# Simulation SPICE Models for Comlinear's Op Amps

National Semiconductor
OA-18
May 2000

National Semiconductor Corporation is a manufacturer and supplier of high-performance analog signal processing components. National's broad signal conditioning product line includes high-speed hybrid and monolithic operational amplifiers, buffers, video amplifiers, multiplexers, automatic gain control integrated circuits, track/hold amplifiers, and analog-to-digital converters. National continues as a leader in developing products offering exceptional performance, speed, quality, reliability and service.

## Introduction

This is a collection of PSpice compatible models for National Semiconductor Corporation amplifiers. For additional information about SPICE Models supporting existing or new products, customers can visit National's web site at *http://www.national.com*. These SPICE Models are created for use on an IBM compatible computer using analysis programs that accept Spice formats. National assumes no responsibility for designs created from these SPICE Models. These SPICE Model files model typical performance at room temperature. AC response is dominated by board layout and package parasitics at frequencies above 500MHz. Before designs are released to production, National suggests that topologies be verified by prototyping the circuit. The part-to-part and over-temperature performance variations of National amplifiers are specified in current data sheets found on National's web site. The changes from the last SPICE Model version are listed in this table:

**TABLE 1. Updates to Spice Models**

| File Name | Description |
|---|---|
| CLC405.CIR | A new SPICE Model. |
| CLC406.CIR | A revised SPICE Model. |
| CLC407.CIR | A new SPICE Model. |
| CLC412.CIR | A new SPICE Model. |
| CLC430.CIR | A revised SPICE Model that improves disabled output response. |
| CLC440.CIR | A new SPICE Model. |
| CLC449.CIR | A new SPICE Model. |
| CLC450.MOD | A new SPICE Model. |

**TABLE 2. Spice Model Subcircuit Files**

| File Name | Description |
|---|---|
| CLC109.CIR | A Low-Power, Wideband, Closed-Loop Buffer. |
| CLC111.CIR | A Very Wideband, Ultra-High Slew Rate, Closed-Loop Buffer. |
| CLC400.CIR | A Wideband, Low-Gain Monolithic Current Feedback Op Amp with Fast Settling (0.05% in 12 ns), Low Power, and an Input Offset Adjustment Pin. |
| CLC401.CIR | A Wideband, High-Gain Monolithic Current Feedback Op Amp with Fast Settling (0.01% in 10 ns) and Low Power. |
| CLC402.CIR | A Low-Gain Monolithic Current Feedback Op Amp with Fast 14-bit Settling (0.0025% in 25 ns) and Low Power. |
| CLC404.CIR | A Wideband Monolithic Current Feedback Op Amp with High Slew Rate. |
| CLC405.CIR | A Low-Cost, Low Power, and 110 MHz Op Amp with Disable. |
| CLC406.CIR | A Wideband, Low-Cost, Low-Power Monolithic Current Feedback Op Amp. |
| CLC407.CIR | A Low-Cost, Low Power, Programmable Gain Buffer with Disable. |
| CLC409.CIR | A Very Wideband, Low Distortion Monolithic Current Feedback Op Amp. |
| CLC410.CIR | A Video Monolithic Current Feedback Op Amp with disable, Fast Settling (0.05% in 12 ns) and an Input Offset Adjust Pin. |
| CLC412.CIR | A Dual Wideband Video Op Amp. |
| CLC414.CIR | A Quad, Low-Power Monolithic Current-Feedback Op Amp. |
| CLC415.CIR | A Quad Wideband Monolithic Current Feedback Op Amp. |
| CLC420.CIR | A High-Speed, Unity Gain Stable Monolithic Voltage Feedback Op Amp. |
| CLC425.CIR | An Ultra Low-Noise, Wideband Monolithic Voltage Feedback Op Amp with Current Supply Adjust. |
| CLC426.CIR | An Ultra Low-Noise, Wideband Monolithic Voltage Feedback Op Amp with Current Supply Adjust and External Compensation. |
| CLC428.CIR | An Ultra Low-Noise, Wideband, Dual Monolithic Voltage Feedback Op Amp. |
| CLC430.CIR | A Wideband Monolithic Current Feedback Op Amp with disable and ±5V to ±15V supply capability. |
| CLC431.CIR | A Dual, Wideband Monolithic Current Feedback Op Amp with High Slew Rate. |
| CLC432.CIR | A Dual, Wideband Monolithic Current Feedback Op Amp with Disable and ±5V to ±15V Supply Capability. |



## Introduction (Continued)

**TABLE 2. Spice Model Subcircuit Files** (Continued)

| File Name | Description |
|---|---|
| CLC440.CIR | A High-Speed, Low-Power Voltage Feedback Op Amp. |
| CLC449.CIR | A 1.2 GHz Ultra-Wideband Monolithic Op Amp. |
| CLC450.MOD | A Single Supply, Low Power, High Output, Current Feedback Amplifier. |
| CLC501.CIR | A High-Speed Output Clamping Monolithic Current Feedback Op Amp for High Gains. |
| CLC502.CIR | A High-Speed Output Clamping Monolithic Current Feedback Op Amp with Fast 14-bit Settling (0.0025% in 25 ns) for Low Gain. |
| CLC505.CIR | A High-Speed, Programmable-Supply Current, Monolithic Current Feedback Op Amp. |
| CLC520.CIR | A Monolithic Amplifier with Voltage Controlled Gain (AGC). |
| CLC522.CIR | A Monolithic Wideband Variable Gain Amplifier. |
| CLC532.CIR | A High-Speed, 2:1 Analog Multiplexer with fast 12-bit settling (0.01% in 17 ns), Low Noise, Low Distortion, and Adjustable Noise Bandwidth. |
| CLC5644.CIR | A Quad, Low-Power Monolithic Current-Feedback Op Amp. |
| CLC5655.CIR | A Quad Wideband Monolithic Current Feedback Op Amp. |
| CLC5665.CIR | A Wideband Monolithic Current Feedback Op Amp with Disable and ±5V to ±15V Supply Capability. |
| CLC5801.CIR | An Ultra Low-Noise, Wideband Monolithic Voltage Feedback Op Amp with Current Supply Adjust. |
| CLC5802.CIR | An Ultra Low-Noise, Wideband, Dual Monolithic Voltage Feedback Op Amp. |

## Start Up Instructions

Download all SPICE Model files of interest to a library on the hard disk. If the library directory is not in the SPICE program's path, the user should set that path in the autoexec-.bat for easier excess. The .INC statement in PSpice should be used in the simulation file to include the SPICE Models subcircuit.

Example: ".INC CLC400.CIR"

## Amplifier Spice Models

These SPICE Model files are written in ASCII file format for IBM-compatible PC's. They are compatible with PSpice and other Spice 2G simulators. For additional detailed information about using PSpice please contact MicroSim (See Reference below). National amplifier SPICE Models are written in a subcircuit format for easy incorporation into larger circuits. A listing of any amplifier subcircuit may be obtained by printing its CLC*.CIR file to a local printer. The subcircuit node assignments match the device pin-outs as shown in the individual device data sheets. An example is an 8 pin op amp.

- Connections: NON-INVERTING INPUT PIN
- | INVERTING INPUT PIN
- | | OUTPUT
- | | | $+V_{CC}$
- | | | | $-V_{CC}$
- | | | | |
- .SUBCKT (NAME) 3 2 6 7 4

Some schematic capture software packages require a different pin connection other than what National uses. Changing the pin order in the .SUBCKT statement will not affect the SPICE Model performance.

## Performance Results

When substitutions of current feedback op amps are made for voltage feedback op amps, results may not be acceptable. Refer to National 's application note OA-13 for a tutorial on current feedback op amp design.

## Parameters Modeled

The following typical performance parameters are modeled by the SPICE Models.

**DC EFFECTS**

- VIO, IBI, IBN
- Supply current vs. supply voltages
- Common mode input/output voltage range
- Load current from supplies
- CMRR

**AC EFFECTS < 500 MHz**

- Frequency response vs. gain & load
- Open loop gain & phase
- Noise
- Small signal input/output impedance

**TIME DOMAIN**

- Rise/fall times
- Slew rates

**SPECIAL FEATURES (WHERE APPLICABLE)**

- Output clamping
- Supply current adjustment
- Offset voltage adjust
- Disable/enable times
- External compensation

## Parameters Not Modeled

- Differential gain and phase
- PSRR
- Harmonic distortion
- Fine scale settling performance
- Thermal tail

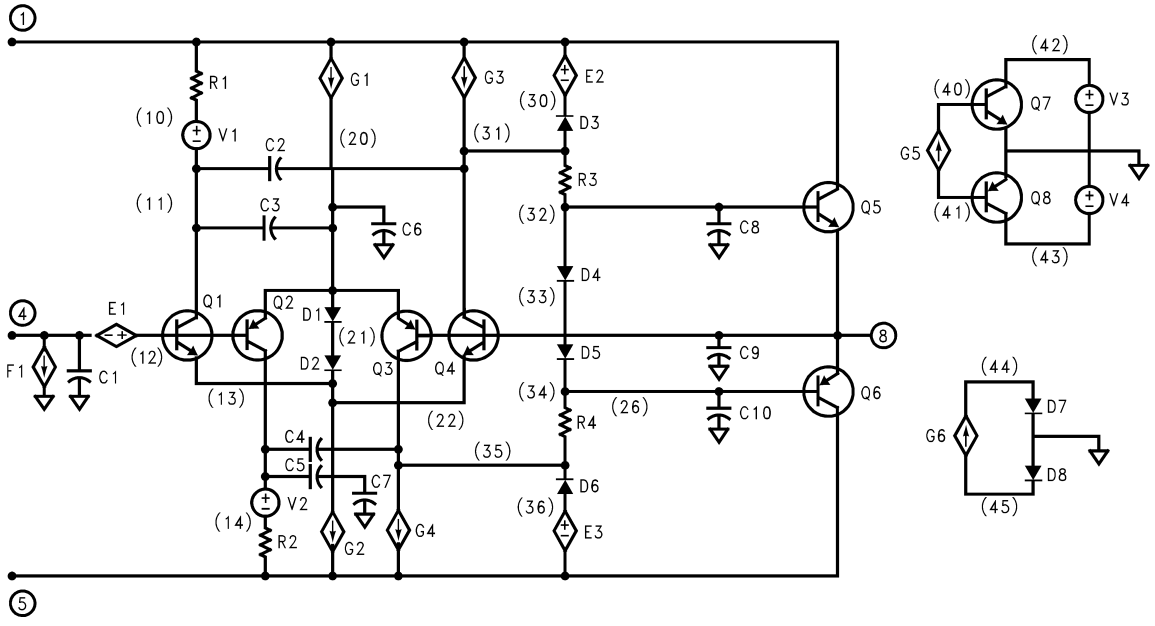
## Parameters Not Modeled (Continued)

- Overdrive recovery time (Except for the CLC501and the CLC502)
- Variation in performance vs. temperature
- Part-to-part performance variation

## Notice

**The information provided within these files and documents is believed to be reliable and correct. National assumes no responsibility for alterations, omissions or inaccuracies. National assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. National does not grant licenses or patent rights to any of the circuits described within this document.**

