

AM/FM RECEIVER MOLECULE – discrete BJT + op–amp radio, STM32G0B1 USB audio

FM_Frontend

FM: high–side LO, IF 10.7 MHz. Varactor tanks use BB910 through a 22 pF series capacitor (reduces RF swing on the diode and sets the tuning ratio).

Antenna, diplexer & FM front end

File: fm_frontend.kicad_sch

IF_10M7

Two 10.7 MHz ceramic filters (230 kHz) around one BJT gain stage, then a BJT mixer with a 10.24 MHz crystal oscillator converts both bands to 455 kHz.

10.7 MHz IF & second conversion to 455 kHz

File: if_10m7.kicad_sch

AM_IF

Gain is set by the tail currents of two BC847BS differential pairs (~40 dB range each); an op–amp integrator holds the detected carrier at ~1 V.

AM 455 kHz IF, AGC & envelope detector

File: am_if.kicad_sch

AM_Frontend

AM 530–1700 kHz is up–converted with a high–side LO at 11.23–12.4 MHz; the image lands at 22–23 MHz and is removed by the 2 MHz LPF, so no tracking preselector is needed.

AM front end (up–conversion to 10.7 MHz)

File: am_frontend.kicad_sch

Tuning_UI

DAC outputs are scaled x1.45 by rail–to–rail op–amps to 0–4.8 V and heavily RC filtered (varactor noise = LO phase noise). The RF tracking tank uses a filtered 12–bit PWM.

Tuning, band switching & user interface

File: tuning_ui.kicad_sch

FM_IF

Each IF cycle transfers a fixed charge C*(Vpp–2Vf) into the op–amp summing node, so the average current is proportional to frequency (40 uA at 455 kHz, +/-6.6 uA at +/-75 kHz).

FM 455 kHz limiter & pulse–count discriminator

File: fm_if.kicad_sch

Molecule_IO

Adom Molecule (Molecule Design Guide v1.0): large / standard machine pins in the four corners, 96 x 96 mm apart on the 32 mm large grid (mounts directly on the base scaffold), and medium machine contacts on the 2 mm grid measured from MP1. All four corner pins are GND; 5 V comes in on the VIN contact (MC1) or USB–C. None of the contacts is needed in use: power, control, audio and firmware updates all run over USB–C. SWD, UART and the audio outputs are optional debug / monitor points; CLK(=B00T0)/3V3 and RST/GND are adjacent pairs for jumper recovery.

Molecule Interface: machine pins & contacts

File: molecule_io.kicad_sch

SIGNAL FLOW

ANT -> diplexer -> FM: 88–108 MHz RF amp (tracked varactor tank) -> BJT mixer <- 98.7–118.7 MHz VCO
-> AM: 0.53–1.7 MHz preamp -> BJT mixer <- 11.23–12.4 MHz VCO (up–conversion)
both -> 10.695 MHz IF (2 ceramic filters + BJT amp) -> BJT mixer <- 10.24 MHz XO -> 455 kHz
AM: ceramic filter -> 2x diff–pair VGA -> post–amp -> diode detector -> op–amp AGC & 5 kHz LPF
FM: BJT limiter -> squarer -> diode–pump pulse–count detector -> op–amp integrator -> 15 kHz LPF
STM32G0B1: ADC samples AM_AUDIO / FM_AUDIO; DAC1/DAC2 tune the VCOs; PWM tunes the FM preselector;
TIM2_ETR counts the limited IF; TIM1 injects 40 MHz–crystal–derived markers at ANT for self–calibration.
USB–C only: UAC audio + CDC control port + DFU runtime; a blank chip boots into ROM USB DFU.

POWER: USB–C 5 V or VIN machine pin (B5819W OR–ing, 500 mA PTC). AP2112K 3.3 V. +5VA for analog/RF.
Band switching: PNP high–side switches (MCU open–drain) power only the active front end.
ADOM MOLECULE: large/standard GND machine pins 96 x 96 mm, 28 medium contacts on the 2 mm grid (all optional).

PCB: 4 layers – F.Cu signal / In1.Cu solid GND / Iq2.Cu power / B.Cu signal + GND pour. 3

Power_MCU

USB–C 5 V in -> PTC -> +5V. AP2112K LDO -> +3V3 (MCU). Ferrite–filtered +5VA (all analog/RF) and +3.3VA (MCU VREF+: ADC / DAC reference). The STM32G0B1 runs USB from HSI48 + CRS and its timers from a 40 MHz crystal; a blank chip boots straight into the ROM USB DFU bootloader.

Power, USB & MCU

File: power_mcu.kicad_sch

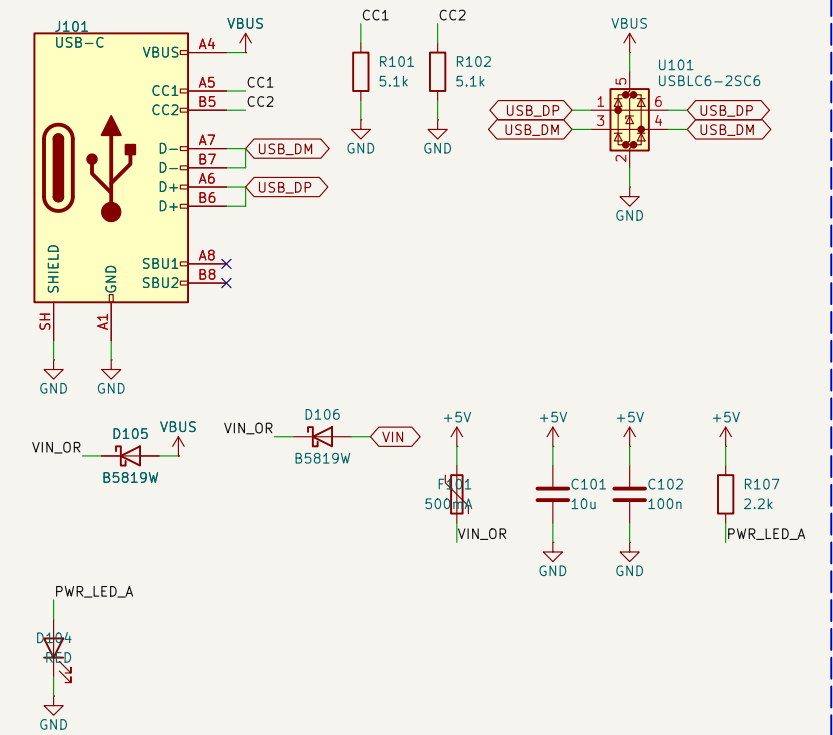
Generated from tools/design.py (single source of truth) 4–layer PCB, JLCPCB–compatible rules Adom		
Sheet: / File: amfm_receiver.kicad_sch		
Title: AM/FM Receiver Molecule – discrete BJT/op–amp radio, STM32G0B1 USB audio		
Size: A3	Date: 2026–09–29	Rev: B (molecule)
KiCad E.D.A. 10.0.6		Id: 1/9

Power, USB & MCU

USB-C 5 V in -> PTC -> +5V. AP2112K LDO -> +3V3 (MCU). Ferrite-filtered +5VA (all analog/RF) and +3.3VA (MCU VREF+: ADC / DAC reference). The STM32G0B1 runs USB from HSI48 + CRS and its timers from a 40 MHz crystal; a blank chip boots straight into the ROM USB DFU bootloader.

