Opamp Darshan

EE3002: Analog Circuits
EE5310: Analog Electronic Circuits

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IIT Madras

LM324: Quad opamp

National Semiconductor

August 2000

LM124/LM224/LM324/LM2902
Low Power Quad Operational Amplifiers

General Description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage
- The unity gain cross frequency is temperature compensated
- The input bias current is also temperature compensated

Advantages

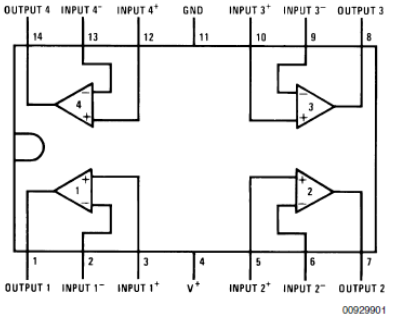
- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and V_{OUT} also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

Features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range:
  Single supply 3V to 32V
  or dual supplies ±1.5V to ±16V
- Very low supply current drain (700 µA)—essentially independent of supply voltage
- Low input biasing current 45 nA (temperature compensated)
- Low input offset voltage 2 mV and offset current: 5 nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0V to V^+ – 1.5V

Connection Diagrams

Dual-In-Line Package

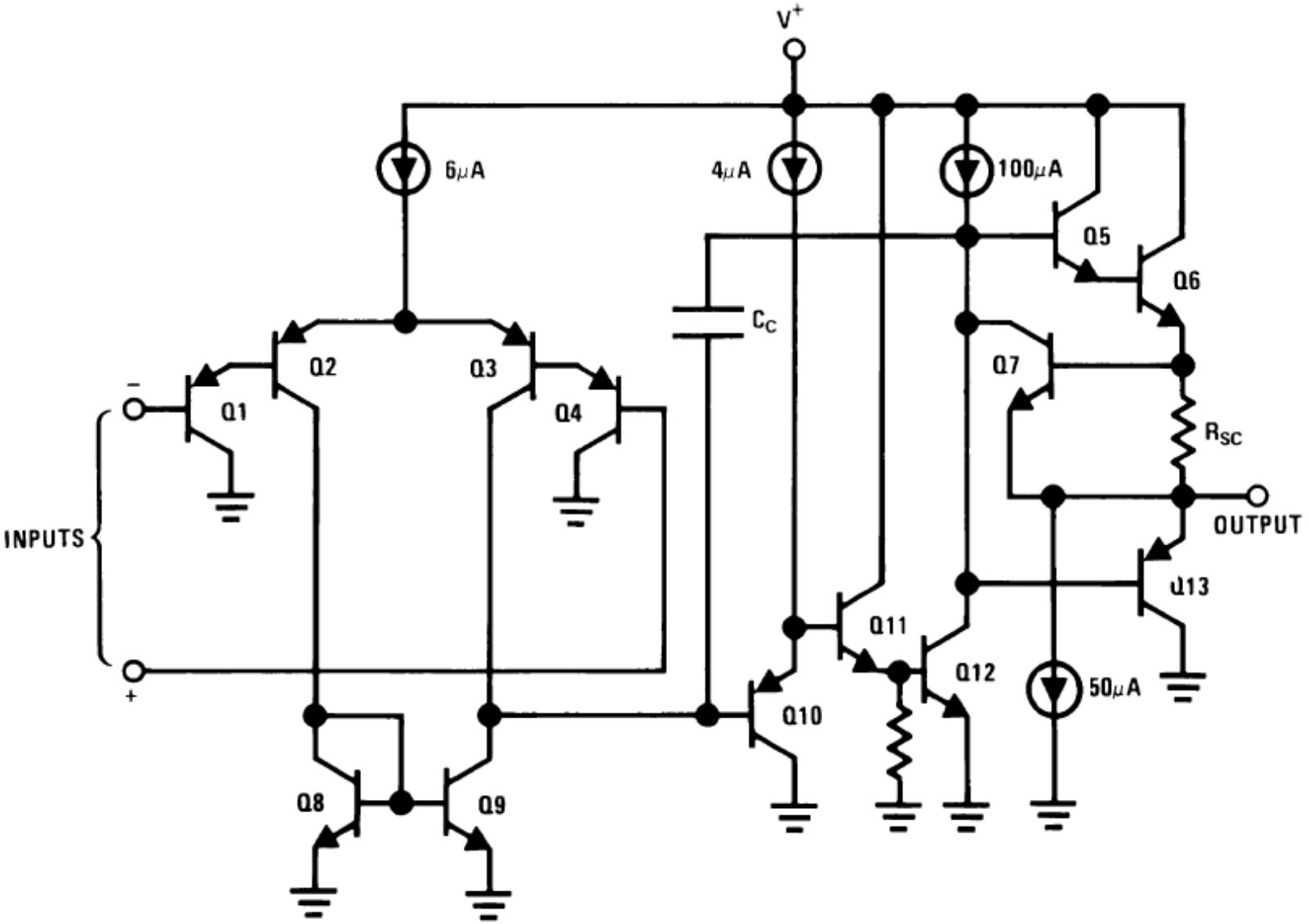


Top View

Order Number LM124J, LM124AJ, LM124J/883 (Note 2), **LM124AJ/883** (Note 1), **LM224J, LM224AJ, LM324J, LM324M, LM324MX, LM324AM, LM324AMX, LM2902M, LM2902MX, LM324N, LM324AN, LM324MT, LM324MTX or LM2902N LM124AJRQML and LM124AJRQMLV**(Note 3)
See NS Package Number J14A, M14A or N14A