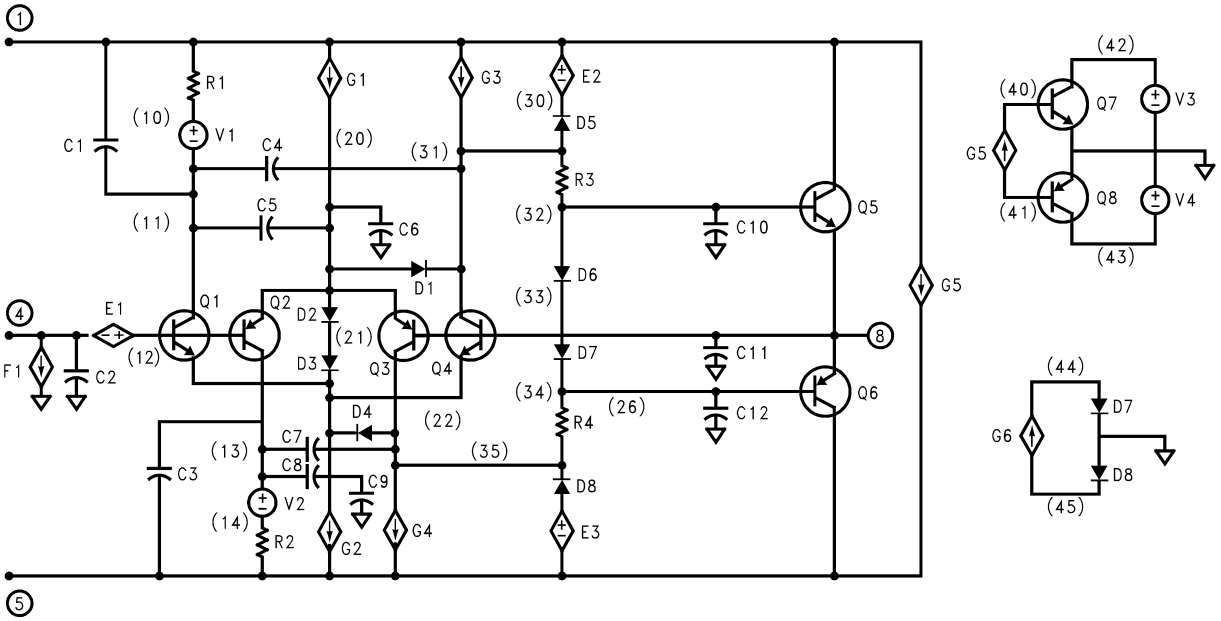
**CLC109**




01278401

**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

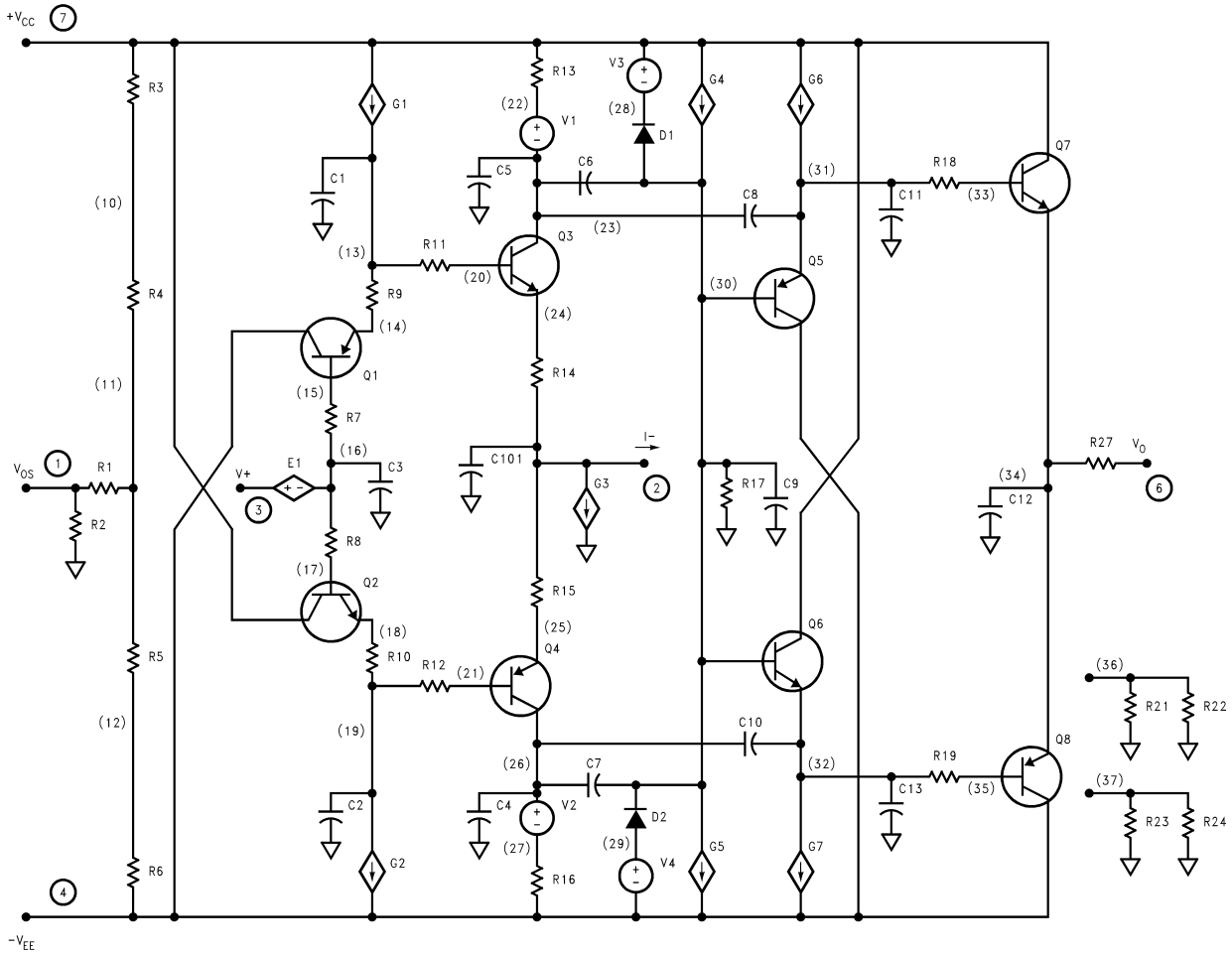
**CLC111**




01278402

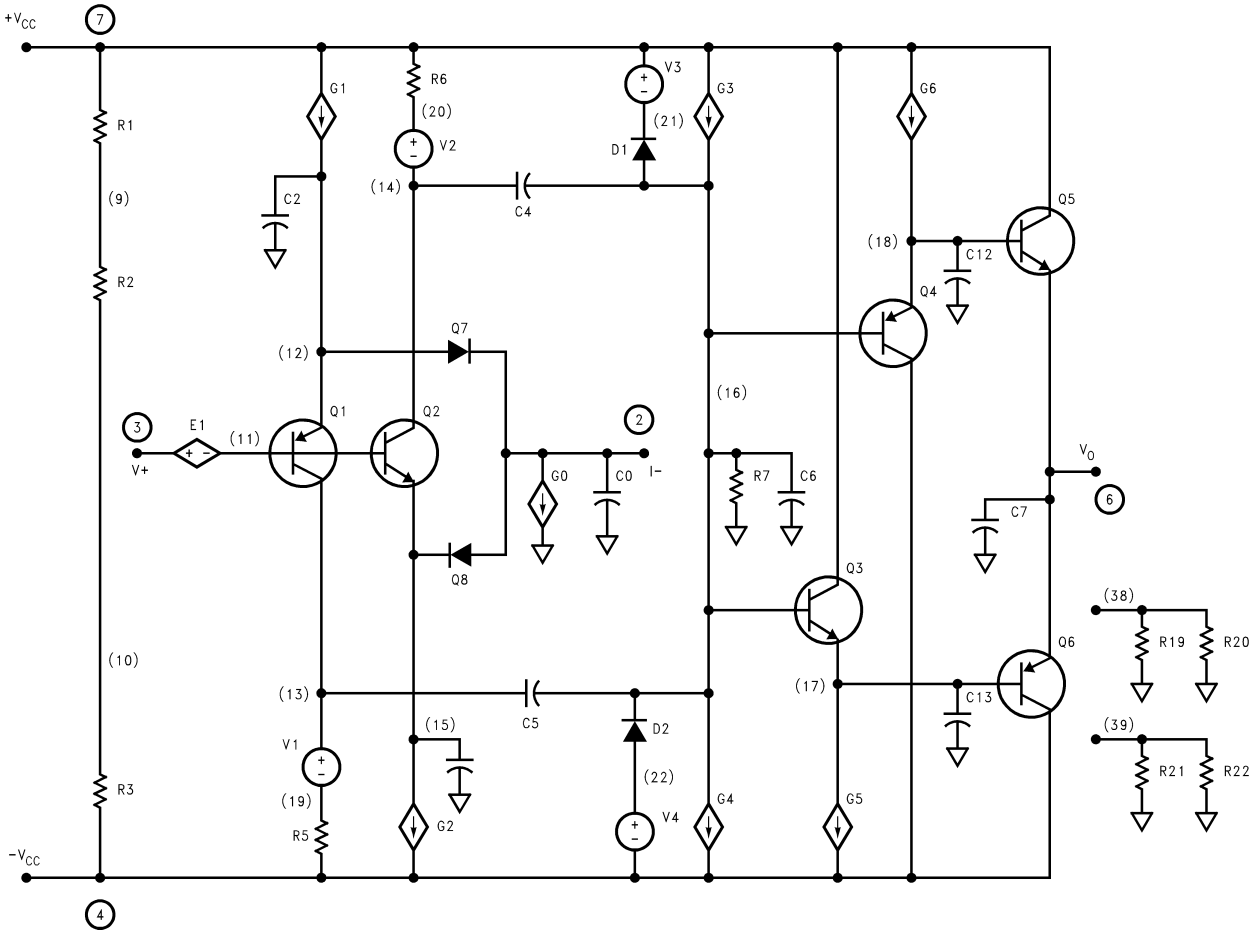
**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC400




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC401




01278404

**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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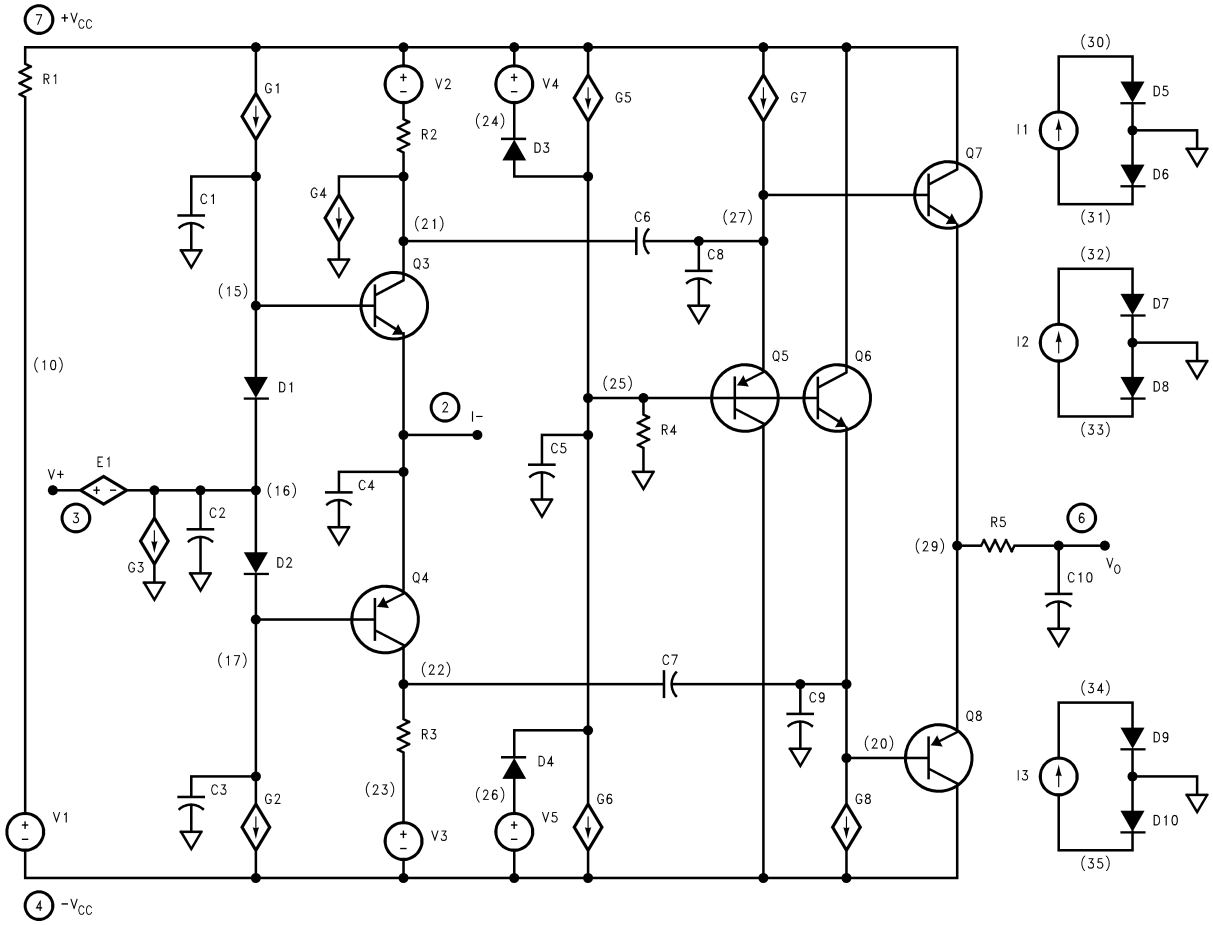
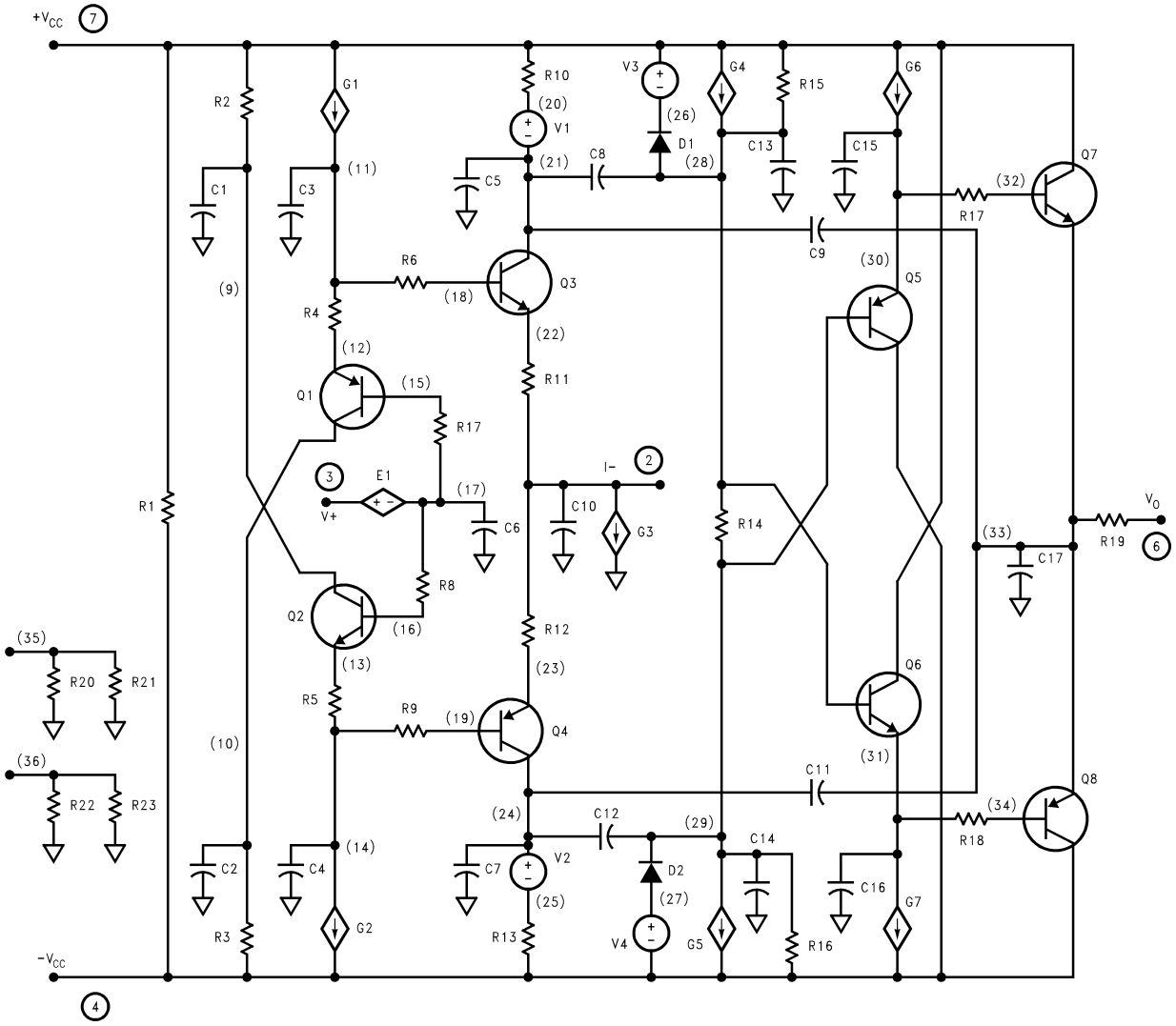



01278405

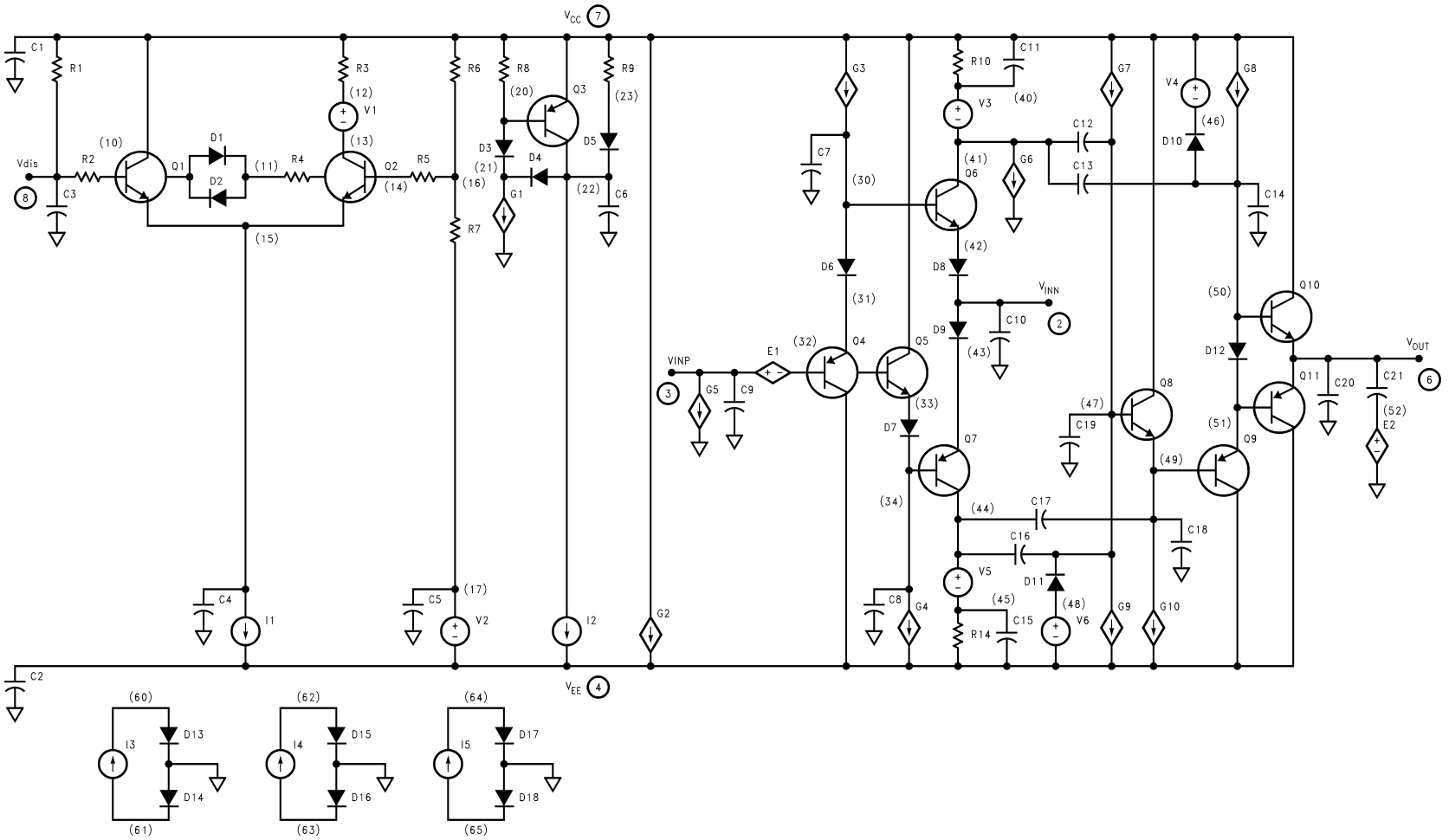
**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC404




