



# Repair of HP83651A Sweeper for an HP8510C VNA System

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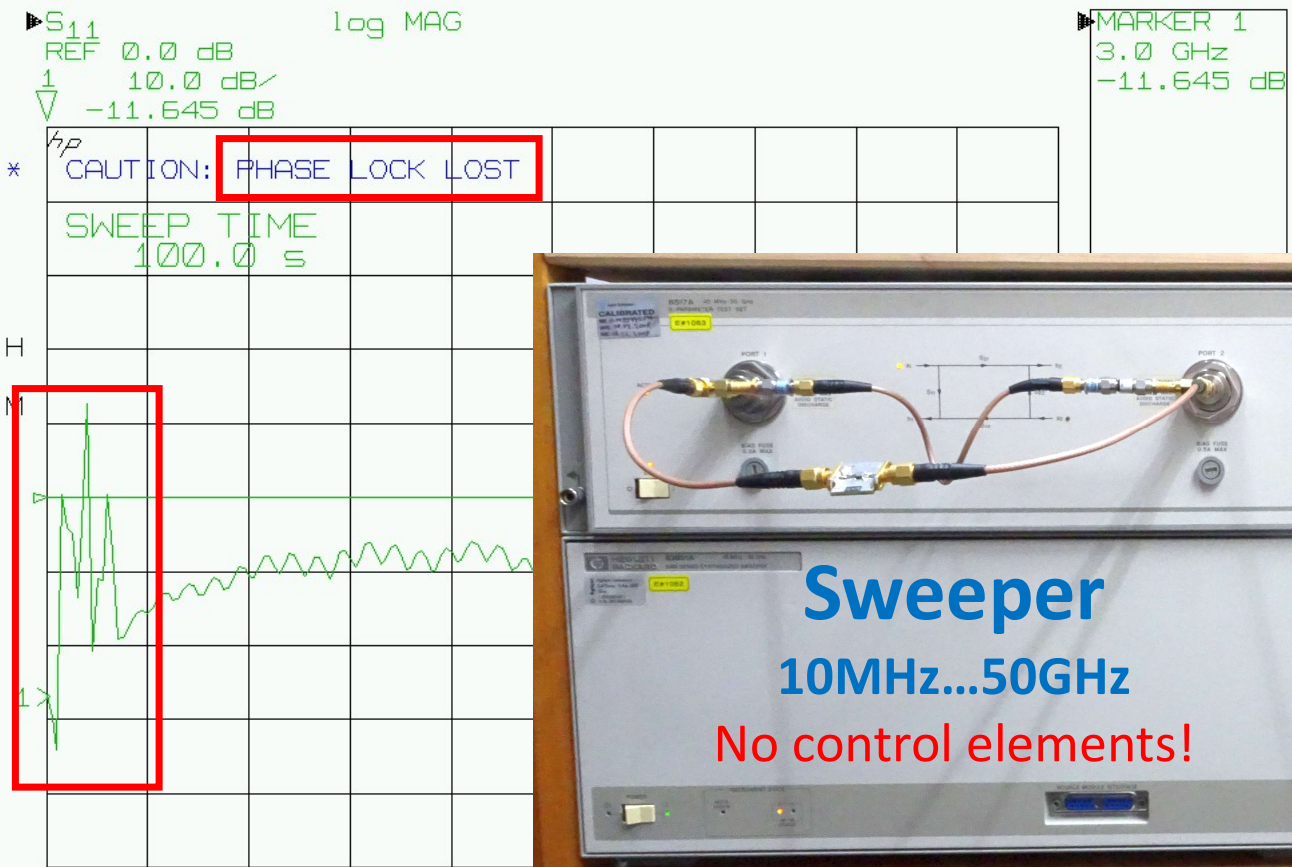
*Thanks to the members of*  
<https://groups.io/g/HP-Agilent-Keysight-equipment>  
and particularly „hp70000freak“ unbeknownst

June, 2026

*In memory of Eric Hecker † 2021*

# Symptom

Low frequency HP8510C Sweep => Phase Lock Lost!



