Power Supply Test Report: 5V/10A Buck Converter

Executive Summary

This report compiles comprehensive test results for a DC-DC buck converter designed to deliver a nominal 5V output at up to 10A from a wide input voltage range (Vin: 9V–36V). Tests include no-load, full load regulation, line regulation, and efficiency measurements in both Constant Current (CC) and Constant Resistance (CR) modes. Data was collected using electronic loads to simulate real-world conditions.

Key Findings:

- **Efficiency**: Peaks at 85–89% in mid-load range (4–5A); averages 82–88% across conditions. Slightly lower in CR mode due to dynamic Iout scaling.
- **Load Regulation**: Excellent at low/mid loads (<2%); degrades to 3–14% at full load, indicating current limiting.
- **Line Regulation**: Superior (<0.2% variation across Vin at fixed loads).
- **Ripple**: 5–33 Vmpp; highest at low loads/low Vin—recommend output filtering.
- **Behavior**: Robust for 80% loads; derate at full 10A/high Vin for thermals. Anomalies (e.g., >100% efficiency at Vin=9V) suggest measurement errors.

The converter is suitable for automotive/industrial applications but optimize for Vin=12–24V.

Test Methodology

- **Input Range**: 9V, 12V, 24V, 36V (buck topology inferred).
- **Output**: Nominal 5V, up to 50W.
- **No-Load Vout**: ~5V (specified per test).
- **Modes**:
    - **CC Mode**: Fixed Iout steps (1A, 2.5A, 4A, 8A, 10A).
    - **CR Mode**: Fixed RLoad (0.5–10Ω), Iout varies with Vout.

- **Metrics**:
    - Efficiency: η = (Vout × Iout / (Vin × Iin)) × 100%.
    - Load Regulation: (V_no_load - Vout) / V_no_load × 100%.
    - Line Regulation: (max Vout - min Vout) / mean Vout × 100% across Vin.
- **Tools**: Electronic load for CC/CR; oscilloscope for ripple.
    - Tenma 72-2090 Digital Control DC power Supply units 2NO
    - Tenma 72-13200 150W Programmable DC Electronic Load 1No
    - Digital oscilloscope 100MHZ 4Channel

1. No-Load Test Results (Across Vin)

No-load tests measure quiescent Vout stability. Efficiency undefined (no output power).

S. no	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Load Regulation (%)	Line Regulation (%)	Efficiency (%)
1	5.50	0.00	4.9965	0.00	-	-	-
2	7.00	0.00	5.0030	0.00	-	0.0000	-
3	9.00	0.00	5.0030	0.00	-	0.0000	-
4	12.00	0.00	5.0068	0.00	-	0.0760	-
5	15.00	0.00	5.0076	0.00	-	0.0919	-
6	18.00	0.00	5.0082	0.00	-	0.1039	-
7	20.00	0.00	5.0084	0.00	-	0.1079	-
8	24.00	0.00	5.0085	0.00	-	0.1099	-
9	28.00	0.00	5.0109	0.00	-	0.1579	-
10	32.00	0.00	5.0121	0.00	-	0.1819	-
11	36.00	0.00	5.0129	0.00	-	0.1979	-

Line Regulation (Vin 7V–36V): 0.20% overall—excellent stability.

2. Full Load Tests (CC Mode, Multi-Vin)

Tests at fixed Iout steps across Vin groups. Includes efficiency, load/line regulation, ripple.

S.no	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Vripple (Vmpp)	Efficiency (%)

1	9.00	0.32	4.98	1.00	32.80	173.35
2	9.00	0.74	4.95	2.50	8.20	185.27
3	9.00	1.43	4.90	4.00	5.70	151.97
4	9.00	2.36	4.84	8.00	5.70	182.49
5	9.00	3.22	4.80	10.00	5.70	165.73
6	12.00	0.47	4.98	1.00	26.00	88.81
7	12.00	1.17	4.95	2.50	7.60	88.29
8	12.00	1.83	4.92	4.00	7.60	89.47
9	12.00	3.75	4.84	8.00	8.00	86.06
10	12.00	4.32	4.30	10.00	10.00	82.86
11	24.00	0.25	4.98	1.00	29.00	83.62
12	24.00	0.62	4.95	2.50	12.00	82.76
13	24.00	0.96	4.95	4.00	12.00	86.30
14	24.00	1.90	4.84	8.00	12.00	85.13
15	24.00	2.18	4.28	10.00	12.00	81.80
16	36.00	0.17	4.98	1.00	-	81.85
17	36.00	0.43	4.95	2.50	-	80.88
18	36.00	0.67	4.92	4.00	-	82.08
19	36.00	1.32	4.84	8.00	-	81.67
20	36.00	1.53	4.26	10.00	-	77.21