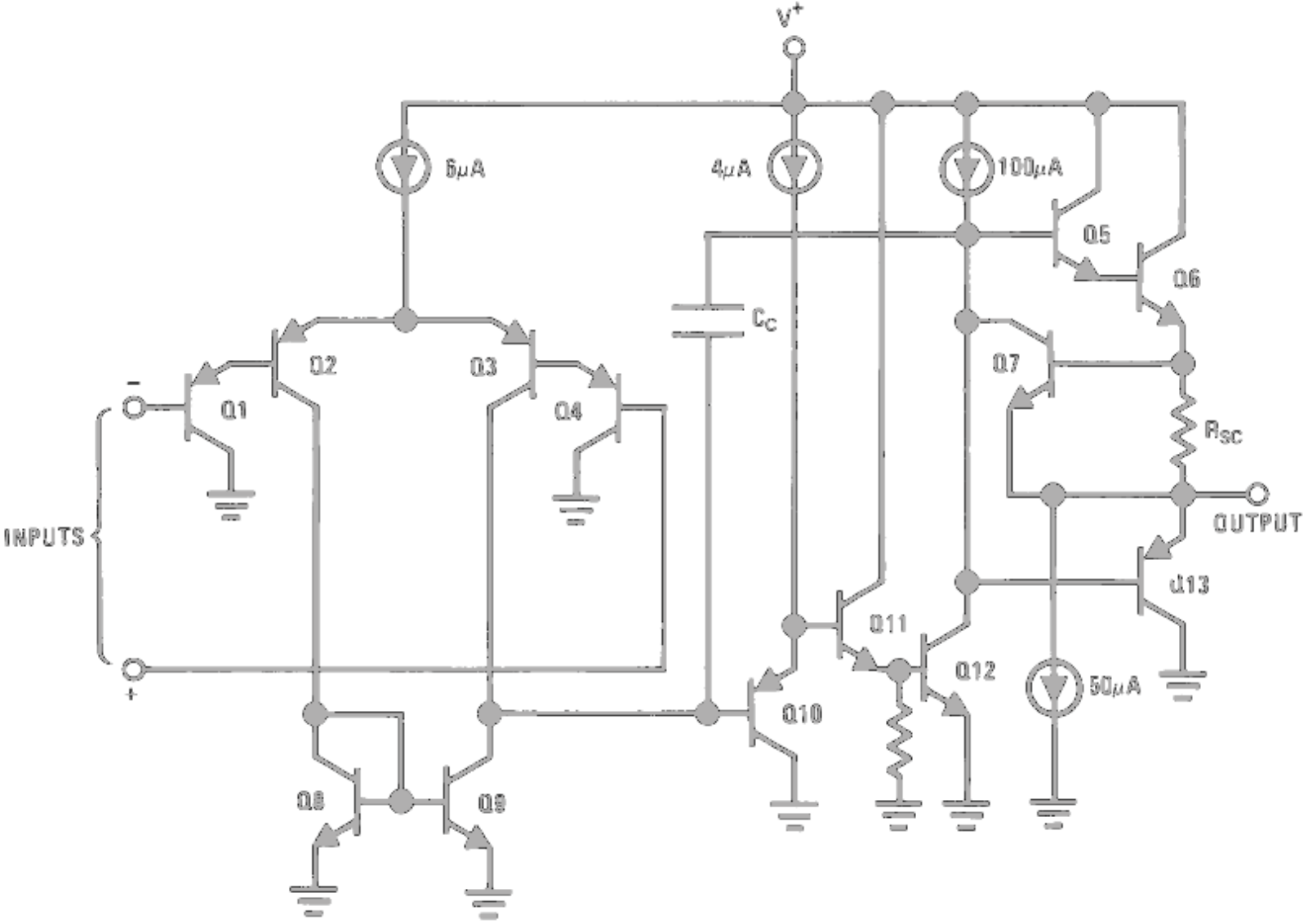
Source: LM324 datasheet

LM324: Opamp schematic



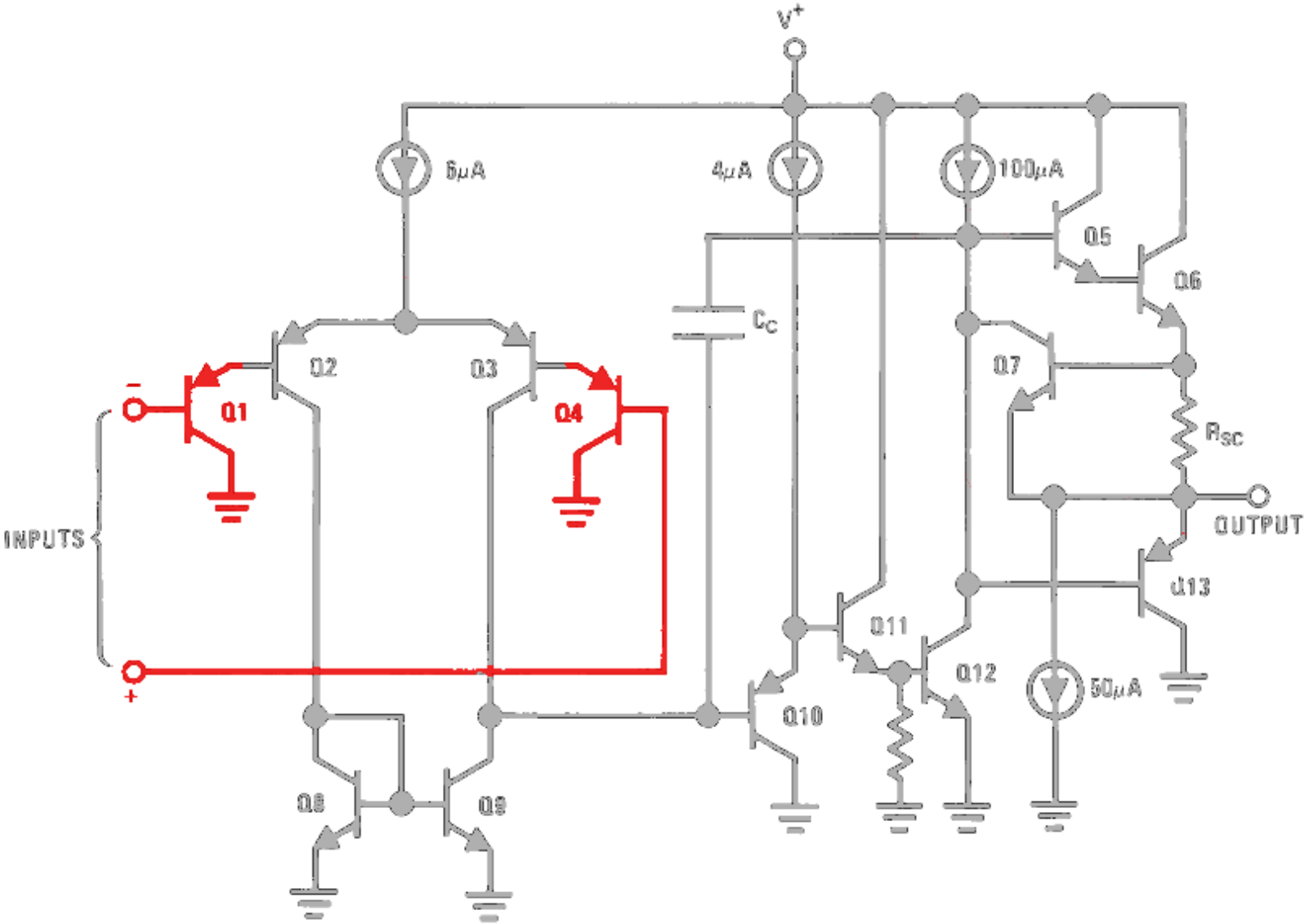
Source: LM324 datasheet

LM324: Opamp schematic



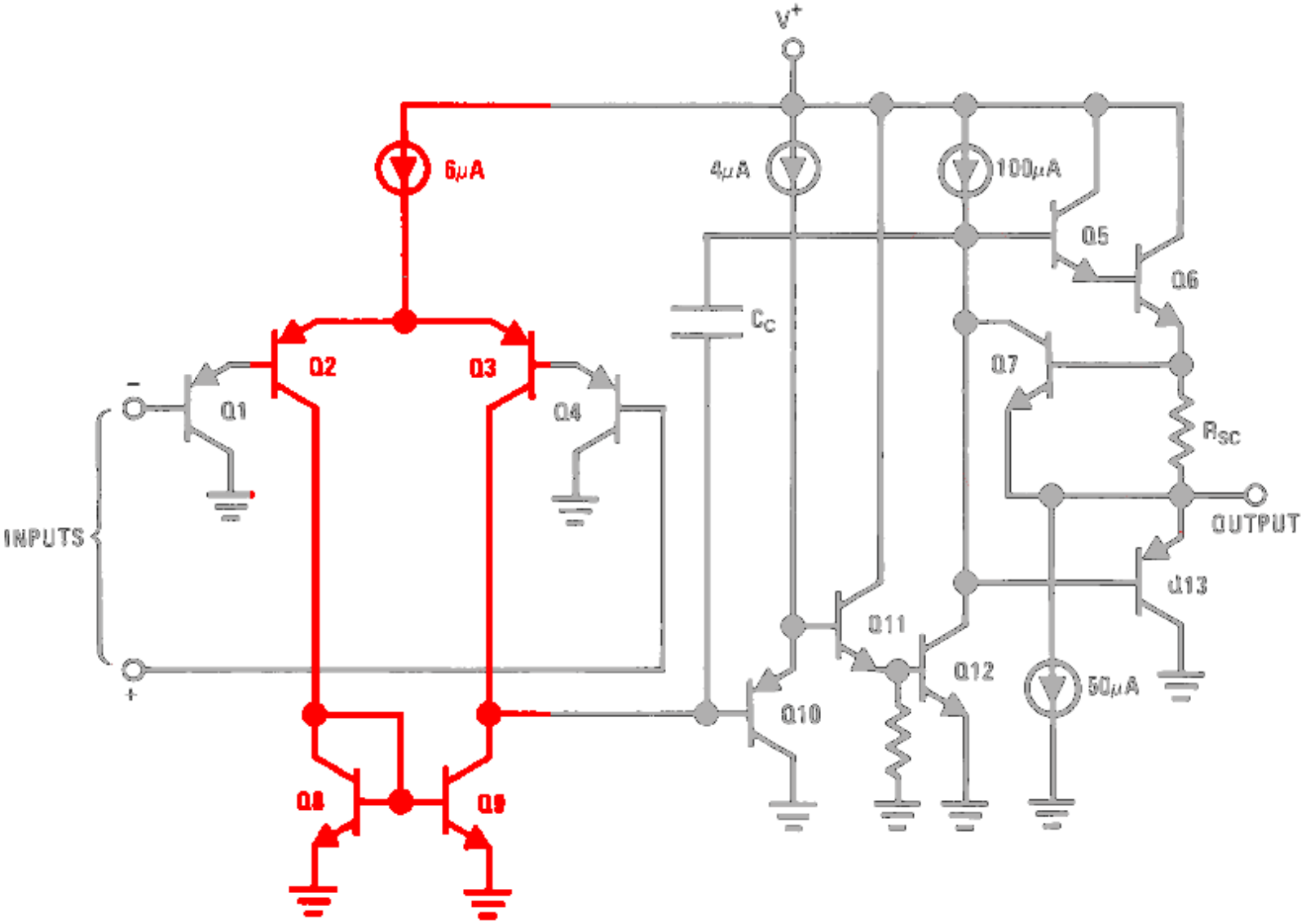
Source: LM324 datasheet

Input buffers for high R_{in}



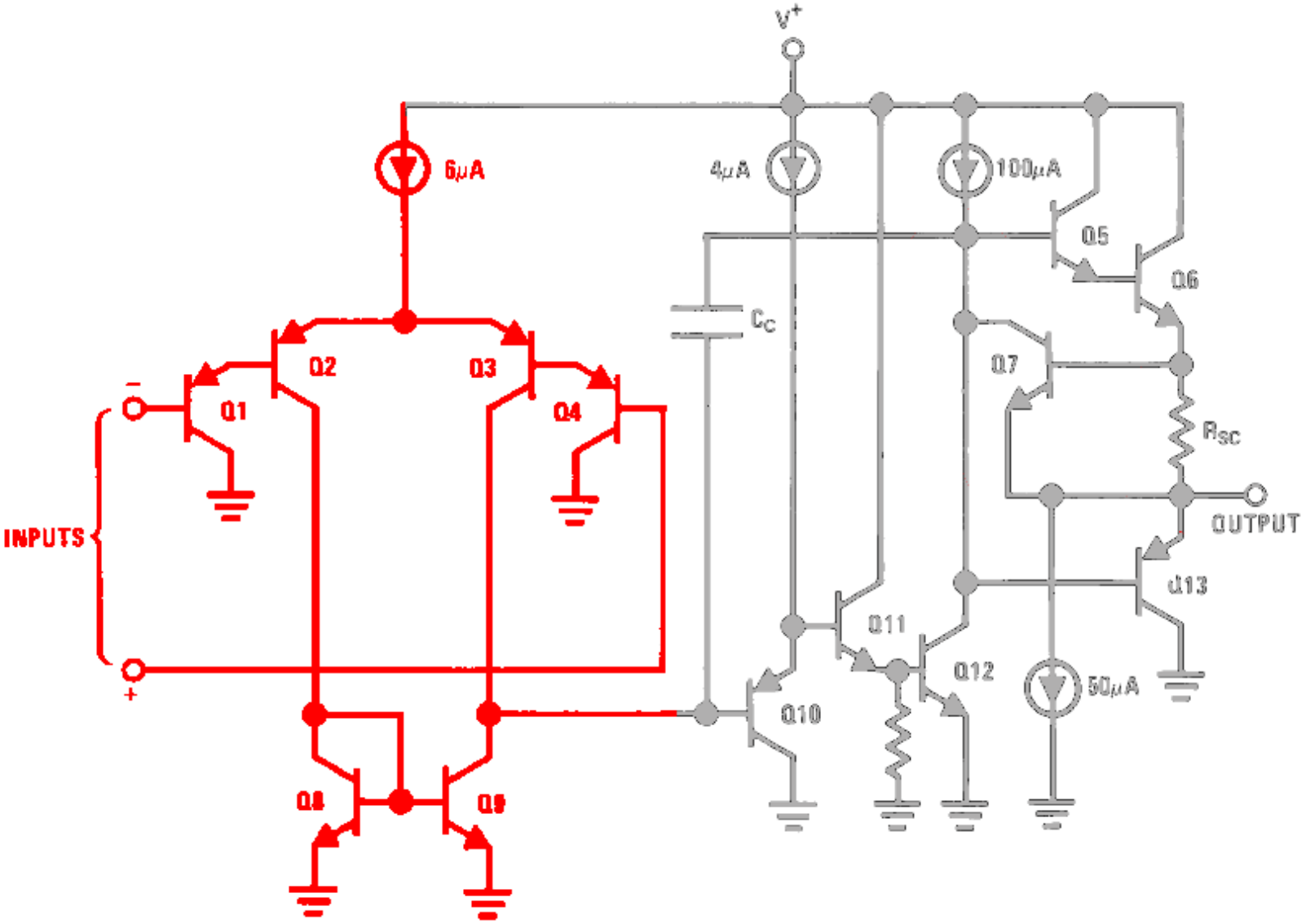
Source: LM324 datasheet

Differential pair + current mirror load



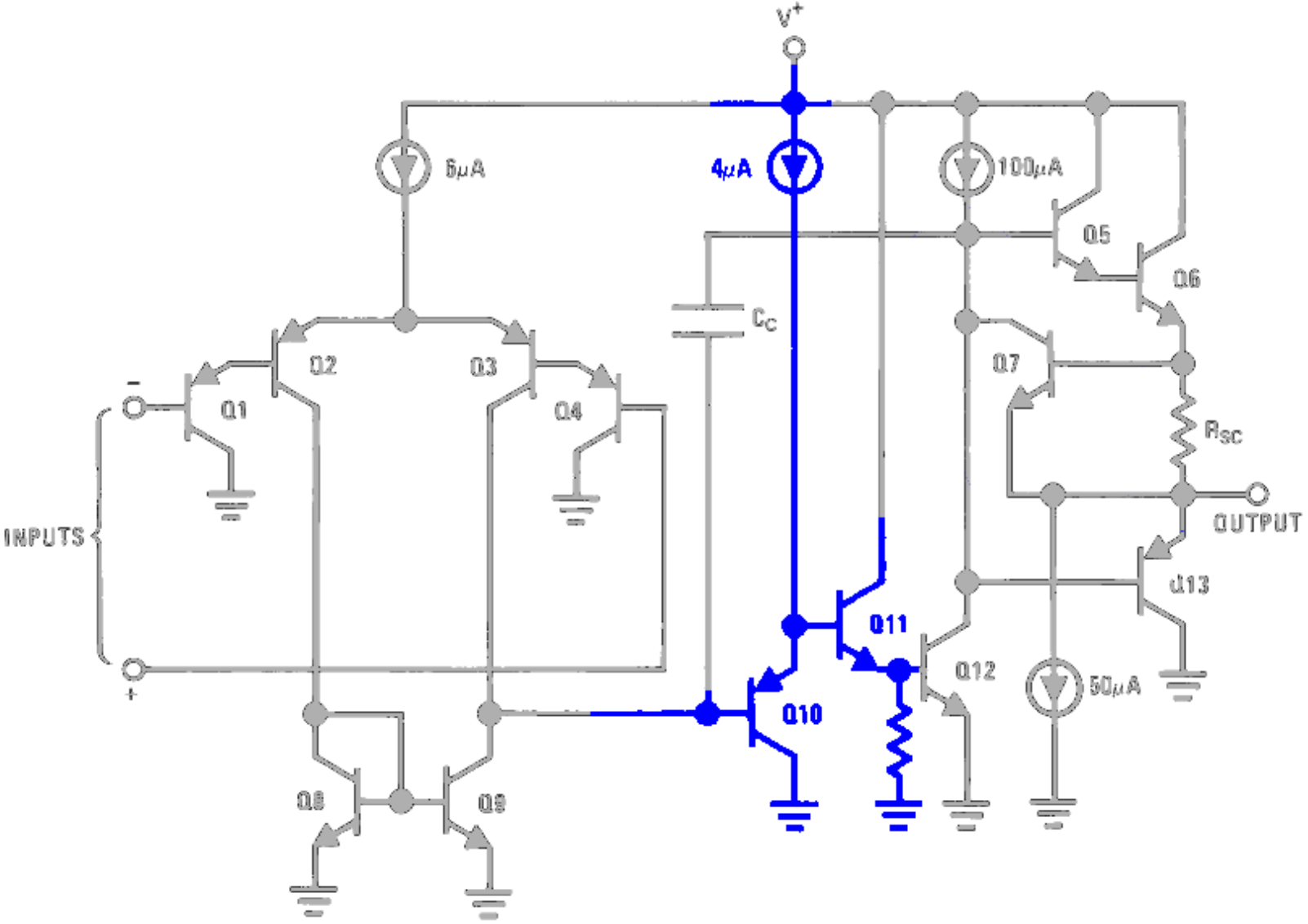
Source: LM324 datasheet

1st stage



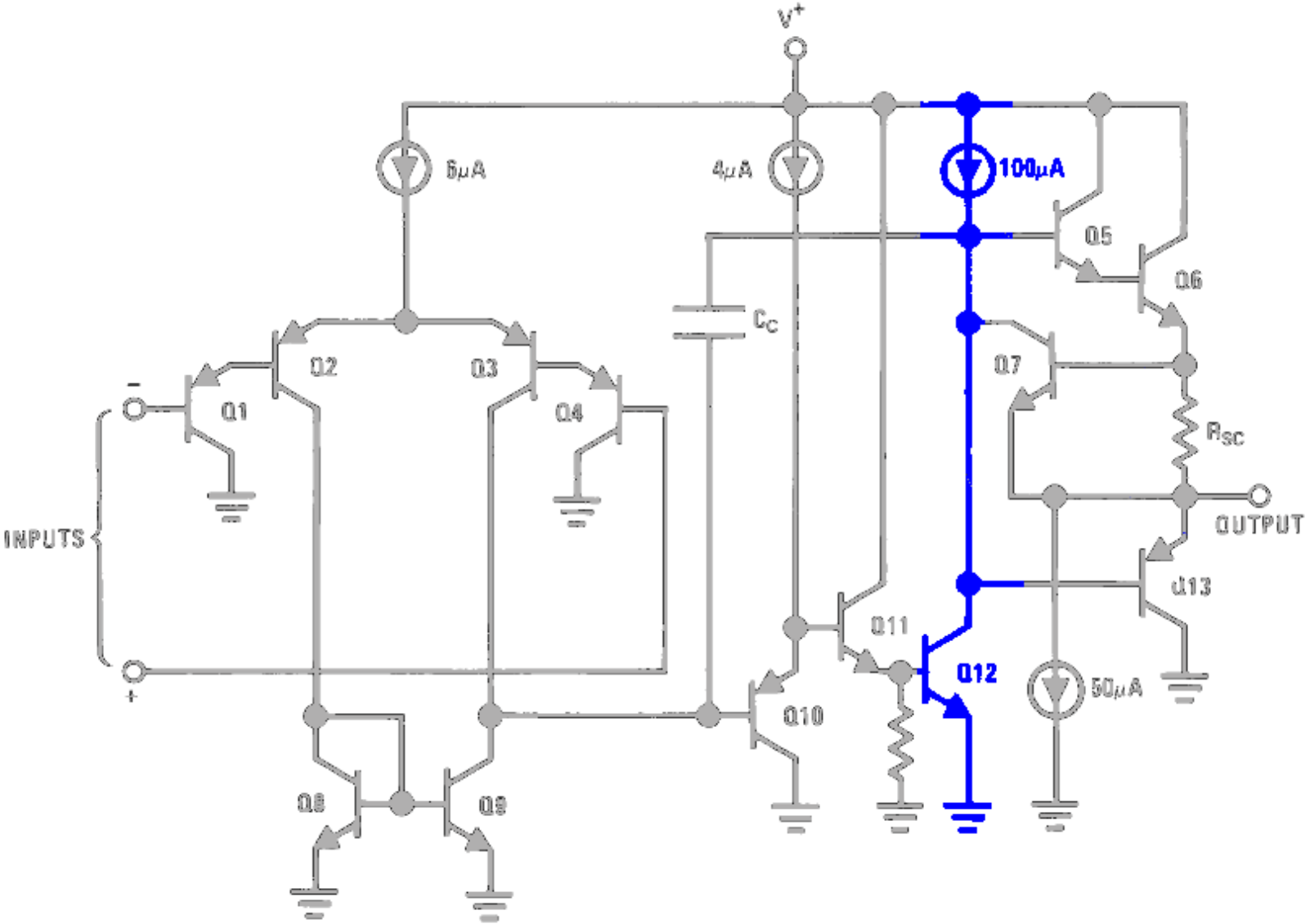
Source: LM324 datasheet

2nd stage input buffer for high R_{in}



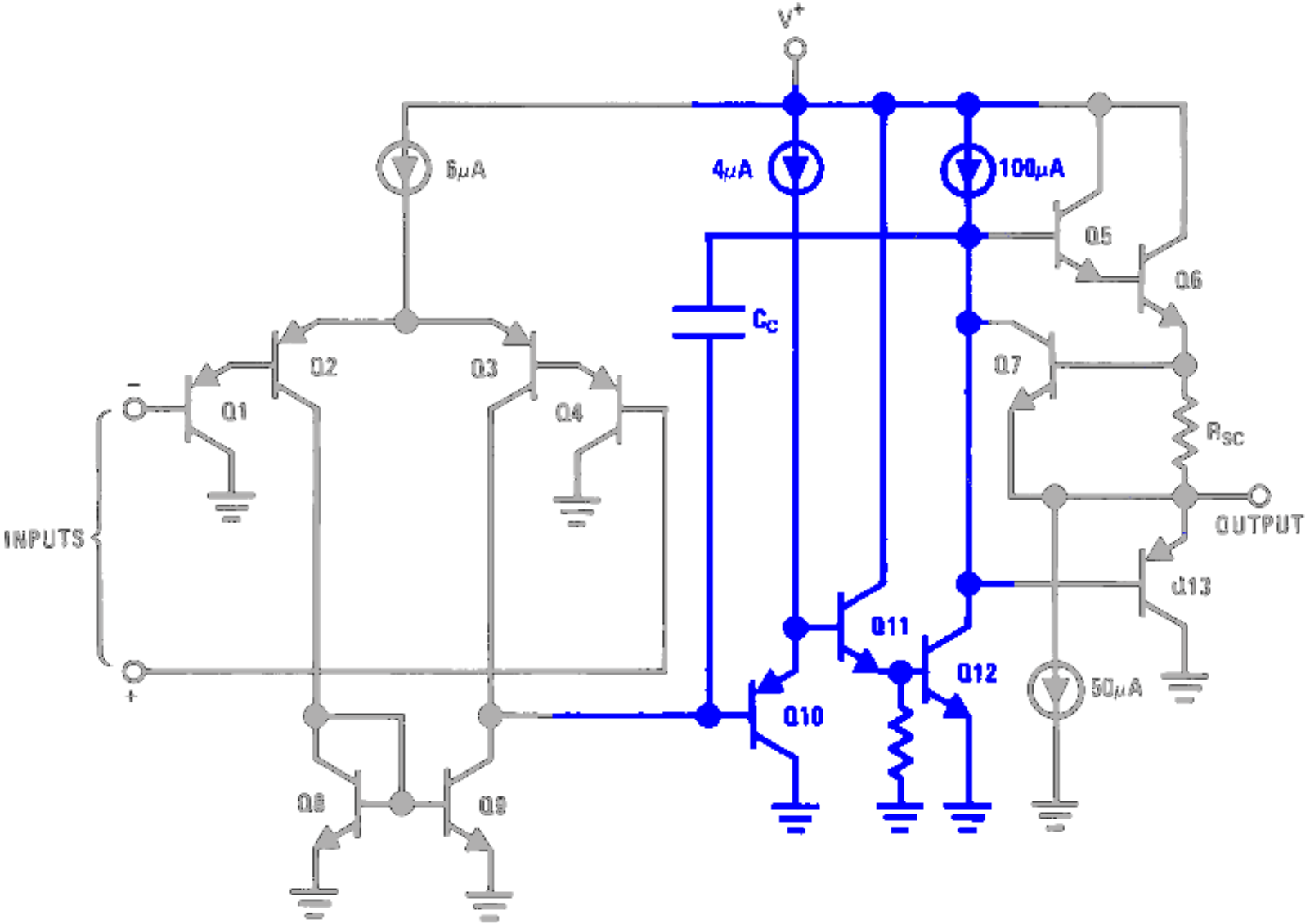
Source: LM324 datasheet

2nd stage common emitter amplifier



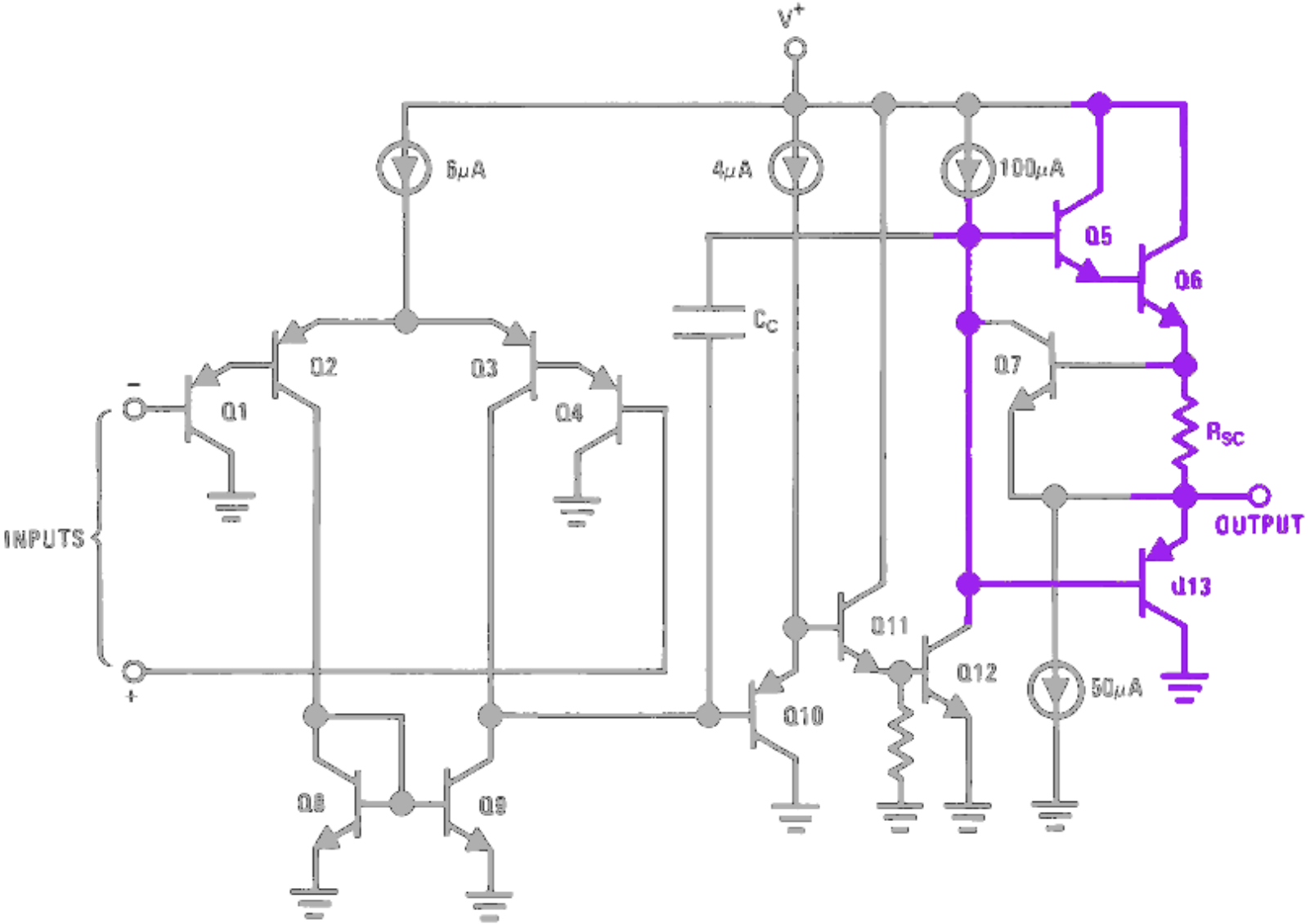
Source: LM324 datasheet

2nd stage with pole splitting



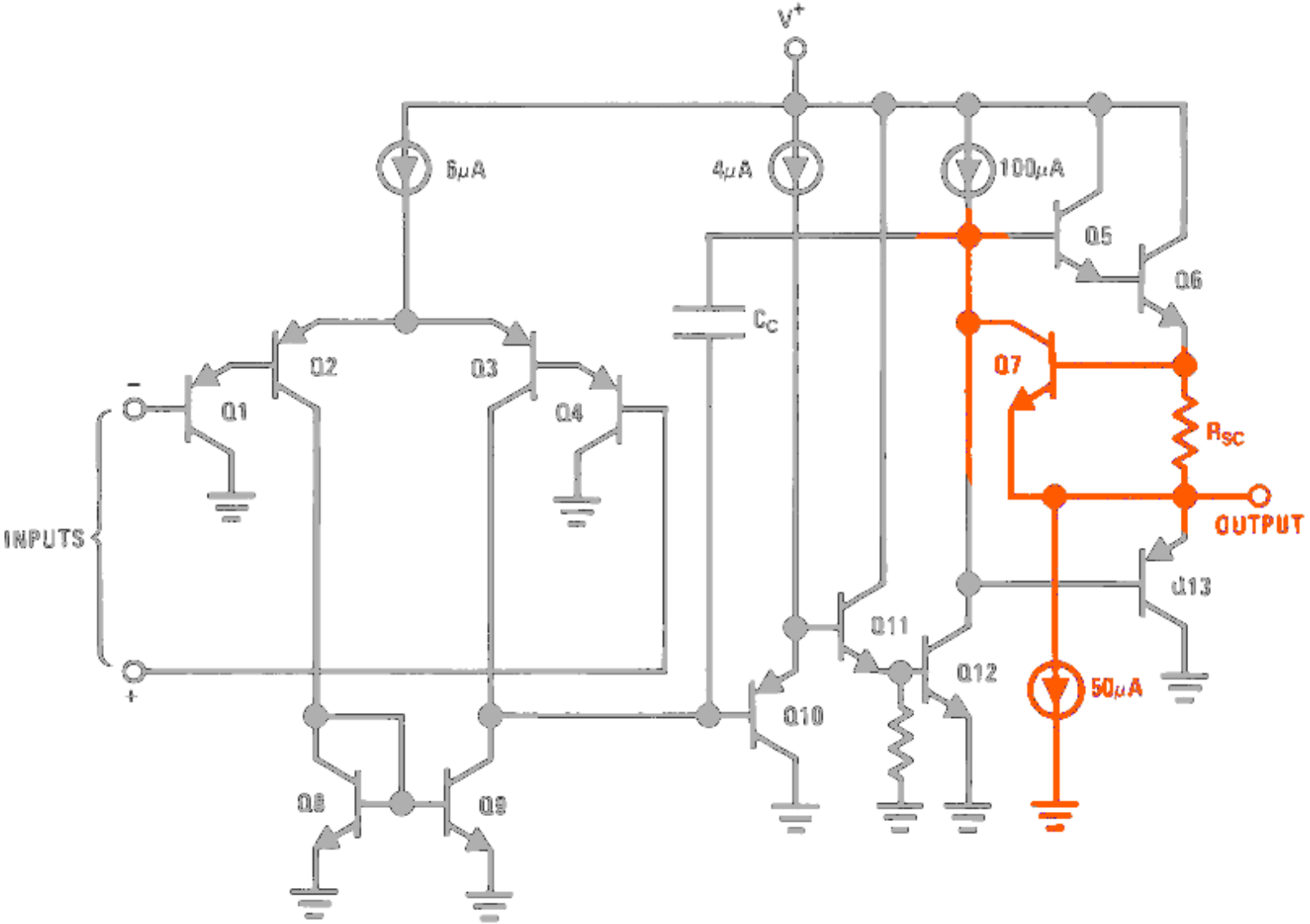
Source: LM324 datasheet

Output buffer: NPN+PNP emitter followers (class AB)



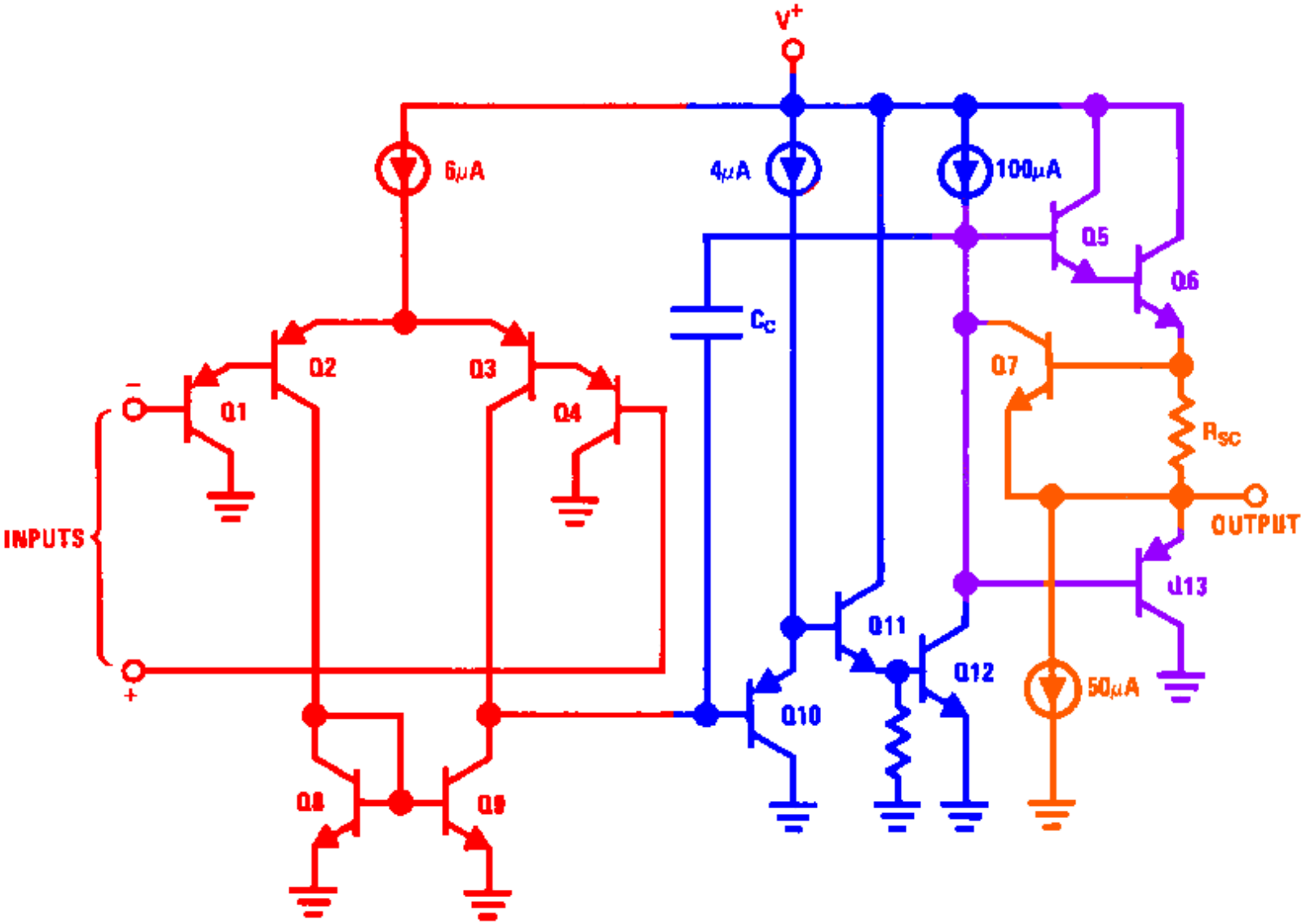
Source: LM324 datasheet

Overload protection



Source: LM324 datasheet

LM324: 2 stages + output buffer



