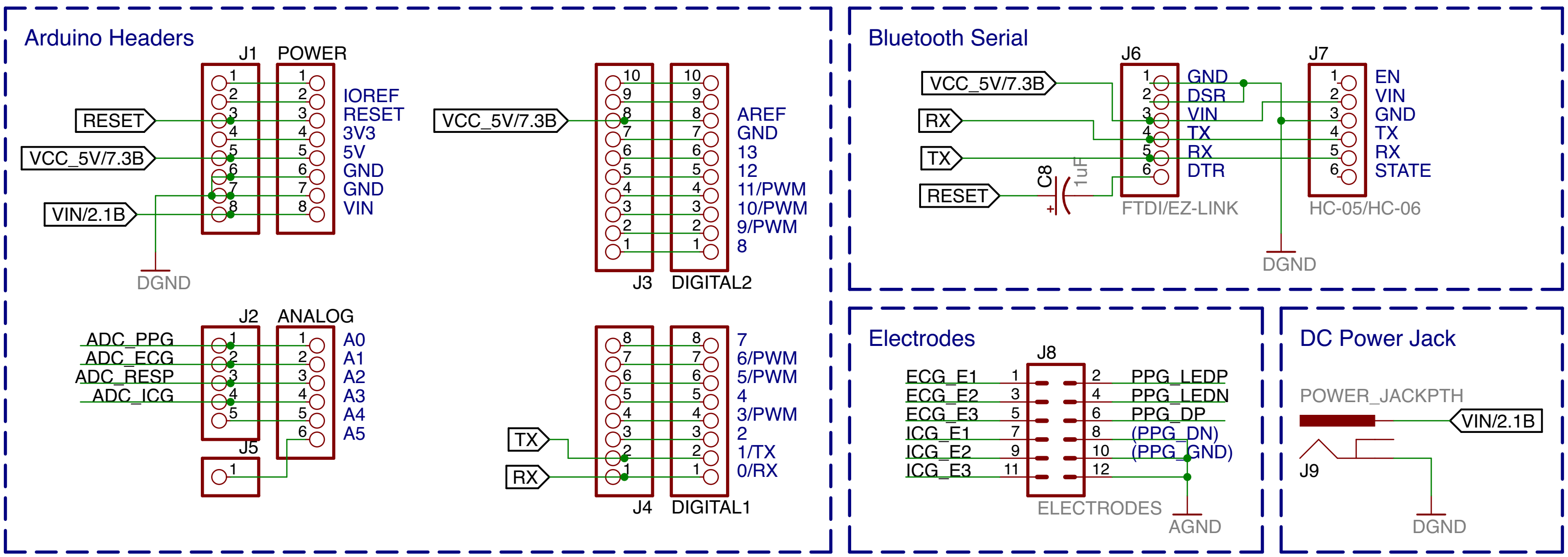
BIOSHIELD INTERFACE



Arduino-compatible headers are provided, with all signals passed through. This allows for stacking additional shields or using alternate Arduino-compatible processors.