START 0.045000000 GHz  
STOP 3.000000000 GHz

31 MAR 25  
13:43:24

# How to Operate the Sweeper without VNA?

Homemade Control Software + GPIB Adapter

DG8SAQ HP83651A control via AR488 GPIB adapter V0.4

File disconnect Diagnosis

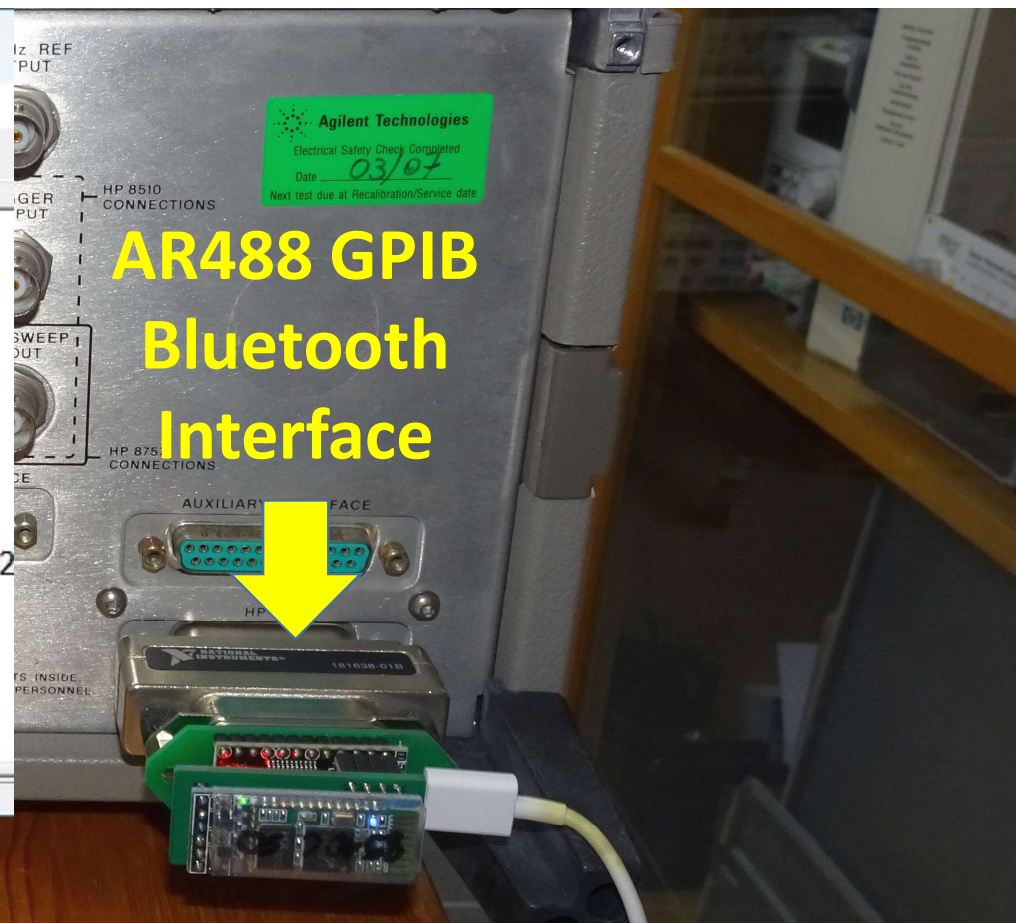
