78XX IC Family, Voltage Regulator

Category: Electronic
written by www.mbsmpro.com | January 12, 2026

Mbsmpro.com, 78XX IC Family, Voltage Regulator, 7805, 7806, 7808, 7810, 7812, 7815, 7818, 7824, 5V, 6V, 12V, 15V, 24V, Linear Regulator, 1.5A, Thermal Protection

---

78XX Voltage Regulator Family: Complete Technical Guide & Applications

The **78XX series** is one of the most widely adopted family of ***linear voltage regulators*** in electronics. These three-terminal ICs have powered countless consumer devices, industrial systems, and hobbyist projects since their introduction decades ago. From a simple **5V supply for microcontrollers** to a robust **24V rail for automation**, the 78XX family delivers fixed regulated voltage with minimal external components.

Whether you are designing a **power supply**, troubleshooting an embedded system, or maintaining legacy equipment, understanding the 78XX lineup—including the **7805, 7812, 7815, 7824**, and their companions—is essential knowledge.

What Is the 78XX Voltage Regulator?

A **voltage regulator** is an electronic component that maintains a *constant output voltage* despite fluctuations in the input supply or changes in the load current. The 78XX family does this using a *linear* approach: it essentially acts as an intelligent resistor, dropping excess input voltage while supplying current at the regulated output level.

The "78XX" designation is a naming convention:

- **"78"** indicates a positive voltage regulator (as opposed to 79XX for negative regulators).

- **“XX”** is replaced by two digits representing the output voltage.

For example:

- **7805** = 5 V output
- **7812** = 12 V output
- **7824** = 24 V output

Complete 78XX Series Specifications & Voltage Breakdown

Below is the definitive reference table for the standard 78XX family, showing all available output voltages, input requirements, and current capability.

IC Model	Output Voltage (V)	Min Input Voltage (V)	Max Input Voltage (V)	Typical Output Current (A)	Package	Typical Application
7805	5.0	7.0	25	1.5	TO-220, TO-3	Microcontroller, logic circuits, SPI devices
7806	6.0	8.5	25	1.5	TO-220	Audio preamplifier, sensor supply
7808	8.0	10.5	25	1.5	TO-220	Industrial sensor supply, panel meters
7810	10.0	12.5	28	1.5	TO-220	Analog circuits, operational amplifier supply
7812	12.0	14.5	30	1.5	TO-220, TO-3	Automotive applications, motor logic control
7815	15.0	17.5	30	1.5	TO-220, TO-3	Industrial automation, TTL logic systems
7818	18.0	20.0	35	1.5	TO-220	Audio amplifier supplies, high-voltage relay logic
7824	24.0	27.0	38	1.5	TO-220, TO-3	Solenoid driver supplies, PLCs, high-power circuits

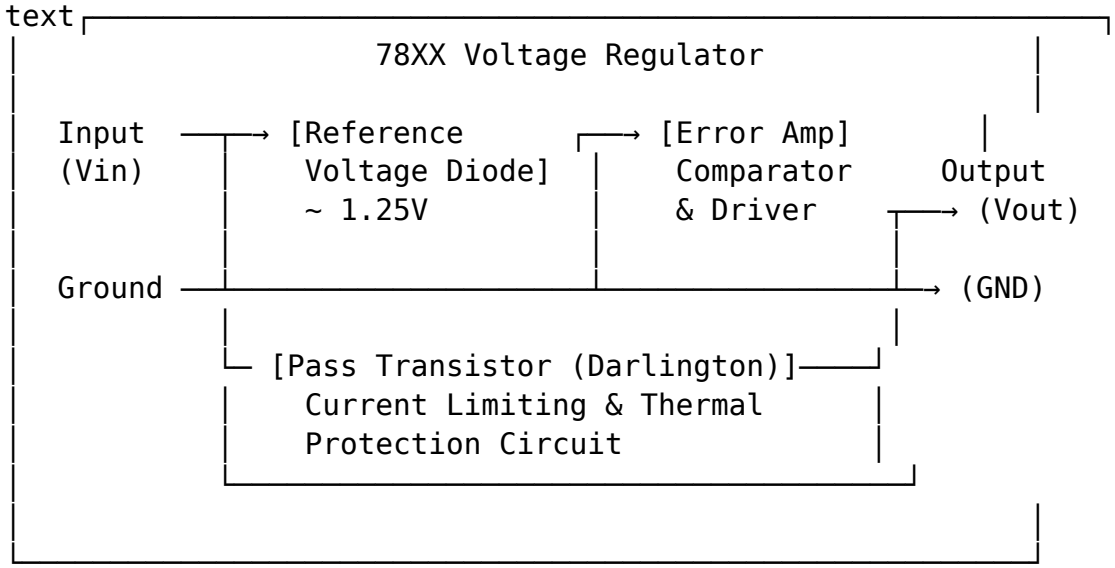
Key observations:

1. **Output voltage range** spans from 5 V to 24 V, covering nearly all common digital and analog supply voltages.
2. **Input voltage must exceed output by at least 2–3 V** (called the *dropout voltage*). For example, the 7805 requires minimum 7 V input to reliably deliver 5 V.
3. **All variants provide up to 1.5 A** continuous output current, making them suitable for moderate-power applications.
4. **Larger output voltages** (7815, 7824) allow higher maximum input voltage, useful in industrial environments.

78XX Internal Architecture & Operating Principle

The 78XX IC is a *monolithic linear regulator*, meaning all components are integrated on a single silicon die. Here is how it works internally:

Functional Block Diagram (Conceptual)



How it regulates:

1. **Reference Voltage:** An internal *Zener diode* generates a stable ~1.25 V reference.
2. **Error Amplifier:** Continuously compares the output voltage (via a voltage divider) against the reference.
3. **Pass Transistor:** A high-power *Darlington transistor* acts as a dynamic resistor, adjusting its resistance to maintain constant output voltage.
4. **Feedback Loop:** If output voltage rises, the error amp reduces pass transistor conductance (increases resistance). If output falls, it increases conductance. This *negative feedback* keeps output voltage rock-steady.

Built-in protection circuits:

- **Current Limiting:** If load current exceeds ~2.2 A (typical), internal circuitry reduces the pass transistor bias, preventing damage.
- **Thermal Shutdown:** If junction temperature exceeds ~125 °C, the regulator shuts down until cooling.
- **Short-Circuit Protection:** If output is shorted to ground, the current limiter engages immediately.

78XX Device Comparison: Series-by-Series Breakdown

Understanding the differences and similarities helps you choose the right device for your design.

78XX vs. 79XX (Negative Regulators)

Feature	78XX (Positive)	79XX (Negative)
Output polarity	Positive voltage	Negative voltage
Ground reference	Ground is 0 V	Ground is 0 V, output below ground
Typical use	Most digital logic, microcontroller power	Dual-supply op-amp circuits, symmetrical supplies
Pin configuration	IN / GND / OUT (left to right)	IN / GND / OUT (same order)
Examples	7805 (5V), 7812 (12V)	7905 (−5V), 7912 (−12V)

78XX vs. LM317 (Adjustable Regulator)

Aspect	78XX (Fixed)	LM317 (Adjustable)
Output voltage	Fixed (e.g., 5V, 12V)	User-adjustable via resistor divider
External parts	Minimal (2 capacitors)	More components (2 resistors + 2 capacitors)
Design flexibility	Low; choose IC for desired voltage	High; one IC, many output voltages
Design complexity	Beginner-friendly	Intermediate
Quiescent current	~3–5 mA	~3–5 mA
Max output current	1.5 A (1 A for 78L variant)	1.5 A (higher for LM350/LM338)

Physical Packages: TO-220 vs. TO-3

The 78XX is available in different packages, each suited to specific thermal and space constraints.

TO-220 Package (Most Common)

- **Dimensions:** Roughly 10 mm × 5 mm × 5 mm tall.
- **Pins:** Three leads (IN, GND, OUT).
- **Mounting:** Can be soldered to PCB directly or mounted on a small heatsink.
- **Thermal resistance (package only):** ~50–65 °C/W (case to ambient without heatsink).
- **Best for:** General-purpose designs, moderate power dissipation (<2 W).