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC405




01278407

**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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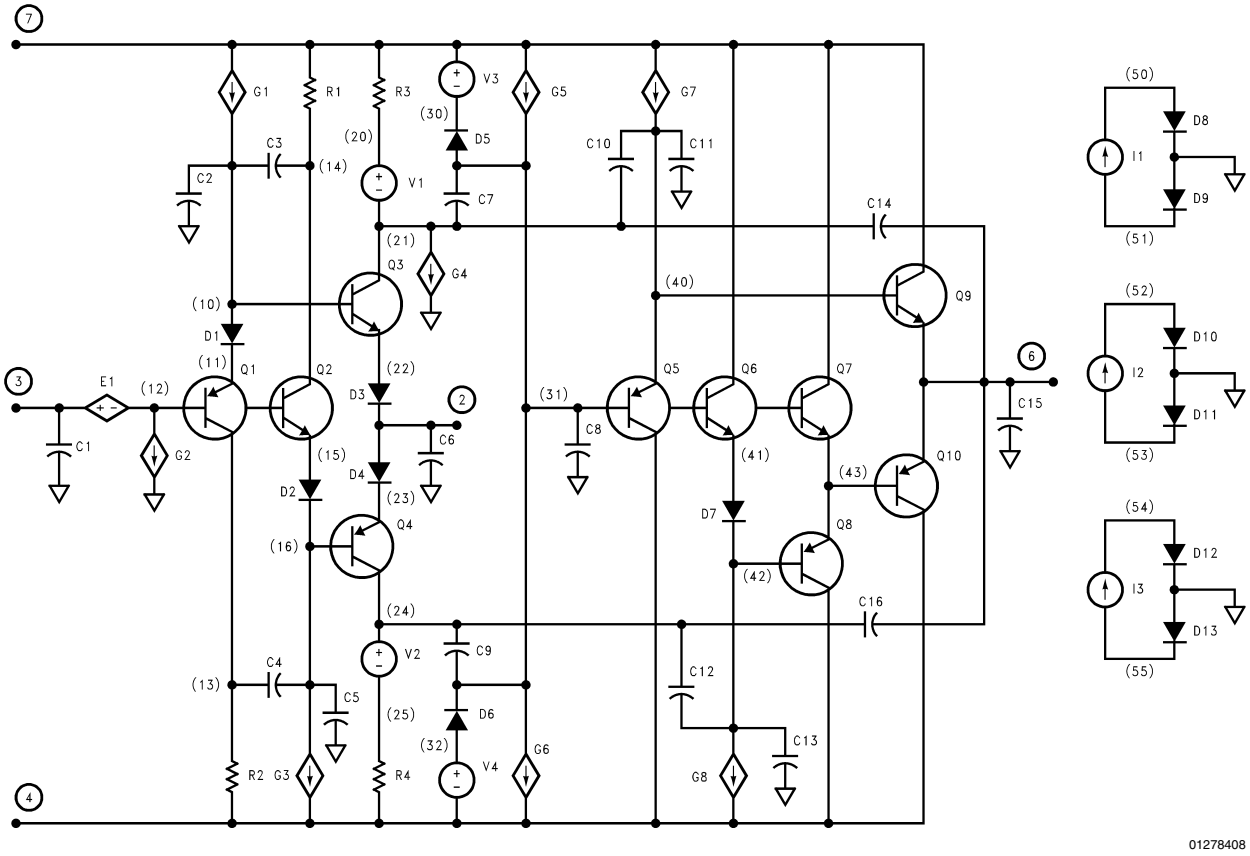
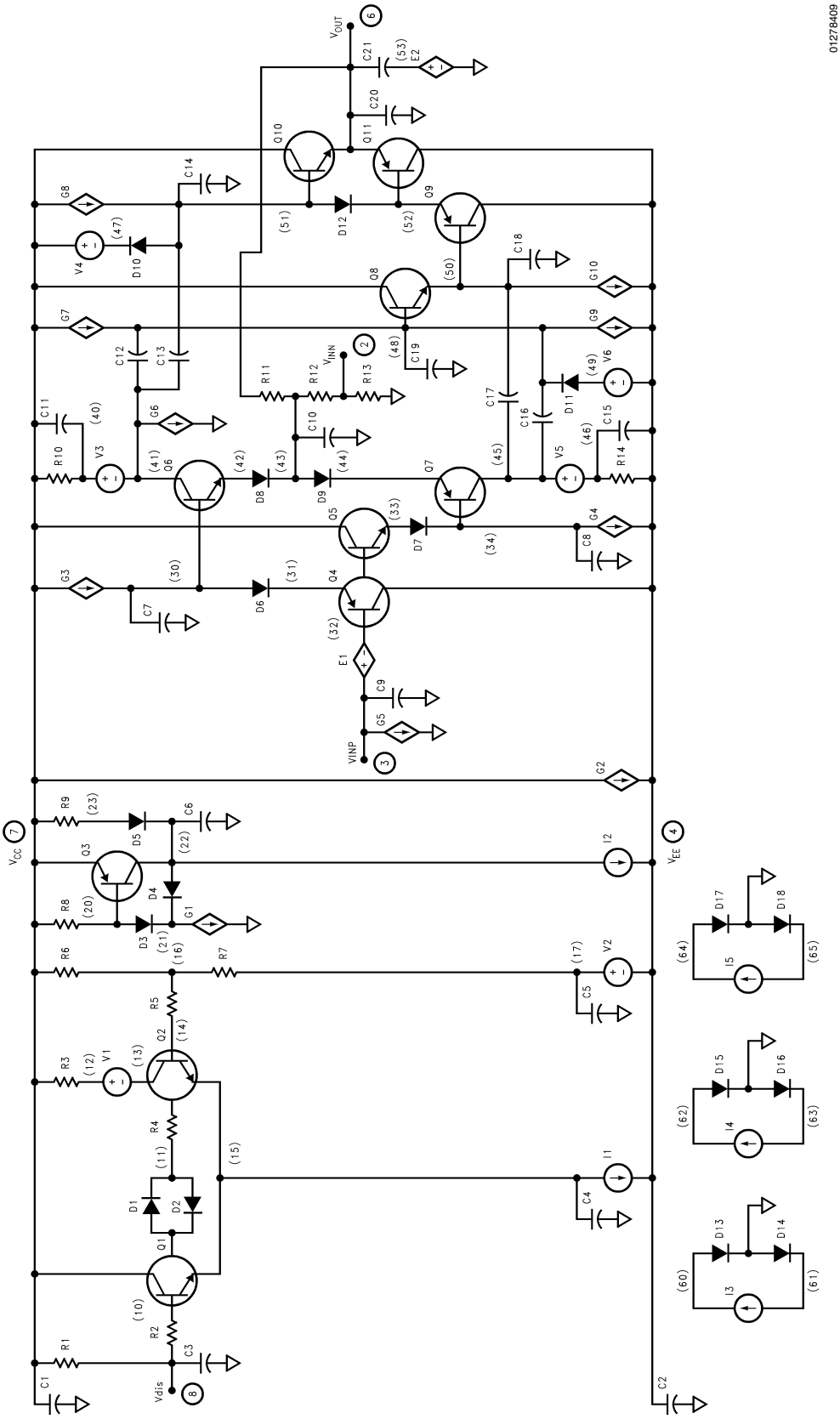



**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

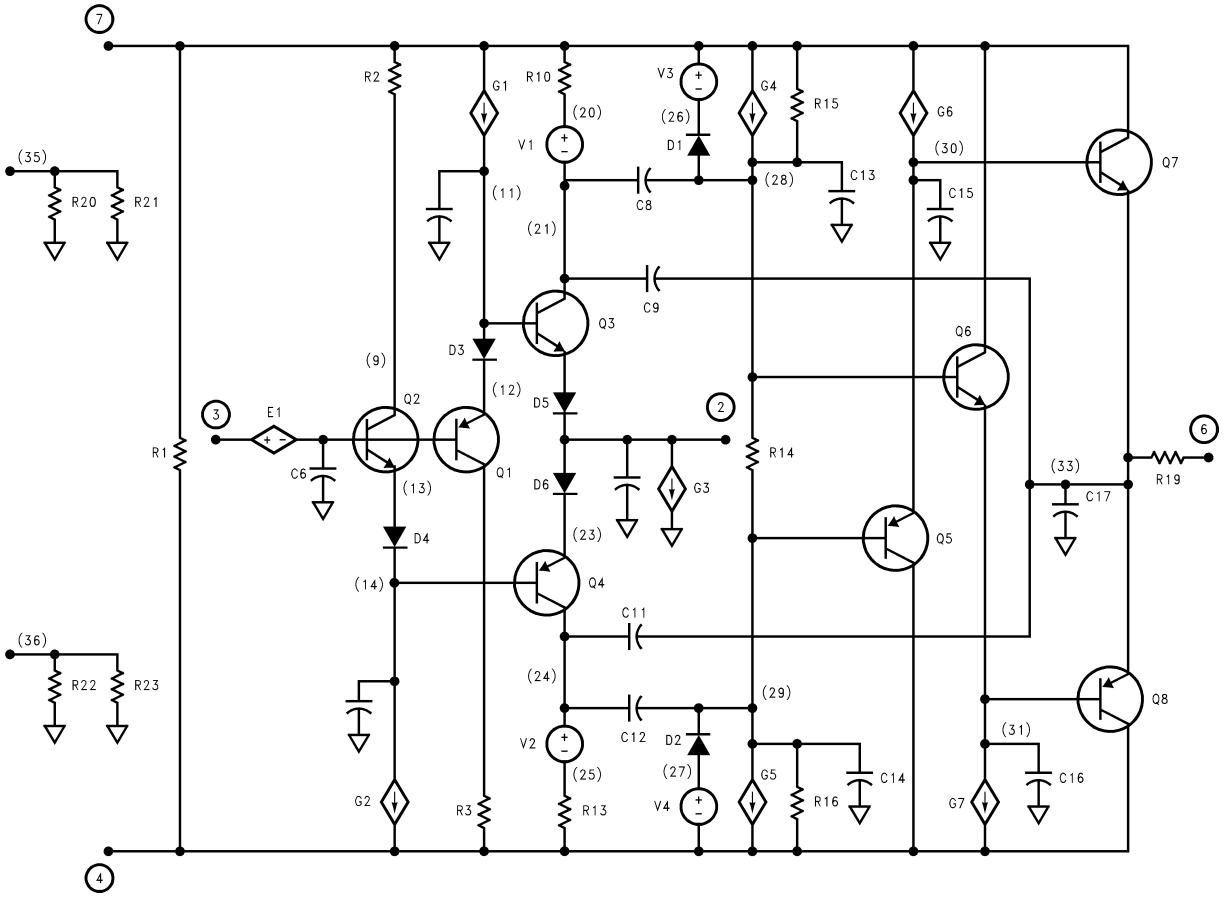
CLC407




01278409

**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC409




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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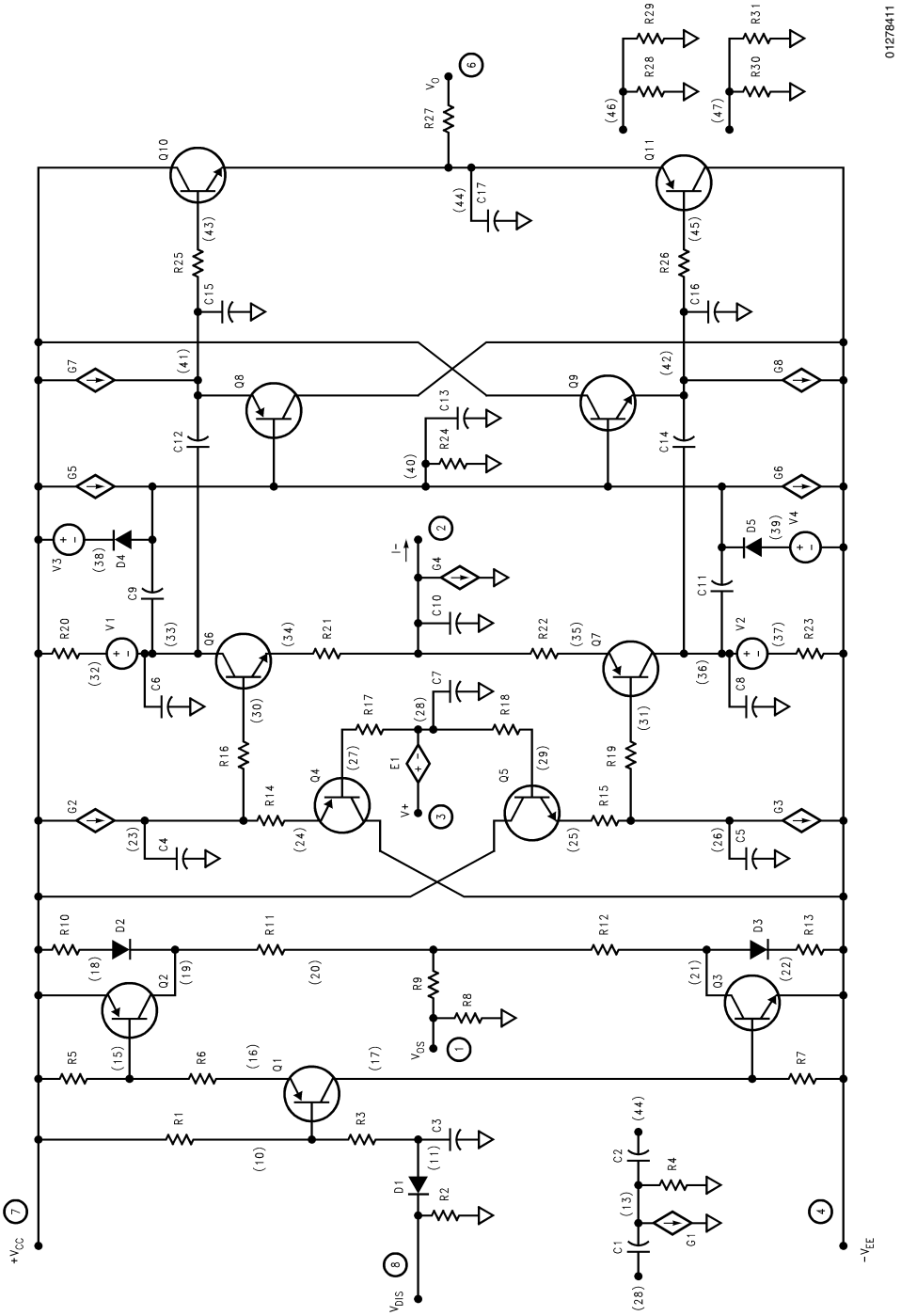