Source: LM324 datasheet

LF347: Quad opamp with JFET input

National Semiconductor

August 2000

LF147/LF347
Wide Bandwidth Quad JFET Input Operational Amplifiers

General Description

The LF147 is a low cost, high speed quad JFET input operational amplifier with an internally trimmed input offset voltage (BI-FET II™ technology). The device requires a low supply current and yet maintains a large gain bandwidth product and a fast slew rate. In addition, well matched high voltage JFET input devices provide very low input bias and offset currents. The LF147 is pin compatible with the standard LM148. This feature allows designers to immediately upgrade the overall performance of existing LF148 and LM124 designs.

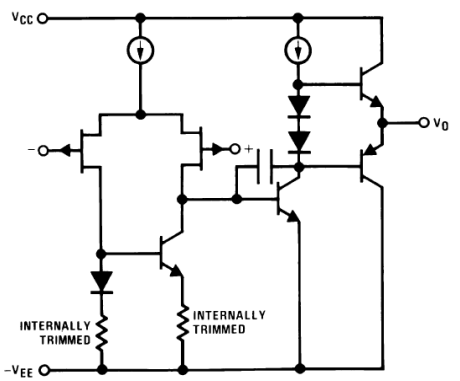
The LF147 may be used in applications such as high speed integrators, fast D/A converters, sample-and-hold circuits and many other circuits requiring low input offset voltage, low input bias current, high input impedance, high slew rate and wide bandwidth. The device has low noise and offset voltage drift.