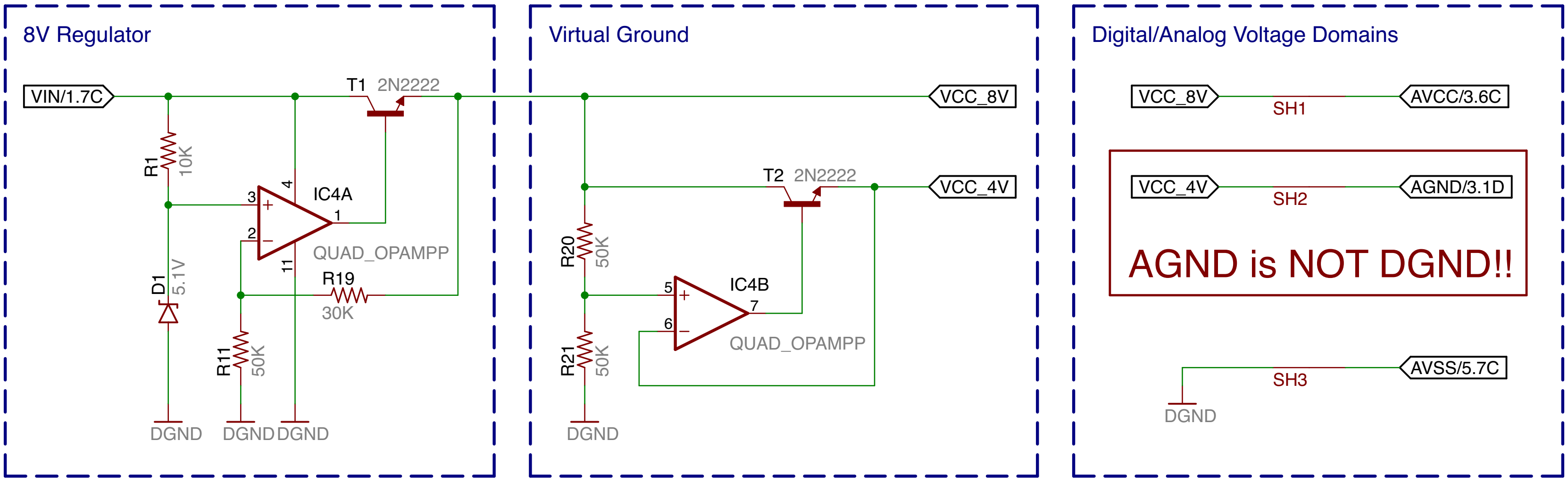
Power is provided EITHER through the DC power jack OR directly into the VIN pin. They are shorted together, so do not connect multiple power supplies to this pin!

Two standard serial->Bluetooth headers are broken out.
J6 is compatible with the standard FTDI header, as well as the Adafruit EZ-LINK. The DTR pin allows wireless reprogramming of the Arduino.
J7 is compatible with the extremely common HC-05 and HC-06 Bluetooth modules.

Note that with sufficient power, other serial->wireless modules can easily be used, such as the popular ESP8266 (WiFi) or an XBee shield.

The ECG, ICG, and PPG electrode interfaces are exposed together on J8.

POWER



The 8V regulator provides a stable 8V rail from an input source.
The input source must be greater than 8V plus the transistor's collector-emitter drop.
For the 2N2222 transistor, the max drop is 0.4V at 150 mA.