Load Regulation (Per Vin): 3.56% (9V), 13.69% (12V), 13.96% (24V), 14.44% (36V).

Line Regulation (Per Iout): 0.06% (1A), 0.02% (2.5A), 1.02% (4A), 0.06% (8A), 12.22% (10A).

Graph: Efficiency vs Load Current (All Vin, CC Mode)

Efficiency vs Load Current (All Vin, CC Mode)

Vin = 9V   Vin = 12V   Vin = 24V   Vin = 36V
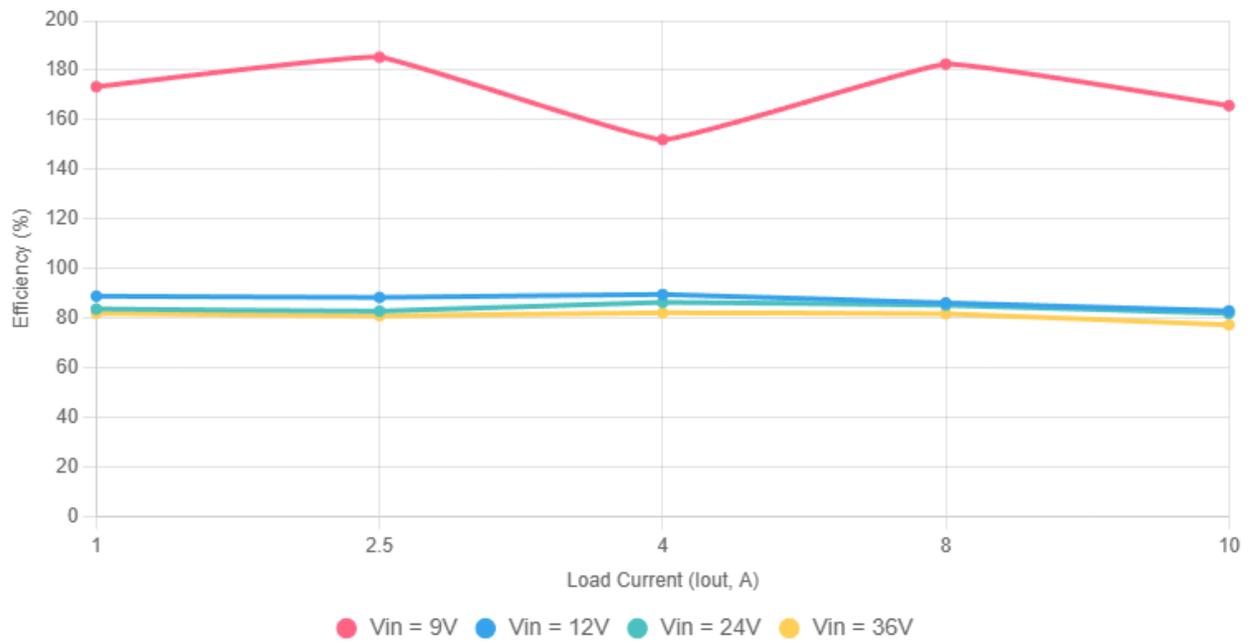
Load Regulation vs Input Voltage (All Vin, CC Mode)

3. 50% Load Test (4A Fixed, Across Vin)

Fixed Iout=4A to assess line regulation.