TO-3 Package (High-Power)

- **Dimensions:** Larger, roughly 25 mm × 10 mm.
- **Mounting tab:** Large metal collector tab for heatsink mounting (provides excellent thermal

path).
- **Thermal resistance (with heatsink):** ~1–2 °C/W (when mounted on large finned heatsink).
- **Best for:** Industrial applications, sustained high current (approaching 1.5 A), harsh environments.

Field note: A 7805 in TO-220 without a heatsink can dissipate only ~500 mW before overheating. The same IC in TO-3 with a proper heatsink can safely handle 10+ watts of continuous dissipation.

Step-by-Step: How to Design a Simple 78XX Power Supply

Example: 12V / 1.5A Regulated Supply Using 7812

Components needed:

Component	Value	Purpose
Transformer (T1)	18 VAC, 2 A	Step down mains voltage
Bridge Rectifier (D1–D4)	1N4007 (or 1N4004) × 4, or bridge module	Convert AC to pulsating DC
Filter Capacitor (C1)	2200 µF, 35 V (electrolytic)	Smooth rectified voltage
Input Bypass (C2)	0.33 µF ceramic	Reduce high-frequency noise at 7812 input
Output Bypass (C3)	0.1 µF ceramic	Reduce output ripple
IC1	LM7812 (or 7812 variant)	Voltage regulator
Heatsink	Aluminum fin, ~1 K/W	Thermal management for 7812
Output LED (optional)	5 mm red LED + 1 kΩ resistor	Power indicator
Fuse (F1)	2 A slow-blow	Protection

Circuit Operation:

1. **AC Input (18 VAC):** From transformer secondary.
2. **Rectification:** Bridge diode converts AC to ~25 VDC (peak), with ripple.
3. **Filtering:** Large capacitor (2200 µF) smooths to ~20–22 VDC steady-state (ripple ~2–3 V).
4. **Regulation:** LM7812 inputs 20–22 VDC, outputs stable 12.0 VDC.
5. **Output:** Clean 12 V can power logic, relays, or motors.

Thermal calculation:

- Input: 20 V, Output: 12 V → Voltage drop = 8 V
- Load current: 1 A (worst case)
- Power dissipation in IC: P = (20 − 12) × 1 = **8 watts**
- Using a 1 °C/W heatsink: Temperature rise = 8 W × 1 °C/W = 8 °C
- If ambient = 25 °C → Junction ≈ 33 °C (well below 125 °C limit)

Essential Capacitor Selection for 78XX Designs

Capacitors at the input and output are **not optional**—they are essential for stable, noise-free operation.

Input Bypass Capacitor (C_in)

Specification	Typical Value	Notes
Value	0.33 µF ceramic or polyester	Blocks high-frequency noise from upstream transformer/rectifier.
Voltage rating	At least 50 V (to handle max input voltage)	Safety margin is important.
Type	Ceramic (X7R dielectric preferred) or film (Mylar)	Avoid electrolytic here; ESR may be excessive.
Placement	Within 1 cm of 7805 input pin	Short leads reduce noise coupling.

Why: Without C_in, AC ripple from the rectifier can cause regulation errors and introduce noise into the output.

Output Bypass Capacitor (C_out)

Specification	Typical Value	Notes
Value	0.1–0.47 µF ceramic	Stabilizes 7805 against transient load changes.
Voltage rating	At least 25 V (output voltage + margin)	35 V ceramic is standard.
Type	Low-ESR ceramic (X7R, 100 nF–470 nF)	Electrolytic capacitors are NOT recommended; high ESR causes instability.
Placement	Within 1 cm of 7805 output pin, and load	Keeps parasitic inductance minimal.

Why: Output capacitor provides fast current during load transients (e.g., when a microcontroller suddenly draws peak current). Without it, output voltage sags momentarily, risking microcontroller brownout or data corruption.