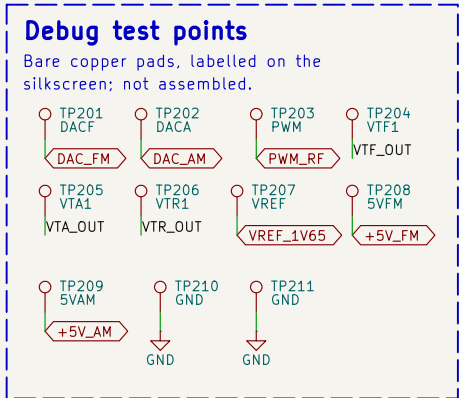
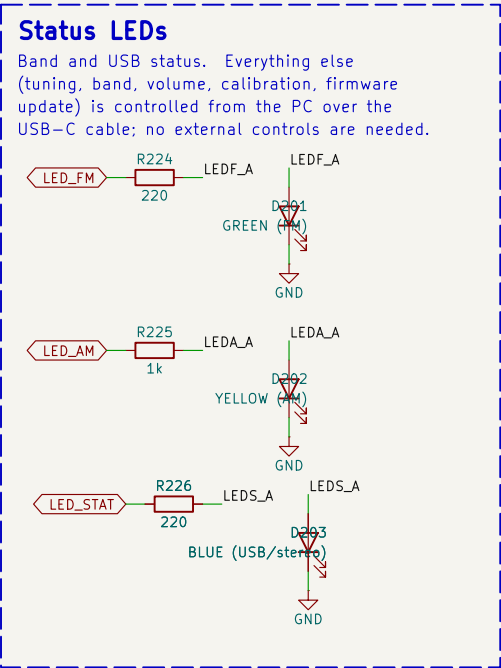
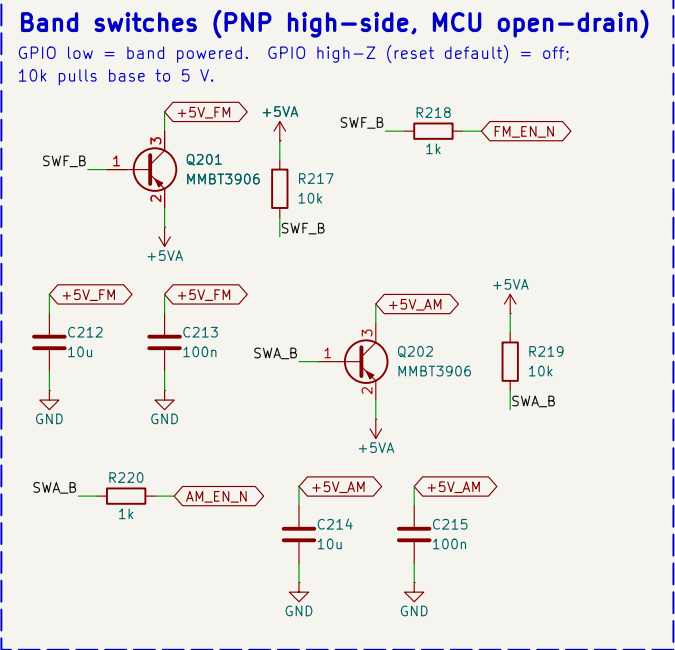
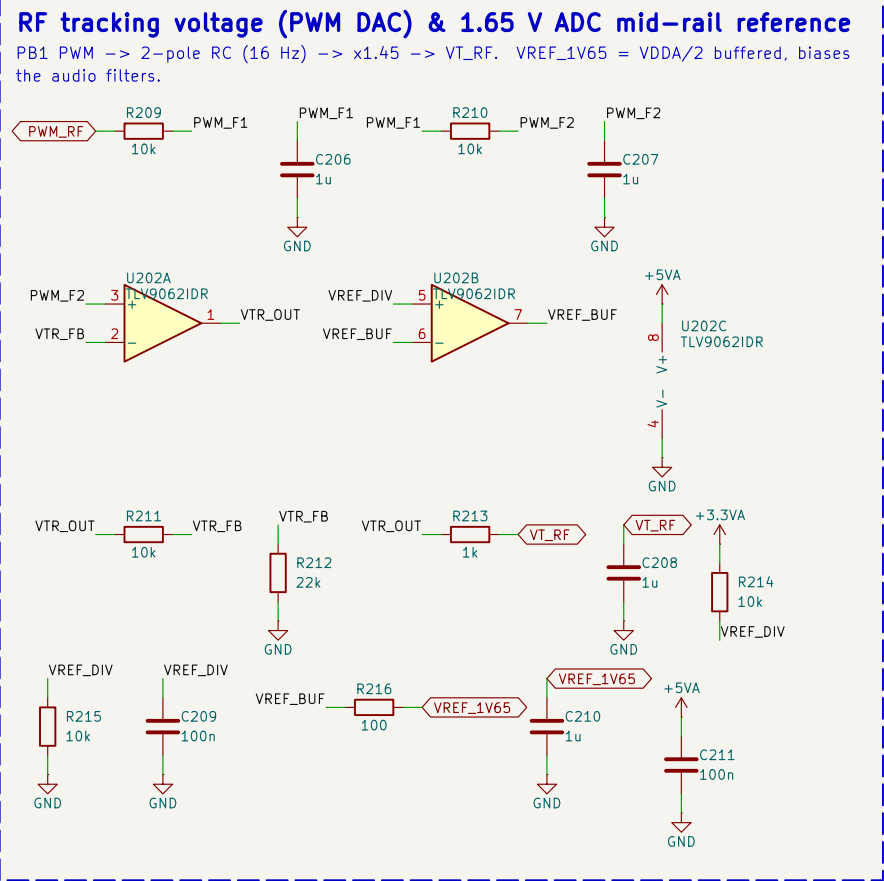
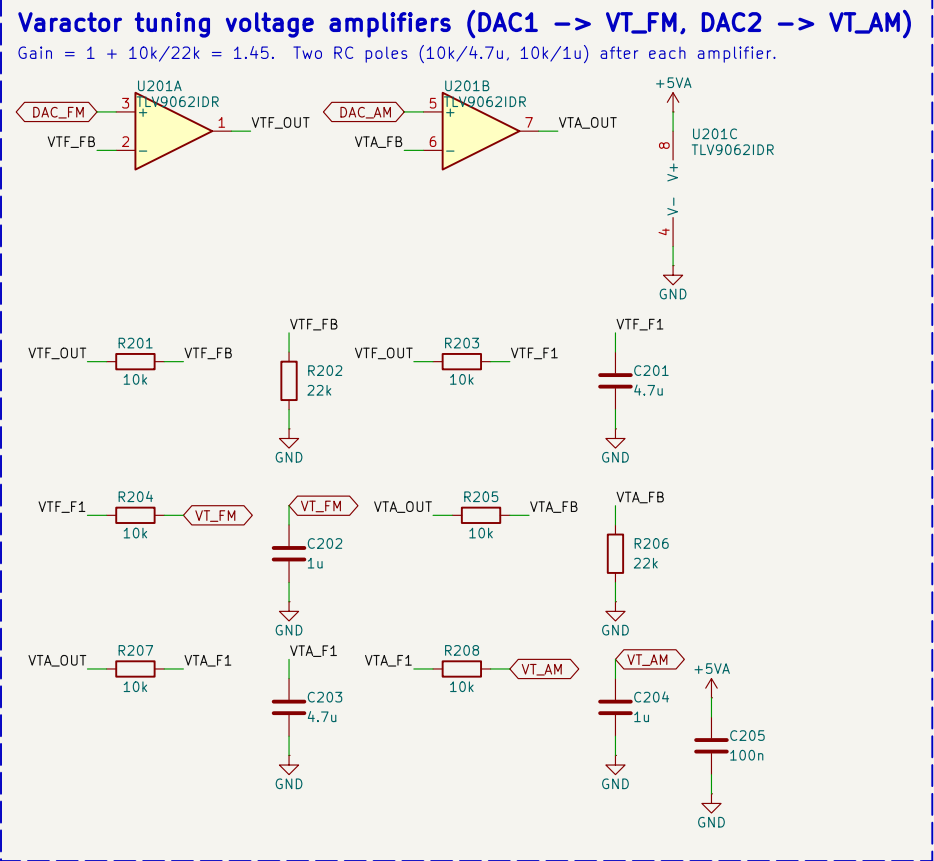
USB-C / machine-pin power input & ESD