CW | Diagnosis | Settings

CW Frequency  GHZ

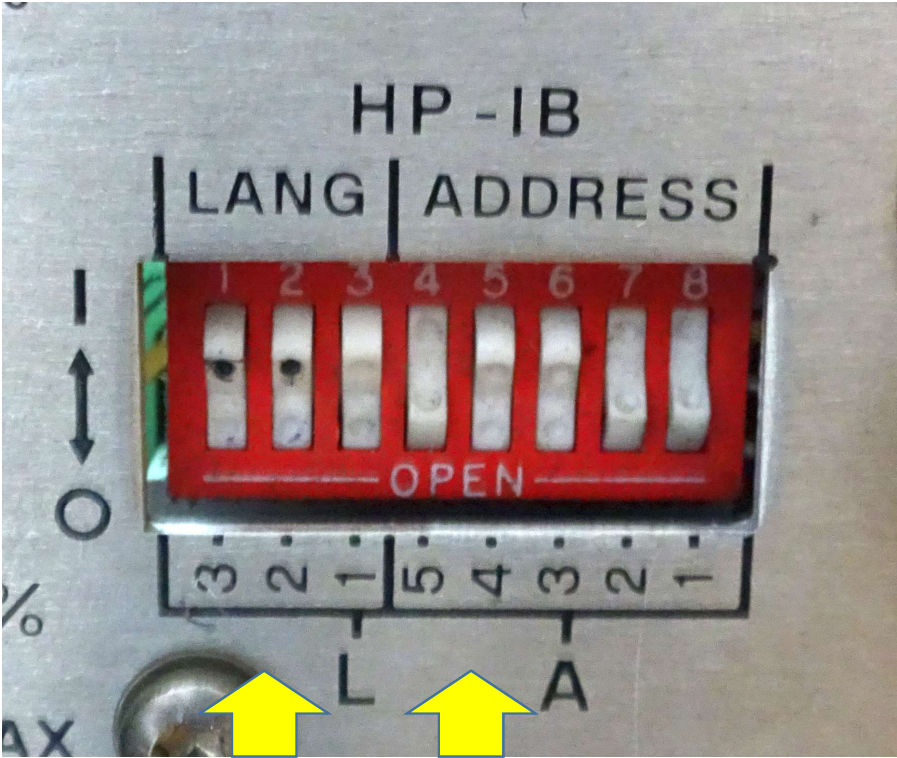
Power  dBm

```
++eos 2
++mode 1
++eoi 1
++addr 19
++auto 0
++dcl
*IDN?
++auto 1
HEWLETT-PACKARD,83651A,302
++auto 0
FREQ:MODE CW
POW:LEV 0
FREQ 3GHZ
```