Heat Dissipation & Thermal Design

The 78XX dissipates as much power as it must “drop” across its internal pass transistor. This heat must be conducted away, or the regulator will shut down.

Thermal Resistance Chain

```
textJunction Temperature (Tj)
        ↓
  ΔT_JC (junction to case)
        ↓
```

```
  ΔT_CS (case to sink)
        ↓
Heatsink Temperature (Th)
        ↓
  ΔT_SA (sink to ambient)
        ↓
Ambient Temperature (Ta)
```

Practical Example: 7812 Regulator in Hot Environment

Given:

- Output voltage: 12 V
- Input voltage: 24 V
- Load current: 1 A
- Ambient temperature: 45 °C (hot climate)
- Maximum allowed junction temperature: 125 °C

Calculate:

1. **Power dissipation:** P = (V_in − V_out) × I = (24 − 12) × 1 = **12 watts**
2. **Thermal budget:** ΔT_max = 125 − 45 = **80 °C**
3. **Required total thermal resistance:** R_θ_total = ΔT / P = 80 / 12 ≈ **6.7 °C/W**
4. **Thermal path breakdown (TO-220 package):**
    - Junction to case (R_θ_JC): ~5 °C/W (device dependent)
    - Case to sink (R_θ_CS): ~0.5 °C/W (with thermal grease on clean surface)
    - Remaining for sink: 6.7 − 5.5 = **1.2 °C/W**
5. **Heatsink requirement:** Must be ≤1.2 °C/W to ambient.
    - A typical **aluminum fin heatsink** in still air provides ~2–3 °C/W.
    - A **fan-cooled or liquid-cooled heatsink** provides ~0.5–1 °C/W.

Conclusion: For 12 W dissipation in a 45 °C ambient, a small **passive aluminum heatsink + forced-air fan** is required to stay within safe temperature limits.

Comparison: 78XX vs. Modern Switching Regulators

The 78XX is old, but still relevant. Here is how it compares to modern alternatives:

Aspect	78XX Linear	LM2596 / MP1584 Buck (Modern Switching)
Efficiency	40–50% (loses much energy as heat)	85–95% (minimal heat dissipation)
Heat management	Heatsink often required for >1 W	Tiny heatsink or none needed
Noise performance	Very quiet (no switching noise)	Some ~500 kHz ripple (acceptable for most)
Cost	$0.30–$1.00	$2–$5
Component count	2–3 components	8–15 components (higher PCB complexity)
Design simplicity	Extremely easy (beginner-friendly)	Moderate (requires inductor selection, PCB layout care)
EMI emission	Very low	Moderate (requires filtering)
Line/load regulation	±2–3% typical	±0.5–1% typical (better)
Reliability	Proven over 40+ years	Proven in last 10–15 years

When to use 78XX: Simple designs, low current (<500 mA), noise-sensitive analog circuits, hobby projects, rapid prototyping.

When to use switching regulators: Battery-powered equipment, space-constrained designs, high-power supplies (>5 W), efficiency-critical systems.

Real-World Applications of 78XX Regulators

1. Microcontroller Power Supply

A hobby project using an Arduino or PIC microcontroller typically uses a **7805** to supply clean 5V to the logic circuits and sensors.

Typical schematic:

- Unregulated supply (9–12 V from USB or battery) → 7805 → Arduino (5V rail)
- Minimal external components; occupies <1 cm^2 of PCB.

2. Industrial Motor Control Panel

A **7812** or **7815** provides the supply for PLC logic, relay drivers, and sensor inputs in an automated manufacturing system.

Design considerations:

- Input derived from 24 VDC industrial bus.
- Large heatsink due to sustained load.
- Extra filtering to reject switching noise from motor VFDs.

3. Audio Preamplifier or Op-Amp Circuit

Dual **7905** / **7805** (or 79X5 / 78X5 pair) create a ±5V symmetrical supply for high-quality audio amplification.

Benefit: The low-noise output of the 78XX makes it ideal for audio preamps, avoiding hum and distortion.