Device-only USB 2.0: 5.1k CC pull-downs, USBLC6 on D+/D-. 5 V comes from USB-C or from the VIN machine contact MC1 (Adom control panel P52 or USB 5 V); B5819W diodes OR the two sources.



Tuning, band switching & user interface

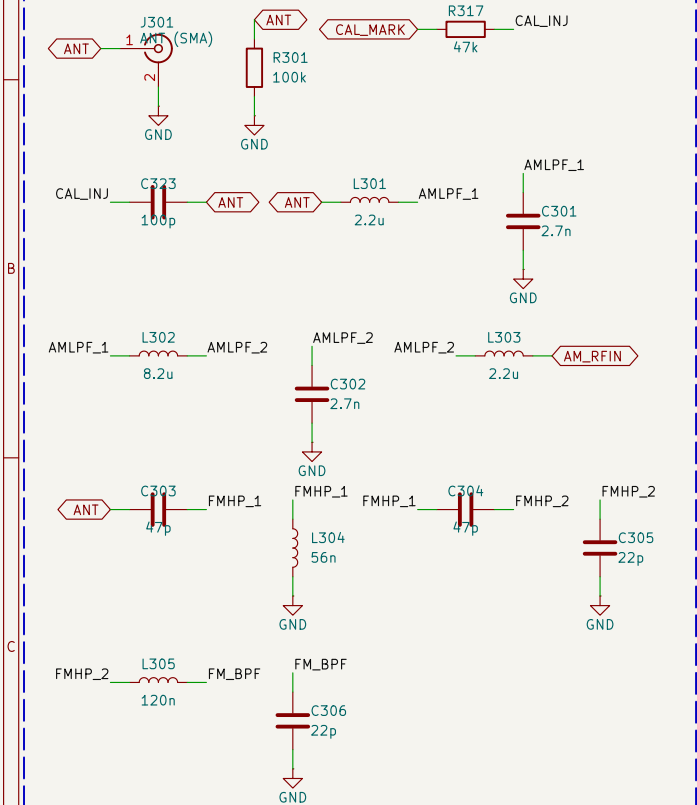
DAC outputs are scaled x1.45 by rail-to-rail op-amps to 0–4.8 V and heavily RC filtered (varactor noise = LO phase noise). The RF tracking tank uses a filtered 12-bit PWM.



FM: high-side LO, IF 10.7 MHz. Varactor tanks use BB910 through a 22 pF series capacitor (reduces RF swing on the diode and sets the tuning ratio).

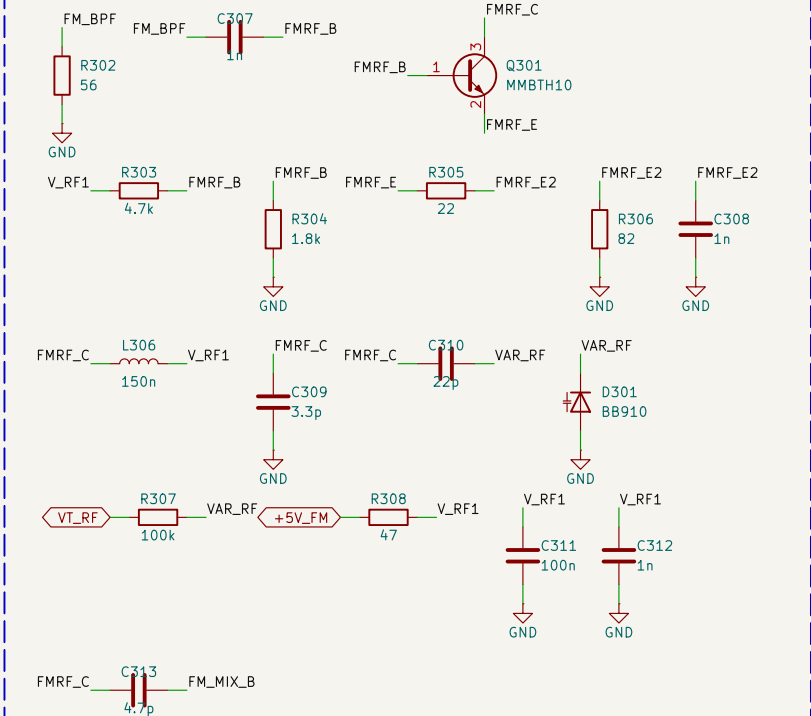
Antenna input & diplexer

AM branch: 5-pole 2 MHz Butterworth LPF (series L first = high Z at VHF). FM branch: 3-pole 70 MHz HPF (series C first = high Z at MF) + 3-pole 130 MHz LPF.



