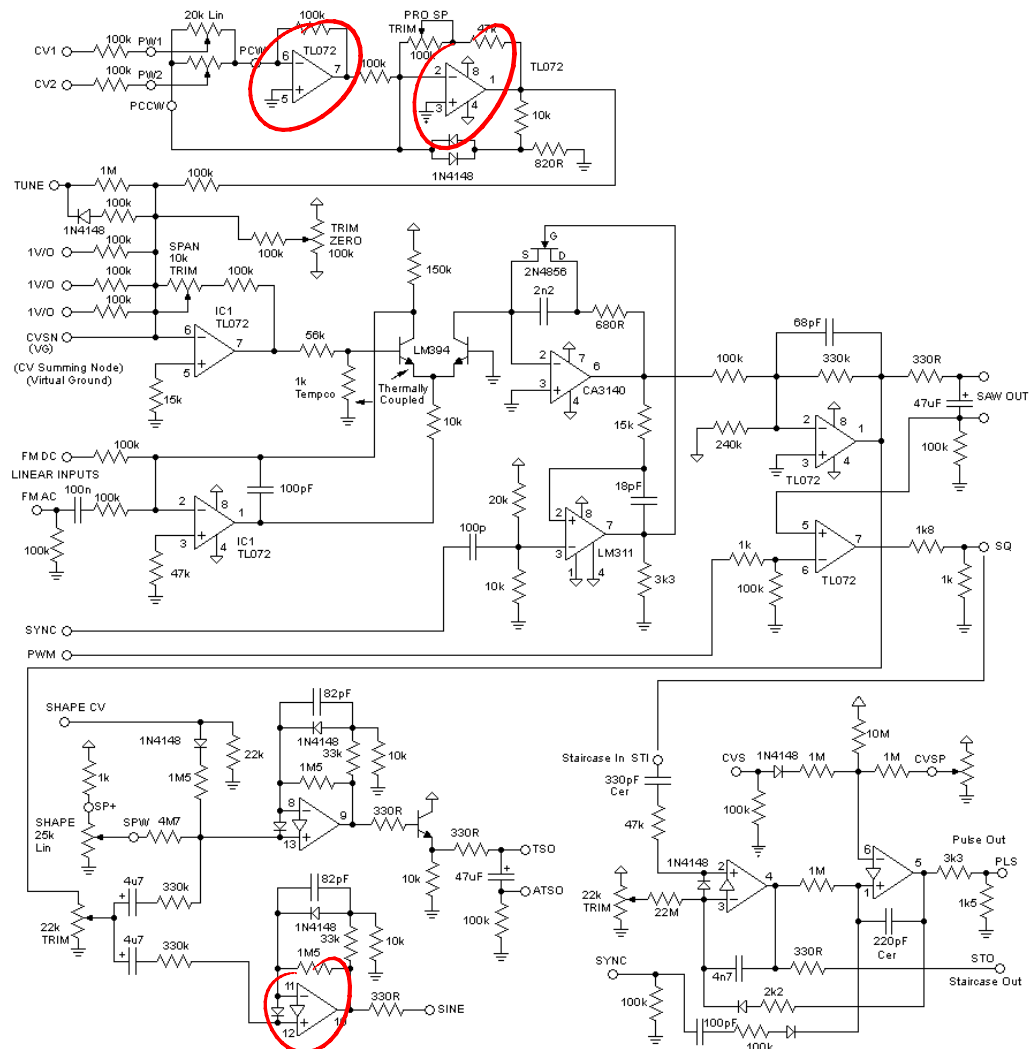


- Op amps are everywhere in practical circuits: (e.g., for solid-state guitar amplifiers, instrumentation, measurement tools, etc.)



- Op amps that can be used to build practical board-level circuits are often implemented via bipolar junction transistor technology