Features

- Internally trimmed offset voltage: 5 mV max
- Low input bias current: 50 pA
- Low input noise current: 0.01 pA/√Hz
- Wide gain bandwidth: 4 MHz
- High slew rate: 13 V/μs
- Low supply current: 7.2 mA
- High input impedance: $10^{12}\Omega$
- Low total harmonic distortion: ≤0.02%
- Low 1/f noise corner: 50 Hz
- Fast settling time to 0.01%: 2 μs

Simplified Schematic

¼ Quad



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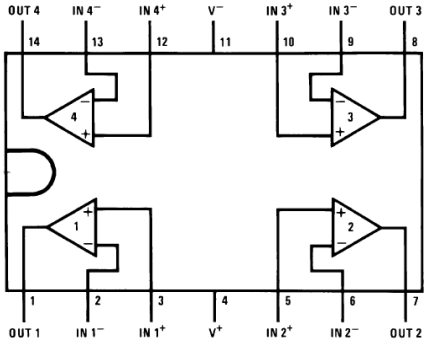
Connection Diagram

Dual-In-Line Package



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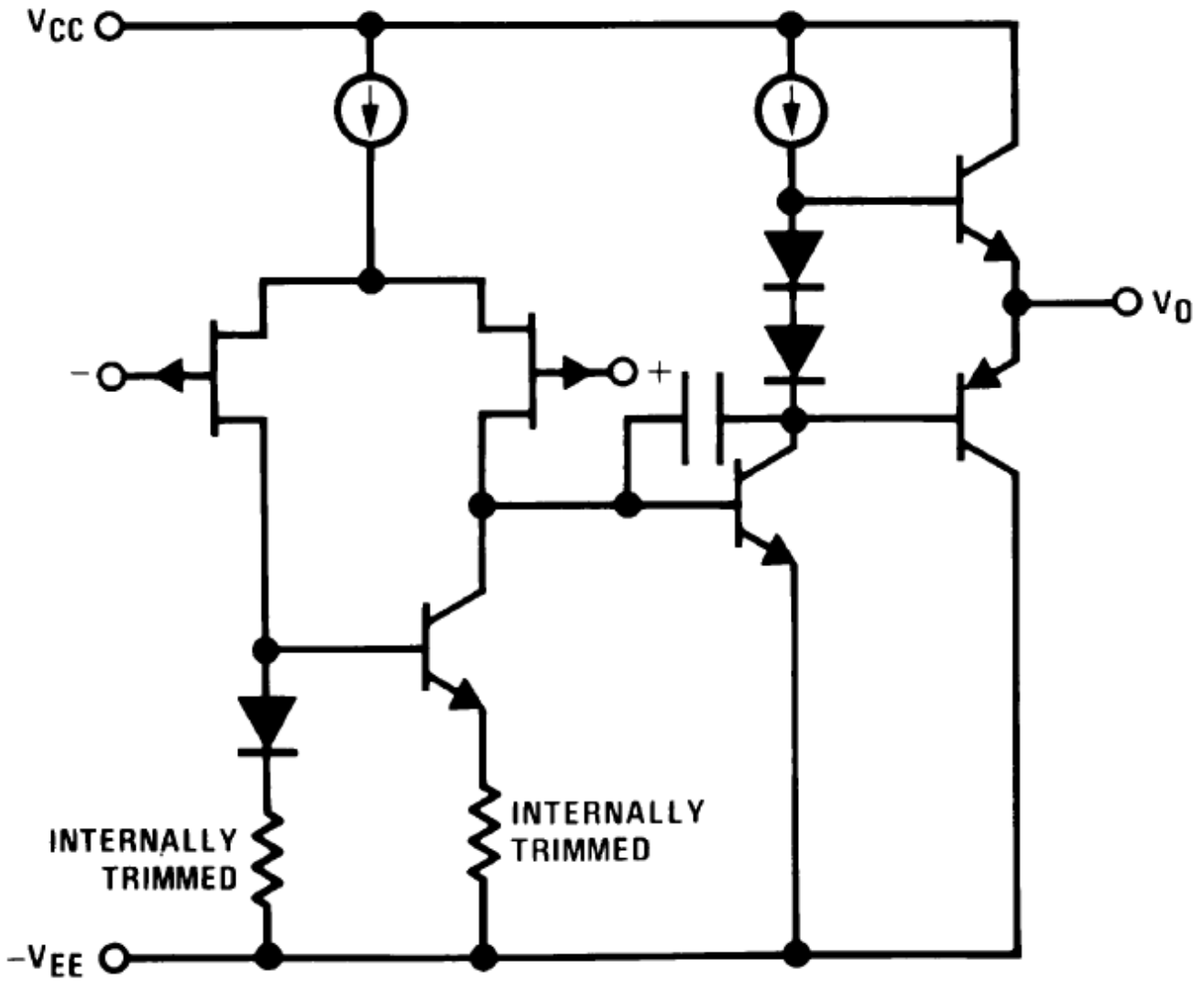
Note 1: LF147 available as per JM38510/11906.

Top View
Order Number LF147J, LF147J-SMD, LF347M, LF347BN, LF347N, LF147J/883, or JL147 BCA (Note 1)
See NS Package Number J14A, M14A or N14A