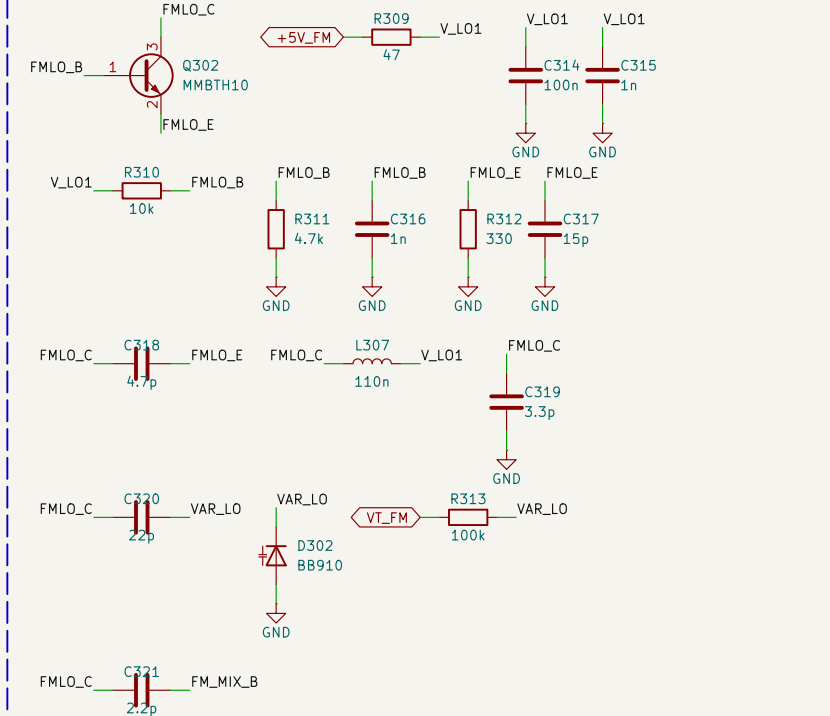
FM RF amplifier with varactor-tracked tank (88–108 MHz)

Ic ~4 mA. Tank 150 nH || (3.3 pF + BB910 via 22 pF); tuned by VT_RF (firmware tracks the LO).



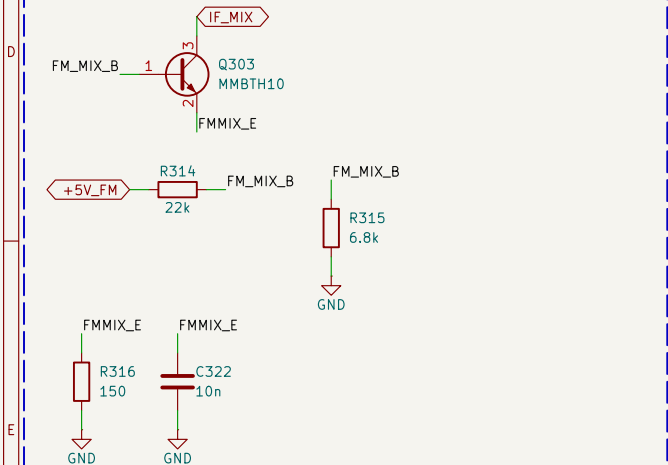
FM local oscillator 98.7–118.7 MHz (common-base Colpitts)

| $I_{le} \sim 2$ mA. Tank 110 nH || (3.3 pF + BB910 via 22 pF); feedback 4.7 pF / 15 pF.
| Tuned by VT_FM.



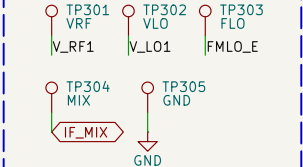
FM mixer (RF + LO at base, IF at collector)

le ~2 mA, emitter bypassed. Collector drives the shared 10.7 MHz IF node.



Debug test points

Bare copper pads, labelled on the
silkscreen; not assembled.



Generated from tools/design.py (single source of truth)
4-layer PCB, JLCPCB-compatible rules
Adom

Adom

Sheet: /FM_Frontend/
File: fm_frontend.kicad_sch

Title: Antenna, diplexer & FM front end

Size: A3	Date: 2026-09-29	Rev: B (molecule)
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Sheet No.	Sheet 2 of 9	Rev. 2 (Microcode)
KiCad E.D.A. 10.0.6		Id: 4/9

7	8
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Rev: B (molecule)

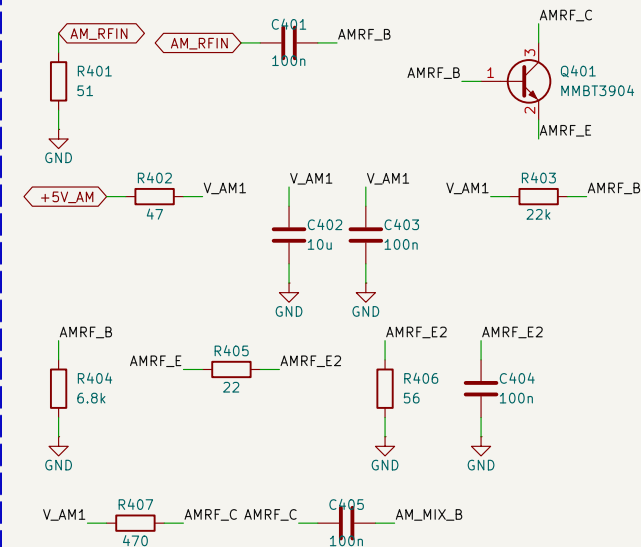
Id: 4/9

AM front end (up-conversion to 10.7 MHz)

AM 530–1700 kHz is up-converted with a high-side LO at 11.23–12.4 MHz; the image lands at 22–23 MHz and is removed by the 2 MHz LPF, so no tracking preselector is needed.

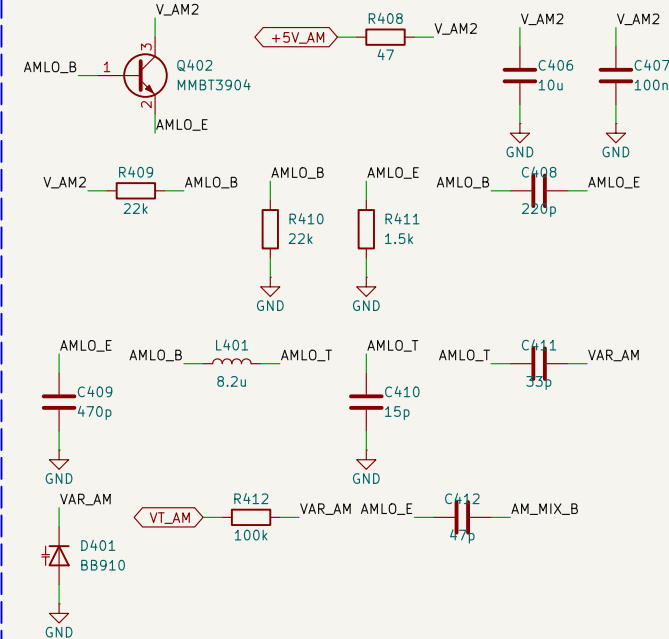
AM RF preamplifier

50 ohm terminated input, $I_c \sim 3.8$ mA, gain ~ 24 dB.