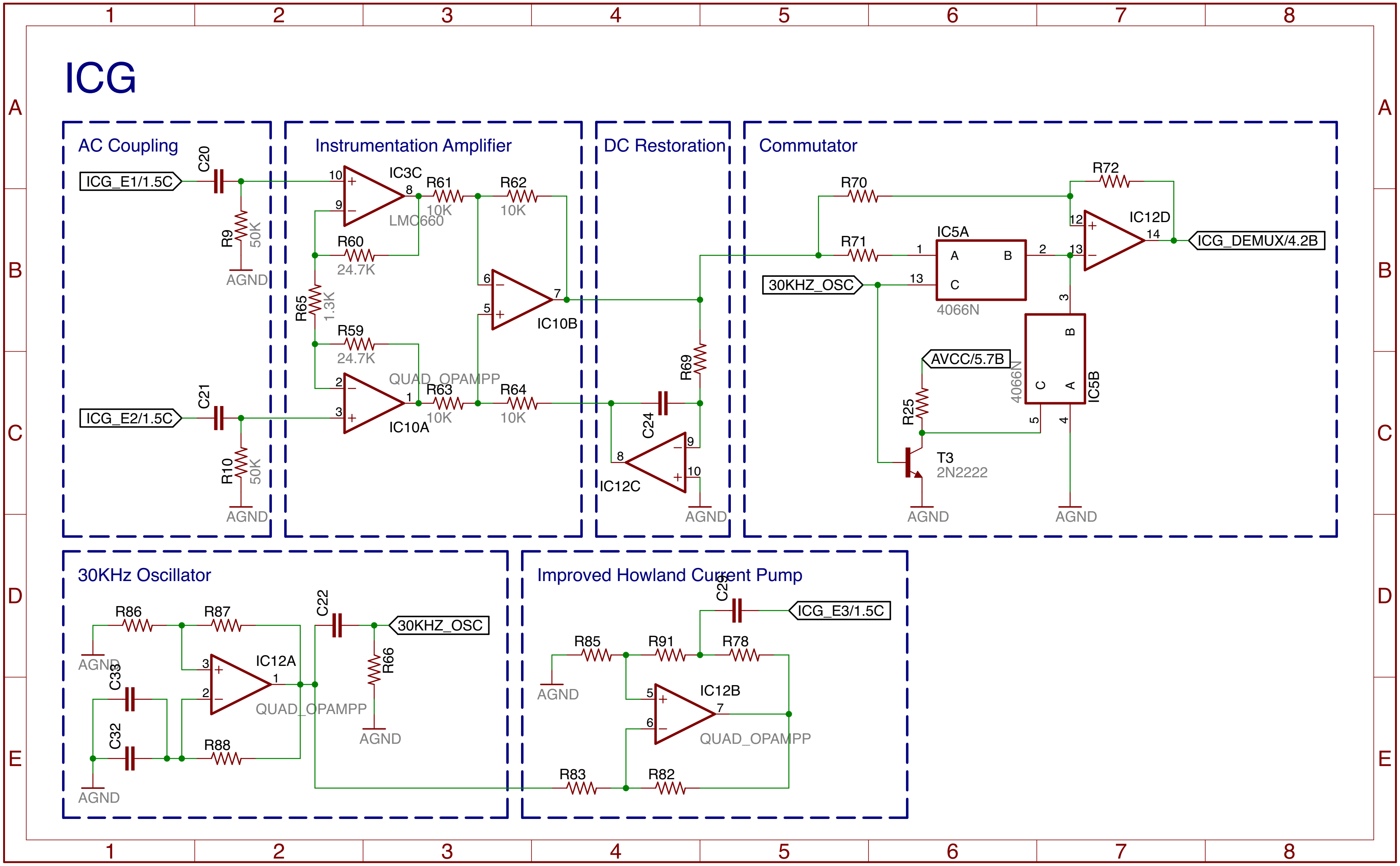
By changing the gain resistors, the 8V regulator voltage can be modified and a different Zener diode can be used.
The output voltage is calculated as follows:

Vout = ((R11 + R19) / R11) * Vzener

The virtual ground stage provides a stable voltage at the center point between the digital ground and the regulator output.