**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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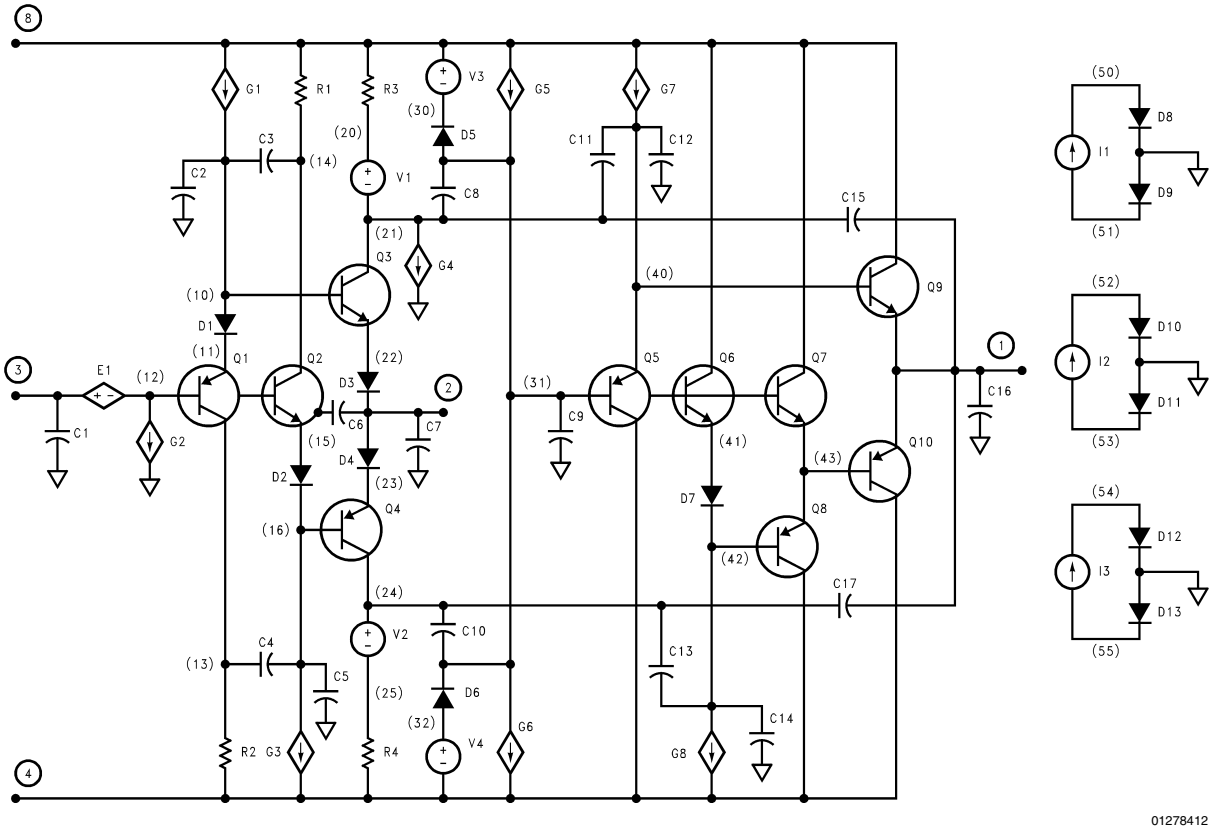


**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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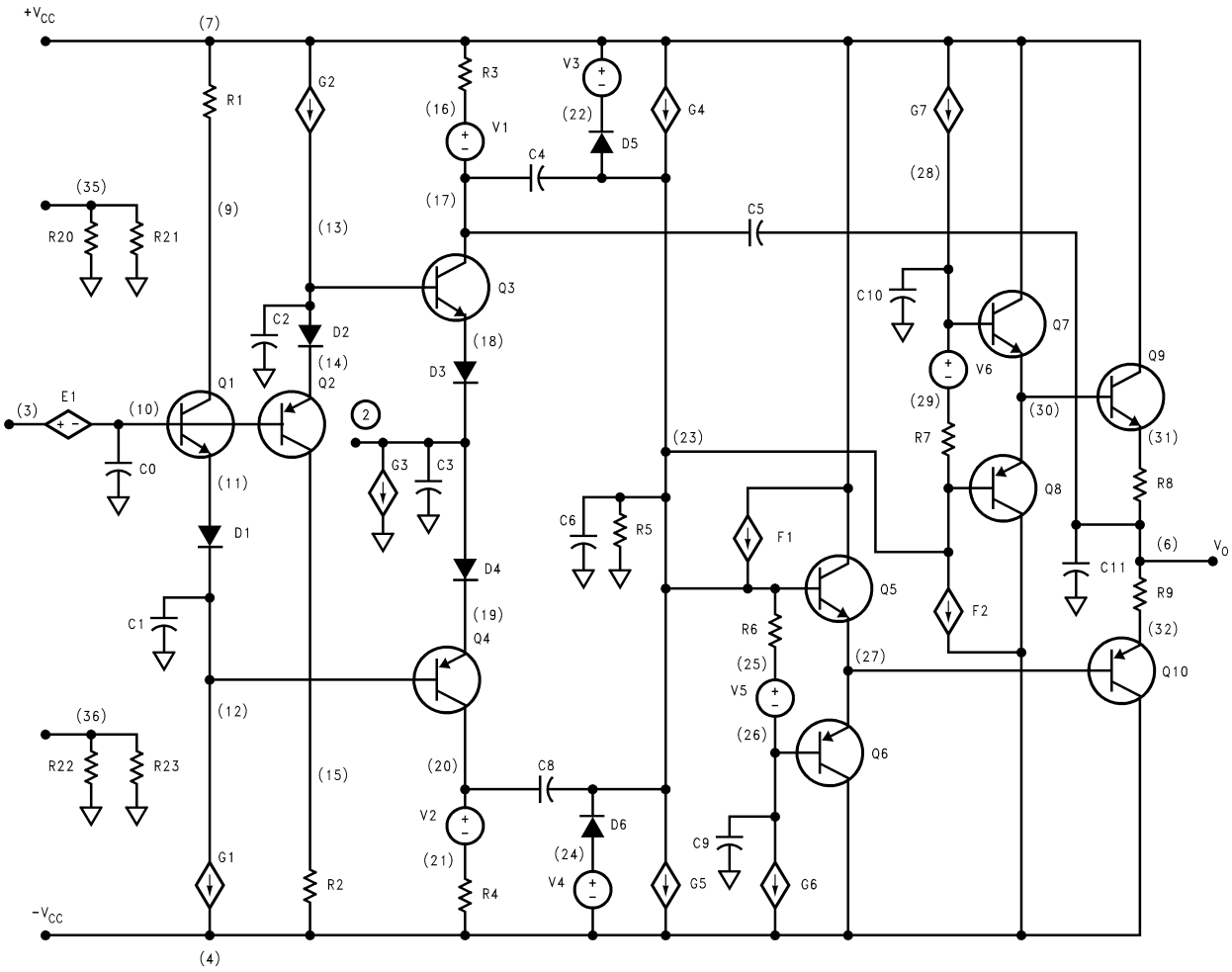


**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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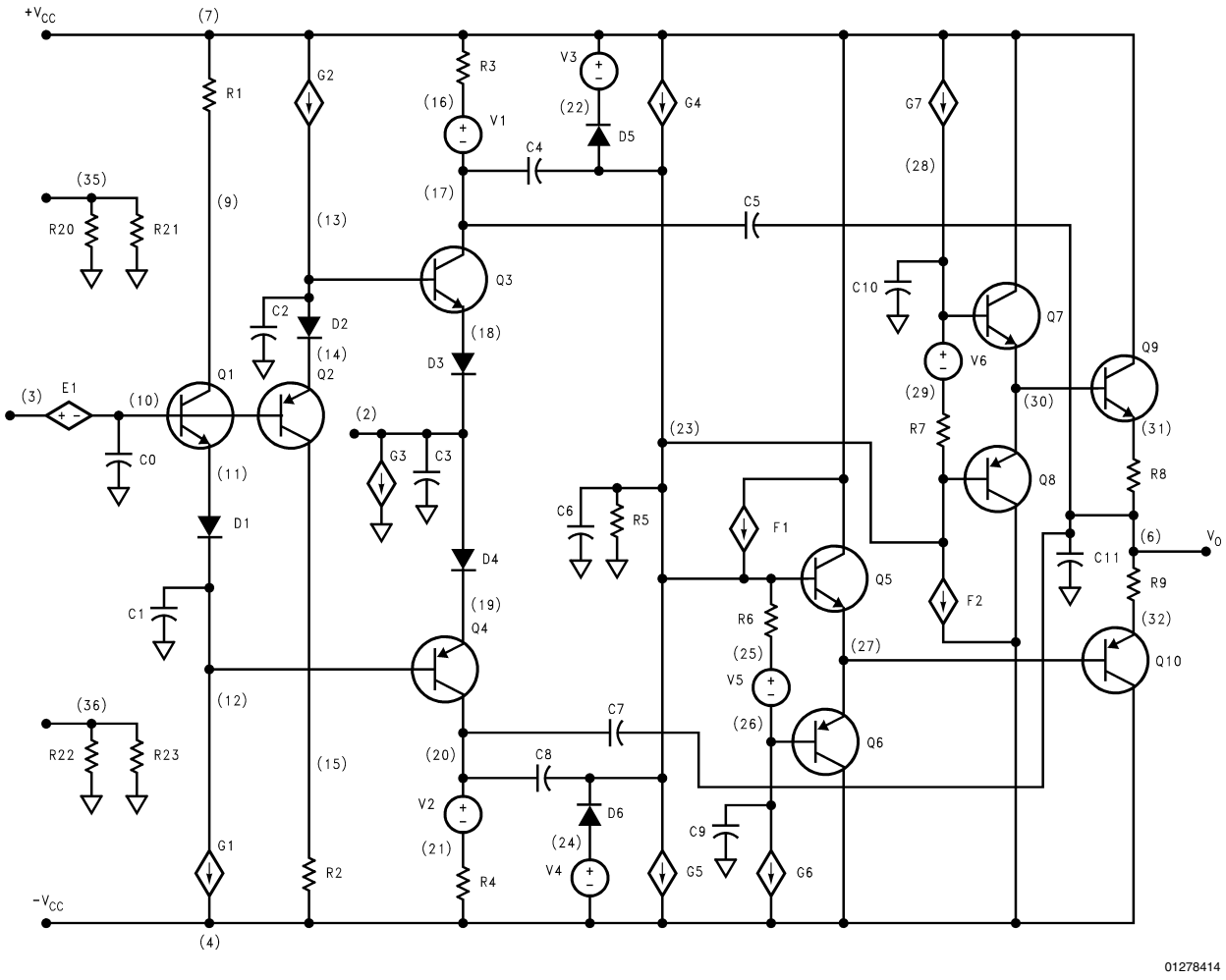
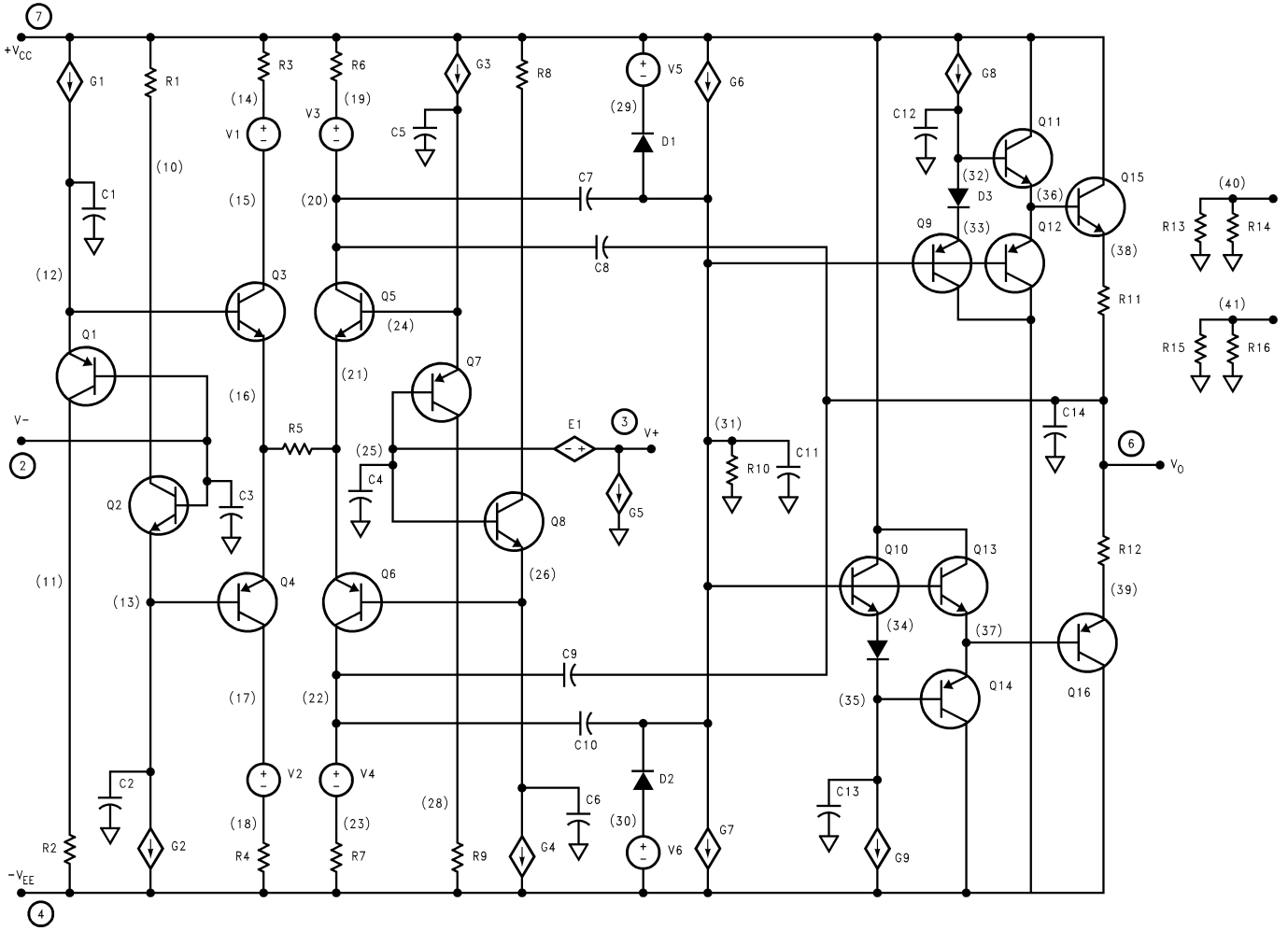