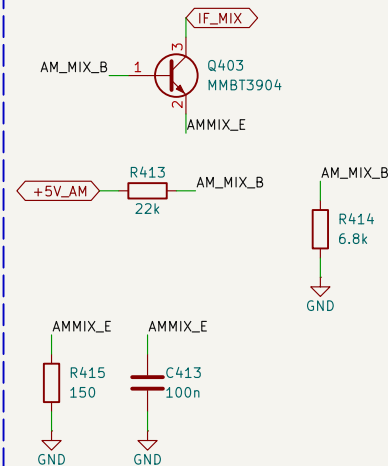
AM local oscillator 11.23–12.4 MHz (Clapp)

L = 8.2 uH in series with 15 pF || (BB910 via 33 pF); divider 220 pF / 470 pF. Tuned by VT_AM.



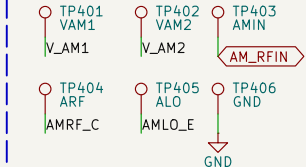
AM mixer

Same topology as the FM mixer; shares the 330 ohm 10.7 MHz IF load.



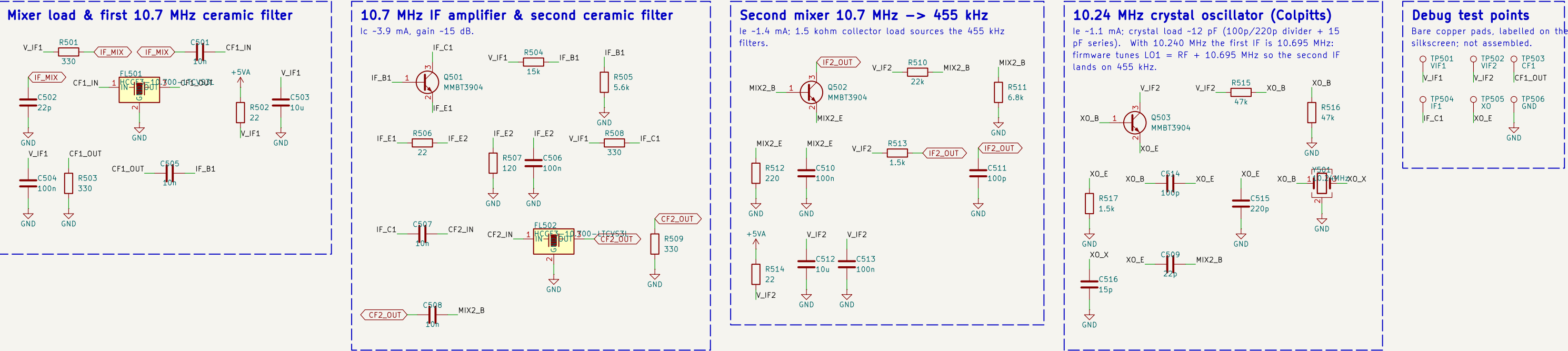
Debug test points

Bare copper pads, labelled on the silkscreen; not assembled.



10.7 MHz IF & second conversion to 455 kHz

Two 10.7 MHz ceramic filters (230 kHz) around one BJT gain stage, then a BJT mixer with a 10.24 MHz crystal oscillator converts both bands to 455 kHz.

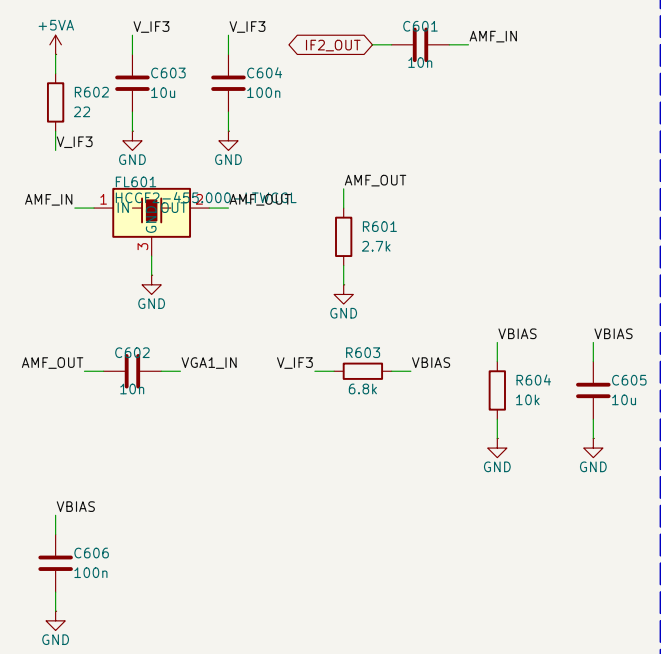


AM 455 kHz IF, AGC & envelope detector

Gain is set by the tail currents of two BC847BS differential pairs (~40 dB range each); an op-amp integrator holds the detected carrier at ~1 V.

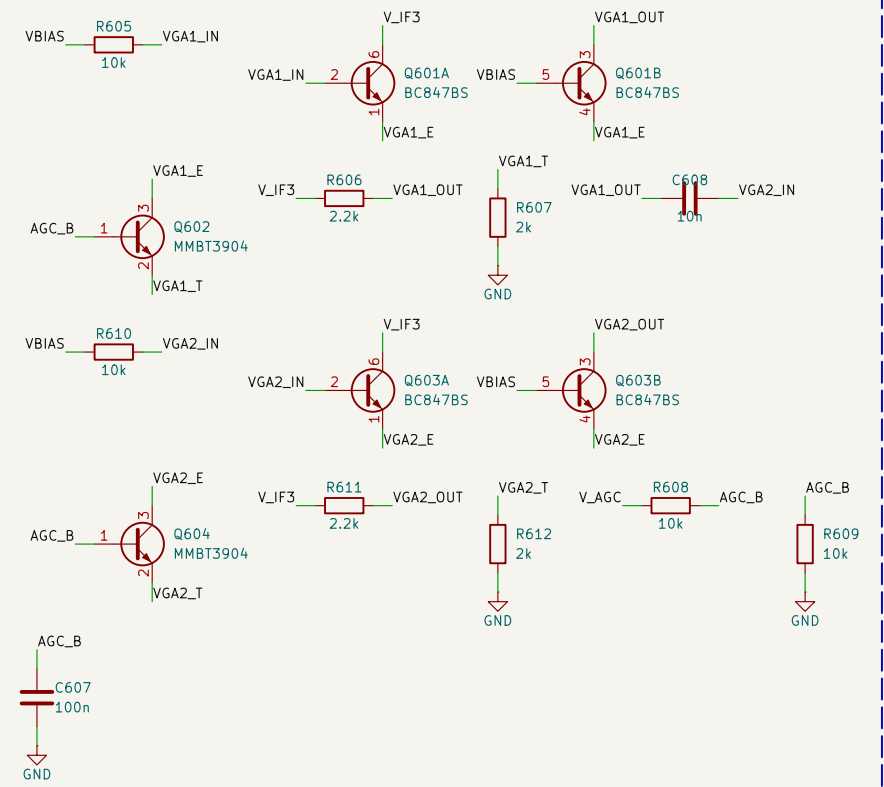
455 kHz AM channel filter & bias

HCCF2-455 LTWGL: +/-4.5 kHz @ 6 dB, 2 kohm terminations.