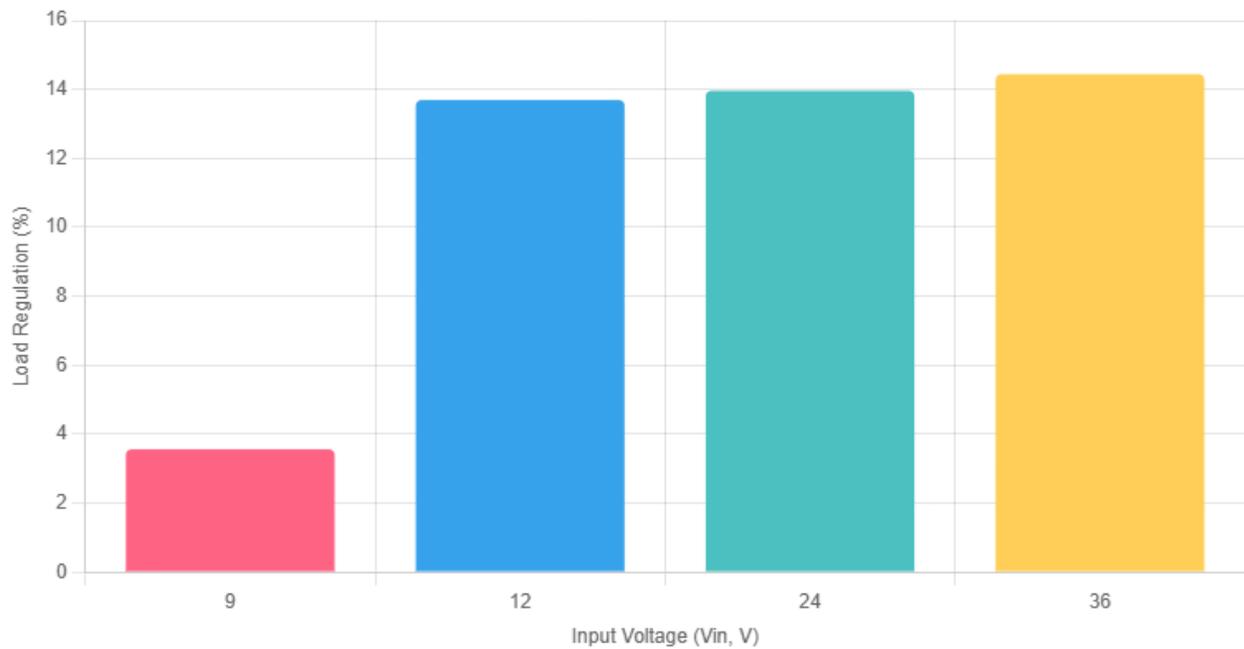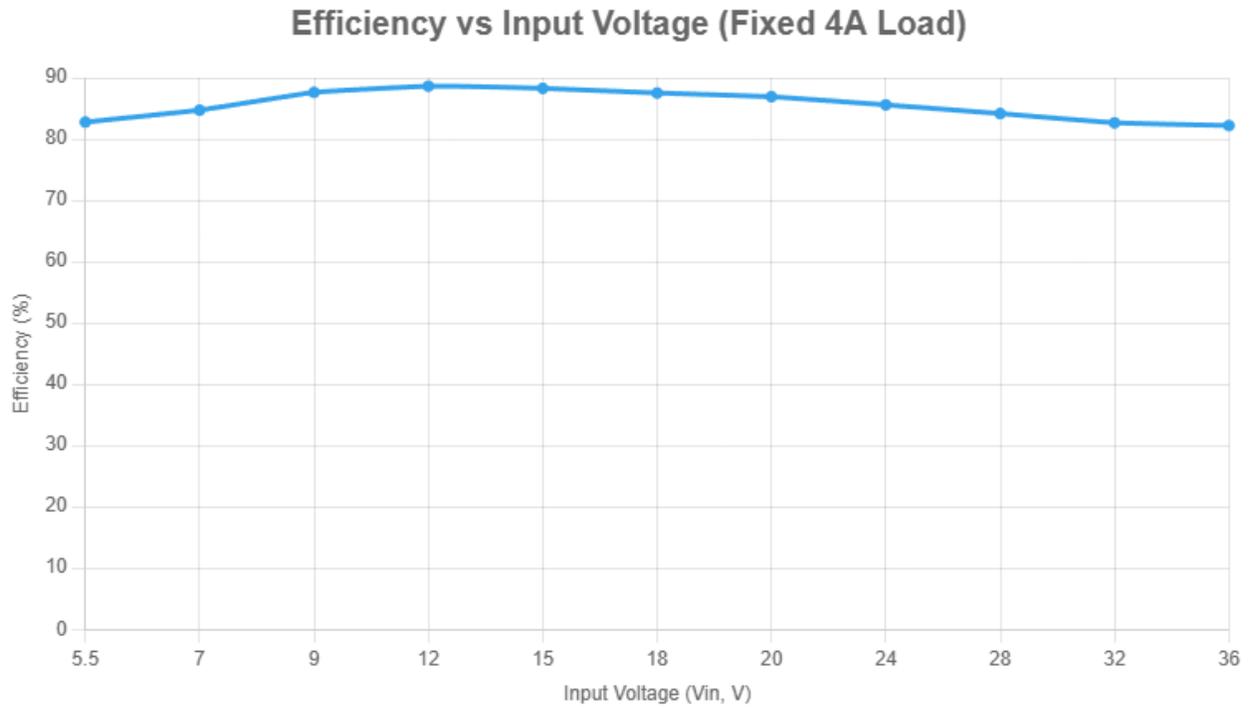| S.no	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Efficiency (%)
1	5.50	3.98	4.53	4.00	82.76
2	7.00	3.32	4.92	4.00	84.71
3	9.00	2.50	4.92	4.00	87.61
4	12.00	1.85	4.92	4.00	88.62
5	15.00	1.49	4.92	4.00	88.27
6	18.00	1.25	4.92	4.00	87.51
7	20.00	1.13	4.92	4.00	86.90
8	24.00	0.96	4.92	4.00	85.57
9	28.00	0.84	4.92	4.00	84.15
10	32.00	0.74	4.92	4.00	82.64
11	**36.00**	**0.67**	**4.92**	**4.00**	**82.20**