**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

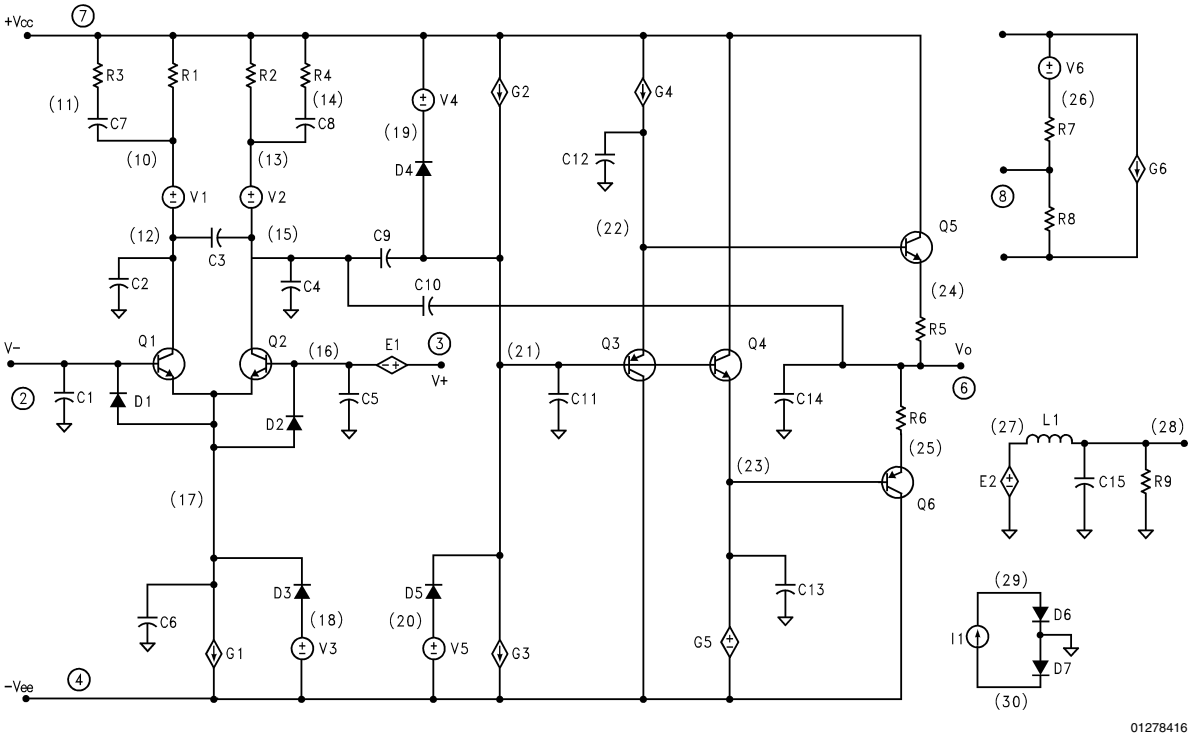
## CLC420




01278415

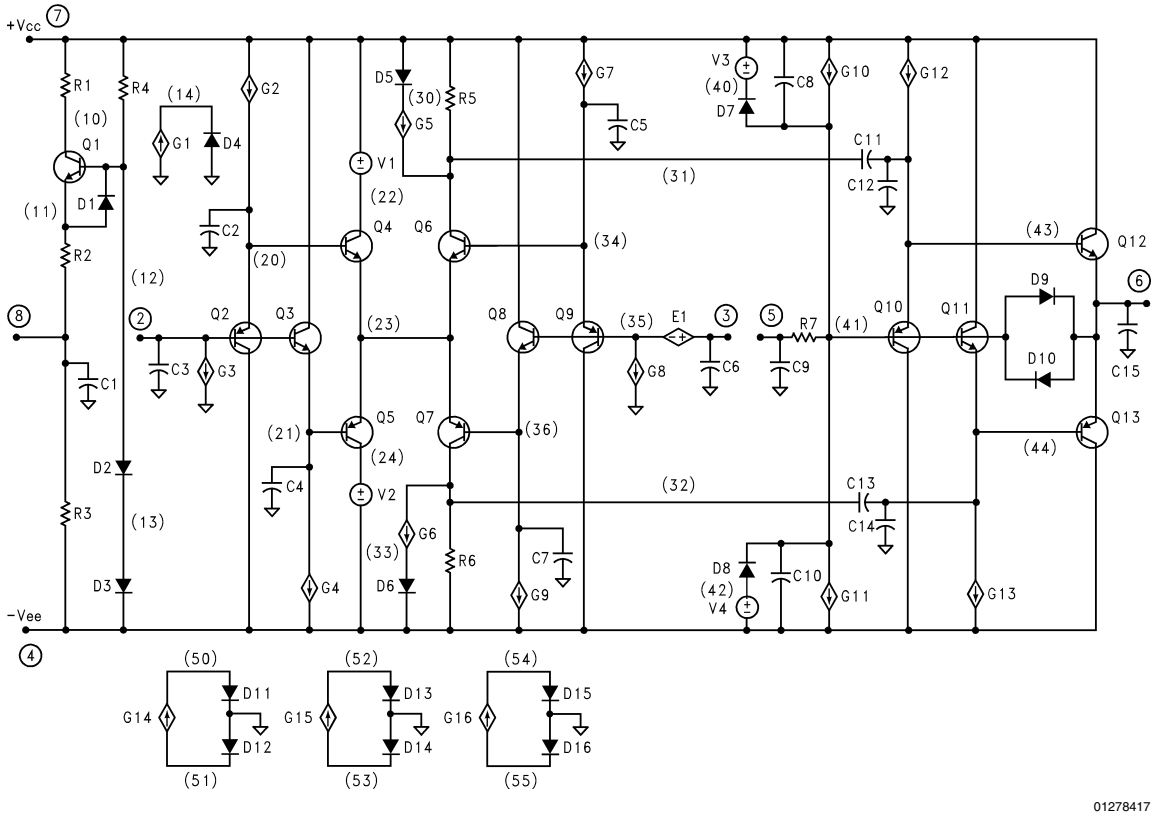
**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC425




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC426




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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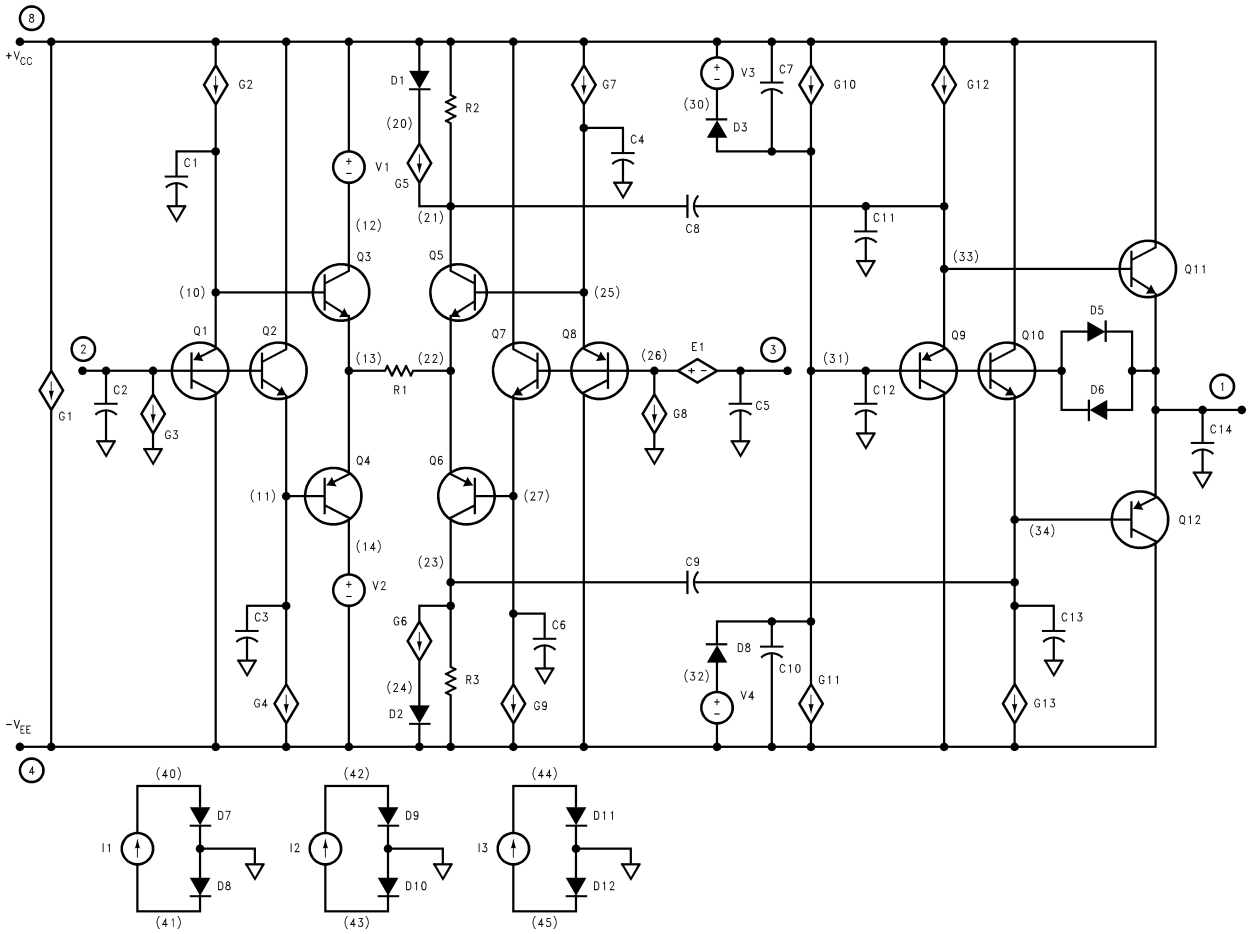


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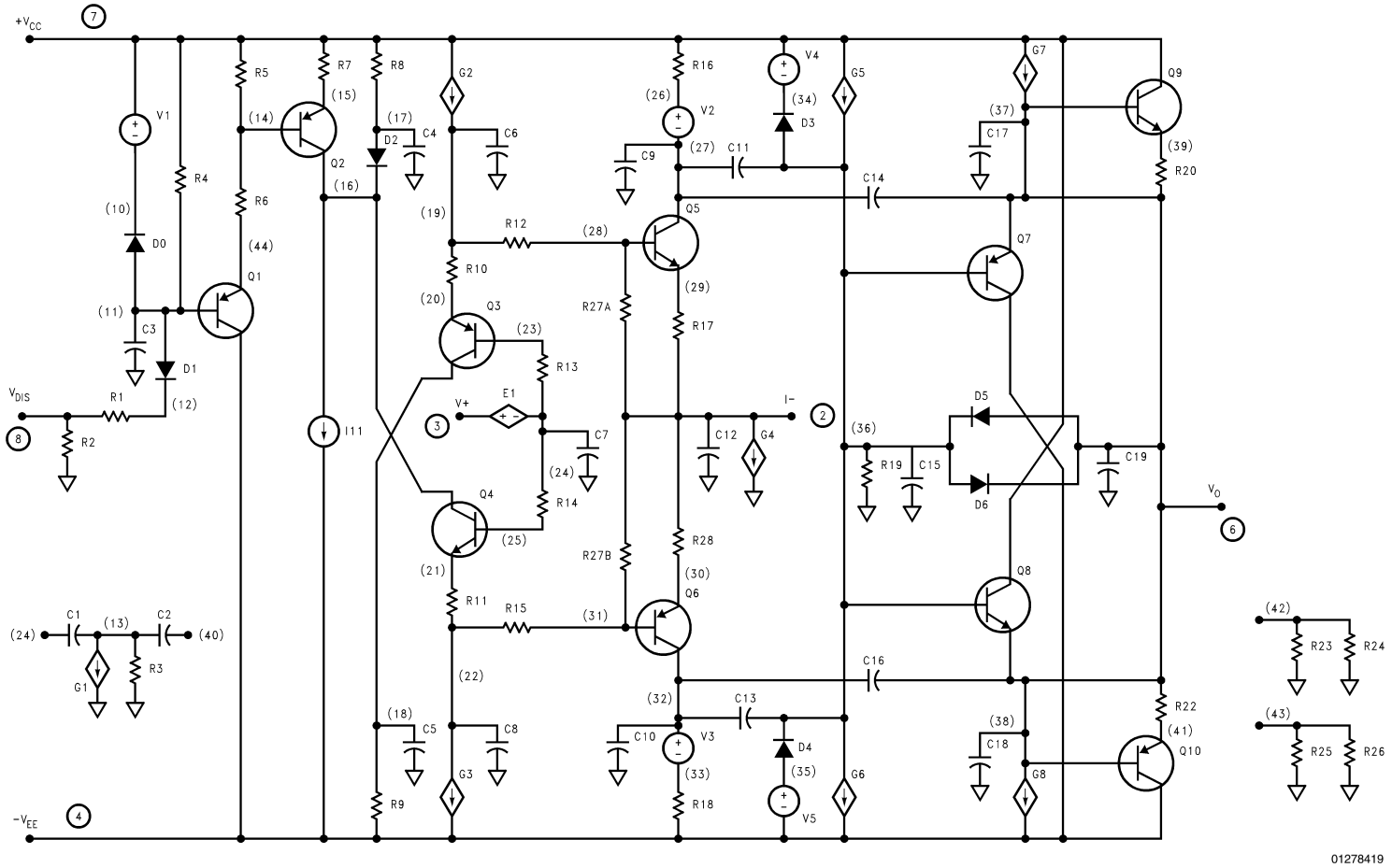
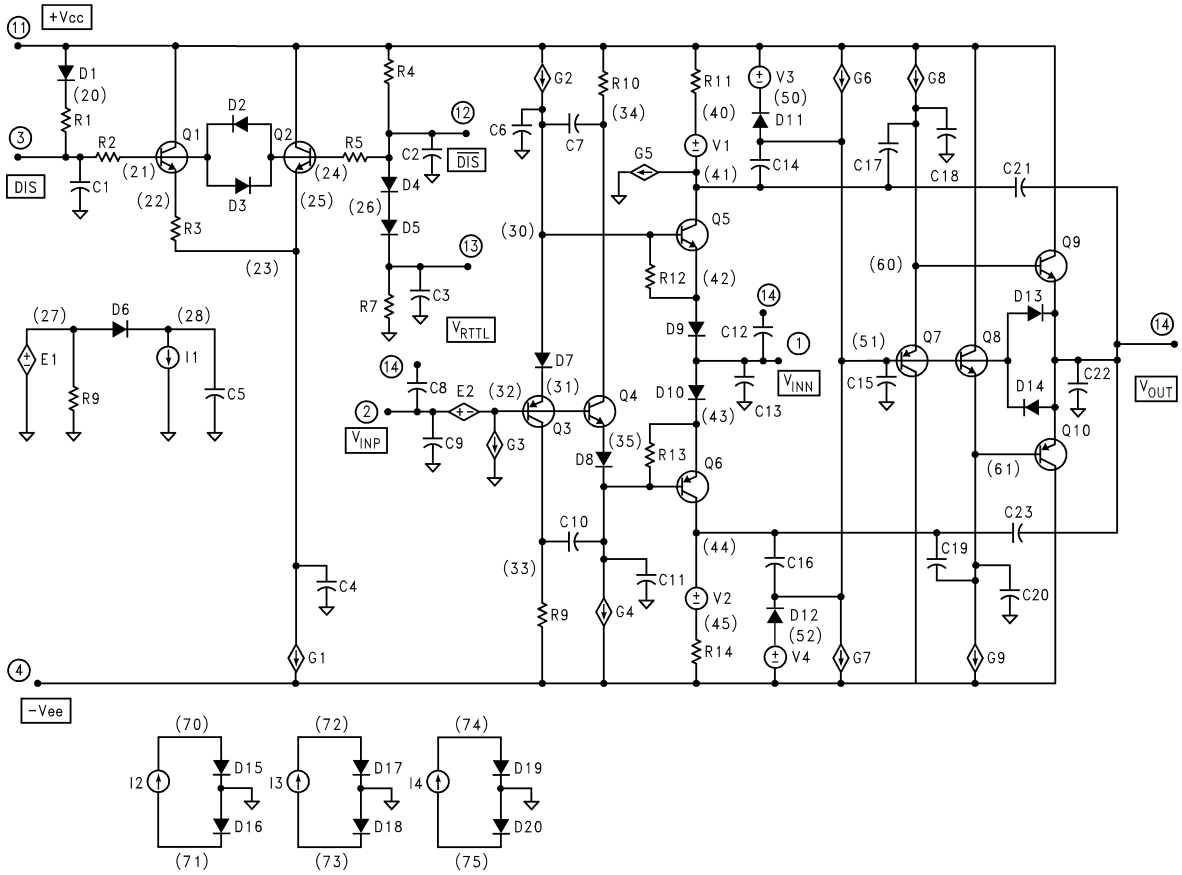
**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