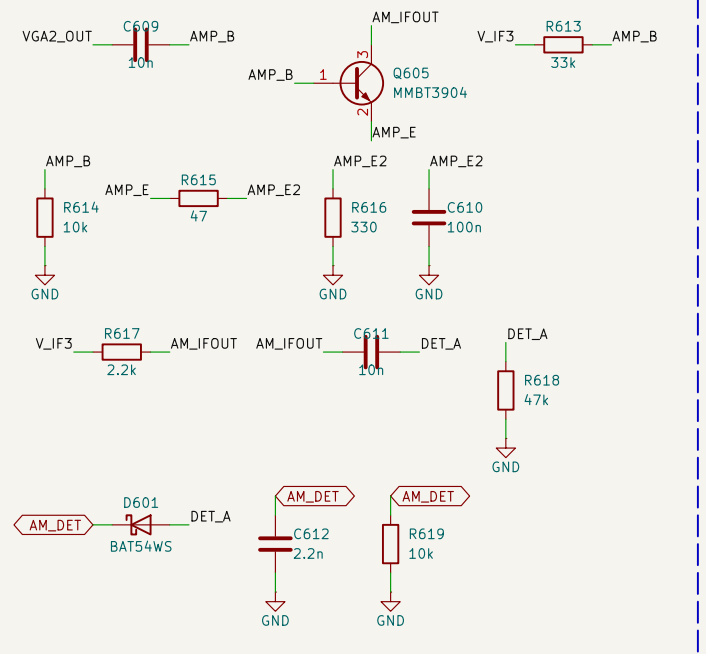
AGC variable-gain IF (2 x BJT differential pair)

Gain per stage = $I_{tail} \cdot R_c / (4 \cdot V_t)$: 0.9 mA -> x19, 10 uA -> x0.2. AGC_B = V_AGC/2.



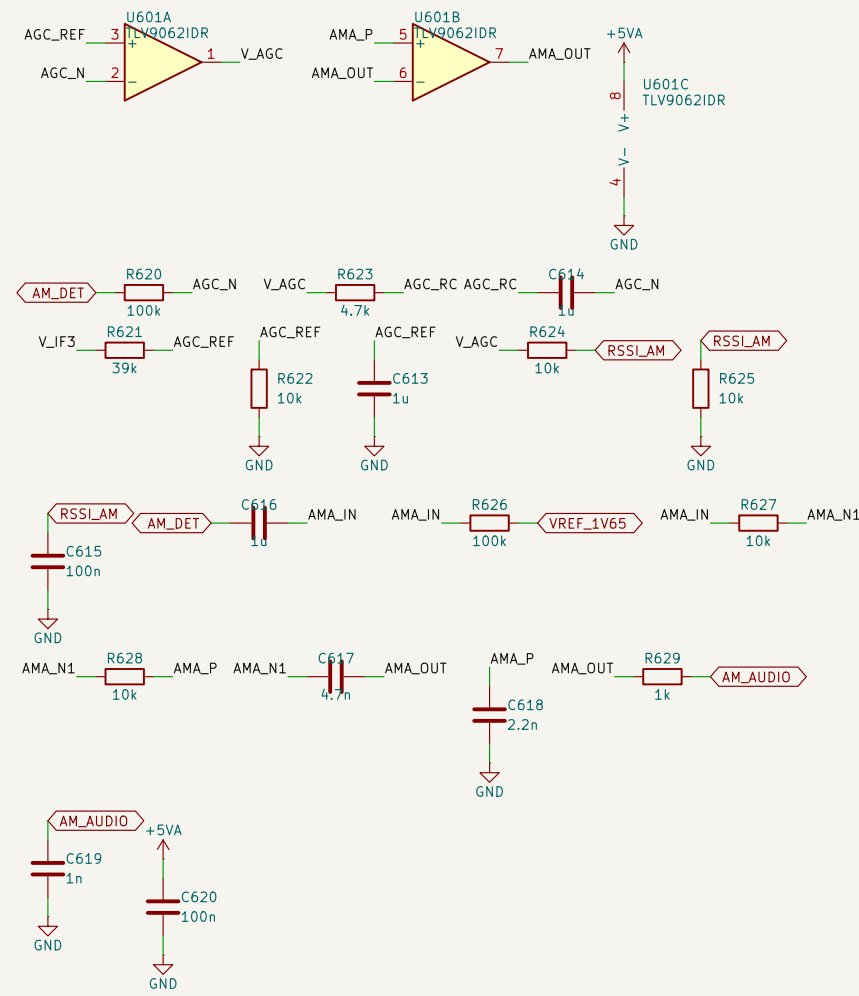
IF post-amplifier & envelope detector

Ic ~1.1 mA, gain ~30. Detector RC = 22 us.



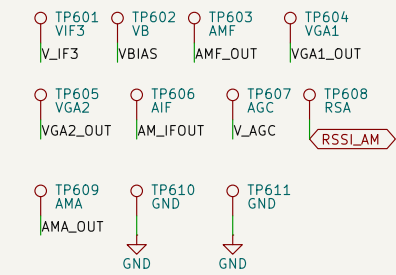
AGC integrator, RSSI & AM audio low-pass (5 kHz)

U601A: PI integrator (100k, 4.7k + 1u) vs 0.98 V reference. U601B: unity-gain Sallen-Key Butterworth 5 kHz, audio re-biased to VREF_1V65 for the ADC.



Debug test points

Bare copper pads, labelled on the silkscreen; not assembled.