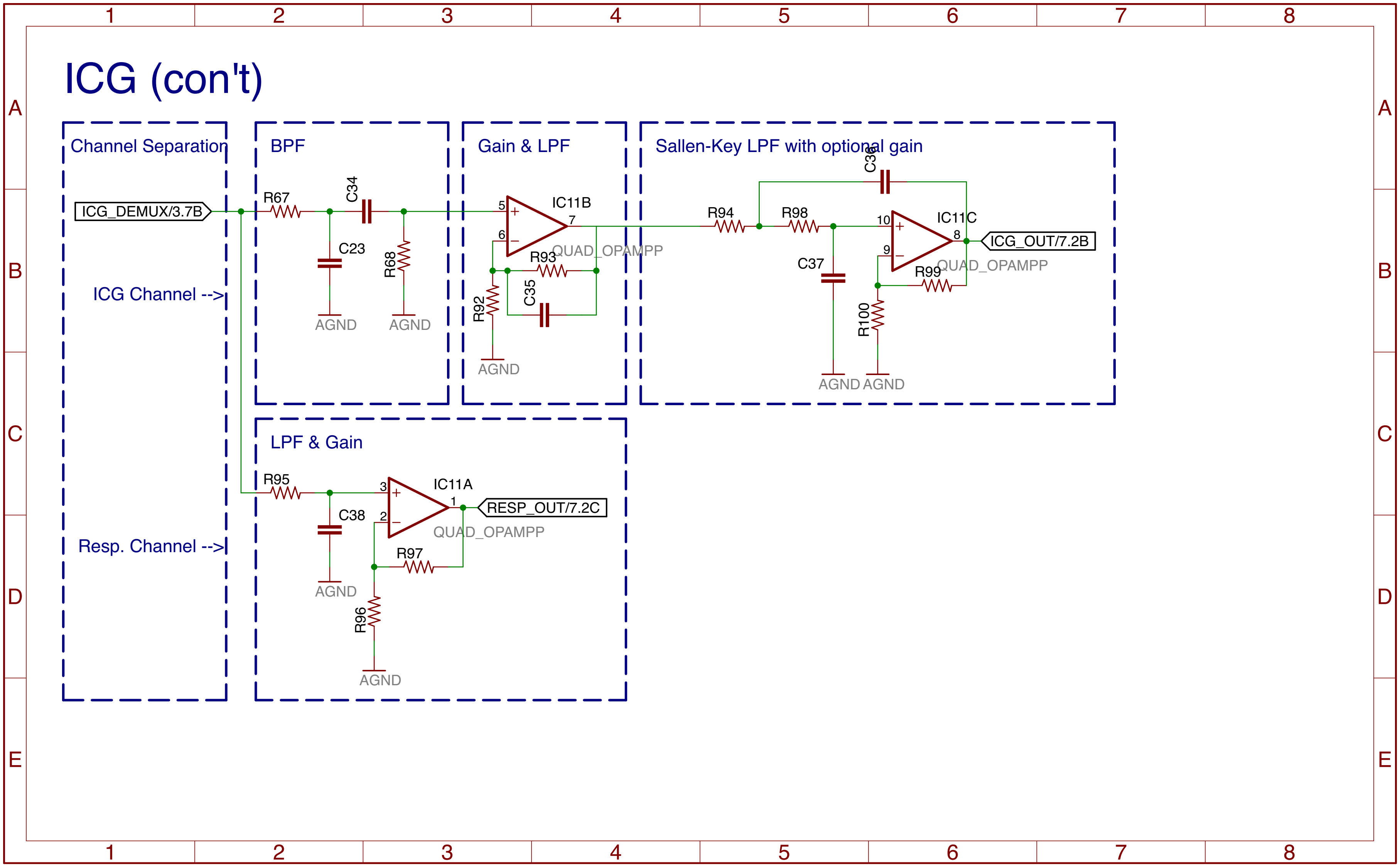
The virtual ground is used as the reference for all of the analog circuitry (ie AGND).
The regulated rail is used as the analog VCC, and the digital ground is used as the analog VSS.
IMPORTANT: AGND is NOT at the same level as DGND!