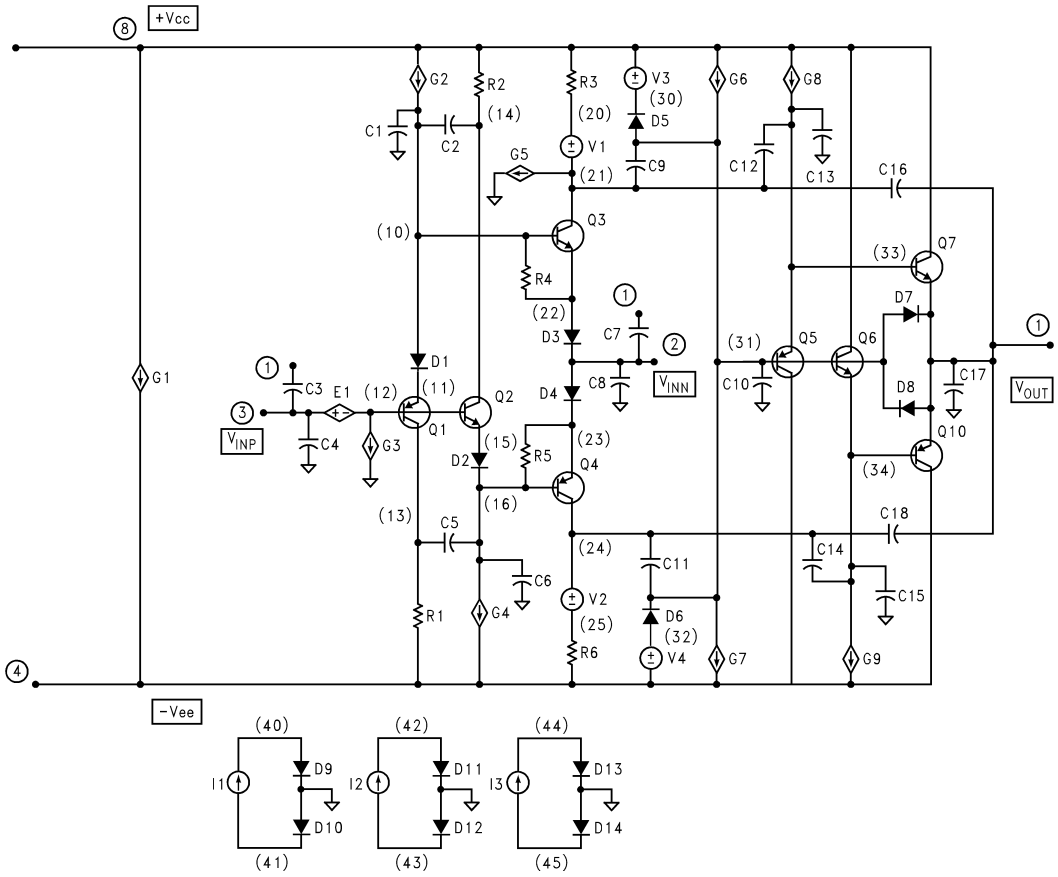
## CLC431




01278420

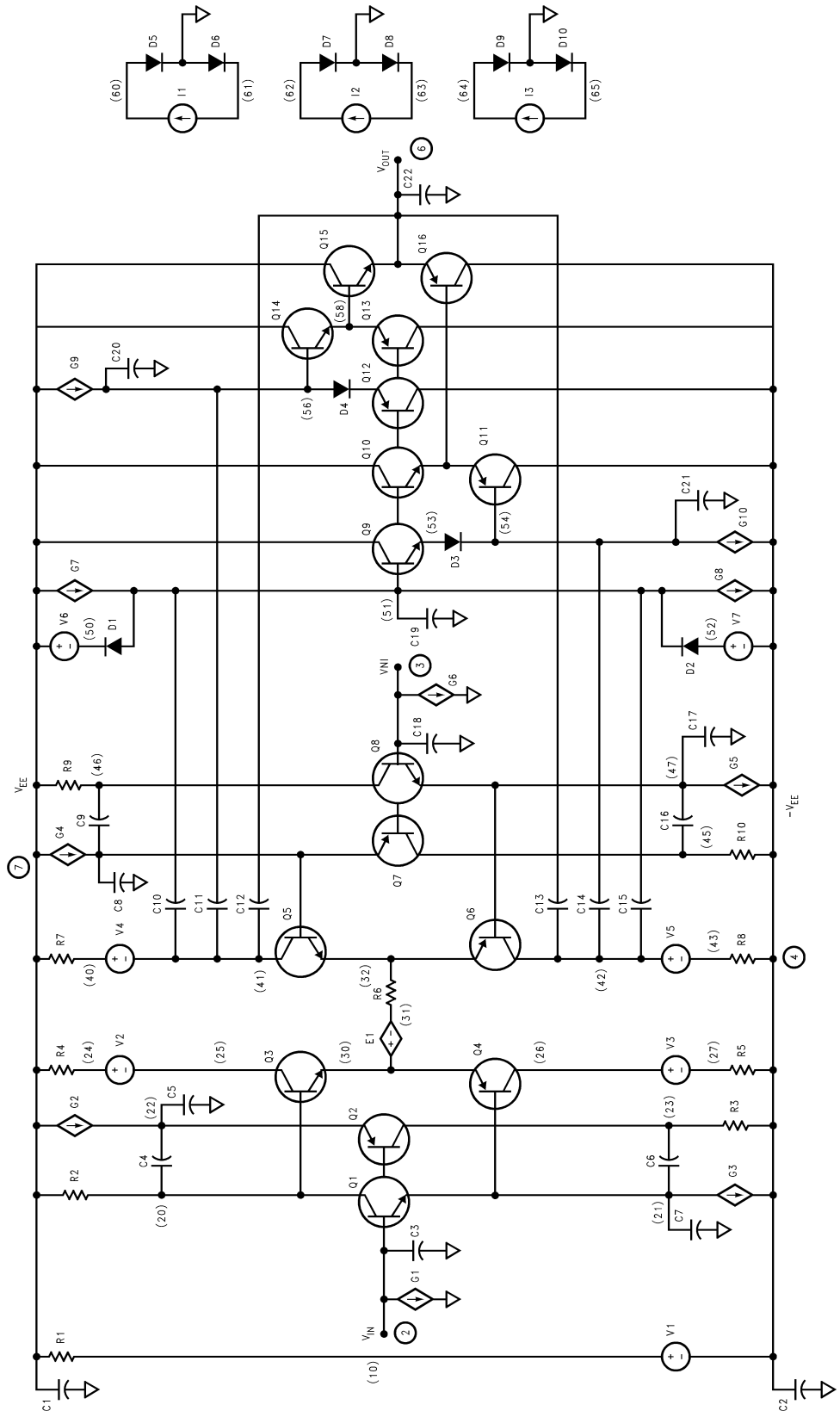
**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC432




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

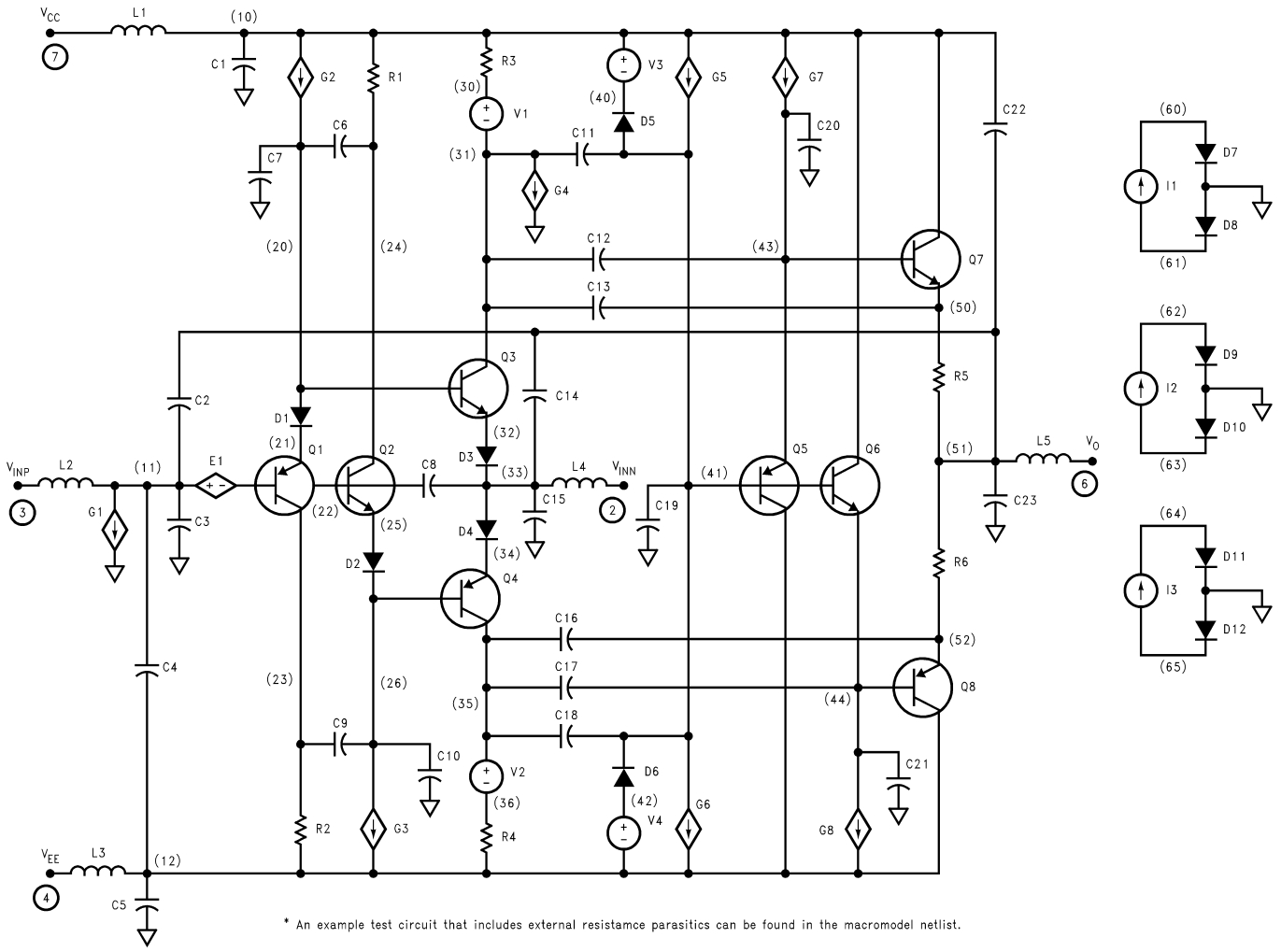
## CLC440




01278422

**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC449

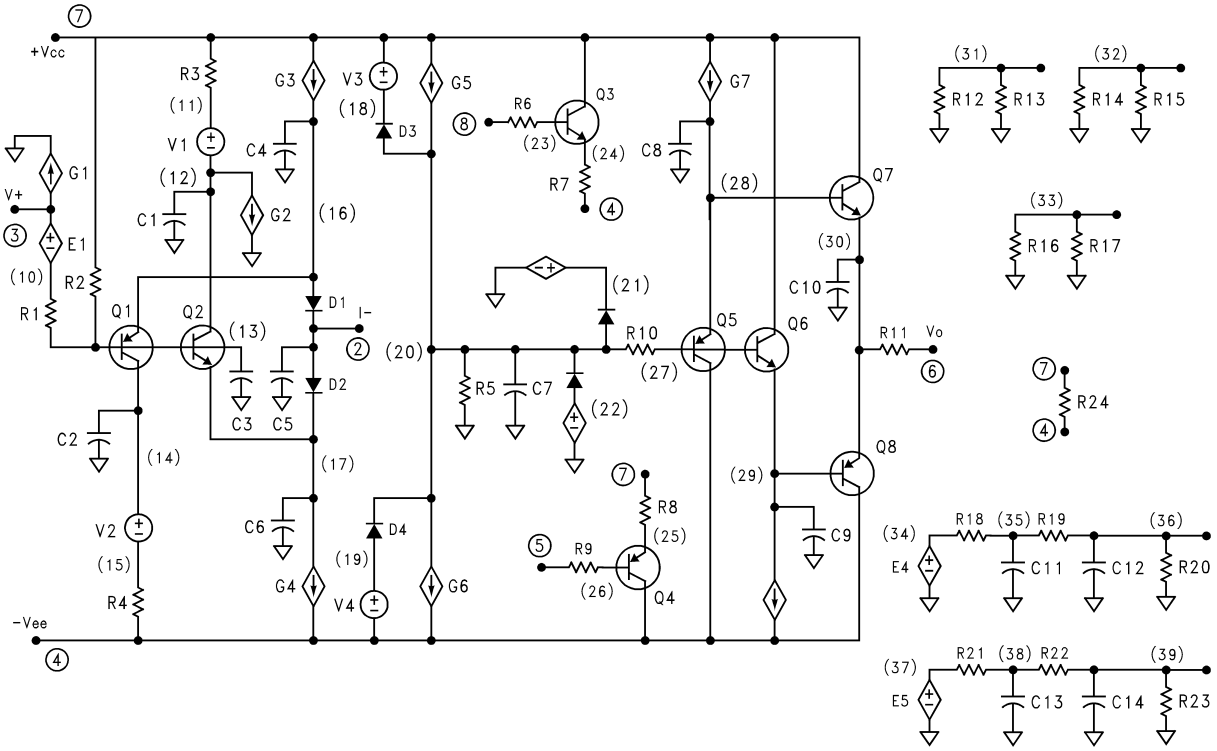



* An example test circuit that includes external resistamce parasitics can be found in the macromodel netlist.

01278423

**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC501




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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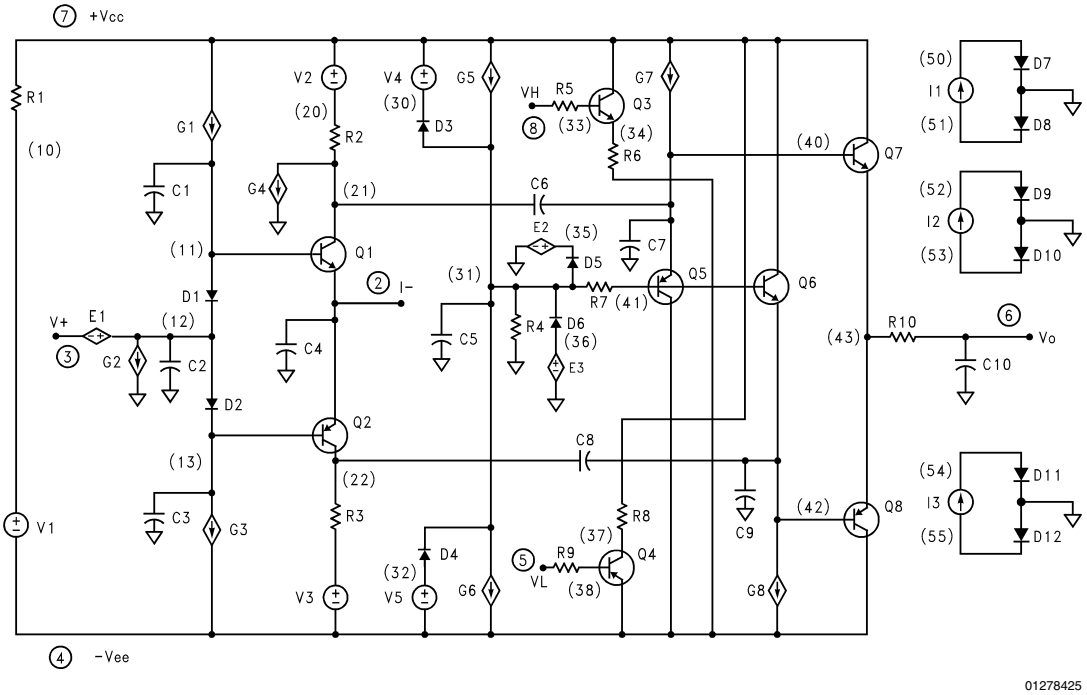