success



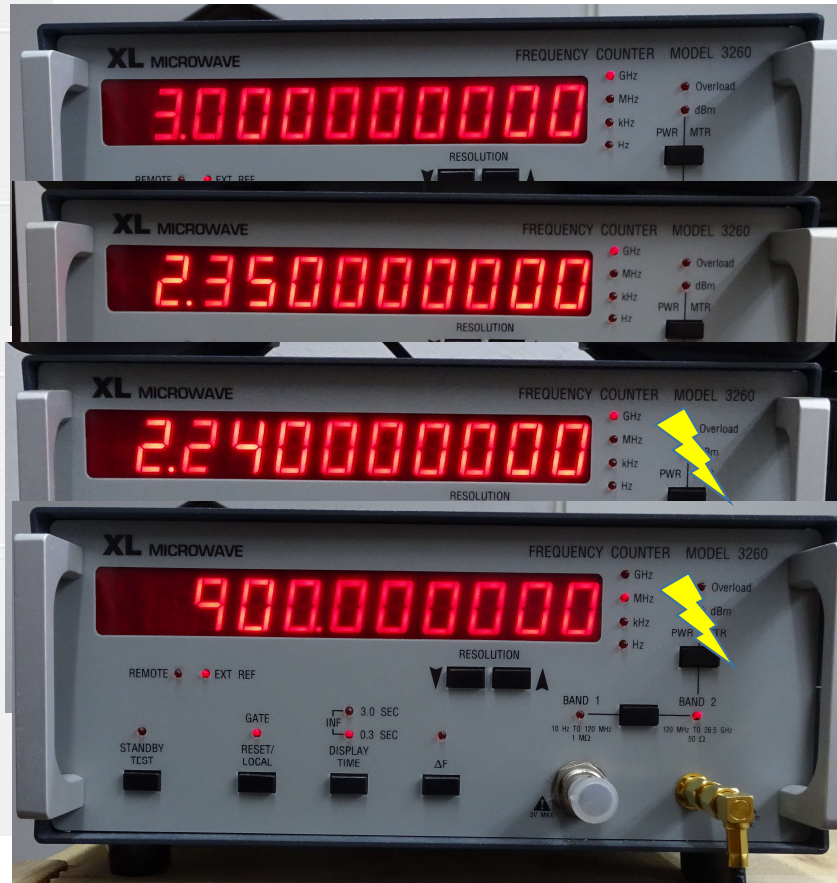
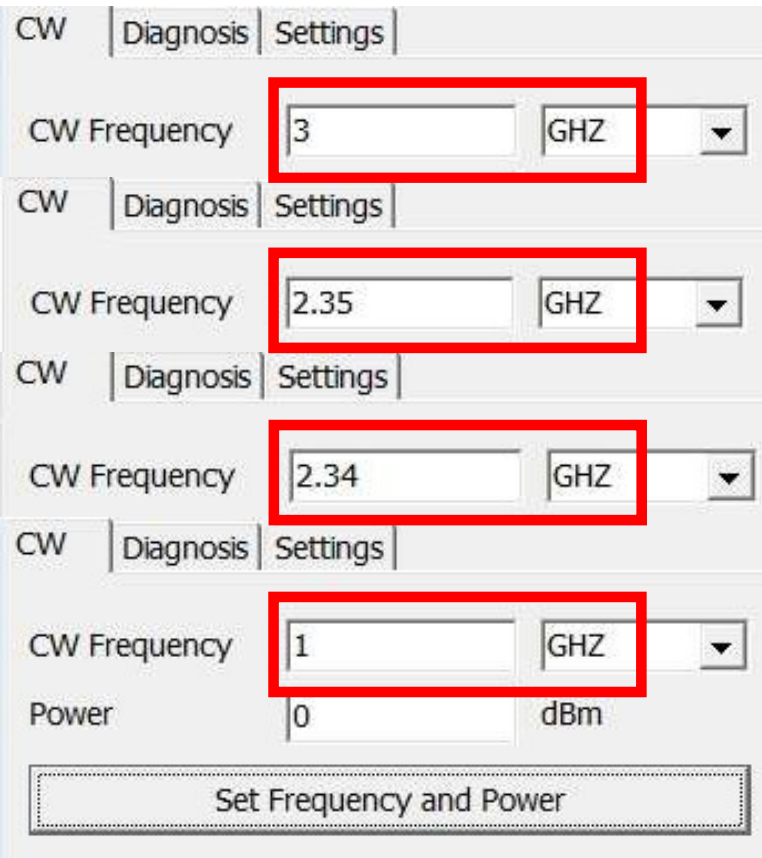
# Don't forget to switch HP83651A from Analyzer to SCPI Mode