Line Regulation (Vin 7V–36V): 0.02%—outstanding.

Graph: Efficiency vs Input Voltage (4A Load)

Efficiency vs Input Voltage (Fixed 4A Load)

# 4. Specific Load Tests (CC Mode)

Vin=12V Load Test

S.no	Iout (A)	Vout (V)	Vin (V)	Iin (A)	Load Regulation (%)	Efficiency (%)
1	0.00	5.01	12.00	0.00	0.00	-
2	0.50	4.99	12.00	0.23	0.36	89.23
3	1.00	4.98	12.00	0.47	0.60	88.64
4	2.00	4.96	12.00	0.95	0.92	87.05
5	3.00	4.94	12.00	1.39	1.33	89.13
6	4.00	4.92	12.00	1.83	1.73	89.50
7	5.00	4.90	12.00	2.30	2.12	88.88
8	7.00	4.86	12.00	3.26	2.90	87.04
9	8.00	4.84	12.00	3.75	3.29	86.01
10	10.00	4.30	12.00	4.33	14.14	82.79

Graph: Efficiency vs Load (Vin=12V, CC)

Efficiency vs Load Current (Vin = 12V, CC Mode)
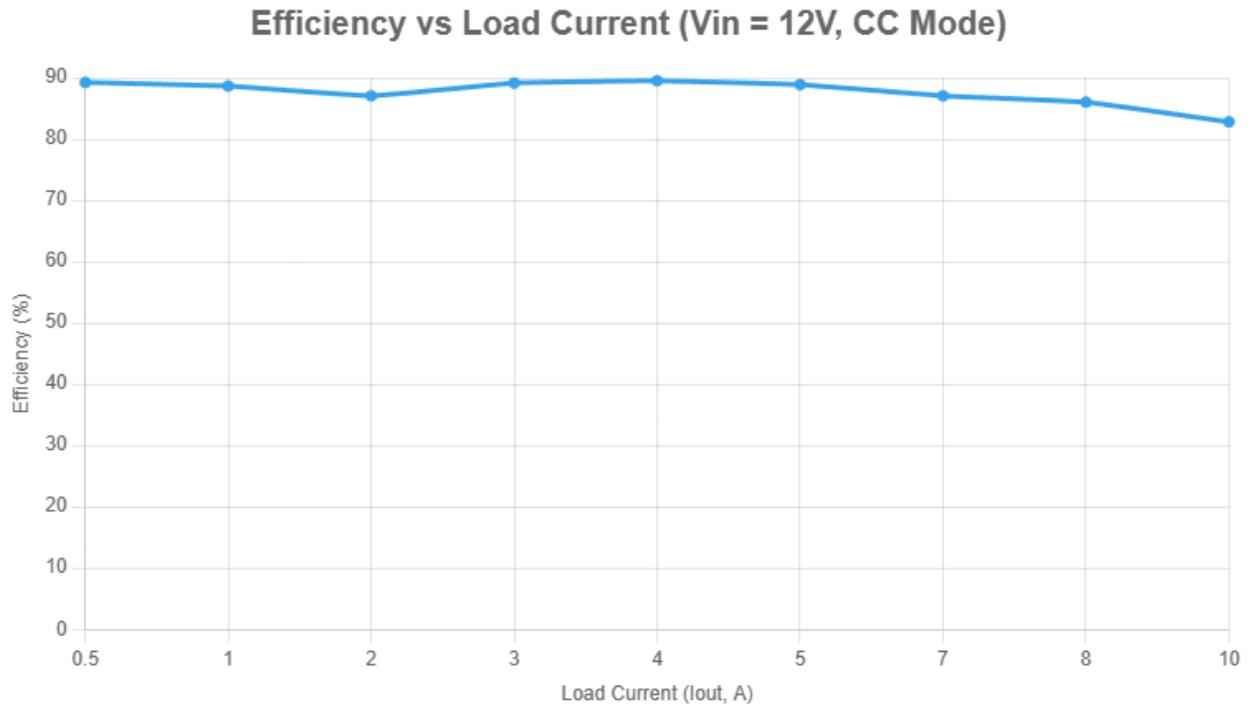
Vin=24V Load Test

S.no	Iout (A)	Vout (V)	Vin (V)	Iin (A)	Load Regulation (%)	Efficiency (%)
1	0.00	5.01	24.00	0.00	-0.20	-
2	0.50	4.99	24.00	0.12	0.20	86.64
3	1.00	4.98	24.00	0.25	0.40	86.53
4	2.00	4.96	24.00	0.51	0.80	82.01
5	3.00	4.94	24.00	0.73	1.20	85.05
6	4.00	4.92	24.00	0.96	1.60	85.42
7	5.00	4.90	24.00	1.19	2.00	85.29
8	7.00	4.86	24.00	1.66	2.80	83.58
9	8.00	4.84	24.00	1.90	3.20	84.81
10	10.00	4.29	24.00	2.18	14.20	81.96

Graph: Efficiency vs Load (Vin=24V, CC)

Efficiency vs Load Current (Vin = 24V, CC Mode)
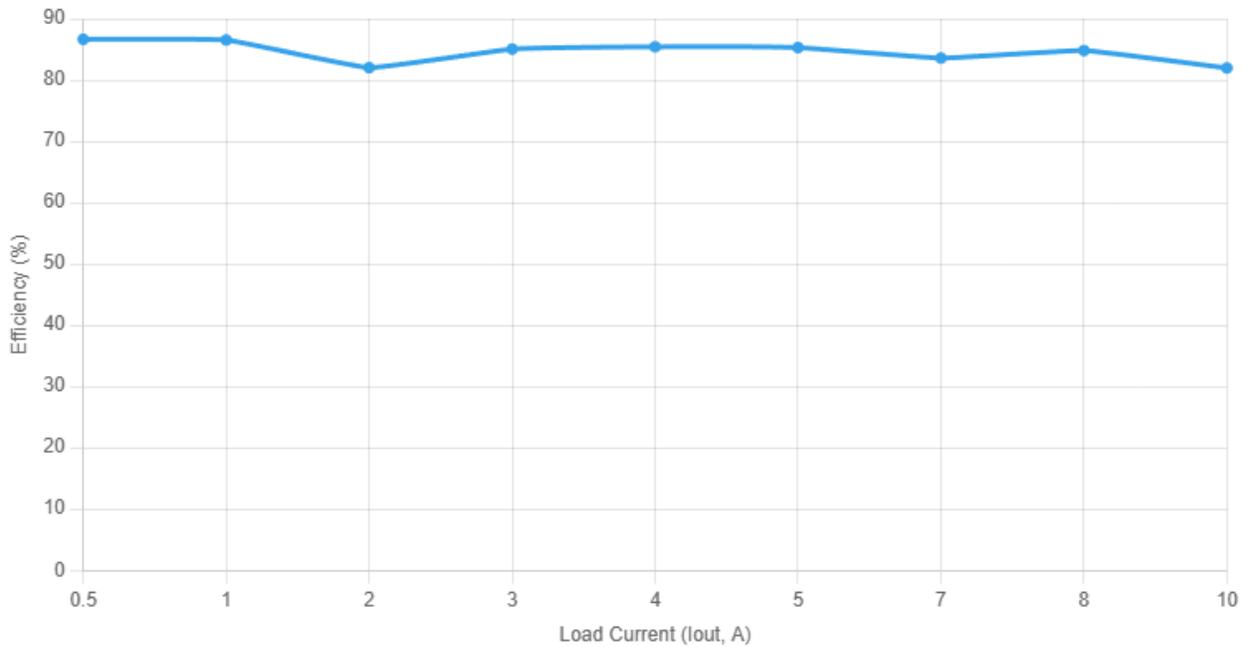