**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

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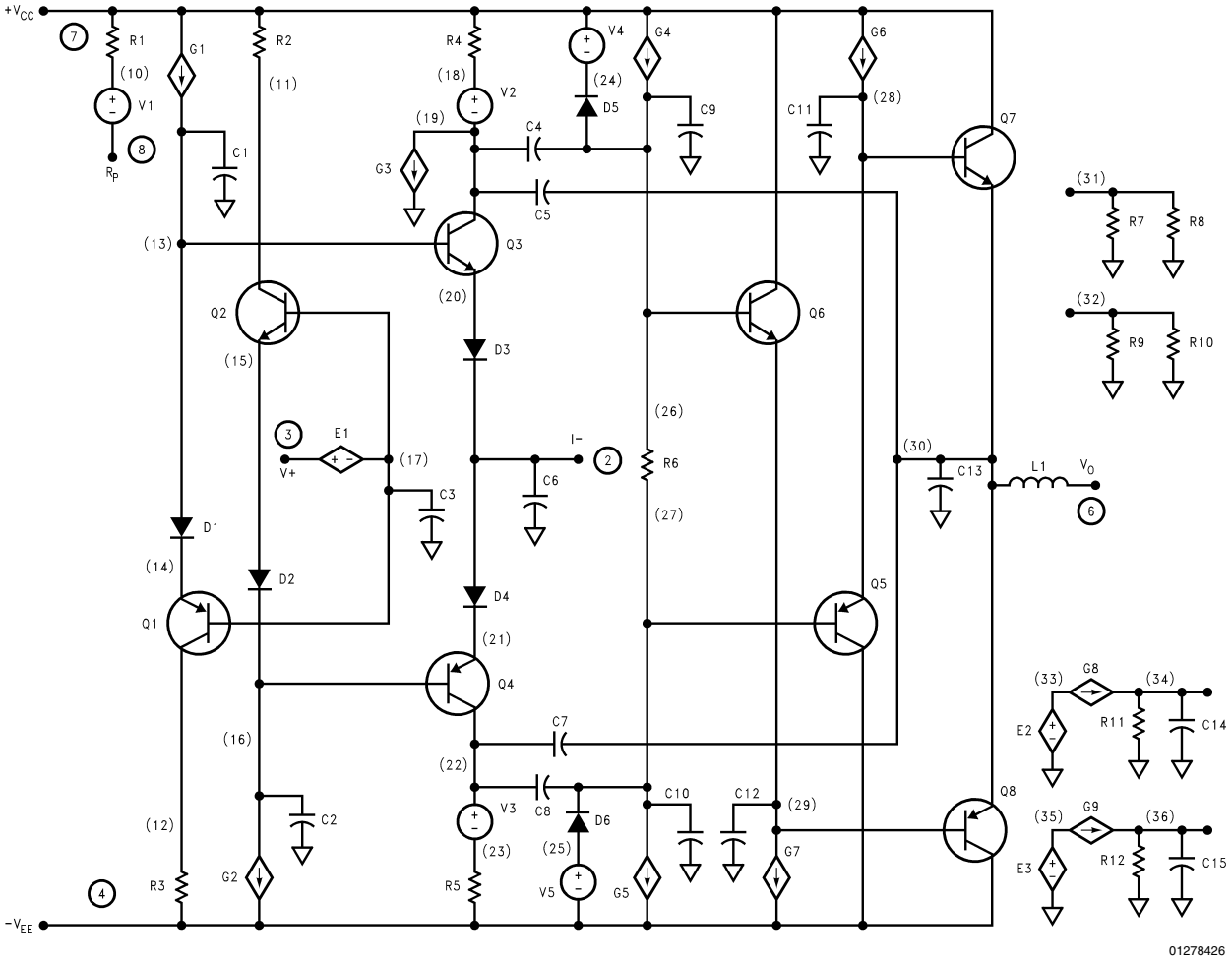
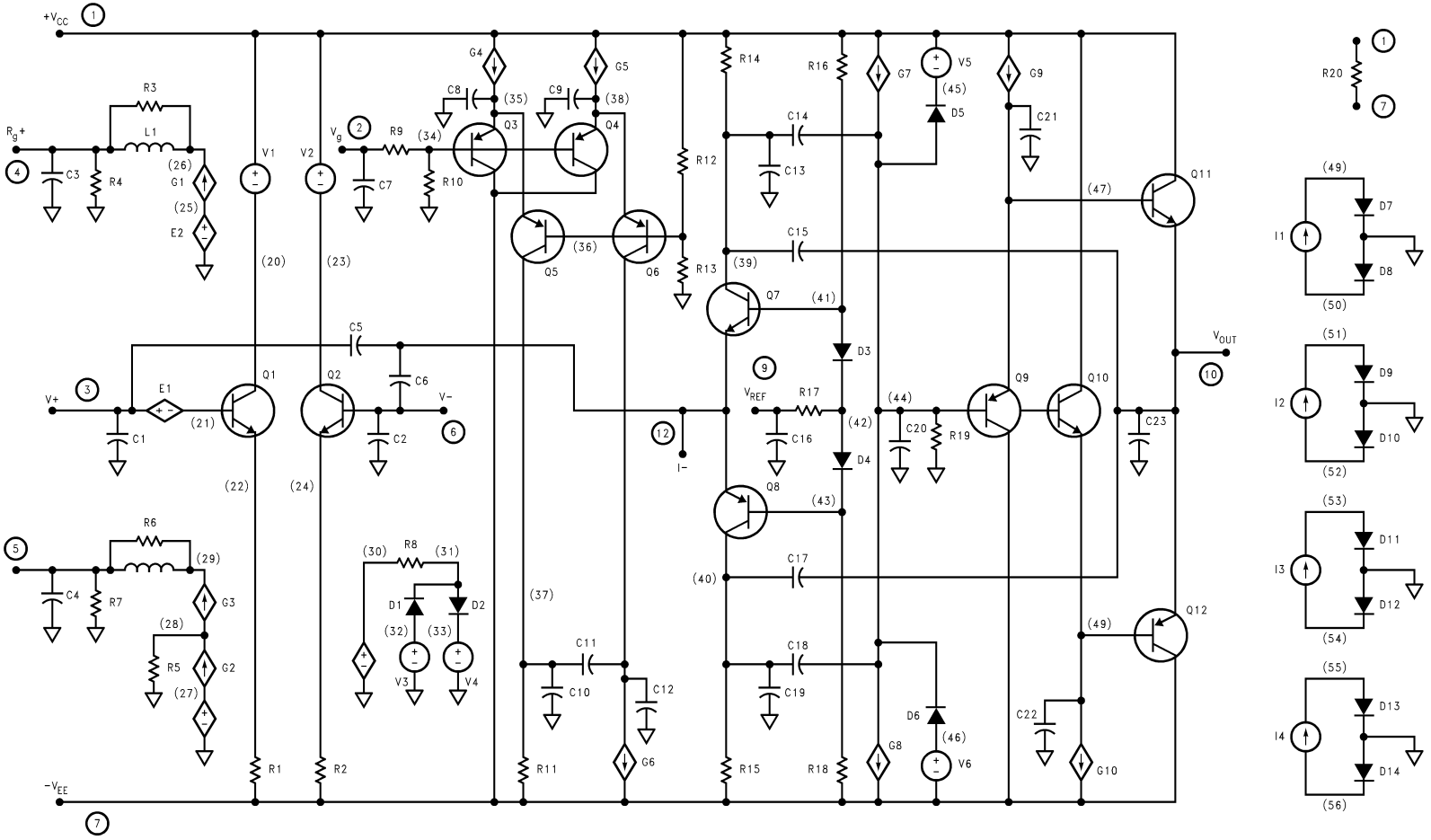



**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC520

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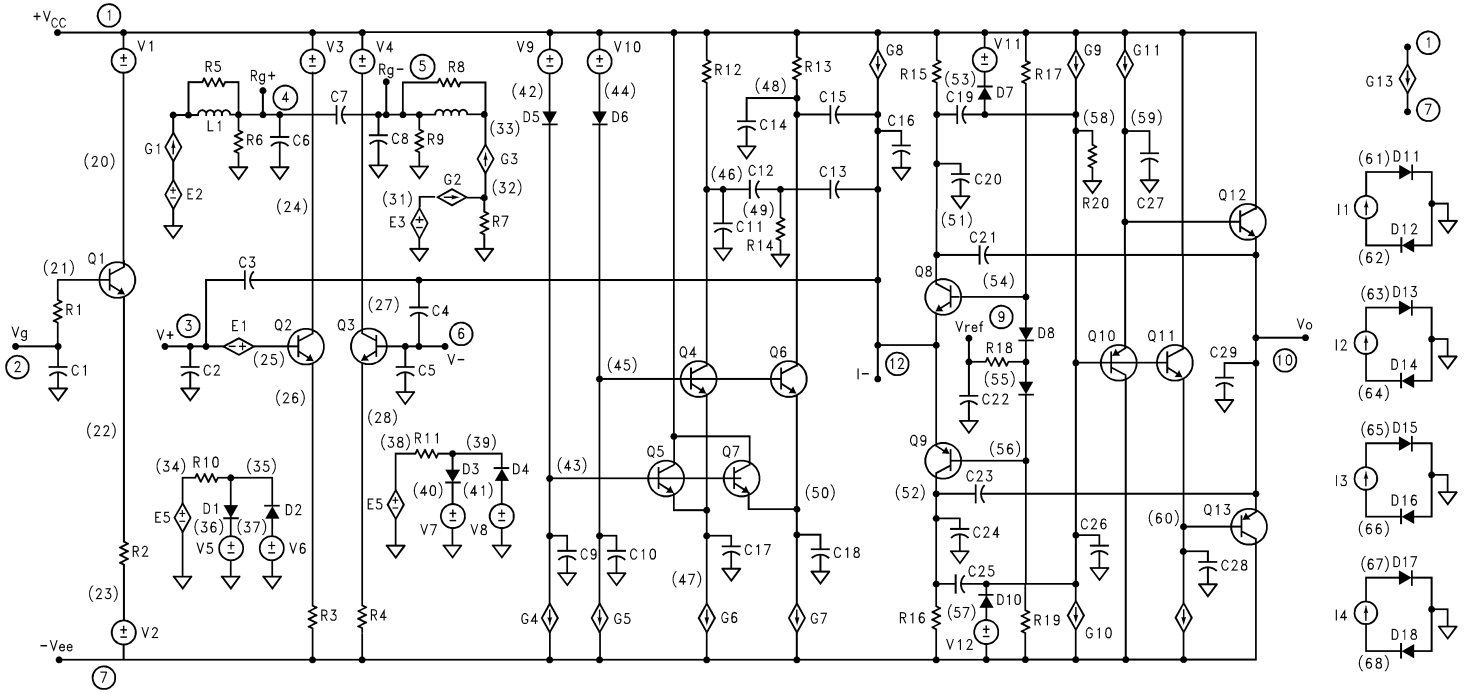
**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC522

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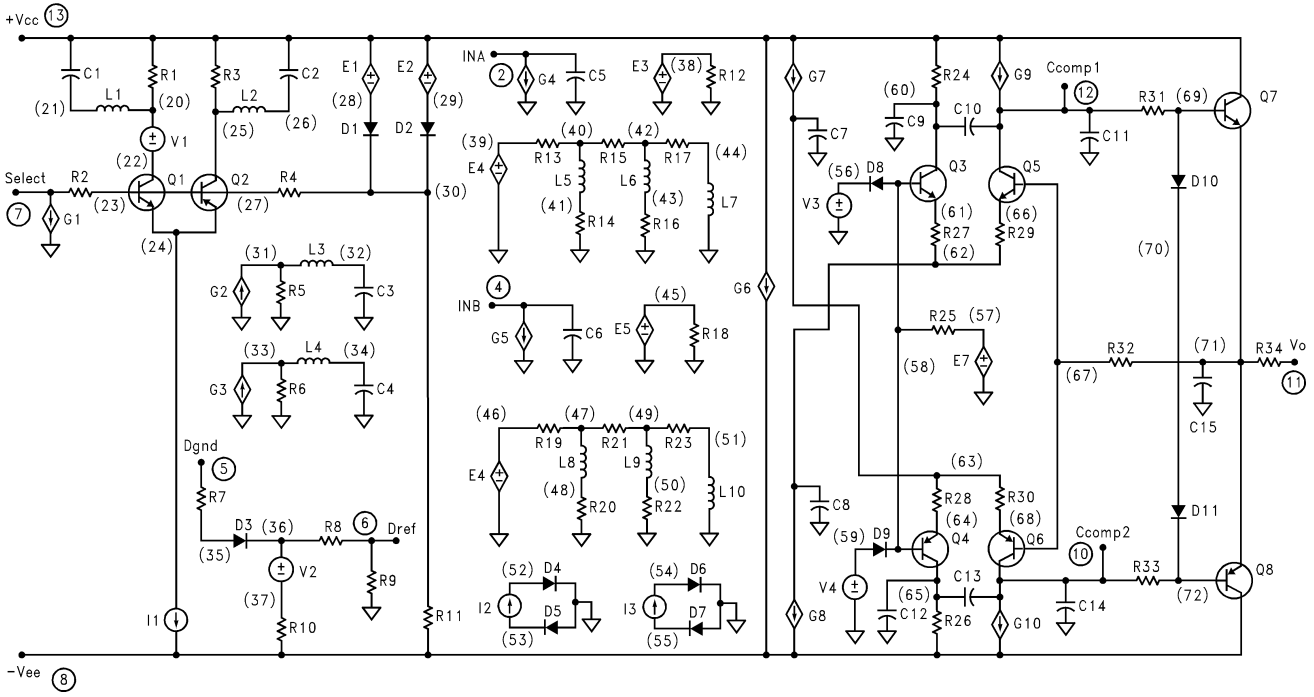
**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