Generated from tools/design.py (single source of truth)
4-layer PCB, JLCPCB-compatible rules

Adom

Sheet: /AM_IF/
File: am_if.kicad_sch

Title: AM 455 kHz IF, AGC & envelope detector

Size: A2 Date: 2026-09-29
KiCad E.D.A. 10.0.6

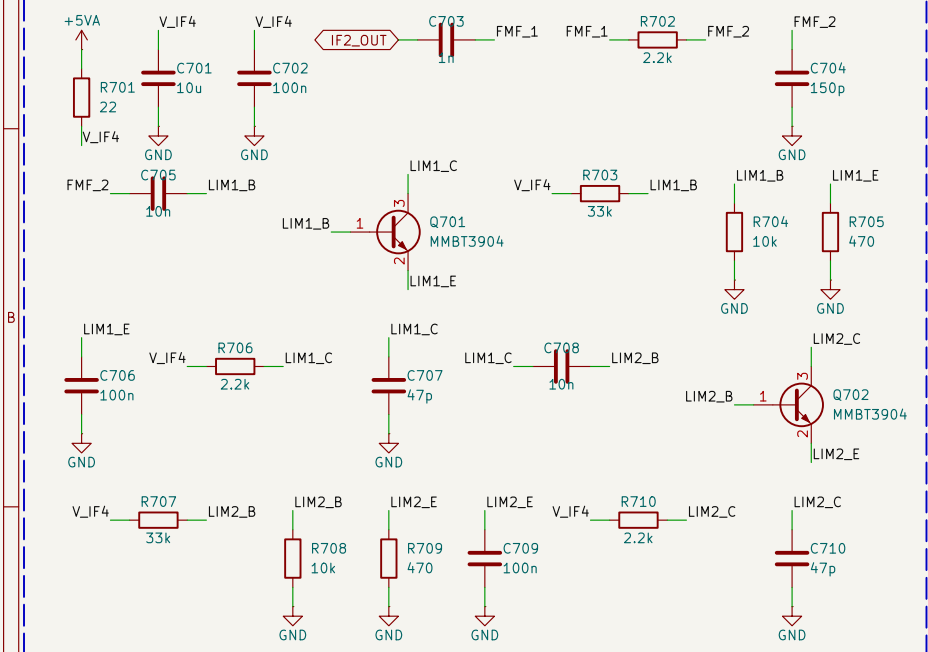
Rev: B (molecule)
Id: 7/9

1	2	3	4	5	6	7	8
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Each 1f cycle transfers a fixed charge $C \cdot (V_{pp} - 2V_f)$ into the op-amp summing node, so the average current is proportional to frequency (40 uA at 455 kHz, +/- 6.6 uA at +/- 75 kHz).

[illegible]

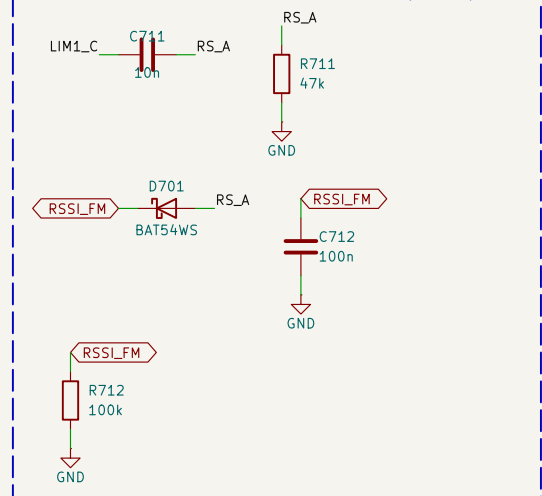
$I_c \sim 0.95 \text{ mA}$ per stage, $\sim 33 \text{ dB}$ per stage.



FM signal—strength detector (seek)

The diagram shows three circuit sections for FM signal strength detection:

- Top Section:** A signal line from `LIM1_C` passes through a capacitor `C711` (10n) to a pin labeled `RS_A`. A resistor `R711` (47k) connects this `RS_A` pin to `GND`.
- Middle Section:** A signal line from `BAT54WS` passes through a diode `D701` to a pin labeled `RS_A`. A resistor `R712` (100k) connects this `RS_A` pin to `GND`. A capacitor `C712` (100n) is connected between the `RSI_FM` input and `GND`.
- Bottom Section:** A signal line from `RSI_FM` is connected to a resistor `R712` (100k), which is then connected to `GND`.

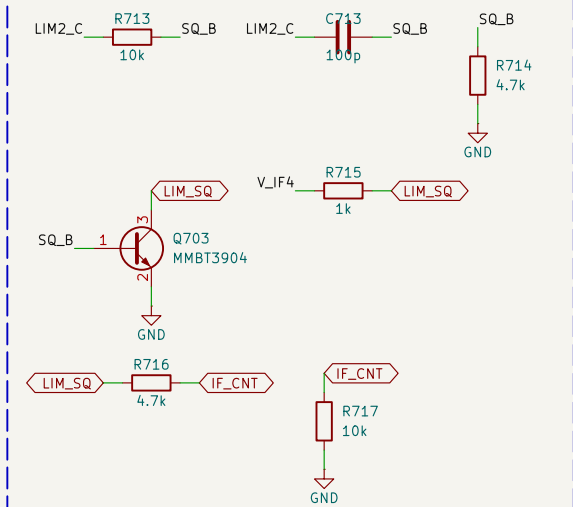
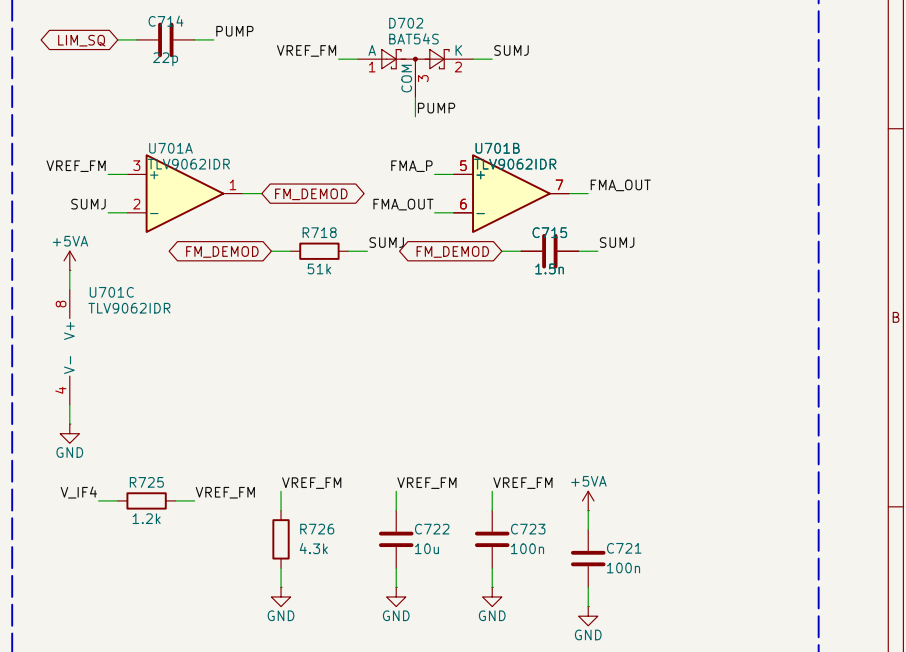


Squarer & IF frequency counter output

DC-coupled saturating switch, threshold ~ 2.2 V on LIM2_C. IF_CNT (3.3 V) $\rightarrow$ TIM2_ETR for AFC.