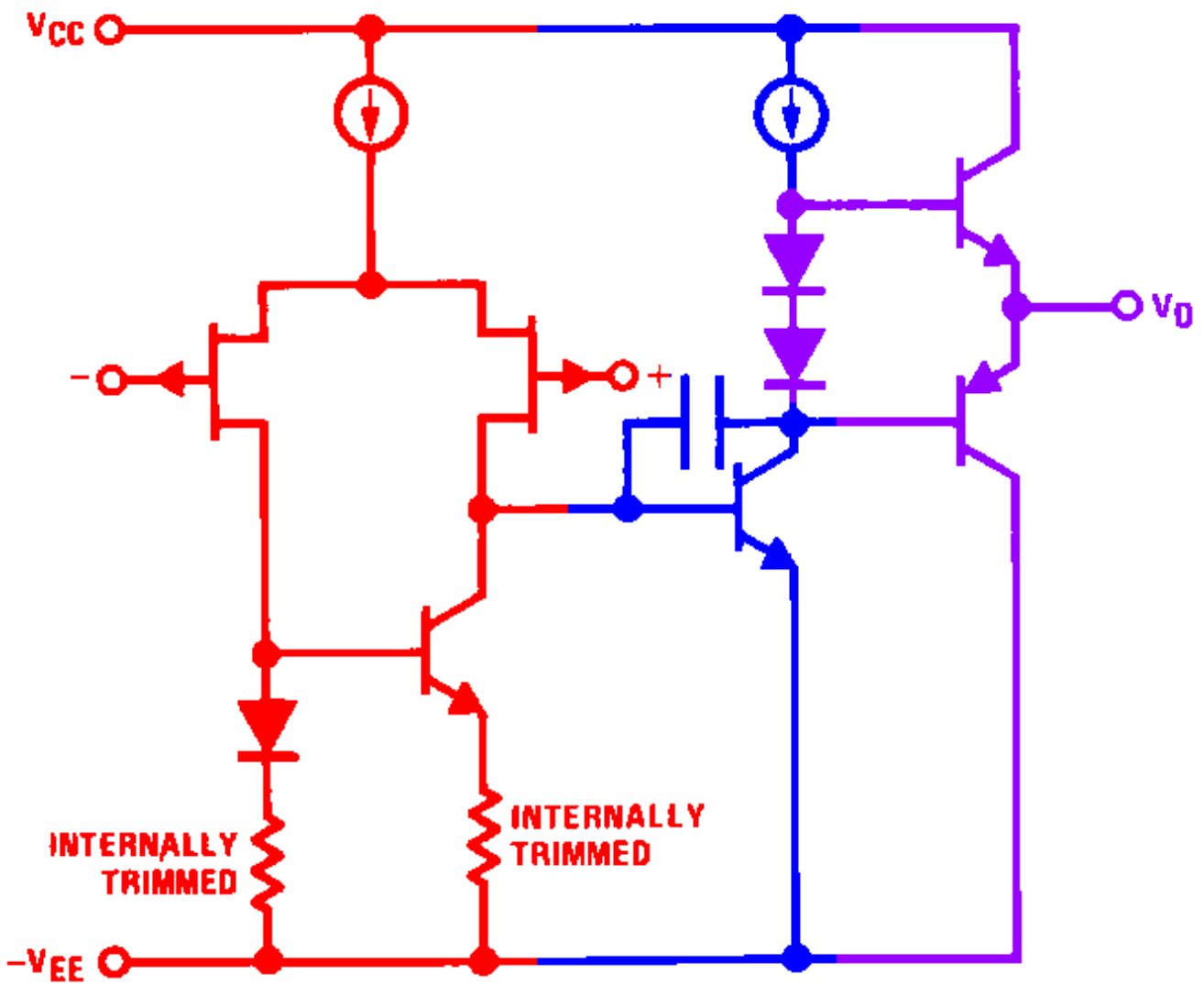
Source: LF347 datasheet

LF347: Simplified schematic



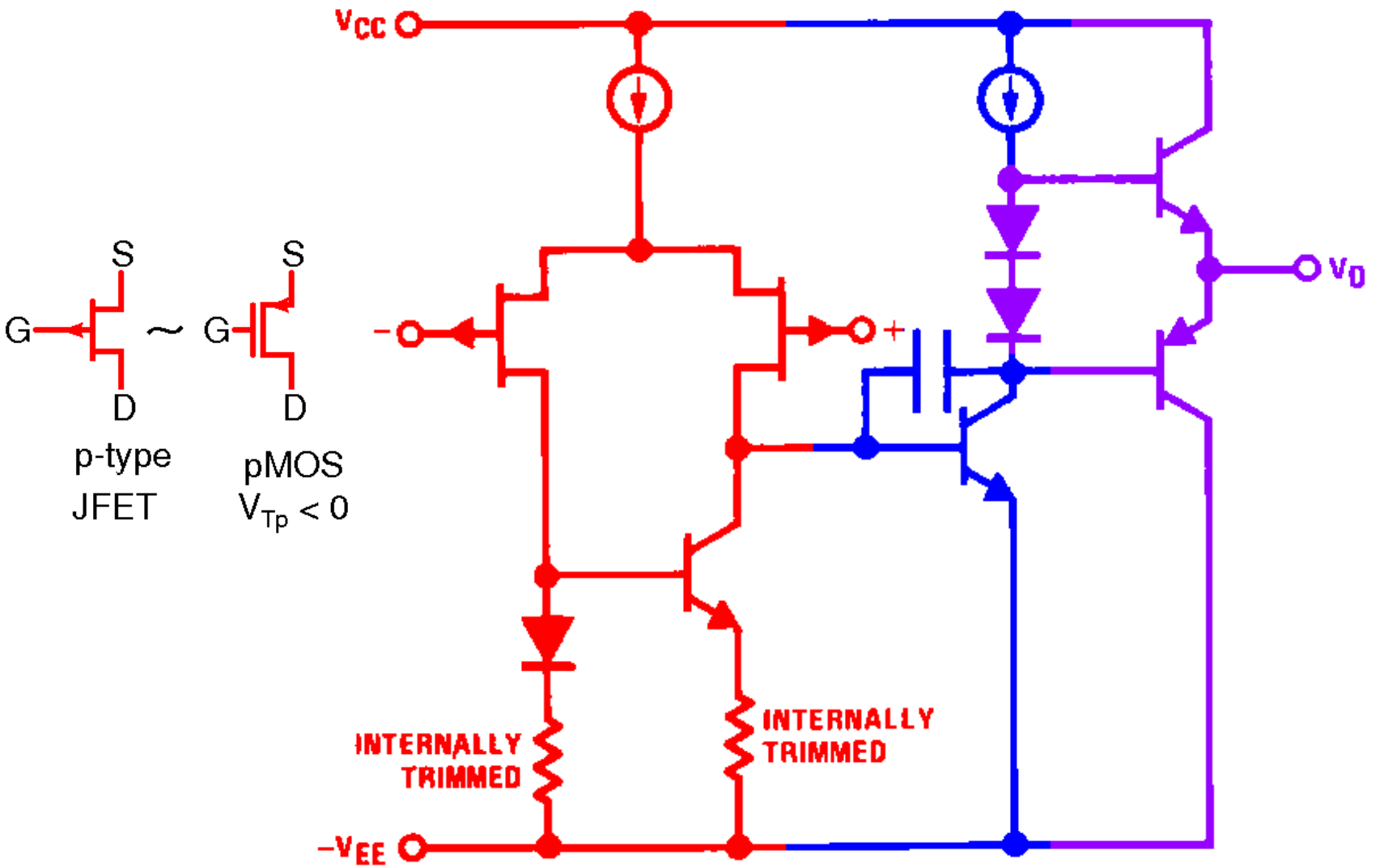
Source: LF347 datasheet

LF347: 2 stages + output buffer



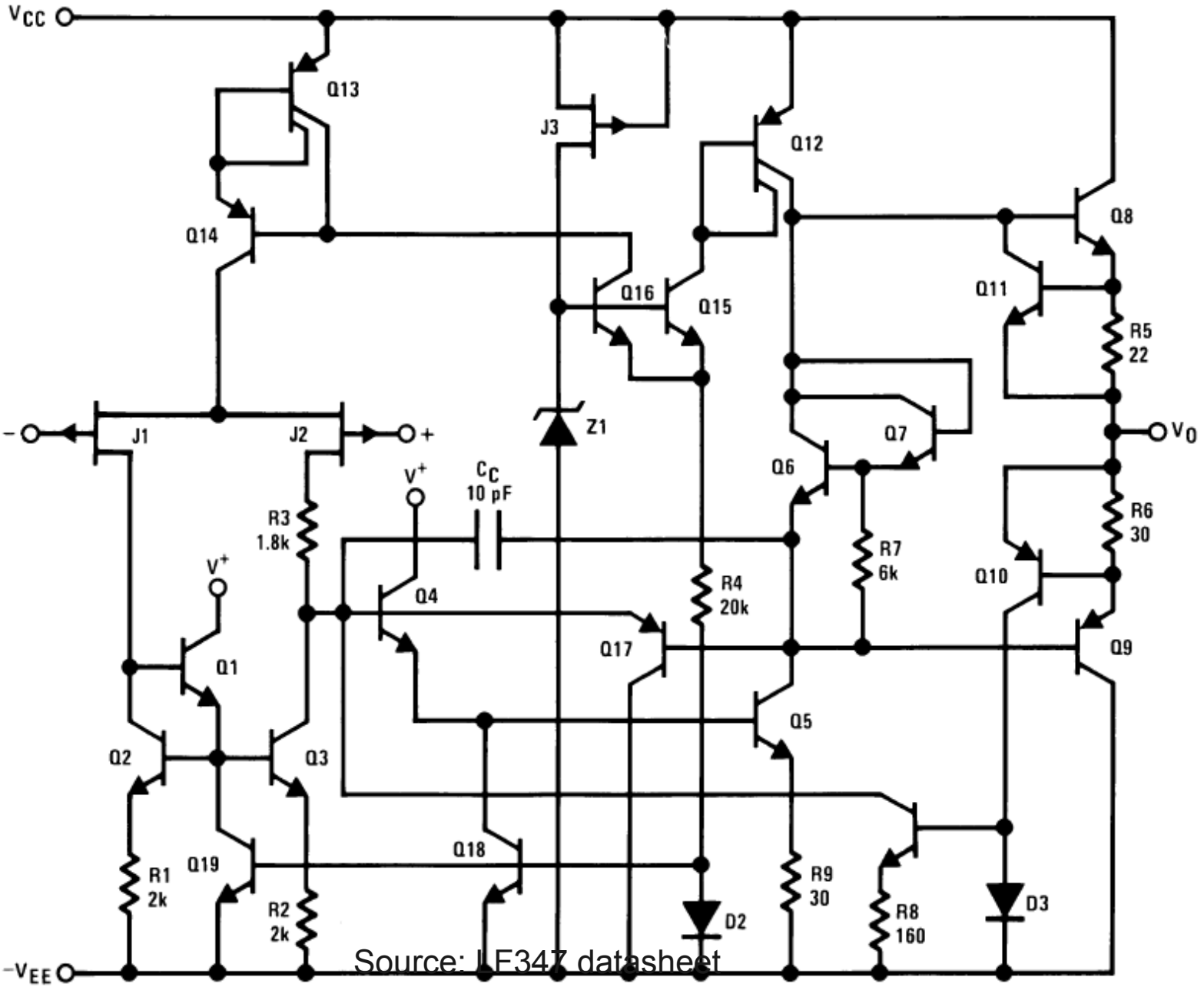
Source: LF347 datasheet

LF347: 2 stages + output buffer



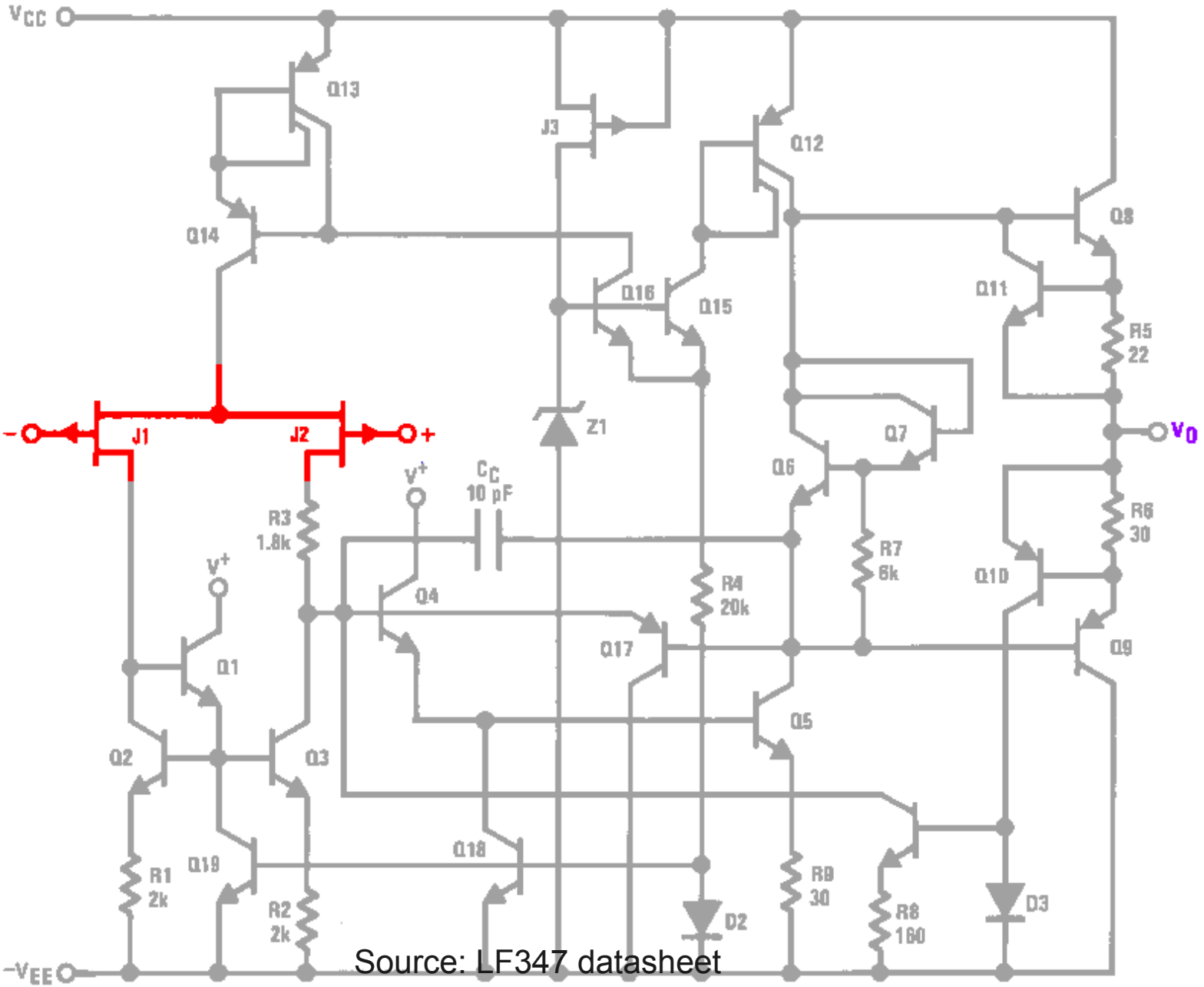
Source: LF347 datasheet

LF347: Schematic



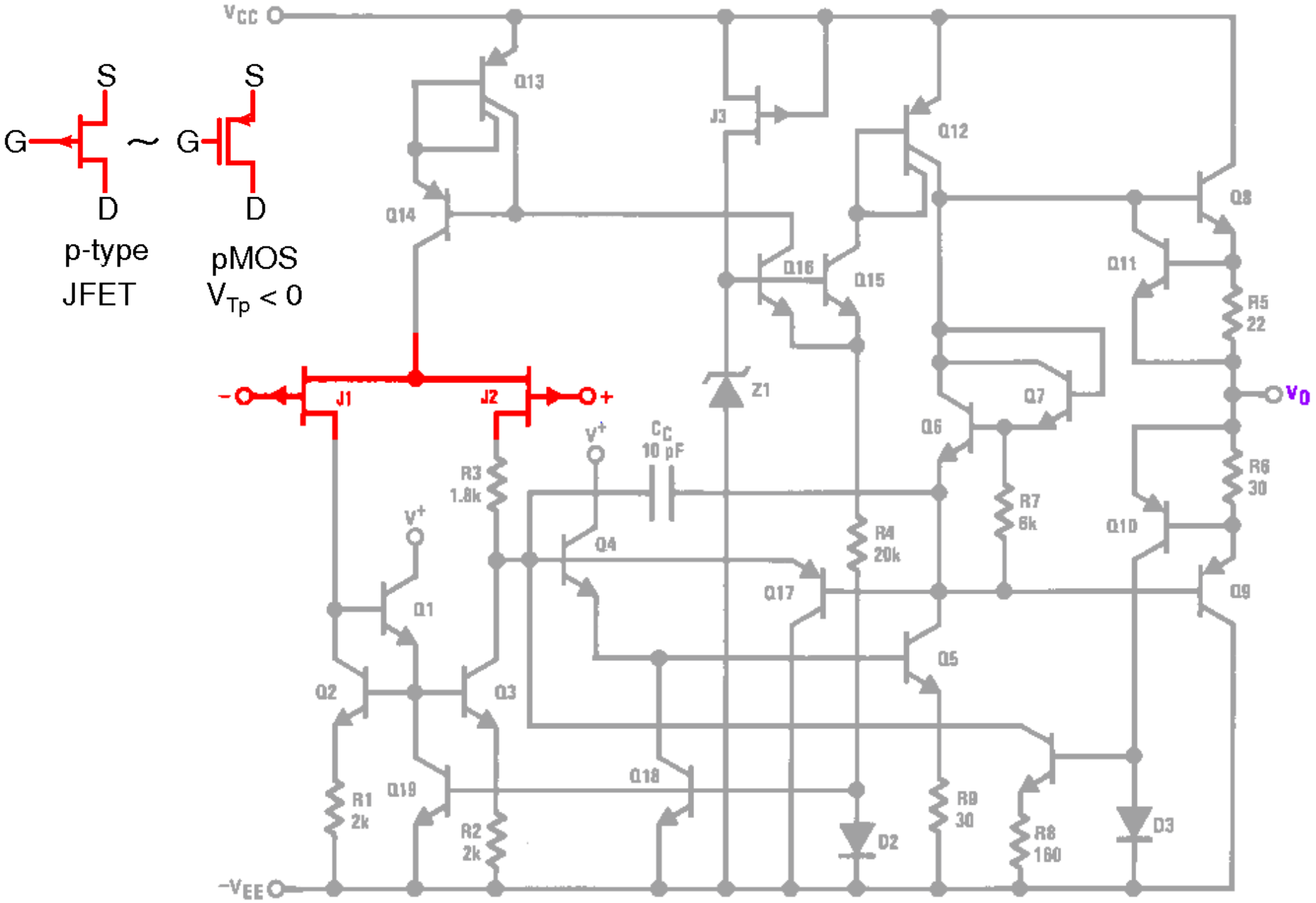
Source: LF347 datasheet

LF347: JFET input stage

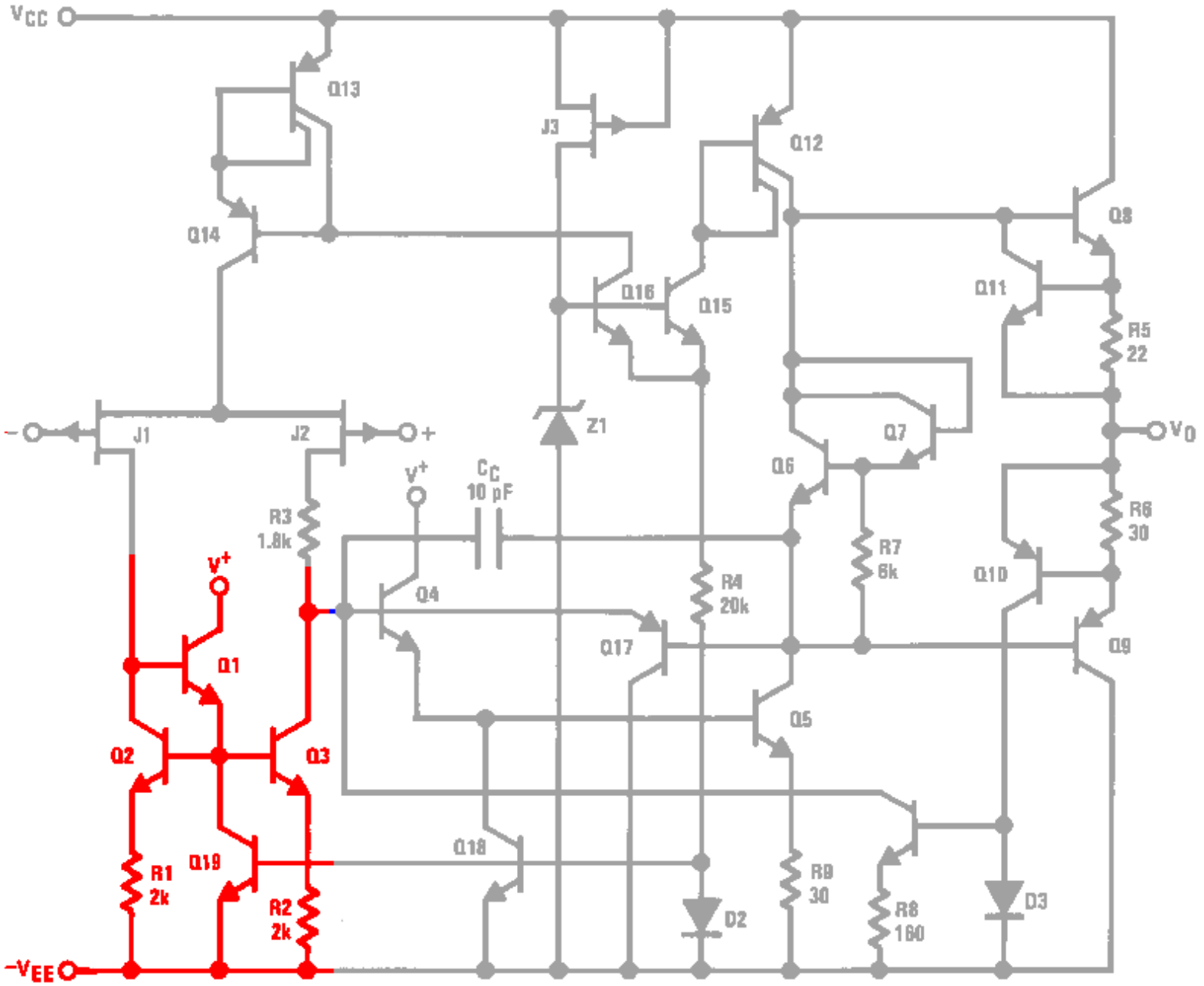


Source: LF347 datasheet

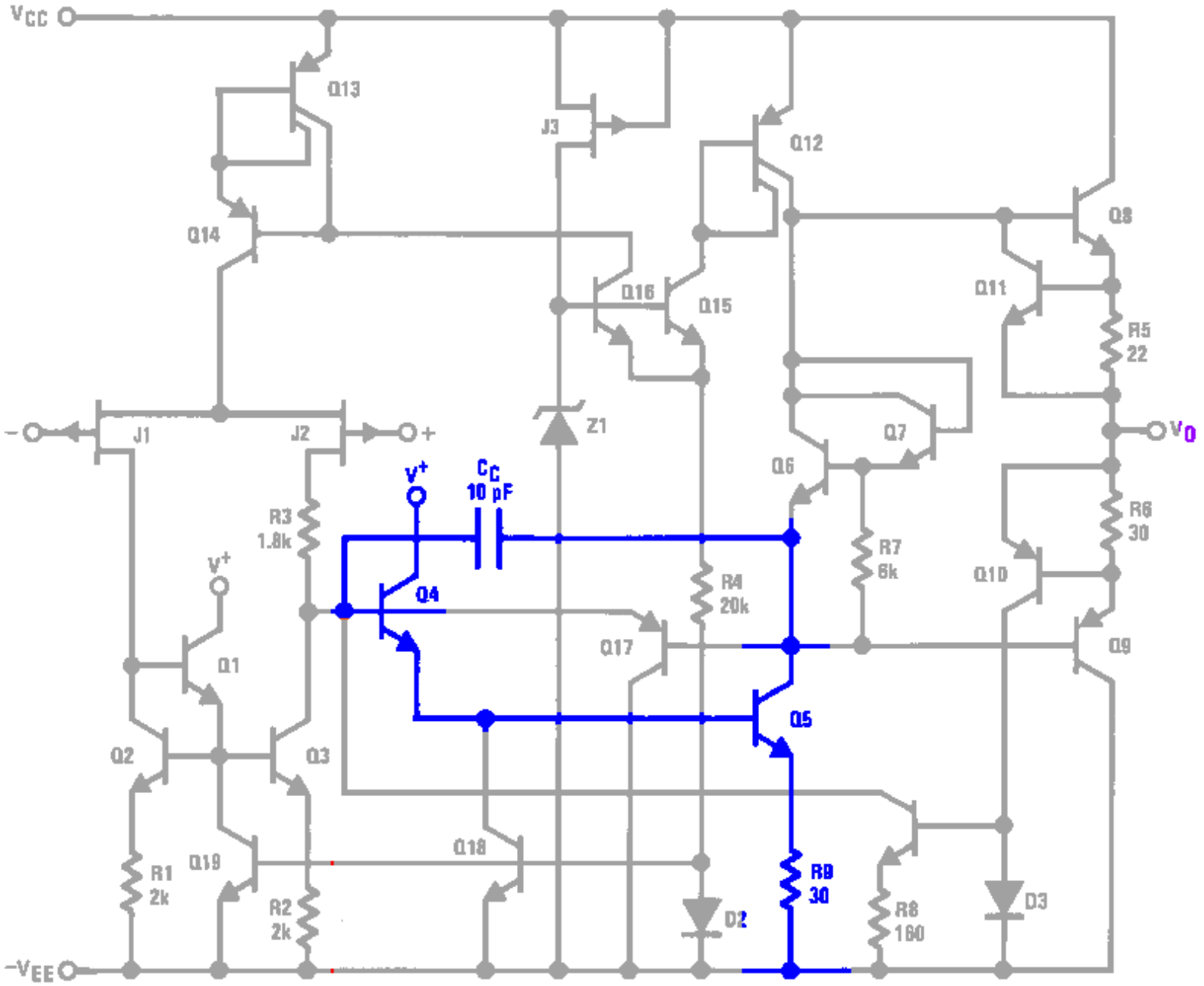
LF347: JFET input stage



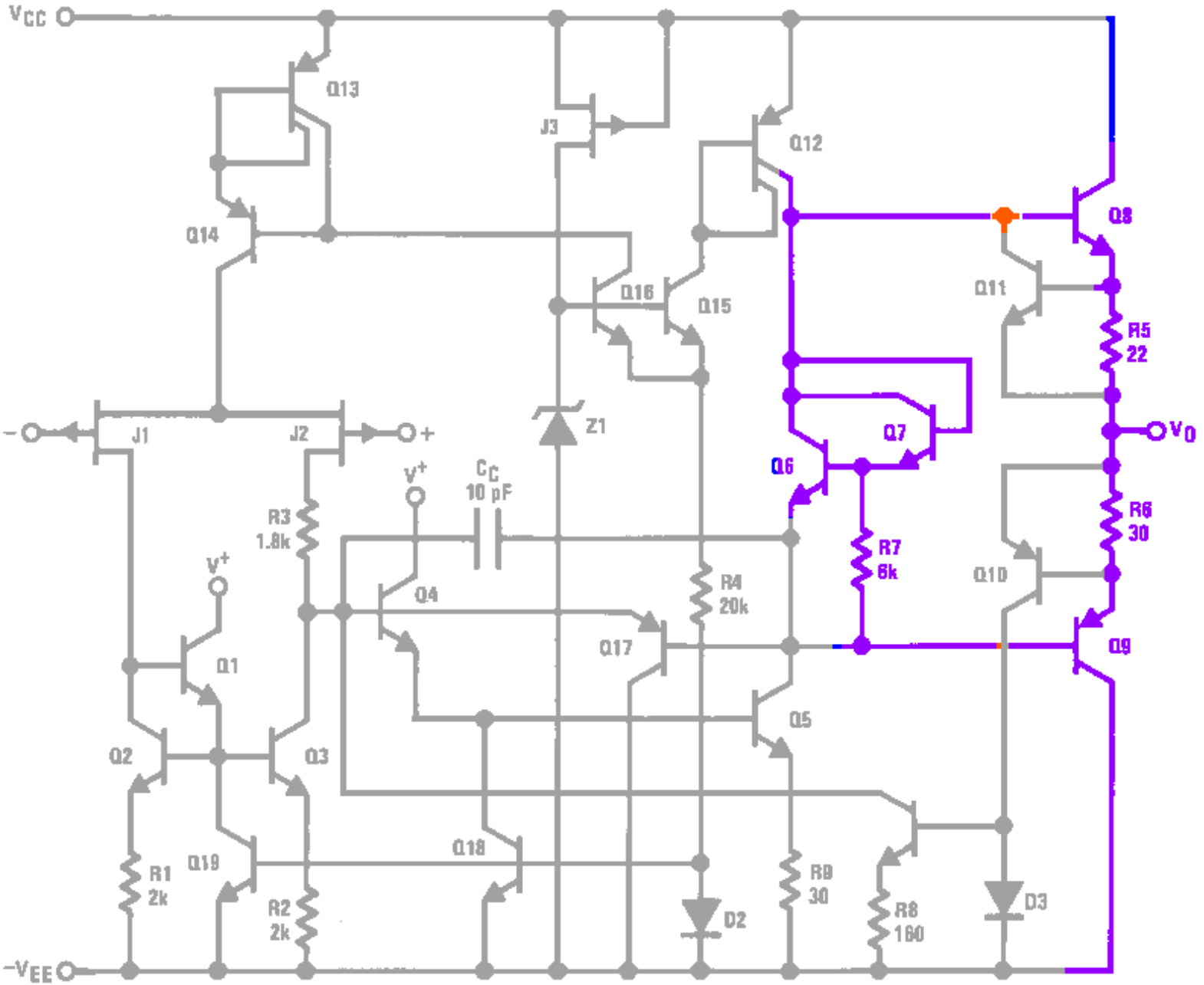
LF347: 1st stage current mirror load



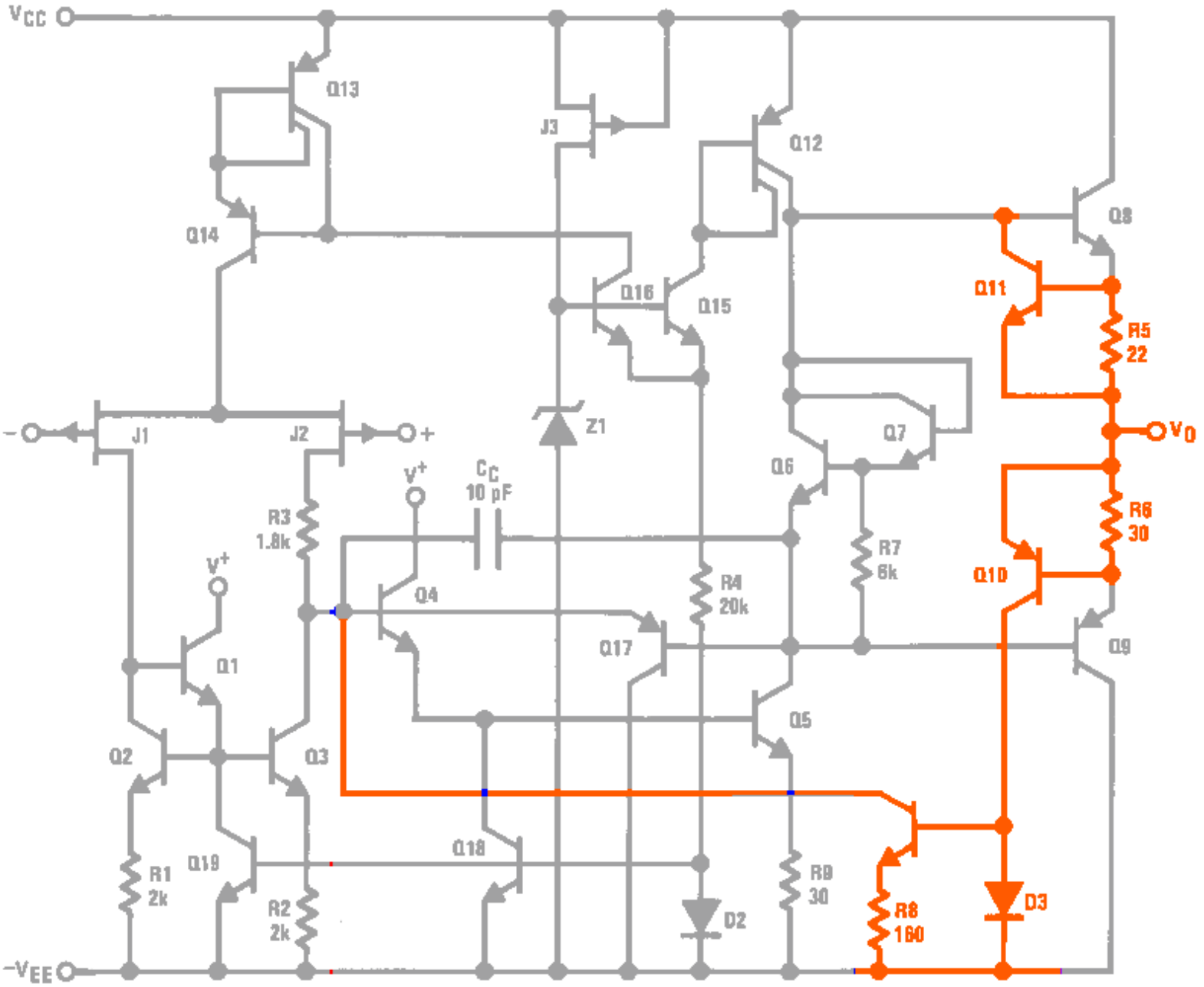
LF347: 2nd stage with pole splitting



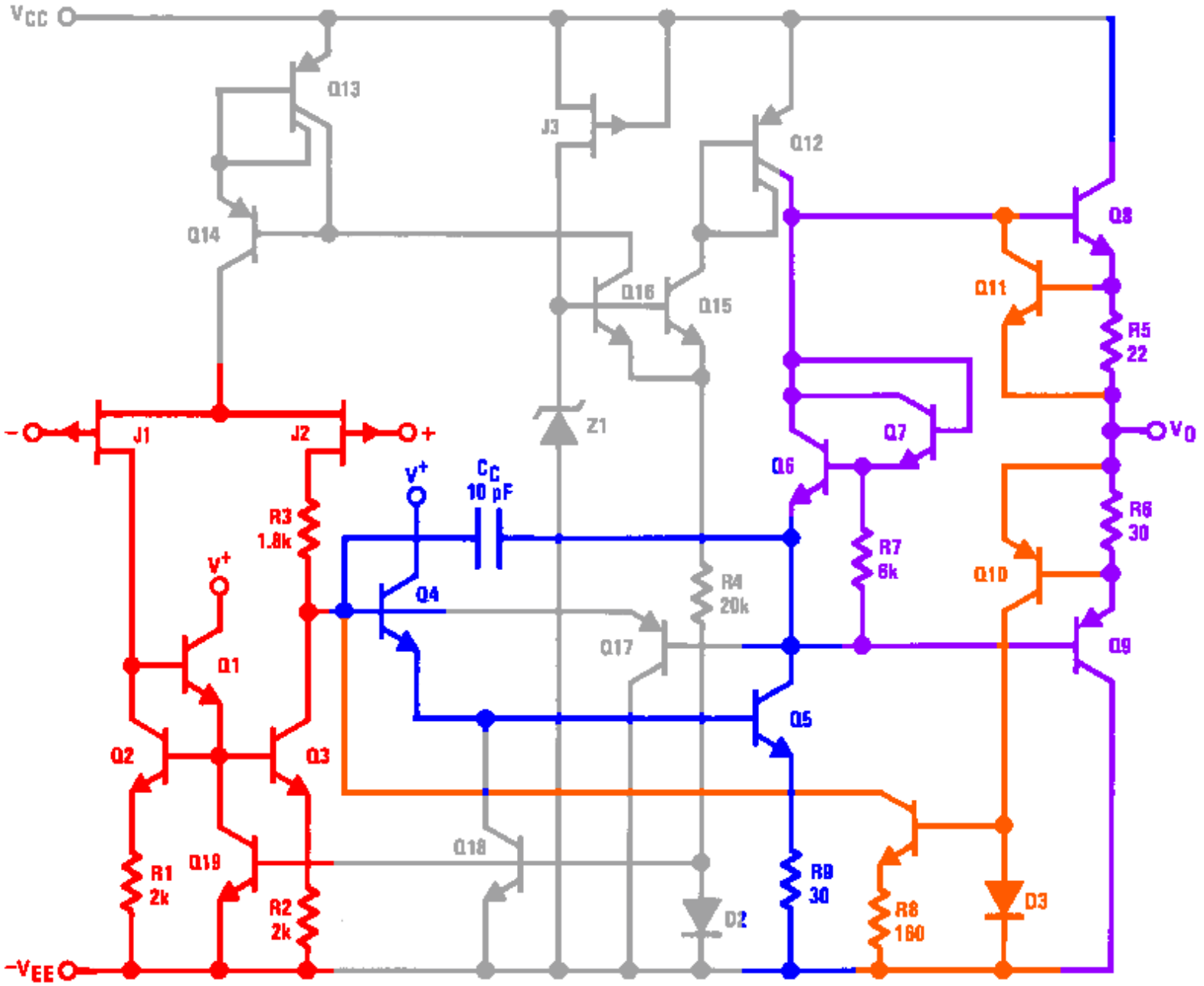
LF347: Class AB output buffer



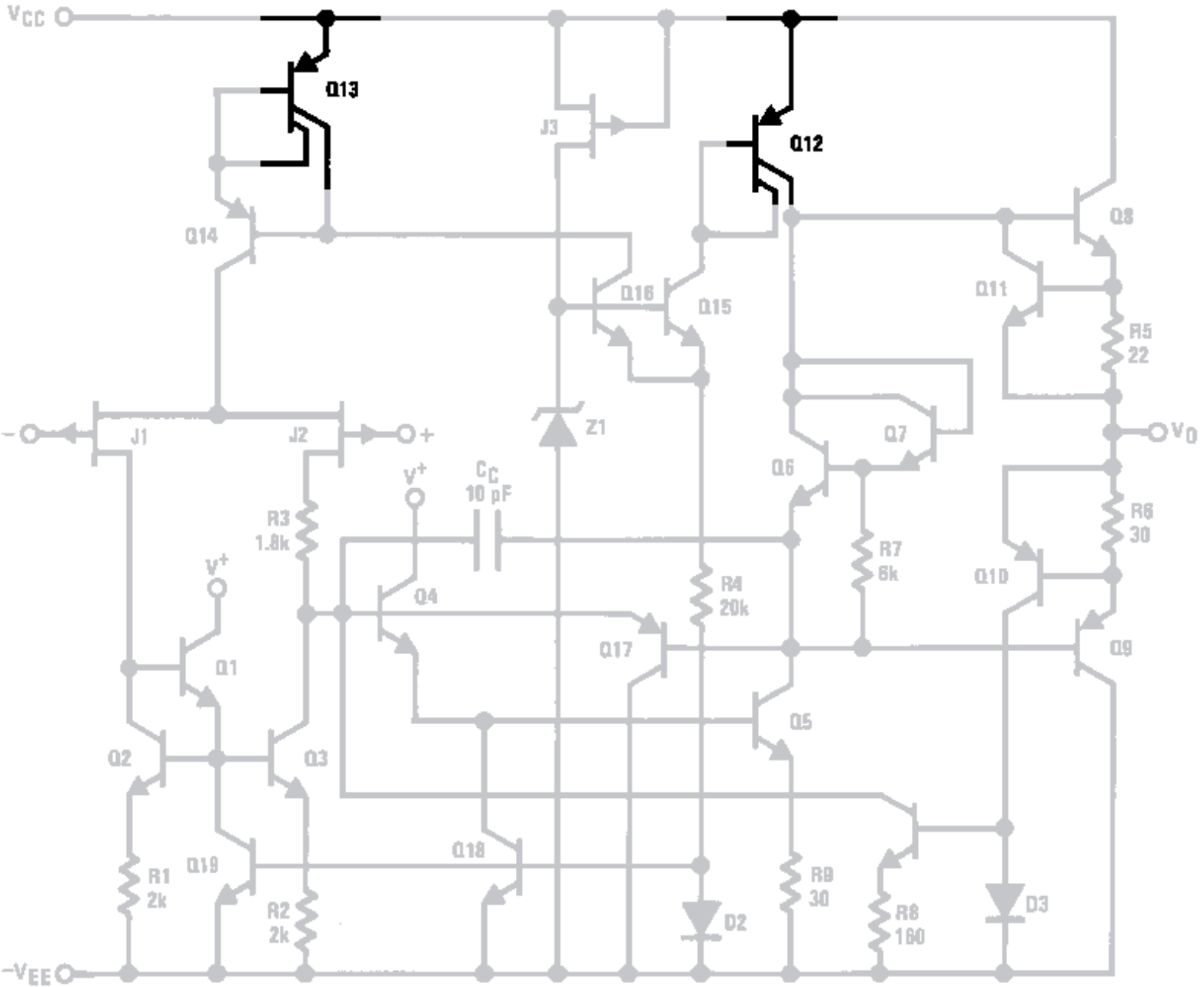
LF347: Overload protection



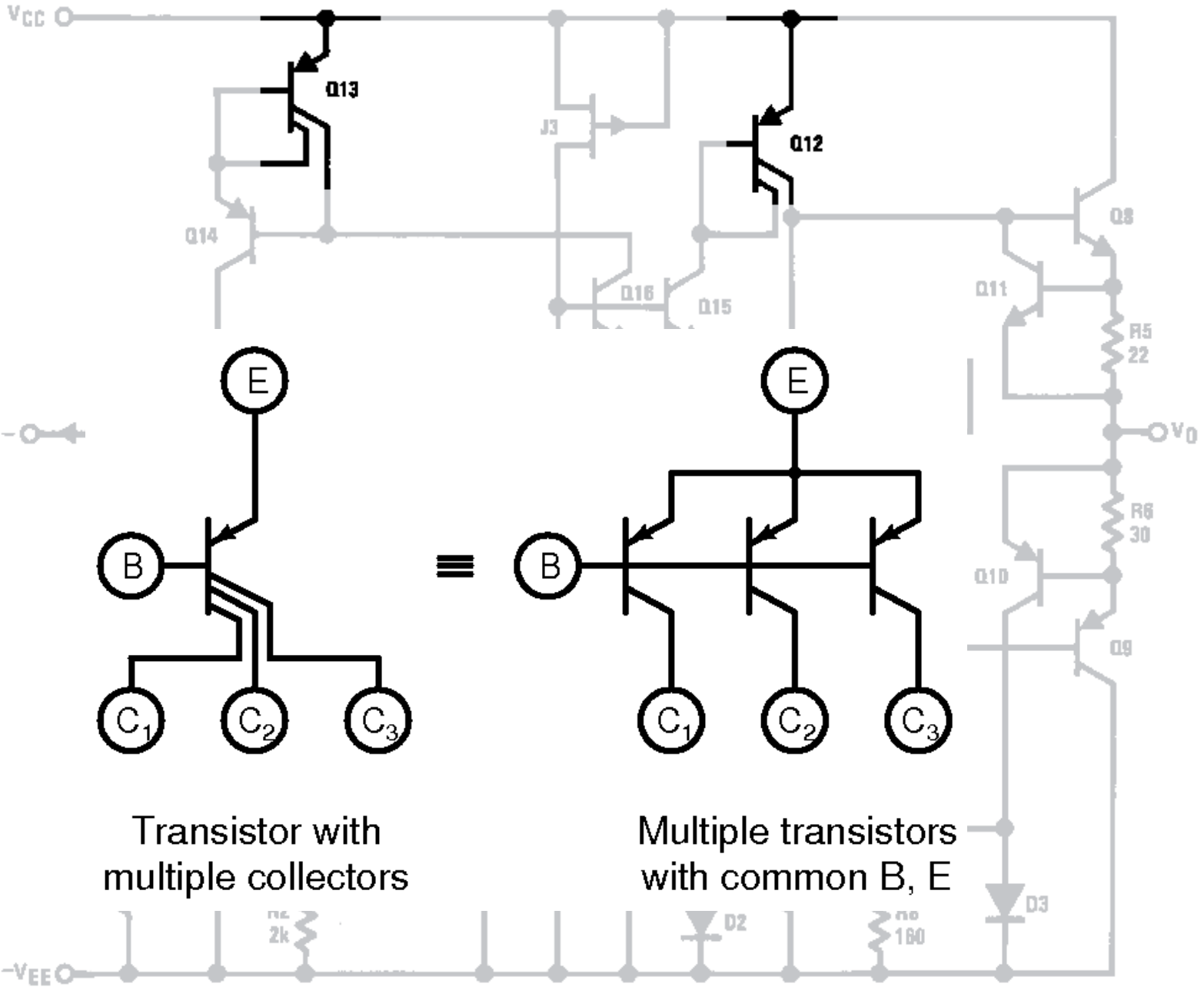
LF347: 2 stages + output buffer



LF347: Multi-collector transistors