**SCPI Adr = 19**

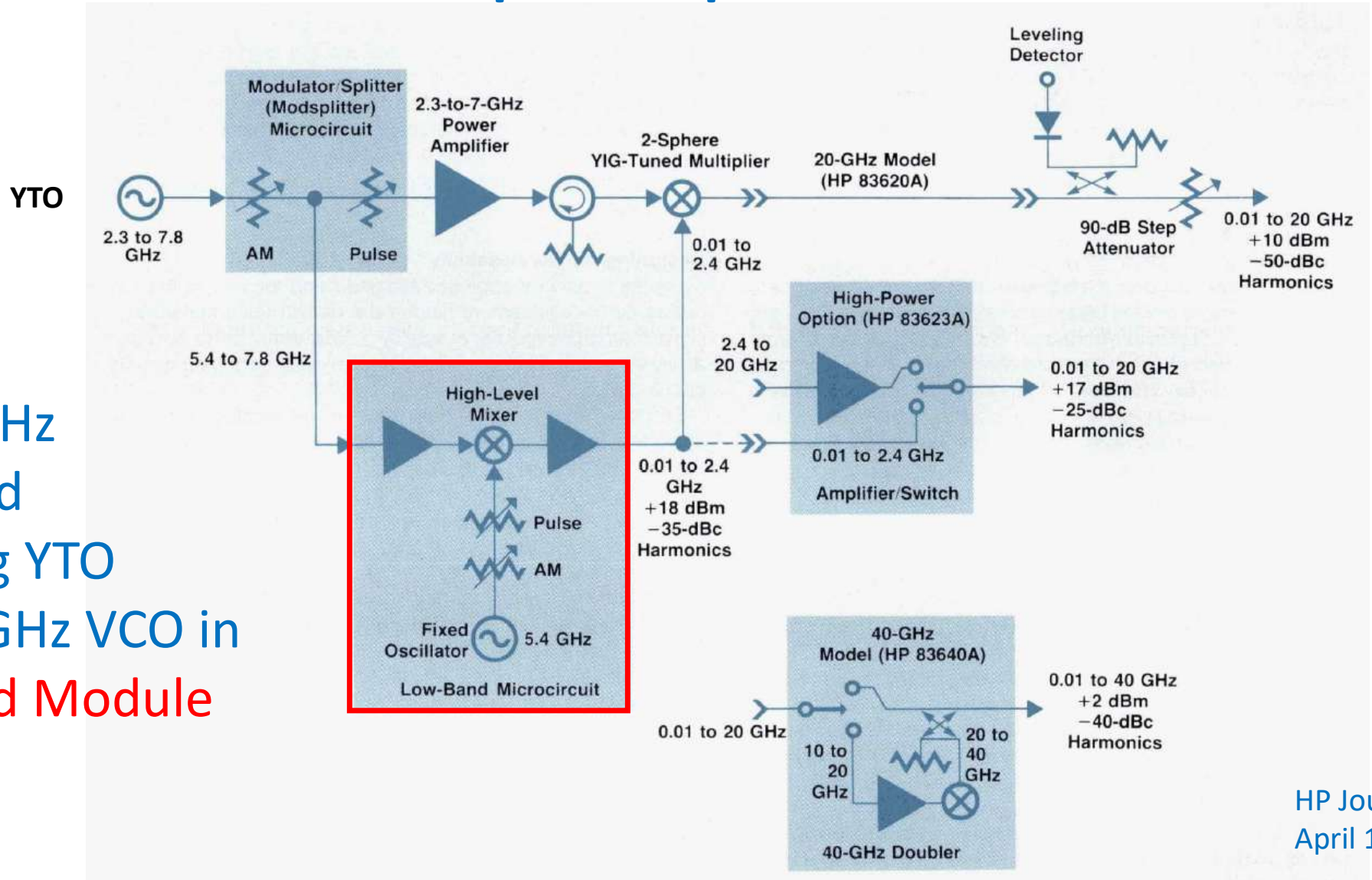
Language	HP-IB Address (Decimal)
SCPI	0
Analyzer	1
CIIL	2

# Problem Manifests Itself



- Sweeper works correctly at 2.35GHz and above
- Below 2.35GHz output frequency is ***exactly 100MHz too low***

