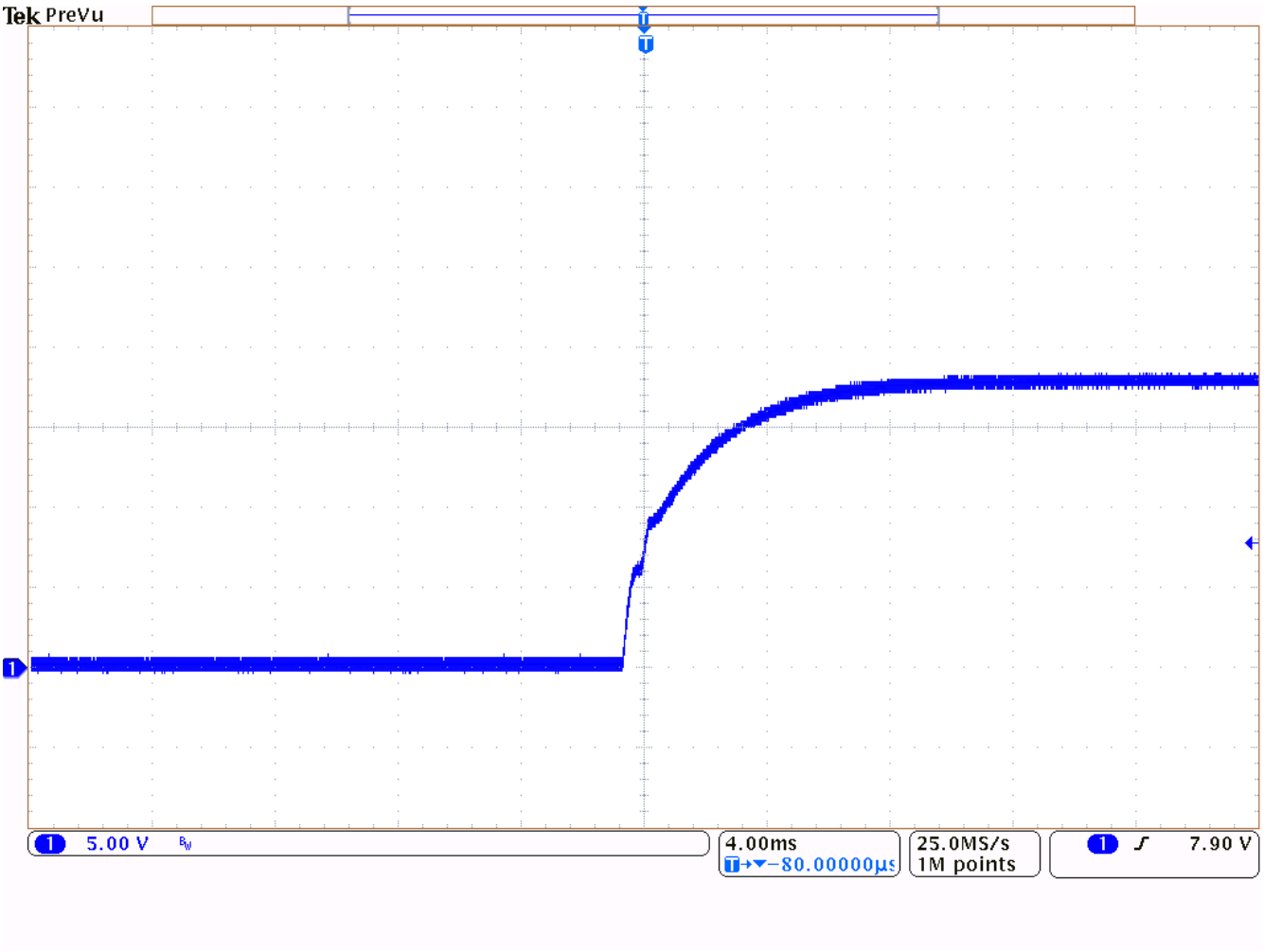


Figure 3-15. Vo1 18-V Start-Up, Io = 11 mA