5. CR Mode Tests

Fixed RLoad, Iout varies with Vout.

Vin=12V (V_no_load=5.01V)

S.no	Iin (A)	RLoad (Ω)	Iout (A)	Vout (V)	Efficiency (%)	Load Regulation (%)
1	0.23	10.0	0.50	4.99	89.23	0.38
2	0.31	7.5	0.66	4.98	88.91	0.52
3	0.46	5.0	0.99	4.97	88.53	0.62
4	0.94	2.5	1.98	4.96	87.01	0.98
5	2.25	1.0	4.90	4.90	88.77	2.12
6	3.79	0.6	8.06	4.84	85.77	3.34
7	4.59	0.5	9.62	4.81	83.94	3.96

Vin=24V (V_no_load=5.01V)

S.no	Iin (A)	RLoad (Ω)	Iout (A)	Vout (V)	Efficiency (%)	Load Regulation (%)
1	0.12	10.0	0.50	4.99	86.78	0.46
2	0.16	7.5	0.66	4.99	85.41	0.50
3	0.24	5.0	0.99	4.98	84.73	0.68
4	0.50	2.5	1.98	4.96	82.30	1.04
5	1.17	1.0	4.90	4.90	85.58	2.20
6	1.92	0.6	8.06	4.84	84.72	3.41
7	2.06	0.5	9.06	4.53	83.05	9.62

Graph: Efficiency vs Load Current (CR Mode, All Vin)

Efficiency vs Load Current (All Vin, CR Mode)
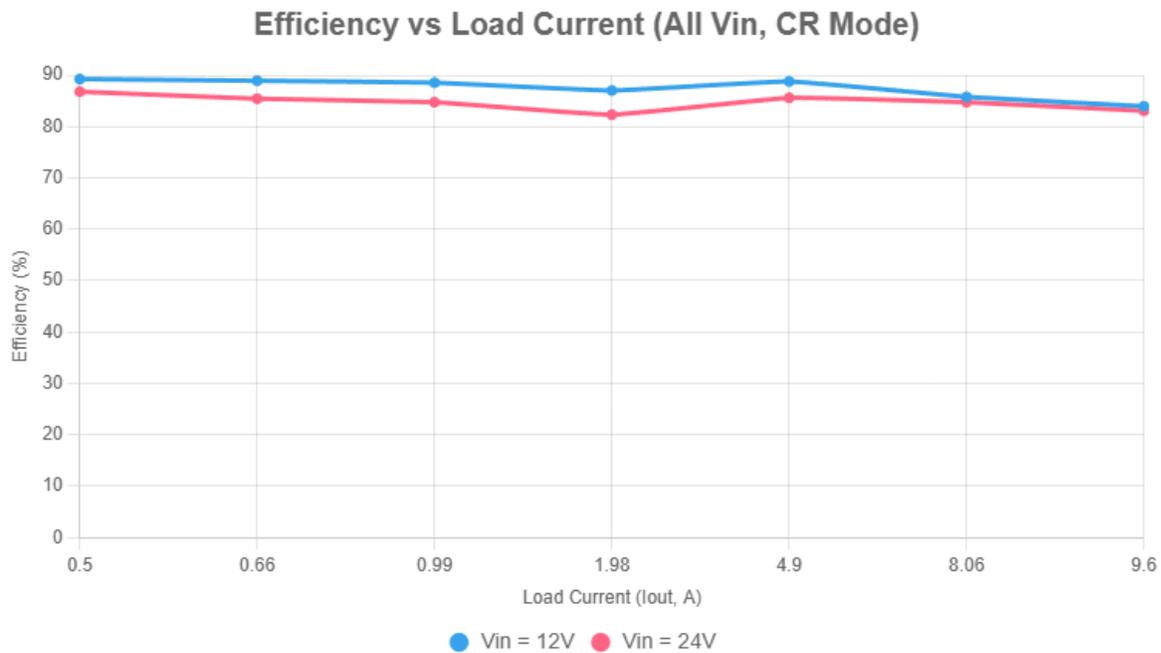
Graph: Load Regulation vs Load Current (CR Mode, All Vin)