ICG

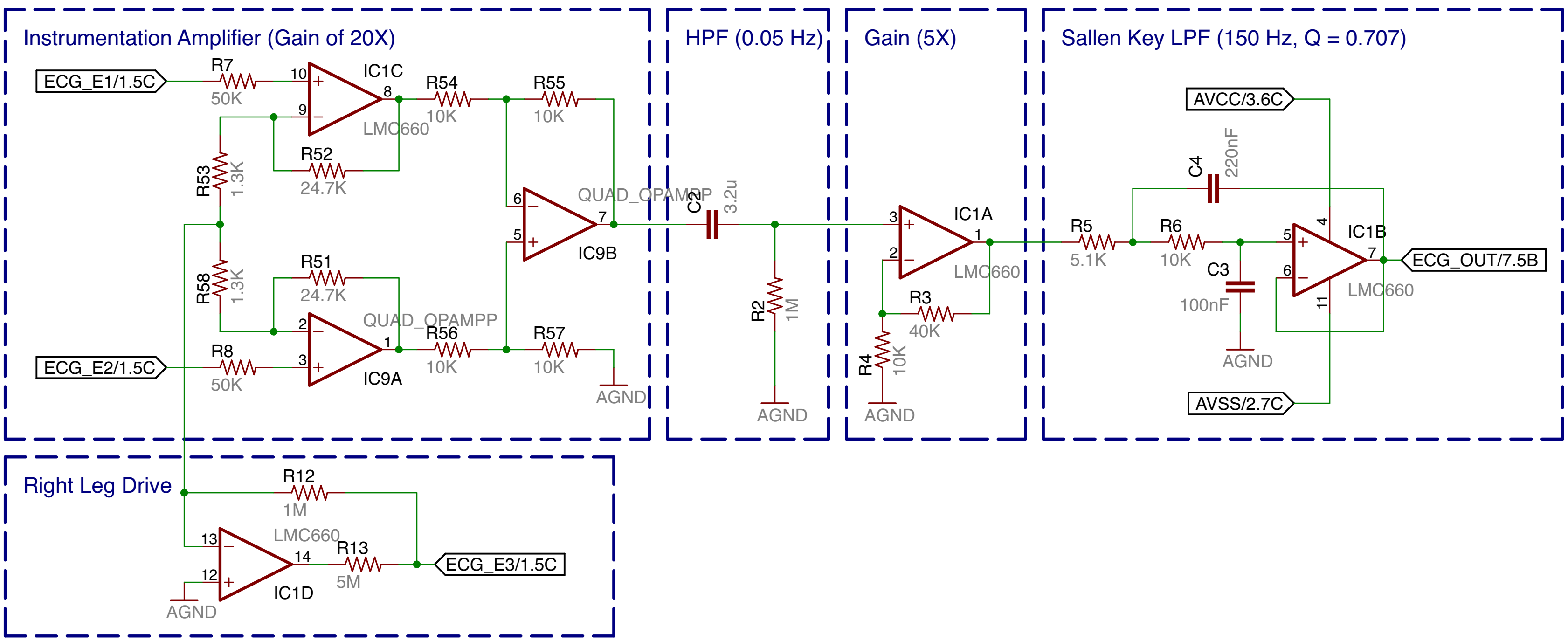


AC Coupling
ICG_E1/1.5C
C20
R9
50K
AGND
ICG_E2/1.5C
C21
R10
50K
AGND
Instrumentation Amplifier
IC3C
LMC660
R61
10K
R62
10K
R60
24.7K
R65
1.3K
R59
24.7K
QUAD_OPAMPP
IC10A
IC10B
R63
10K
R64
10K
DC Restoration
R69
C24
IC12C
AGND
Commutator
R70
R71
R72
IC12D
ICG_DEMUX/4.2B
IC5A
A
B
C
4066N
30KHZ_OSC
IC5B
AVCC/5.7B
R25
T3
2N2222
AGND
AGND
30KHz Oscillator
R86
R87
AGND
C33
C32
IC12A
QUAD_OPAMPP
R88
AGND
C22
30KHZ_OSC
R66
AGND
Improved Howland Current Pump
C23
ICG_E3/1.5C
R85
R91
R78
AGND
IC12B
QUAD_OPAMPP
R83
R82

ICG (con't)


Channel Separation
ICG_DEMUX/3.7B
ICG Channel -->
Resp. Channel -->
BPF
R67
C34
C23
R68
AGND
AGND
Gain & LPF
IC11B
QUAD_OPAMPP
R93
R92
C35
AGND
Sallen-Key LPF with optional gain
C36
R94
R98
IC11C
ICG_OUT/7.2B
QUAD_OPAMPP
C37
R99
R100
AGND AGND
LPF & Gain
R95
IC11A
C38
RESP_OUT/7.2C
QUAD_OPAMPP
R97
AGND
R96
AGND