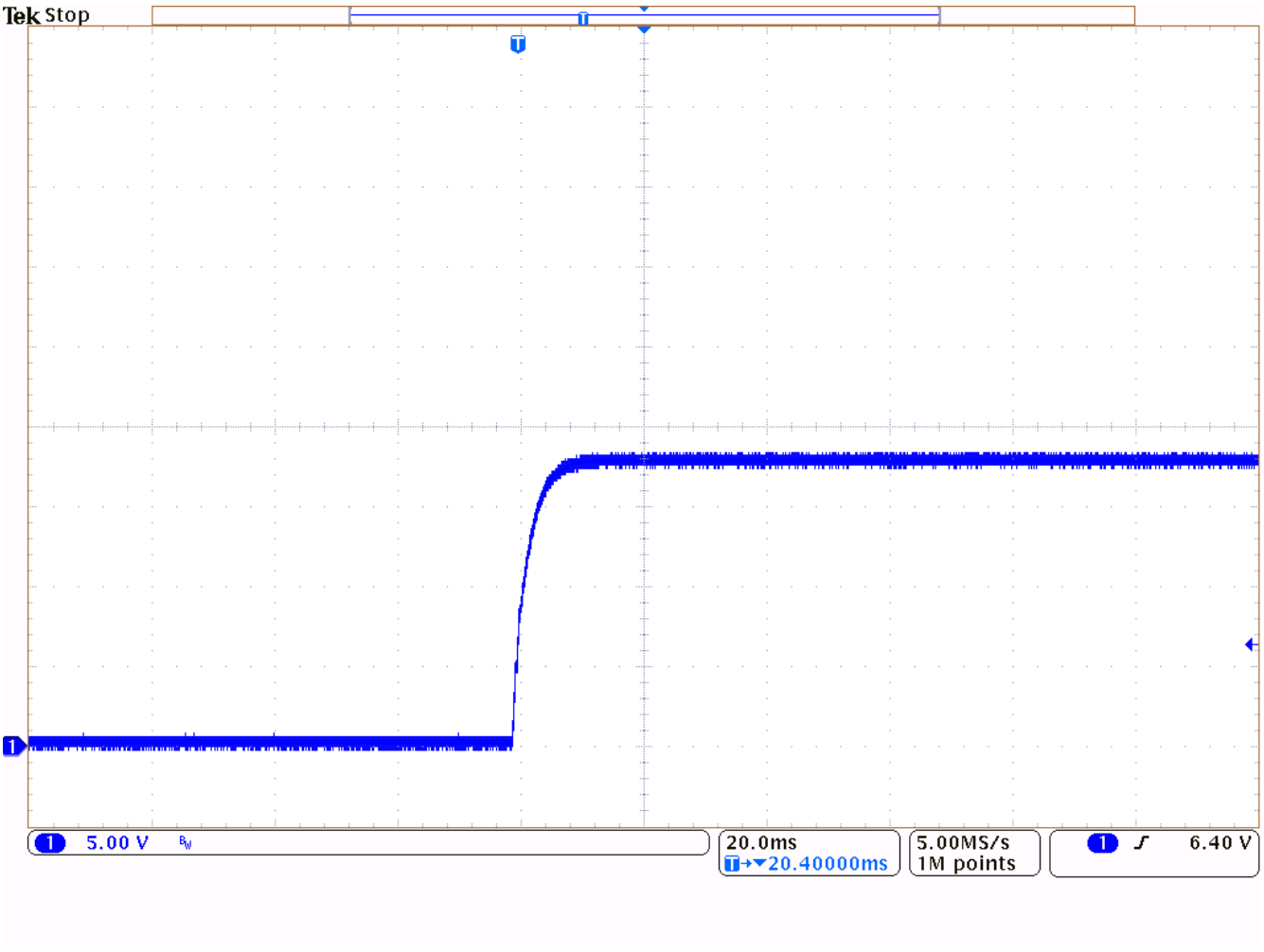


Figure 3-16. Vo1 18-V Start-Up, Io = 22 mA

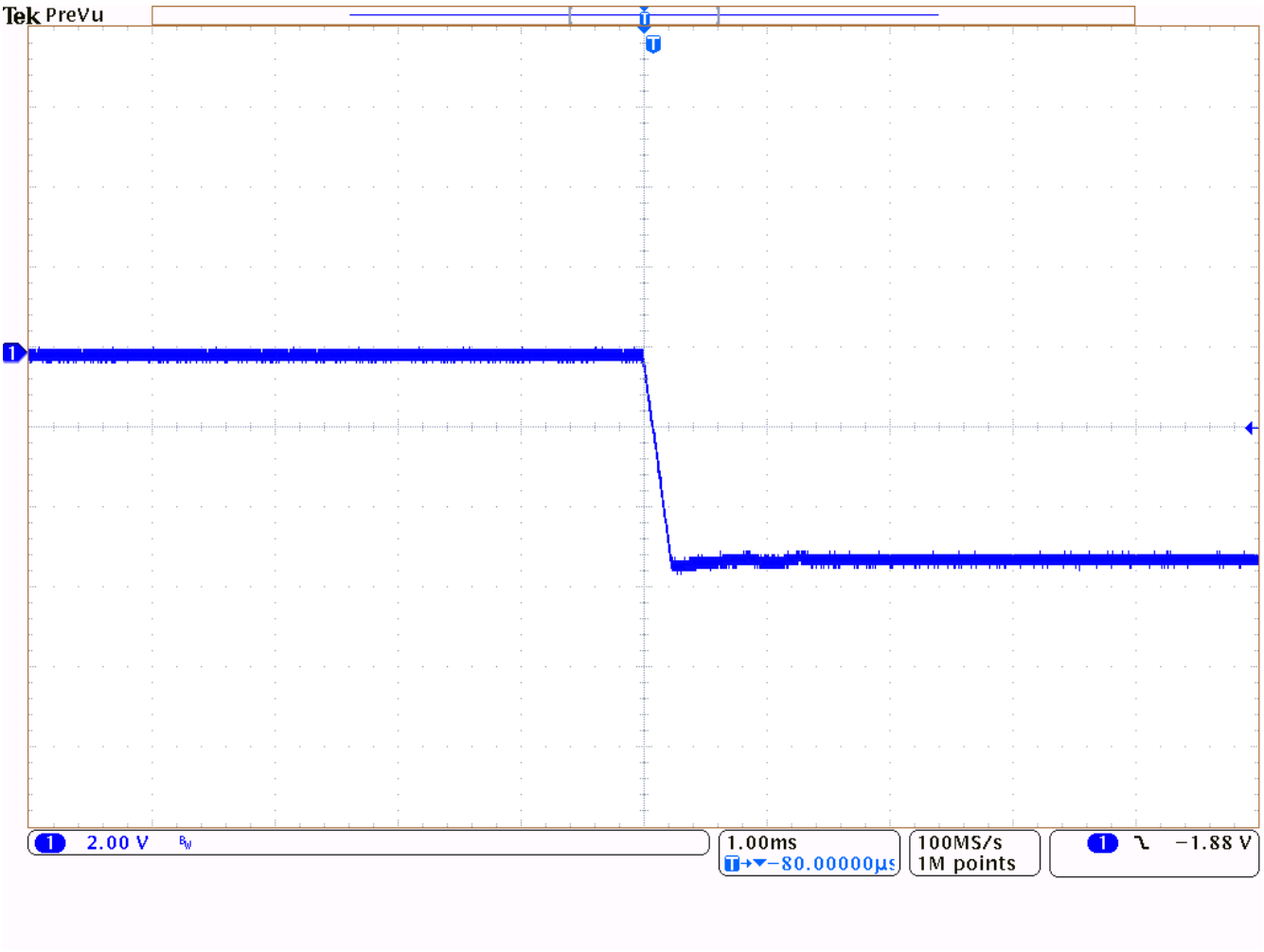