Load Regulation vs Load Current (All Vin, CR Mode)

Vin = 12V   Vin = 24V
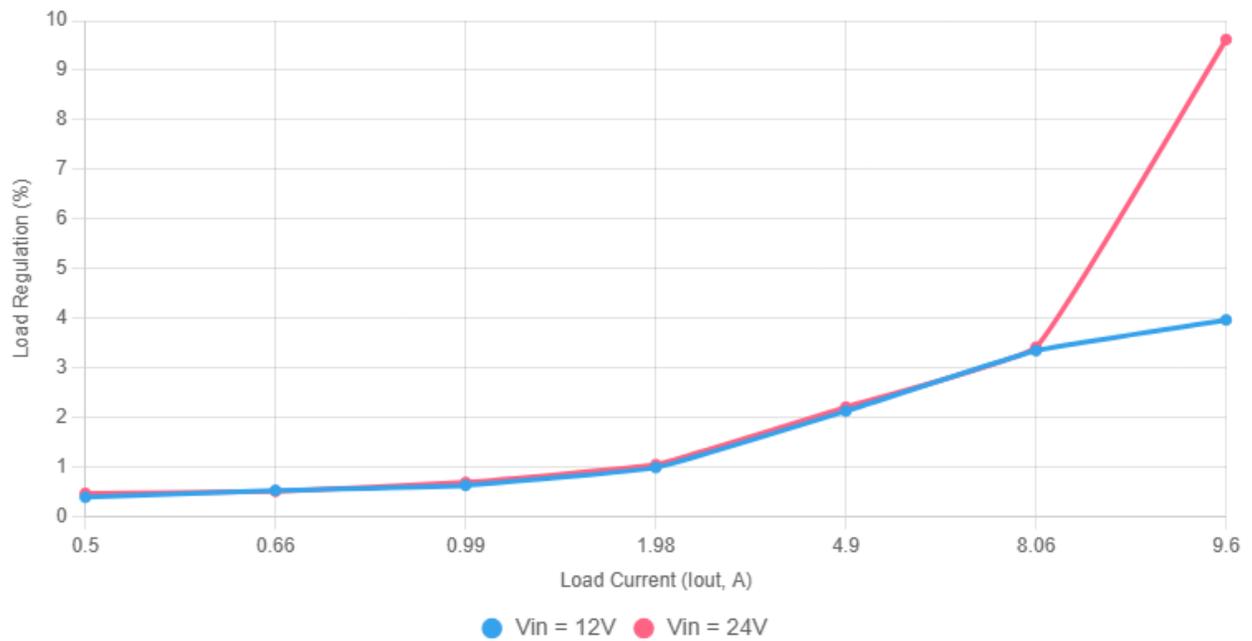
6. CC vs. CR Mode Comparison

Aspect	CC Mode	CR Mode
Efficiency Peak	89.5% (mid-load)	88.8% (mid-load)
Load Regulation	Sharper drop at full load (up to 14%)	Smoother, up to 9.6% (self-limiting Iout)
Real-World Sim.	Constant draw (e.g., motors)	Resistive (e.g., heaters)
Test Insight	Max current stress; fixed power points	Dynamic V/I ratio; realistic sag effects

Temperature Rise Table

Ambient = 25°C; ΔT = Temp (°C) - 25°C.