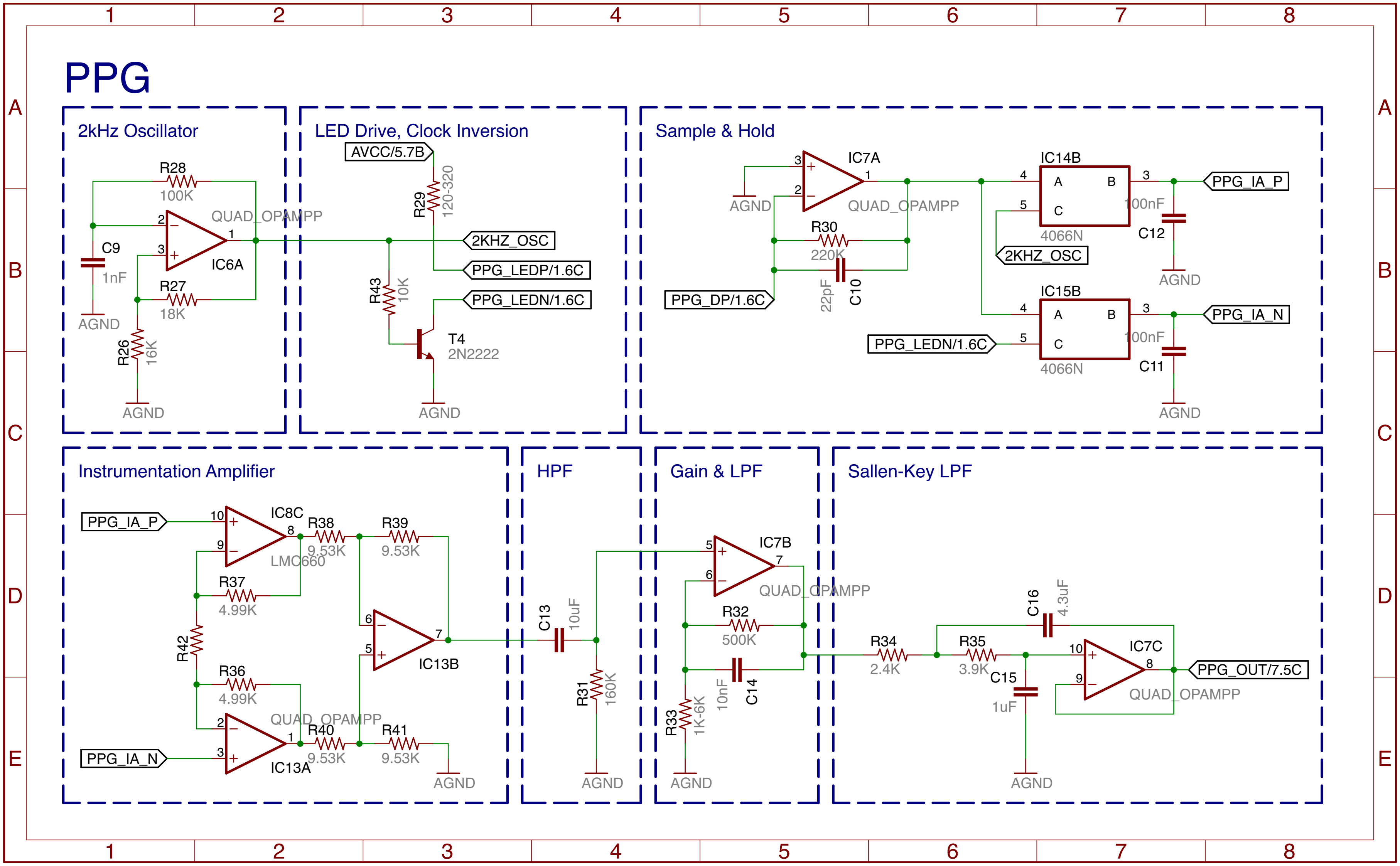
ECG



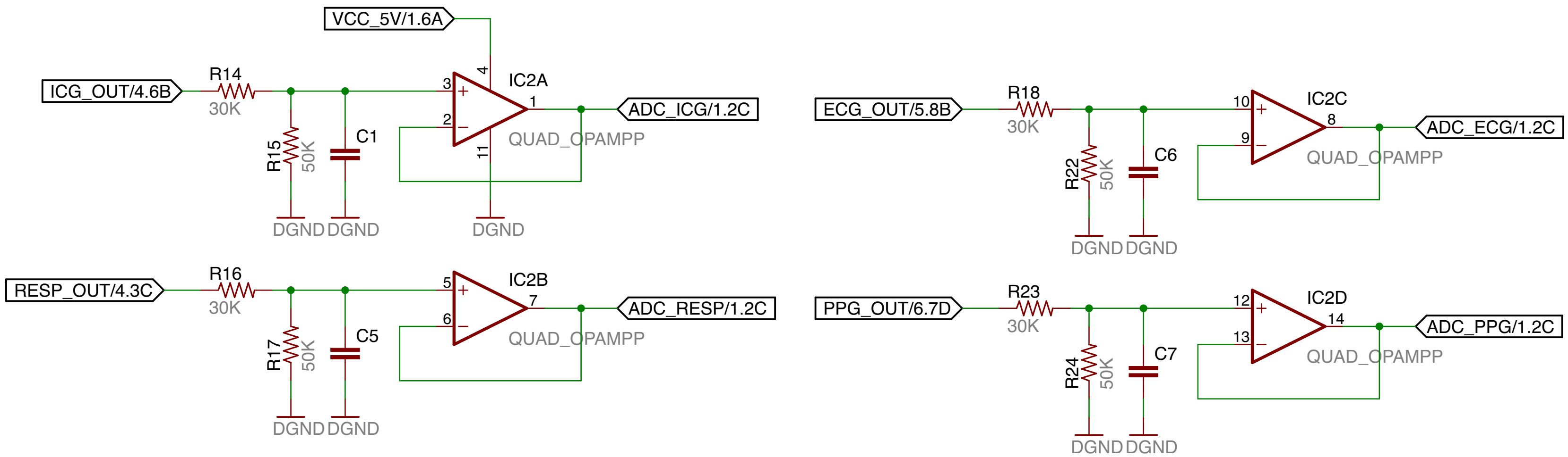
Gain is split across both sides of the high pass due to the DC offset on the inputs.
To mitigate large input offsets, the IA gain should be reduced until the IA output is no longer saturated.
The second stage gain should be increased to compensate for the reduced gain in the first stage.

The Sallen-Key Lowpass Filter is designed for a cutoff frequency of 150 Hz and Q = 0.707 for a maximally flat passband.

Right Leg Drive is a mechanism for improving the common-mode rejection. The 5Mohm resistor limits the drive current to the body.


PPG
2kHz Oscillator
R28
100K
QUAD_OPAMPP
C9
1nF
IC6A
R27
18K
AGND
R26
16K
AGND
LED Drive, Clock Inversion
AVCC/5.7B
R29
120-320
2KHZ_OSC
PPG_LEDP/1.6C
PPG_LEDN/1.6C
R43
10K
T4
2N2222
AGND
Sample & Hold
IC7A
QUAD_OPAMPP
AGND
R30
220K
22pF
C10
PPG_DP/1.6C
IC14B
4066N
100nF
C12
PPG_IA_P
2KHZ_OSC