4. Legacy Equipment Service

Older industrial equipment (1990s–2000s) used 78XX extensively in their power supplies. Technicians repairing or rebuilding such equipment must understand the 78XX thoroughly.

Troubleshooting 78XX Problems

Symptom: No Output Voltage

Possible Cause	Diagnosis	Solution
Regulator not powered	Check input voltage with multimeter	Verify upstream supply and connections
Input capacitor shorted	Measure voltage across C_in	Replace with correct voltage-rated part
Regulator overheated (thermal shutdown)	Feel the IC—is it very hot?	Check load current, improve heatsinking, verify input voltage
IC itself failed (rare)	Input OK, output open circuit	Replace IC; test in known-good circuit

Symptom: Output Voltage Too Low

Possible Cause	Diagnosis	Solution
Excessive load current	Measure current with clamp meter	Load exceeds 1.5 A; use higher-rating supply
Input voltage too low	Measure V_in; compare to minimum for that IC	Increase input voltage (must be ≥ V_out + 2 V)
Output shorted or nearly shorted	Measure output resistance	Remove short; check for solder bridges, damaged components
Output capacitor failed (high ESR)	Observe ripple on scope; may be excessive	Replace output capacitor with low-ESR ceramic

Symptom: Output Voltage Too High

Possible Cause	Diagnosis	Solution
Wrong IC selected (e.g., 7815 instead of 7812)	Check IC markings carefully	Identify and replace with correct model
Open circuit in feedback path (unlikely in fixed-output)	Very rare; would require internal IC failure	Replace regulator

---

Professional Design Tips & Best Practices

1. **Always use bypass capacitors.** Do not skip them, even in “test” circuits. Many circuit failures trace back to missing or wrong capacitors.
2. **Mount heatsink before power-on testing.** Even a short 1–2 minute test without heatsinking can destroy a 78XX under load.
3. **Use thermal compound.** A small dab of *thermally conductive grease* between IC and heatsink dramatically improves heat transfer.
4. **Check component datasheets.** Manufacturers (ST Microelectronics, TI, ON Semiconductor) provide detailed thermal and electrical specs; not all 78XX variants are identical.
5. **Protect against reverse polarity.** If input can be reversed, add a **1N4007 diode** in series with the input (cathode toward 7805) to prevent reverse voltage damage.
6. **Use a dropout voltage margin.** Design so that minimum input is at least **3 V above** the rated output under worst-case conditions (supply sag, load surge).
7. **PCB layout matters.** Keep input and output capacitor leads short; use ground planes to reduce noise coupling.

Focus Keyphrase (≤191 characters)

78XX voltage regulator family 7805 7812 7815 7824 linear IC, fixed positive output 1.5A, thermal protection, datasheet specifications, power supply circuit design

---

SEO Title

78XX Voltage Regulator Family: 7805, 7812, 7815, 7824 – Complete Specifications, Circuit Design & Applications | Mbsmpro.com

---

Meta Description

Complete guide to the 78XX voltage regulator family. Learn 7805, 7812, 7815, 7824 specifications, pinouts, thermal design, circuit applications, capacitor selection, and troubleshooting for fixed regulated power supplies.