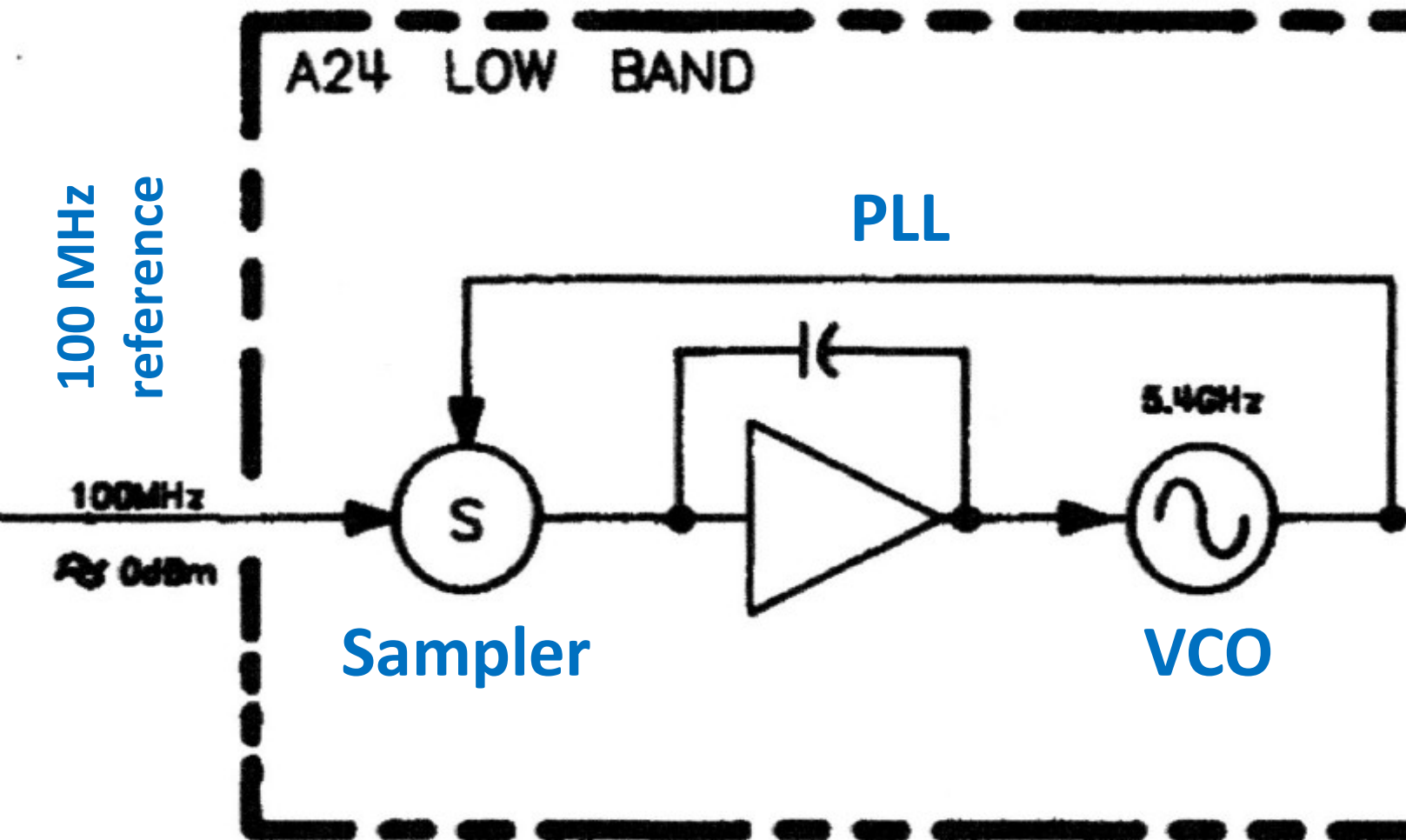
# Principle of Operation



$f < 2.35\text{GHz}$   
generated  
by mixing YTO  
with 5.4GHz VCO in  
**Low-Band Module**

# Block Diagram Low-Band Module

from HP8360 Service Manual



- 5.4GHz VCO locking to wrong harmonic of 100MHz reference
- No schematics
- Not serviceable



**Replacement?**

# Possible Replacement Part

Find similar items from **xihu888** (99.6% positive) [Shop store on eBay](#) Sponsored

## HP Agilent 5086-7463 Low Band Module for 8360 Series 83620A/B, 83640A/B, 83650AB

**Great & Vast Technology (gvtcom)** (443)  
100% positive [Seller's other items](#) [Message seller](#)

**US \$2,450.00**

No way!!!

as low as \$117.62/mo with **Klarna**. [Learn more](#)

Condition: **Used** ⓘ

*"Tested, good working condition. (We have many good working 8360 series generators been able to"...* [Read more](#)

Quantity:  5 available

[Buy It Now](#)

[Add to cart](#)

[♥ Add to Watchlist](#)