LF347: Multi-collector transistors



LF356: JFET input opamp

LF155/LF156/LF256/LF257/LF355/LF356/LF357 JFET Input Operational Amplifiers

Check for Samples: LF155, LF156, LF355, LF356, LF357

FEATURES

Advantages

- **Replace Expensive Hybrid and Module FET Op Amps**
- **Rugged JFETs Allow Blow-Out Free Handling Compared with MOSFET Input Devices**
- **Excellent for Low Noise Applications Using Either High or Low Source Impedance—Very Low 1/f Corner**
- **Offset Adjust Does Not Degrade Drift or Common-Mode Rejection as in Most Monolithic Amplifiers**
- **New Output Stage Allows Use of Large Capacitive Loads (5,000 pF) without Stability Problems**
- **Internal Compensation and Large Differential Input Voltage Capability**

APPLICATIONS

- **Precision High Speed Integrators**
- **Fast D/A and A/D Converters**
- **High Impedance Buffers**
- **Wideband, Low Noise, Low Drift Amplifiers**
- **Logarithmic Amplifiers**
- **Photocell Amplifiers**
- **Sample and Hold Circuits**

DESCRIPTION

These are the first monolithic JFET input operational amplifiers to incorporate well matched, high voltage JFETs on the same chip with standard bipolar transistors (BI-FET™ Technology). These amplifiers feature low input bias and offset currents/low offset voltage and offset voltage drift, coupled with offset adjust which does not degrade drift or common-mode rejection. The devices are also designed for high slew rate, wide bandwidth, extremely fast settling time, low voltage and current noise and a low 1/f noise corner.

Common Features

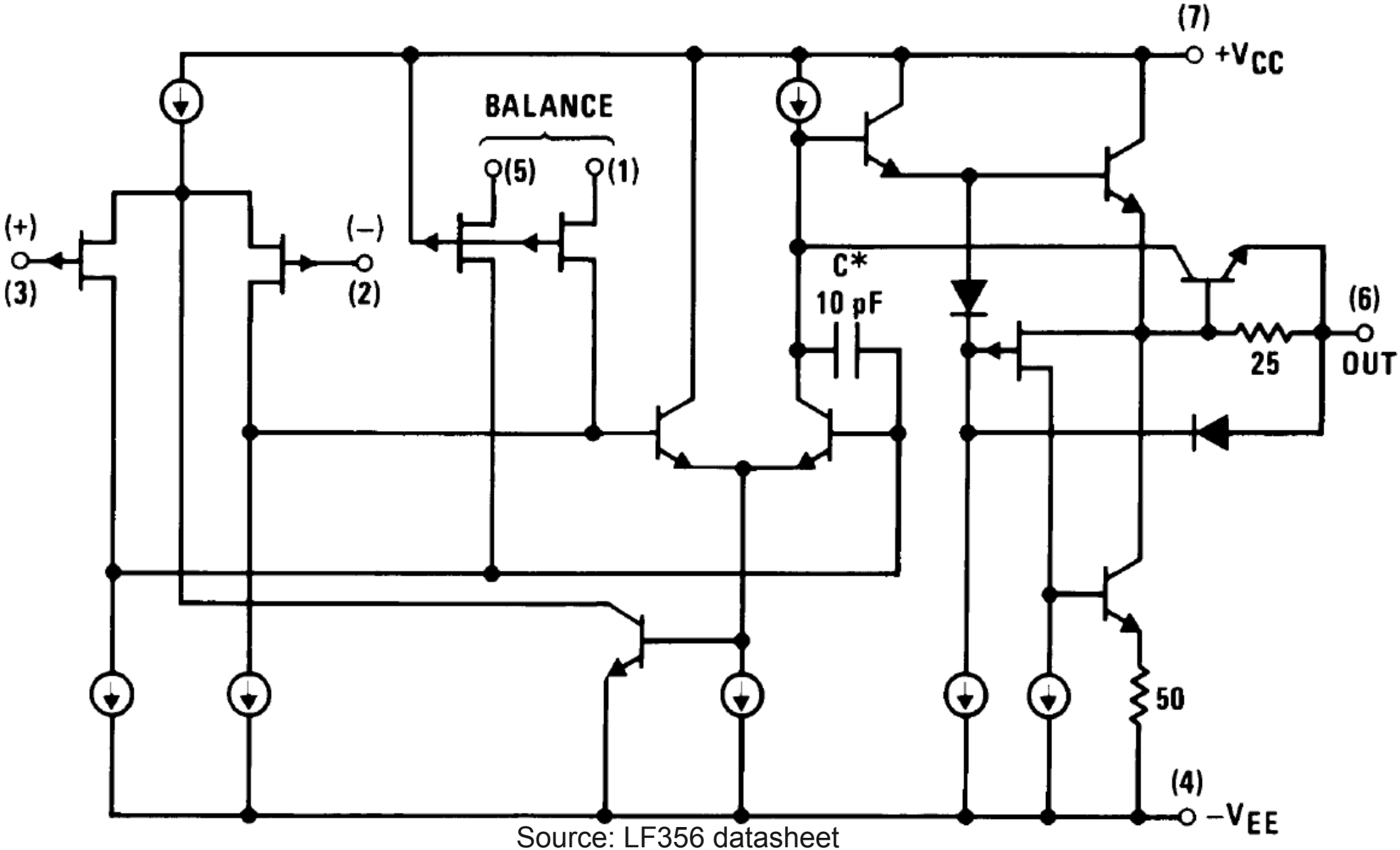
- Low Input Bias Current: 30pA
- Low Input Offset Current: 3pA
- High Input Impedance: $10^{12}\Omega$
- Low Input Noise Current: 0.01 pA/$\sqrt{Hz}$
- High Common-Mode Rejection Ratio: 100 dB
- Large DC Voltage Gain: 106 dB

Table 1. Uncommon Features

	LF155/ LF355	LF156/ LF256/ LF356	LF257/ LF357 (A_V=5)	Units
Extremely fast settling time to 0.01%	4	1.5	1.5	µs
Fast slew rate	5	12	50	V/µs
Wide gain bandwidth	2.5	5	20	MHz
Low input noise voltage	20	12	12	nV / $\sqrt{Hz}$