Slug

`78xx-voltage-regulator-family-7805-7812-7815-specifications-guide`

Tags

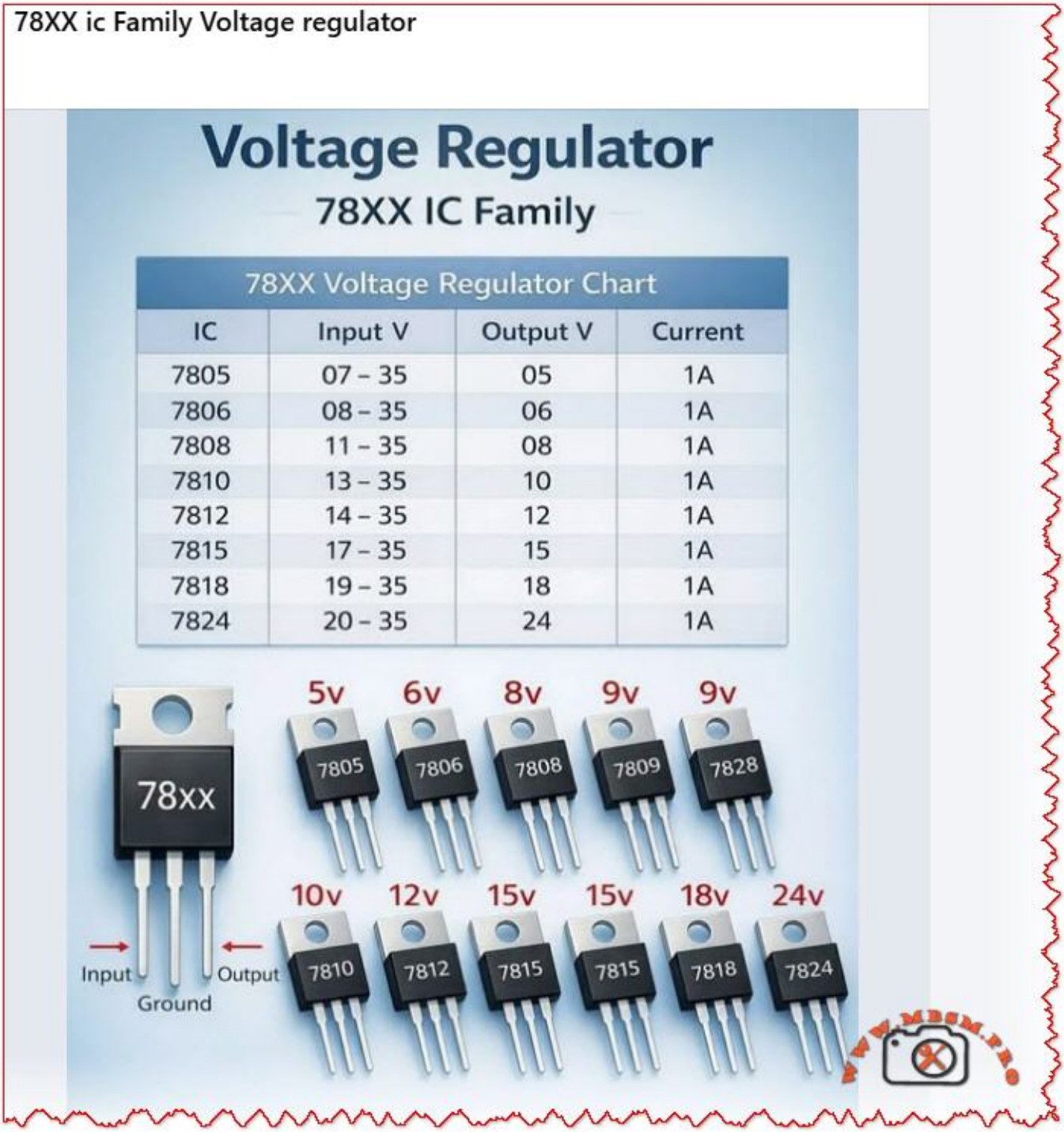
78XX voltage regulator, 7805, 7812, 7815, 7824, linear voltage regulator, LM78XX family, positive voltage regulator, regulated power supply, TO-220 TO-3 package, thermal management, power supply design, microcontroller power, industrial supply, Mbsmgroup, Mbsm.pro, mbsmpro.com, mbsm, voltage regulation circuit

---

Excerpt (first 55 words)

The **78XX series** is the industry-standard family of linear voltage regulators, providing fixed regulated output from 5V to 24V at up to 1.5A. This comprehensive guide covers the **7805, 7812, 7815, and 7824** variants, their specifications, internal architecture, thermal design, practical circuit applications, and professional troubleshooting tips for reliable power supply design.

78XX ic Family Voltage regulator



78XX IC Family, Voltage Regulator mbsmpro
componentsexplorer.com-Download 78xx Voltage Regulator DatasheetDownload