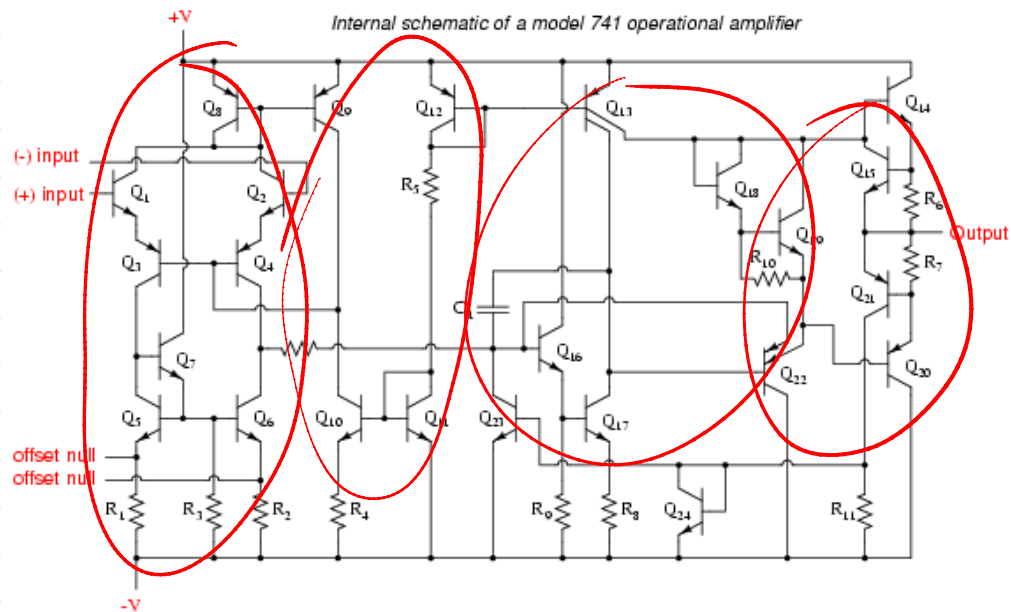
EE 140

Op Amps Are Everywhere

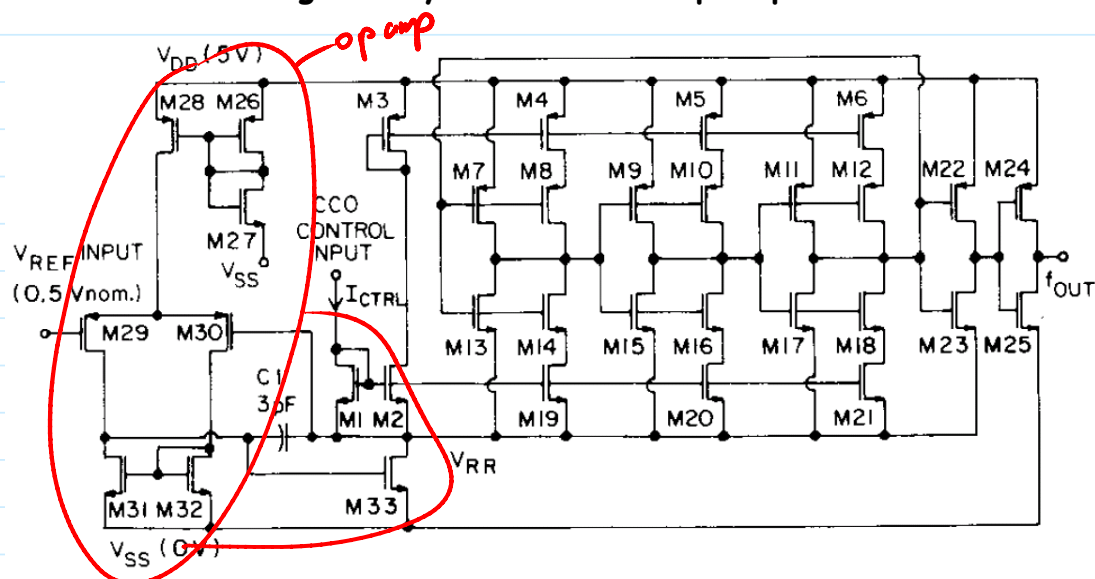
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- e.g., the 741 op amp, which has been a workhorse instrumentation op amp for decades



- Today, application specific integrated circuits (ASICs) for mixed analog/digital signal applications (e.g., A/D converters) utilize many op amps on the die level
 - ↳ such ASICs generally utilize CMOS op amps



-
- The circuit diagram shows a multi-stage CMOS op-amp. Key components include:
- Transistors:** Q1-Q4 (PMOS), M1-M24 (NMOS).
 - Resistors:** R1 (1K), R2 (6K), R3 (7K), R4 (7K), R5 (7K), R6 (39K).
 - Capacitors:** C1 (0.5V biasing network), C2 (3pF compensation capacitor).
 - Handwritten Annotations:**
 - A red circle highlights the input differential pair (M1, M2) and their associated resistors (R1, R2).
 - A blue oval encircles the second stage (M13, M14, M15, M16, M17, M18).
 - A green arrow points from the text "op amp." to the output node.
 - The label "MAGIC VOLTAGE" points to the gate of M15.
 - The label "I BIAS OUTPUT" points to the output of the biasing network.

- Again, this course will focus mainly on the innards of op amps
- Focus: CMOS, with some BJT coverage so you can work with practical board-level circuits, as well
- The first step towards analyzing and designing op amps is to understand the transistor technologies upon which they are based