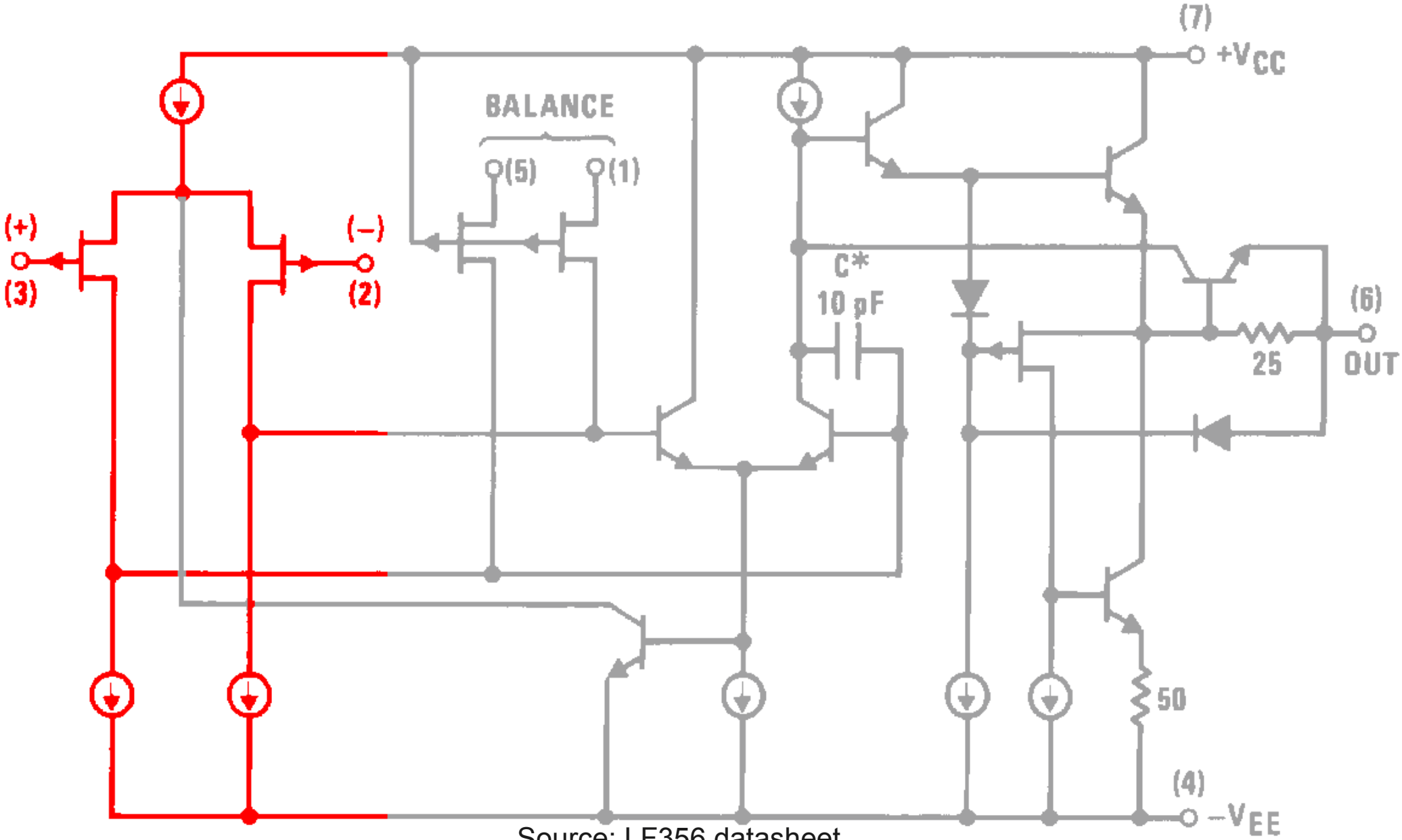
Source: LF356 datasheet

LF356: Simplified schematic



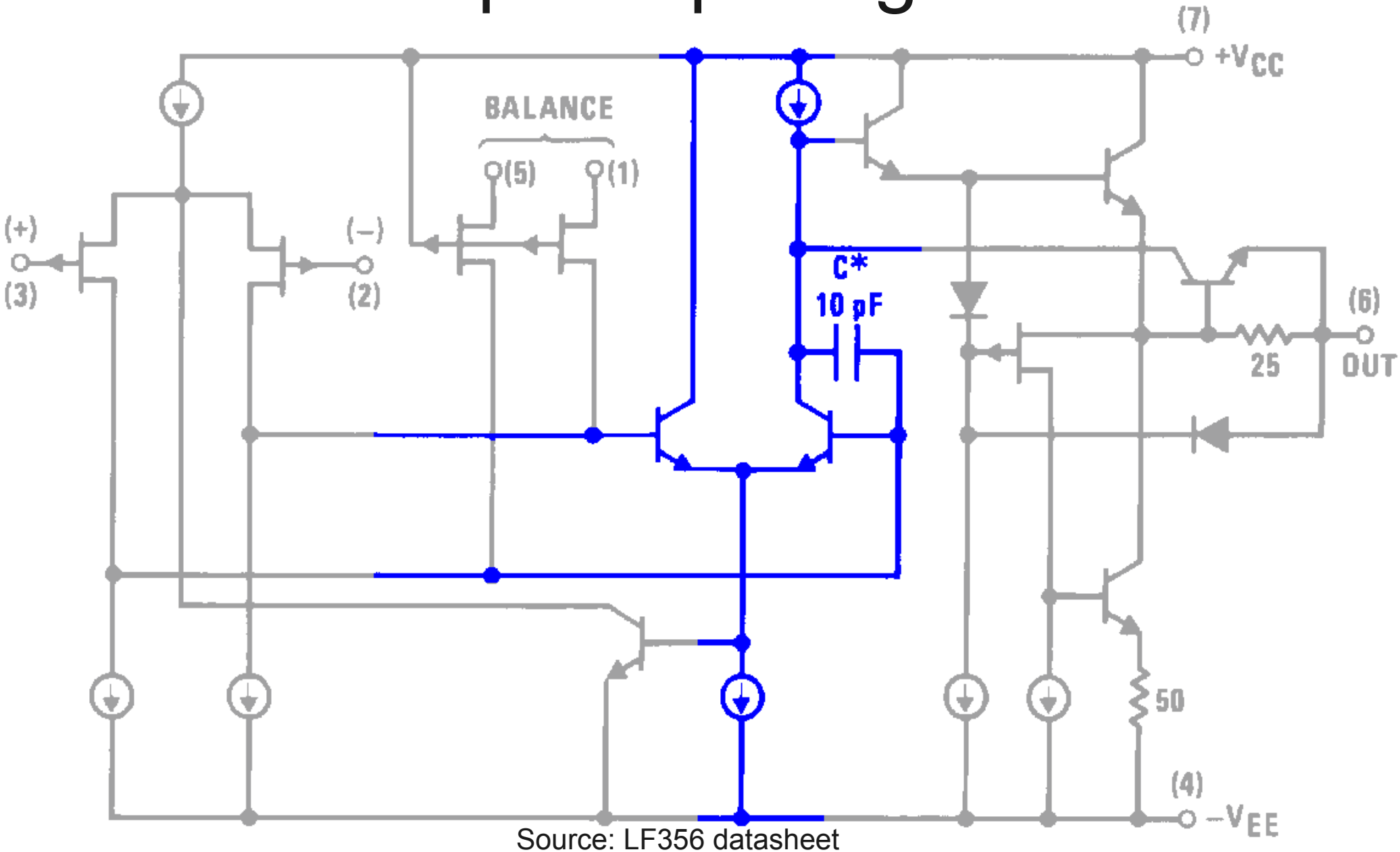
Source: LF356 datasheet

LF356: Input differential pair



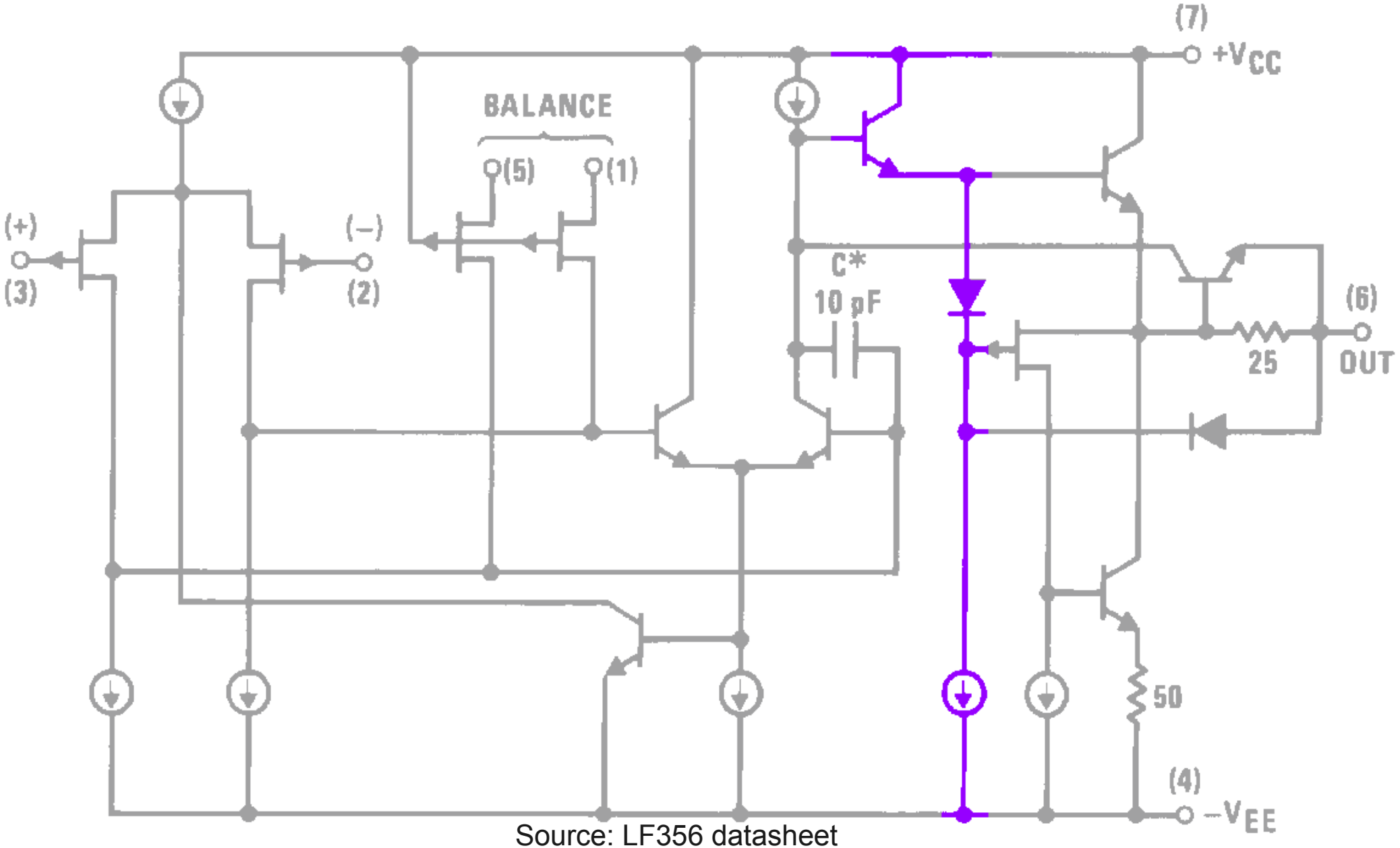
Source: LF356 datasheet

LF356: 2nd stage differential pair + pole splitting



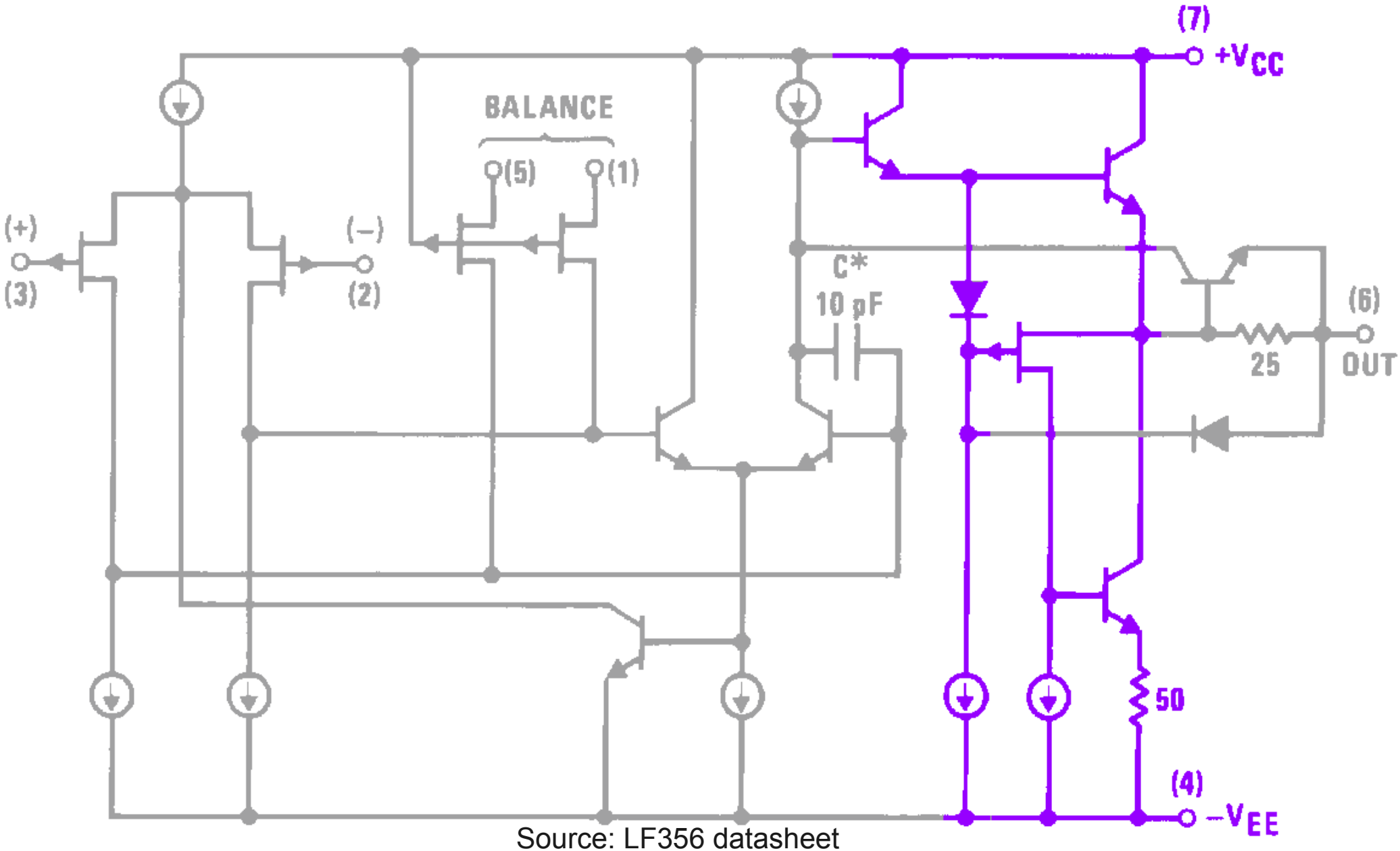
Source: LF356 datasheet

LF356: Pre-buffer



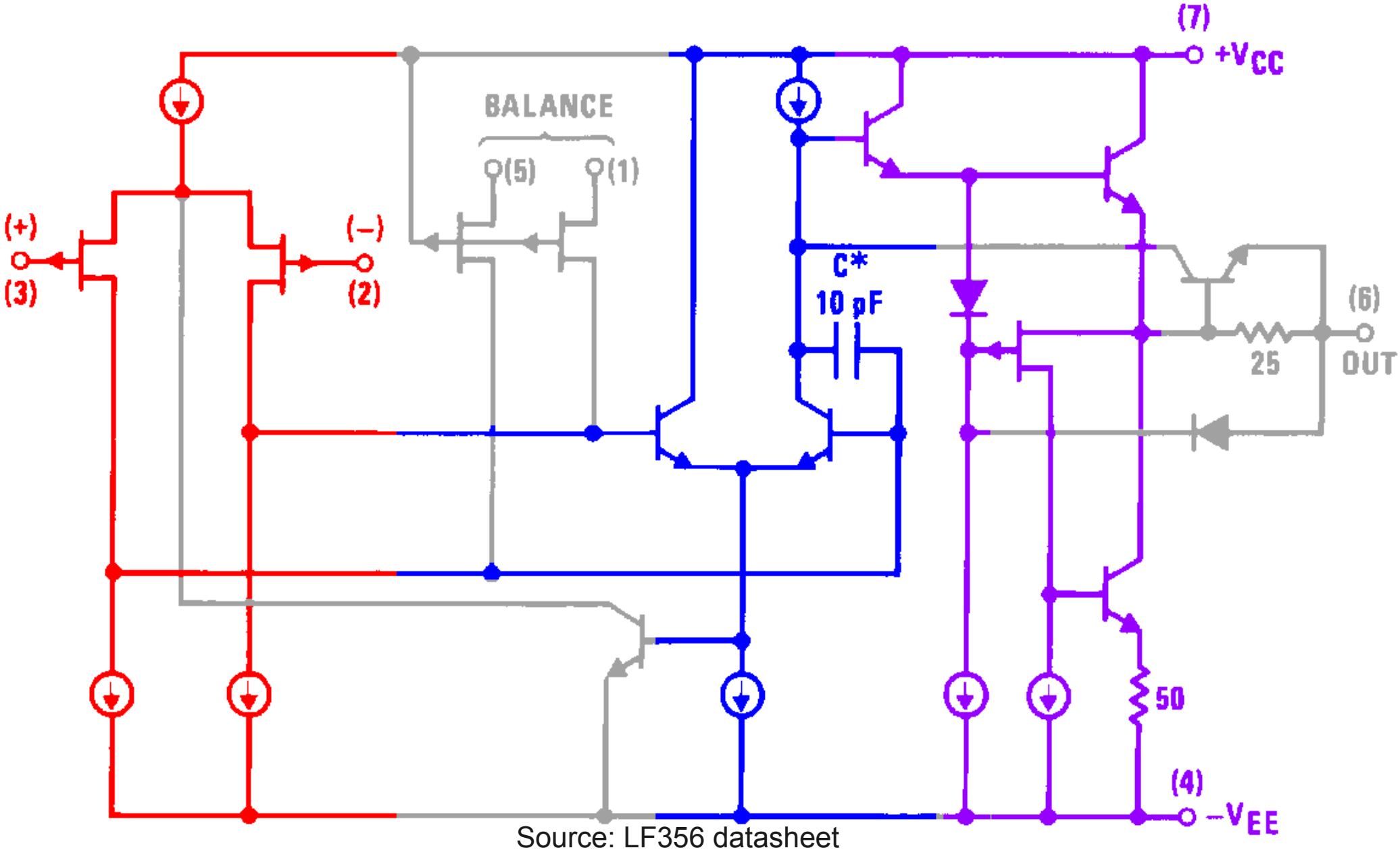
Source: LF356 datasheet

LF356: Pre-buffer + Output buffer



Source: LF356 datasheet

LF356: 2 stages + output buffer



Source: LF356 datasheet

Things to do

- Read and understand opamp data sheets
- Read and understand opamp schematics
- Calculate g_m, R_i, R_o, ω_u etc.
  - Possible at least for purely BJT stages
  - Bias current is the only significant variable
  - Assume some β(say 100)
- Correlate stage properties with data sheet values
  - e.g. signal swing limits, input current etc.