The circuit diagram illustrates the squarer and IF frequency counter output. It features two input signals, LIM2_C and IF_CNT, which are connected to a DC-coupled saturating switch (Q703, MMBT3904). The output of the switch is connected to the IF_CNT input of the TIM2_ETR for AFC. The circuit includes several resistors: R713 (10k) and R714 (4.7k) are connected to LIM2_C and IF_CNT respectively. R715 (1k) is connected to the output of the switch. R716 (4.7k) is connected to the IF_CNT input. The output of the switch is also connected to the IF_CNT input of the TIM2_ETR for AFC.

DC-coupled saturating switch, threshold ~2.2 V on LIM2_C. IF_CNT (3.3 V) → TIM2_ETR for AFC.

[illegible]
$$FM_DEM0D = VREF_FM - I \cdot 51k \text{ (~1.8 V at 455 kHz). } 51k \parallel 1.5 \text{ nF} = 76 \text{ us.}$$


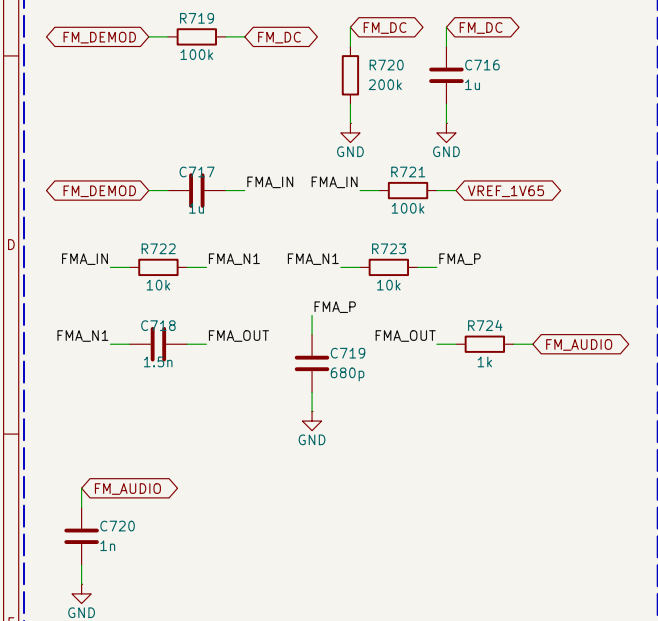
FM output & FM audio low-pass (15 kHz)

FM_DC = $2/3 \times \text{FM_DEMODO}$ (0.1 s) for AFC/tuning. U701B unity-gain Sallen-Key 15.8 kHz, removes 19 kHz pilot.

The schematic diagram illustrates the FM output and audio low-pass filter circuit. It features several interconnected blocks and components:

- FM_DEMOD** block is connected to **R719** (100k), which then connects to the **FM_DC** block.
- The **FM_DC** block is connected to **R720** (200k), which is connected to **GND**.
- The **FM_DC** block is also connected to **C716** (1u), which is connected to **GND**.
- The **FM_DEMOD** block is connected to **C717** (1u), which is connected to **FMA_IN**.
- The **FMA_IN** signal is connected to **R721** (100k), which is connected to **VREF_1V65**.
- The **FMA_IN** signal is also connected to **R722** (10k), which is connected to **FMA_N1**.
- The **FMA_N1** signal is connected to **R723** (10k), which is connected to **FMA_P**.
- The **FMA_N1** signal is also connected to **C718** (1.5n), which is connected to **FMA_OUT**.
- The **FMA_OUT** signal is connected to **C719** (680p), which is connected to **GND**.
- The **FMA_OUT** signal is also connected to **R724** (1k), which is connected to the **FM_AUDIO** block.
- The **FM_AUDIO** block is connected to **C720** (1n), which is connected to **GND**.

FM_DC = 2/3 x FM_DEMOD (0.1 s) for AFC/tuning. U701B unity-gain Sallen-Key 15.8 kHz, removes 19 kHz pilot.



Debug test points

Bare copper pads, labelled on the silkscreen; not assembled.

TP701 VIF4

TP702 LIM1_C

TP703 LIM2_C

TP704 RSF

TP705 CNT

TP706 VRFM

TP707 FMDC

TP708 FMA

TP709 GND

TP710 GND

V_IF4

LIM1_C

LIM2_C

RSSI_FM

IF_CNT

VREF_FM

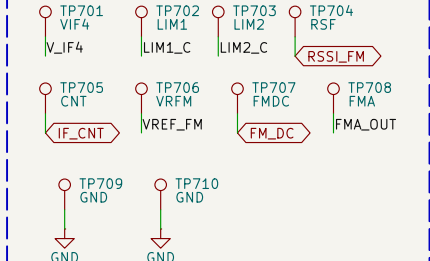
FM_DC

FMA_OUT

GND

GND

Bare copper pads, labelled on the silkscreen; not assembled.

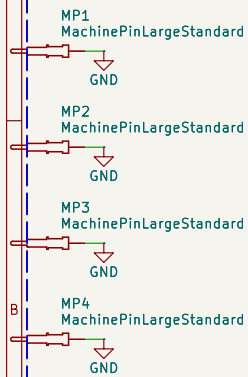


Molecule interface: machine pins & contacts

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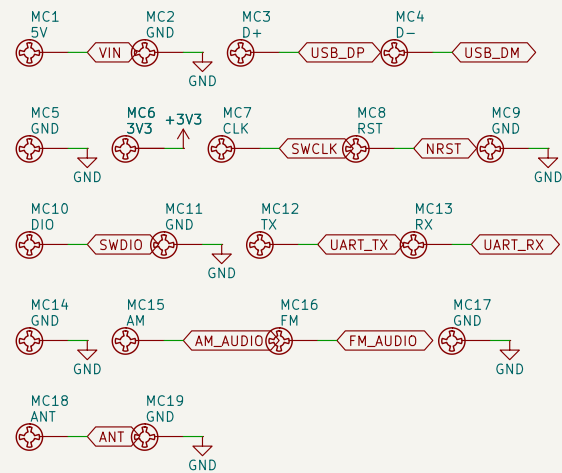
Corner machine pins, large (pincer grip points)

MP1..MP4 = GND (5 V enters on contact MC1 or USB-C).



Edge contacts (wired to the control panel / other molecules)

Left edge: power, USB, SWD (CLK doubles as BOOT0), reset, UART, audio out. Right: antenna (in parallel with the SMA jack).



Probe contacts (machine-probe points; accept probe needles)

10.7 MHz and 455 kHz IF, AM detector, FM discriminator, limiter output, the three tuning voltages, +5VA.