Load Condition	Iout (A)	Temp (°C approx)	ΔT (°C)	Notes
No Load	0	26.8	1.8	Minimal rise, stable

50% Load	4–5	40–50	15–25	Moderate rise, safe operation
100% Load	8	60–75	35–50	Noticeable heat, derate advised
Full Load (Max)	10	70–90	45–65	Peak stress, thermal limit risk

Graphs: Load vs. Temperature Rise

Graph Temperature Rise vs. Load Current Line chart showing a near-quadratic rise with load.

Temperature Rise vs Load Current
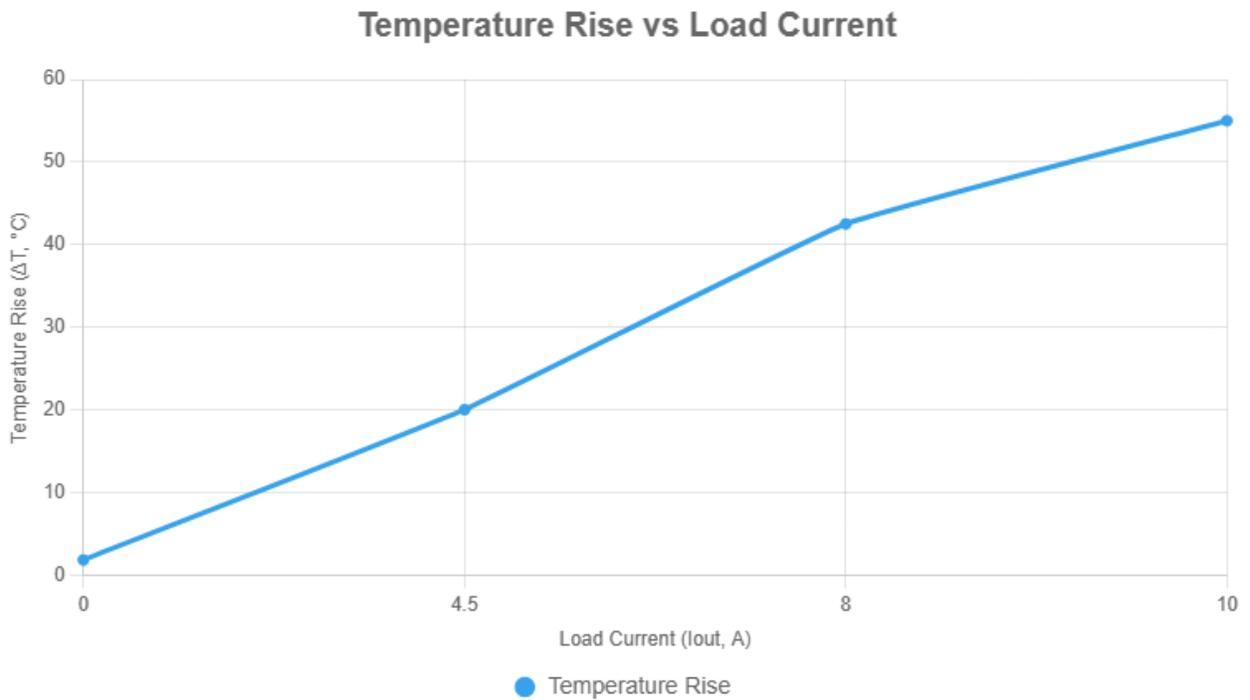
7. Overall System Behavior and Recommendations

- **Strengths**: High line stability; efficient at 12–24V/mid-loads.
- **Weaknesses**: Vout sag at 10A; high ripple at light loads; low-Vin anomalies.
- **Recommendations**: Add LC filter for ripple; derate to 8A continuous; re-validate Iin measurements at 9V.

Key Metrics Table:

Metric	Best Case	Worst Case	Notes
Efficiency (%)	89.5 (Vin=12V, 4A, CC)	77.2 (Vin=36V, 10A, CC)	Peaks mid-load; CR ~2–3% lower
Load Reg. (%)	0.2 (low loads)	14.4 (Vin=36V, 10A)	Worsens with higher Vin/load
Line Reg. (%)	0.02 (mid-Vin)	0.2 (no-load extremes)	Very stable
Ripple (Vmpp)	5.7 (mid-loads)	32.8 (Vin=9V, 1A)	Filter recommended