AGND
IC15B
4066N
100nF
C11
PPG_IA_N
PPG_LEDN/1.6C
AGND
Instrumentation Amplifier
PPG_IA_P
IC8C
LMC660
R38
9.53K
R39
9.53K
R37
4.99K
R42
R36
4.99K
IC13B
QUAD_OPAMPP
R40
9.53K
R41
9.53K
PPG_IA_N
IC13A
AGND
HPF
C13
10uF
R31
160K
AGND
Gain & LPF
IC7B
QUAD_OPAMPP
R32
500K
10nF
C14
R33
1K-6K
AGND
Sallen-Key LPF
C16
4.3uF
R34
2.4K
R35
3.9K
C15
1uF
IC7C
PPG_OUT/7.5C
QUAD_OPAMPP
AGND

ADC INPUT



Each module translates the 8V signals into 5V levels compatible with the Arduino ADC.
The resistor divider has an attenuation of G = 50K / (30K + 50K) = 5 / 8.

The op-amp is configured as a unity gain buffer, and provides a low output impedance to the ADC.
IMPORTANT: If using alternate parts, ensure that the op amp for this stage is stable in a unity gain configuration!

The capacitor adds an optional extra pole for any final antialiasing.
The pole's corner frequency is calculated as: f = 1 / (2 * pi * (30K II 50K) * C)