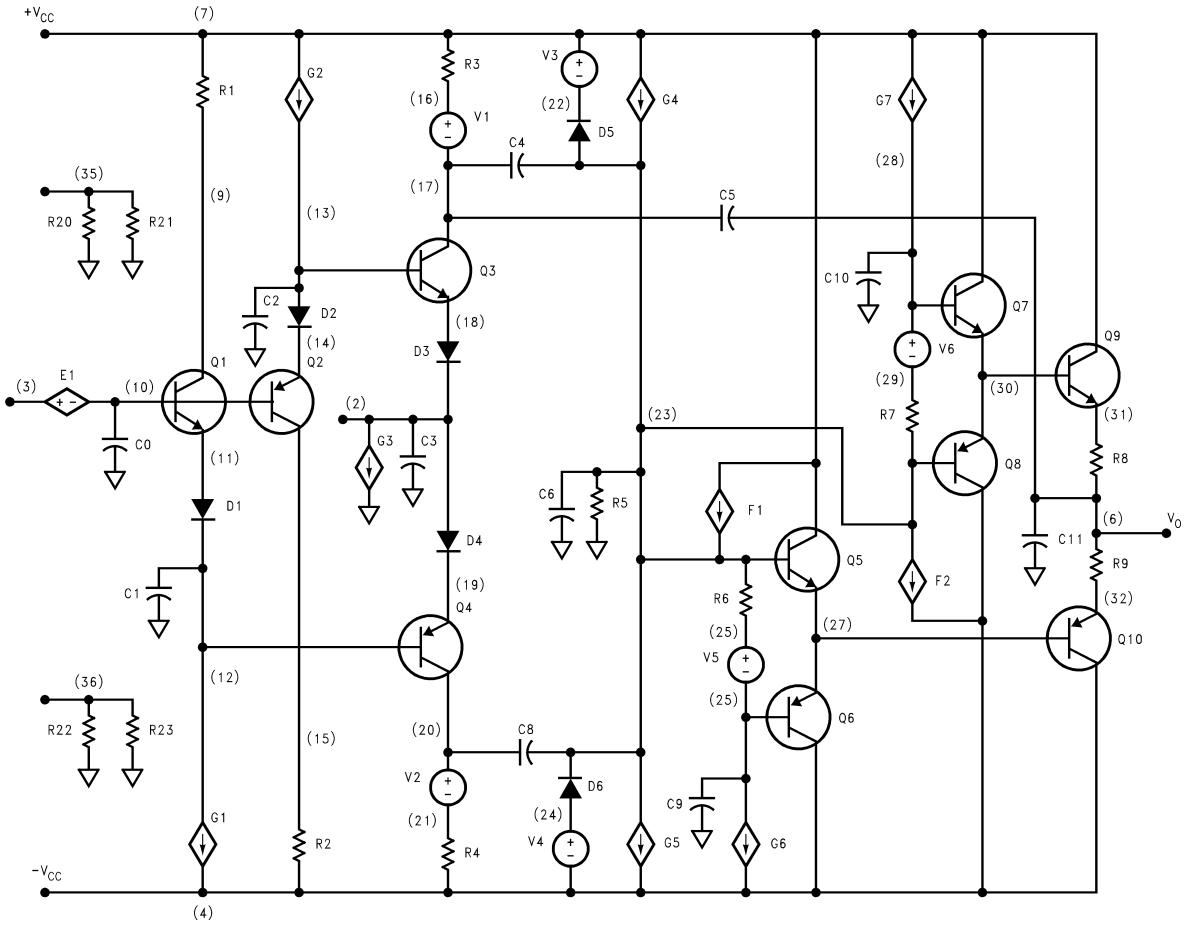
## CLC532




01278429

**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC5644

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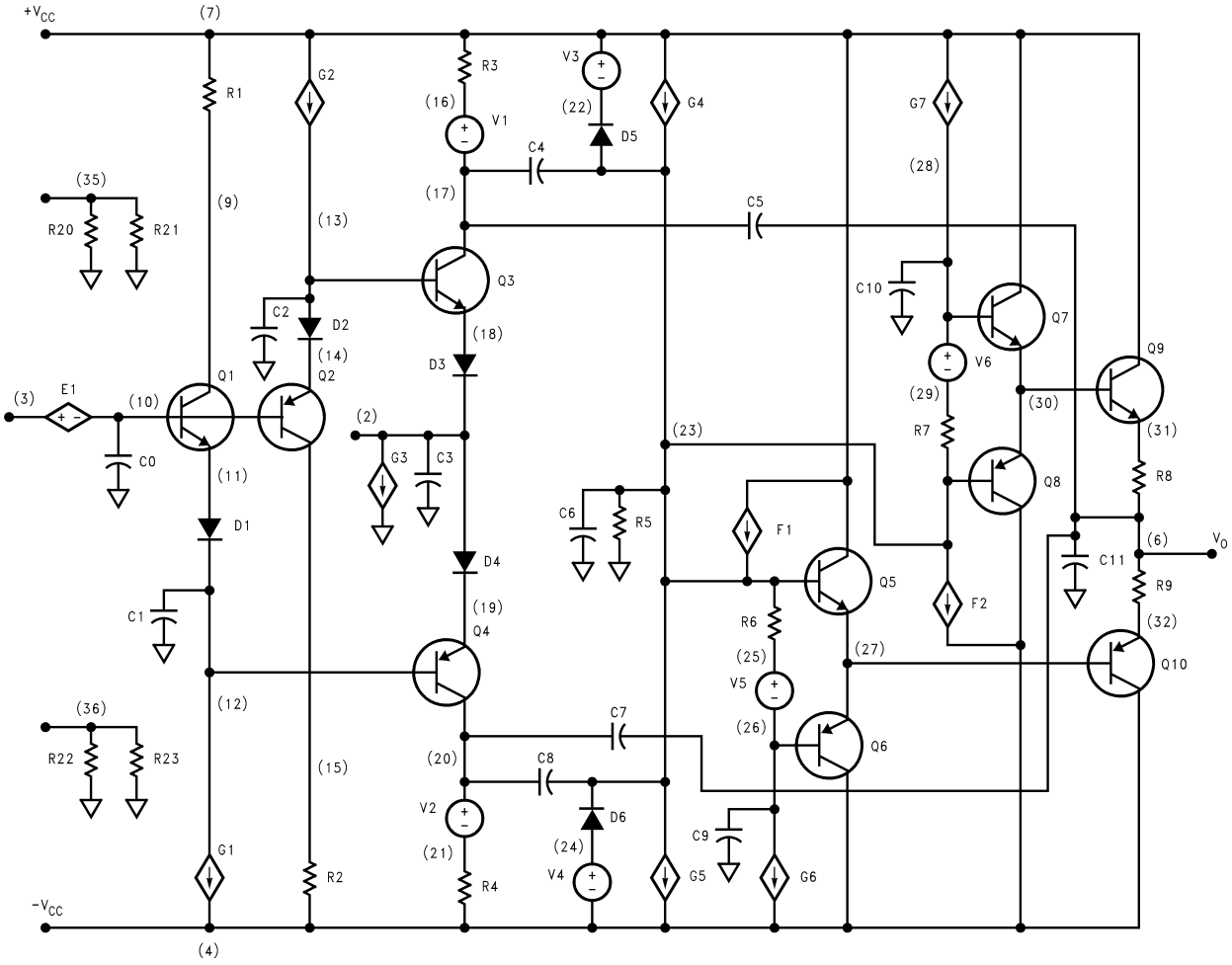
**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

## CLC5654

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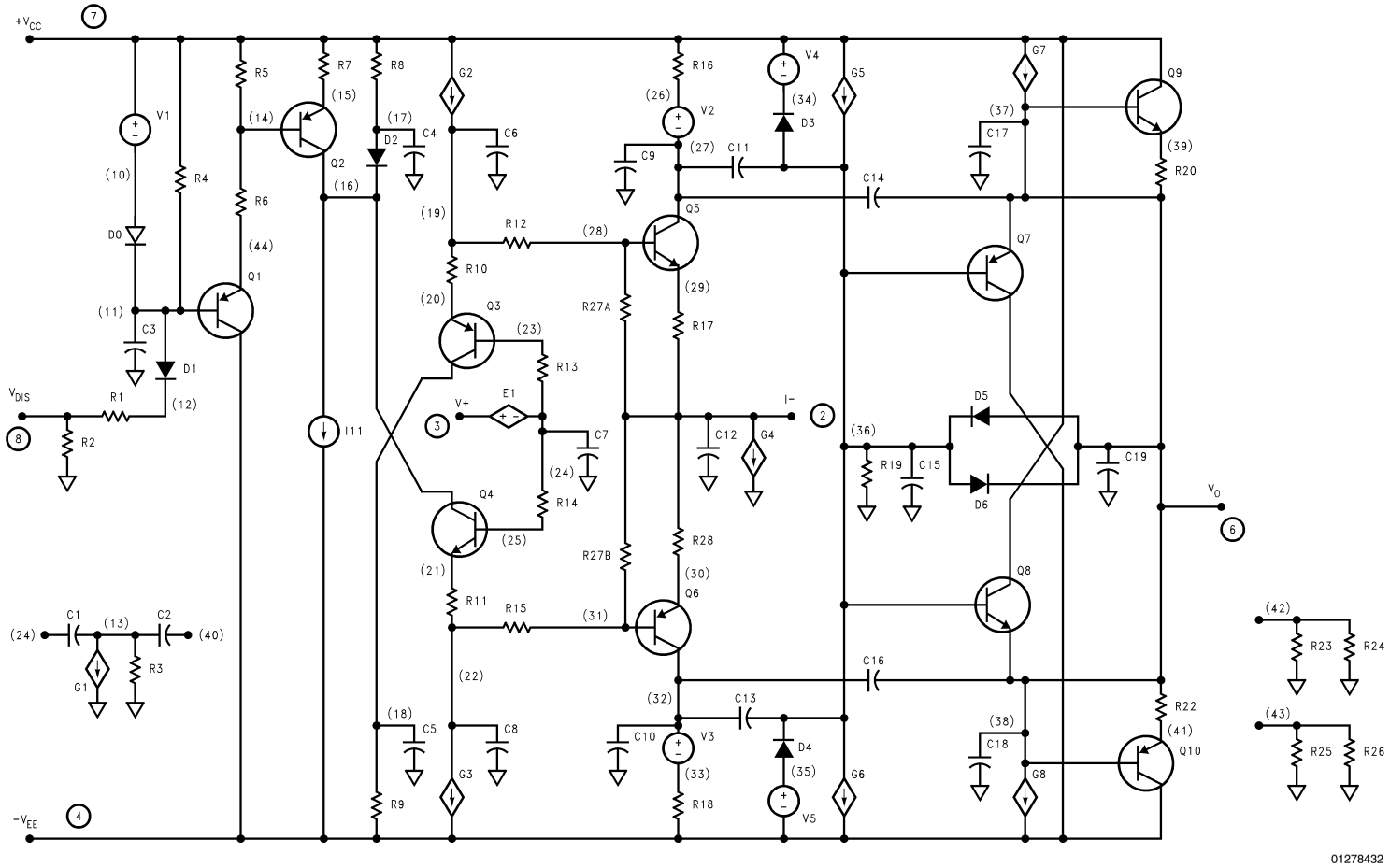
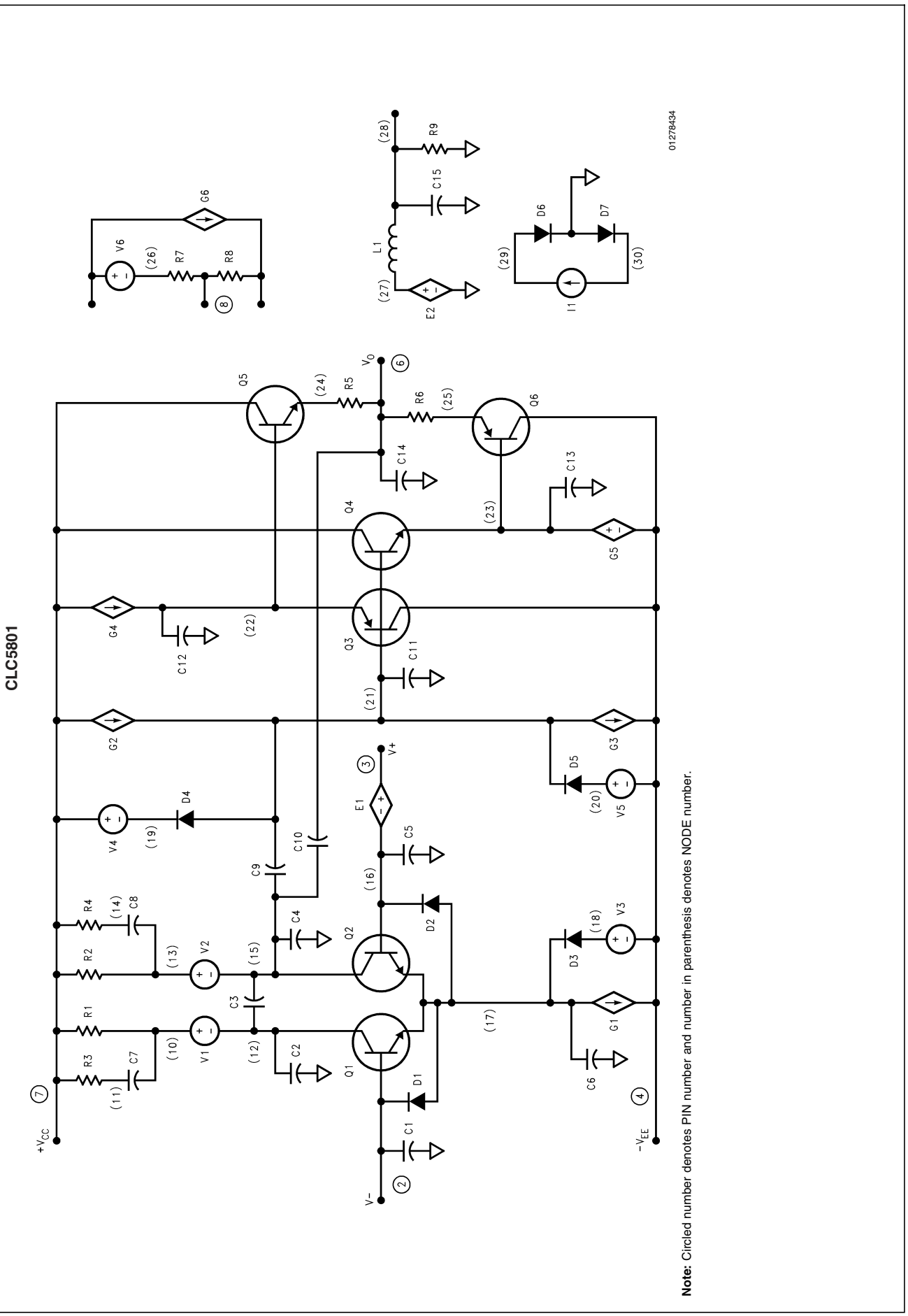
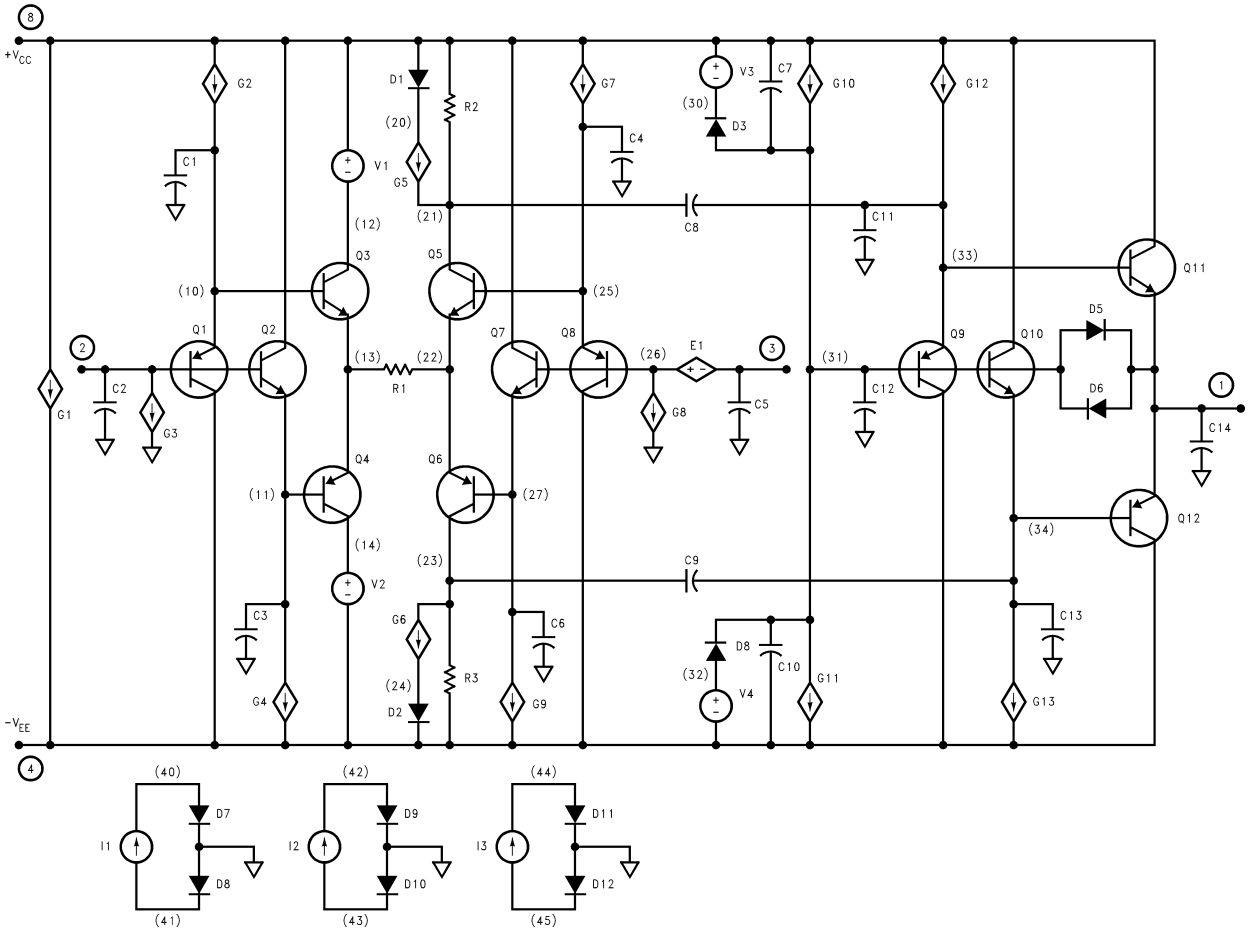



**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.




**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

CLC5802




01278433

**Note:** Circled number denotes PIN number and number in parenthesis denotes NODE number.

The circuits included in this application note have been tested with National Semiconductor parts that may have been obsoleted and/or replaced with newer products. Please refer to the CLC to LMH conversion table to find the appropriate replacement part for the obsolete device.

## References

1. National's 1993/1994 Databook and 1995 Databook Supplement of standard products.
2. MicroSim Corporation, 20 Fairbanks, Irvine, CA 92718 USA, (714) 770-3022, (800) 245-3022.

## Notes

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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