Figure 3-17. Vo1 –5-V Start-Up, Io = 11 mA

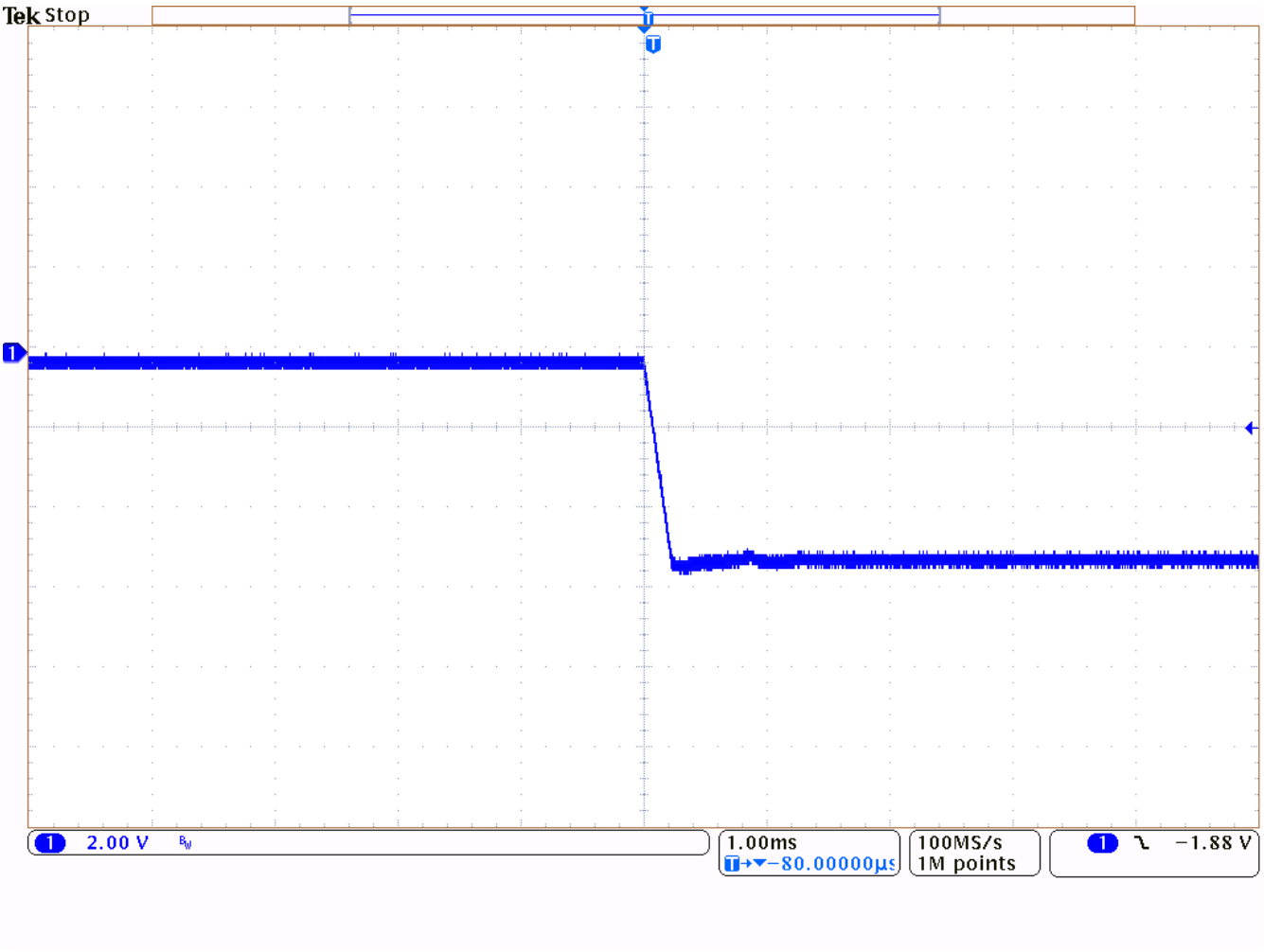


Figure 3-18. Vo1 –5-V Start-Up, Io = 22 mA

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