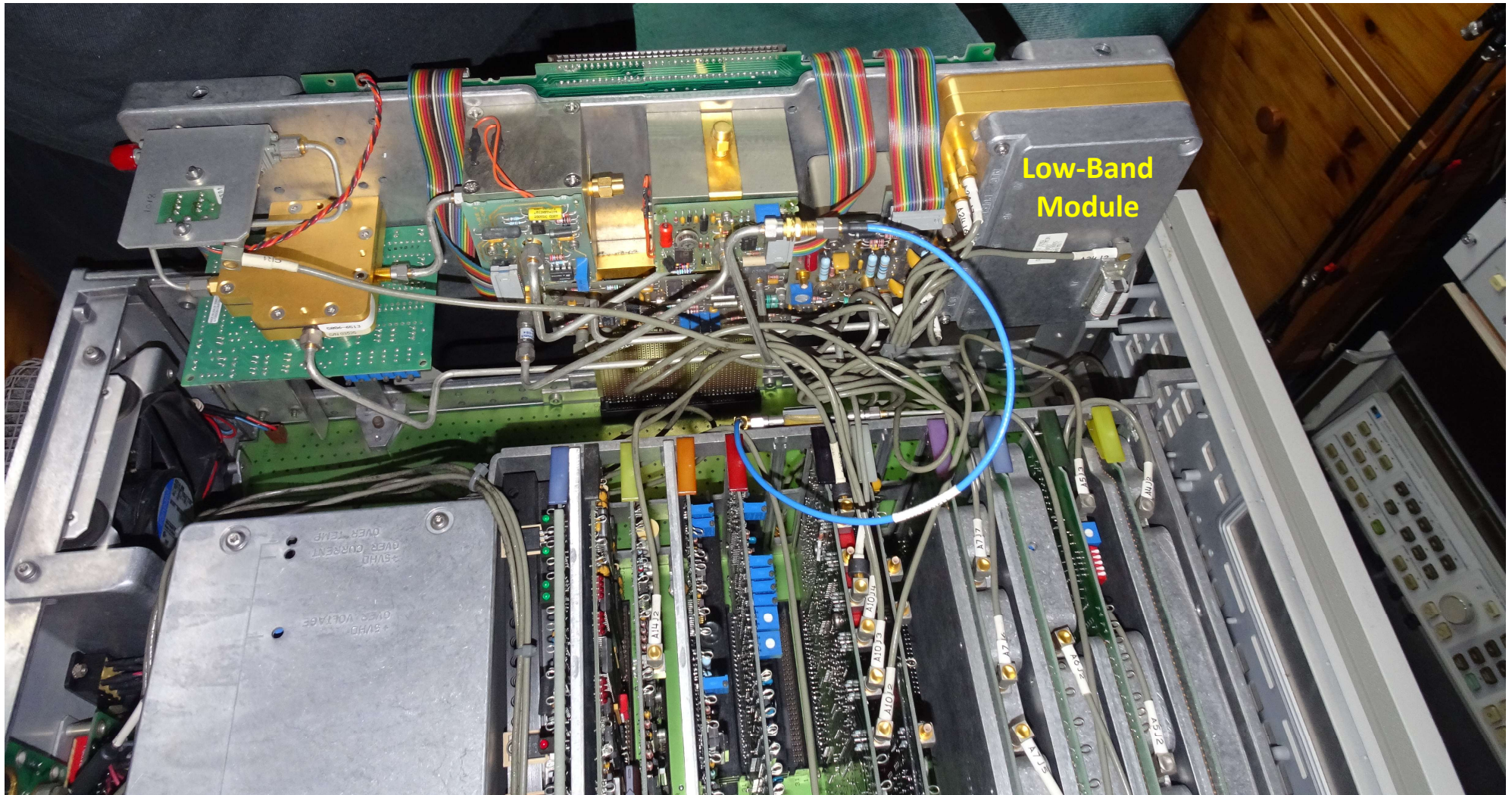


# Taking closer Look

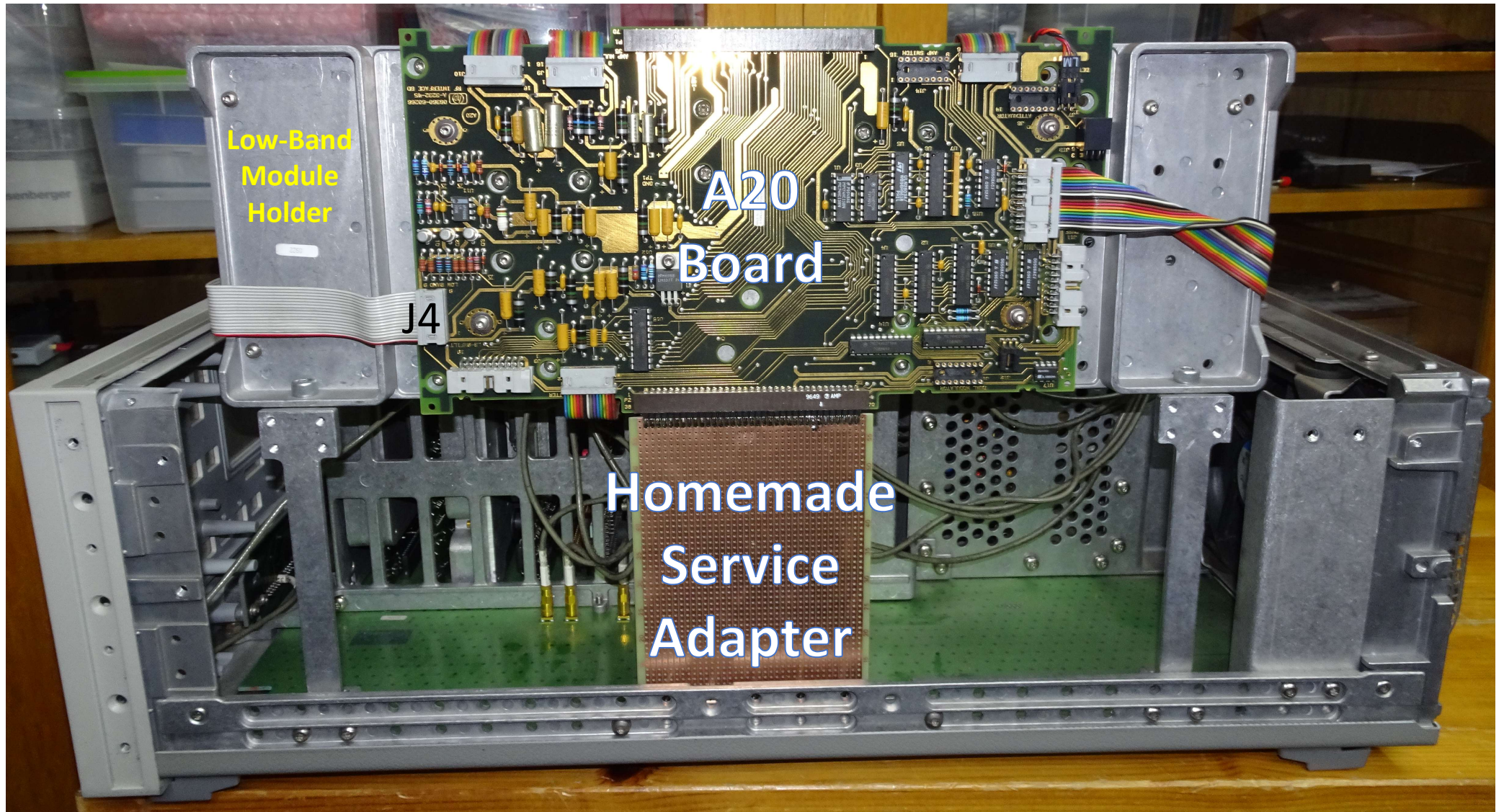
HP83651A RF Deck



# HP83651A RF Deck in Service Position (1)



## HP83651A RF Deck in Service Position (2)



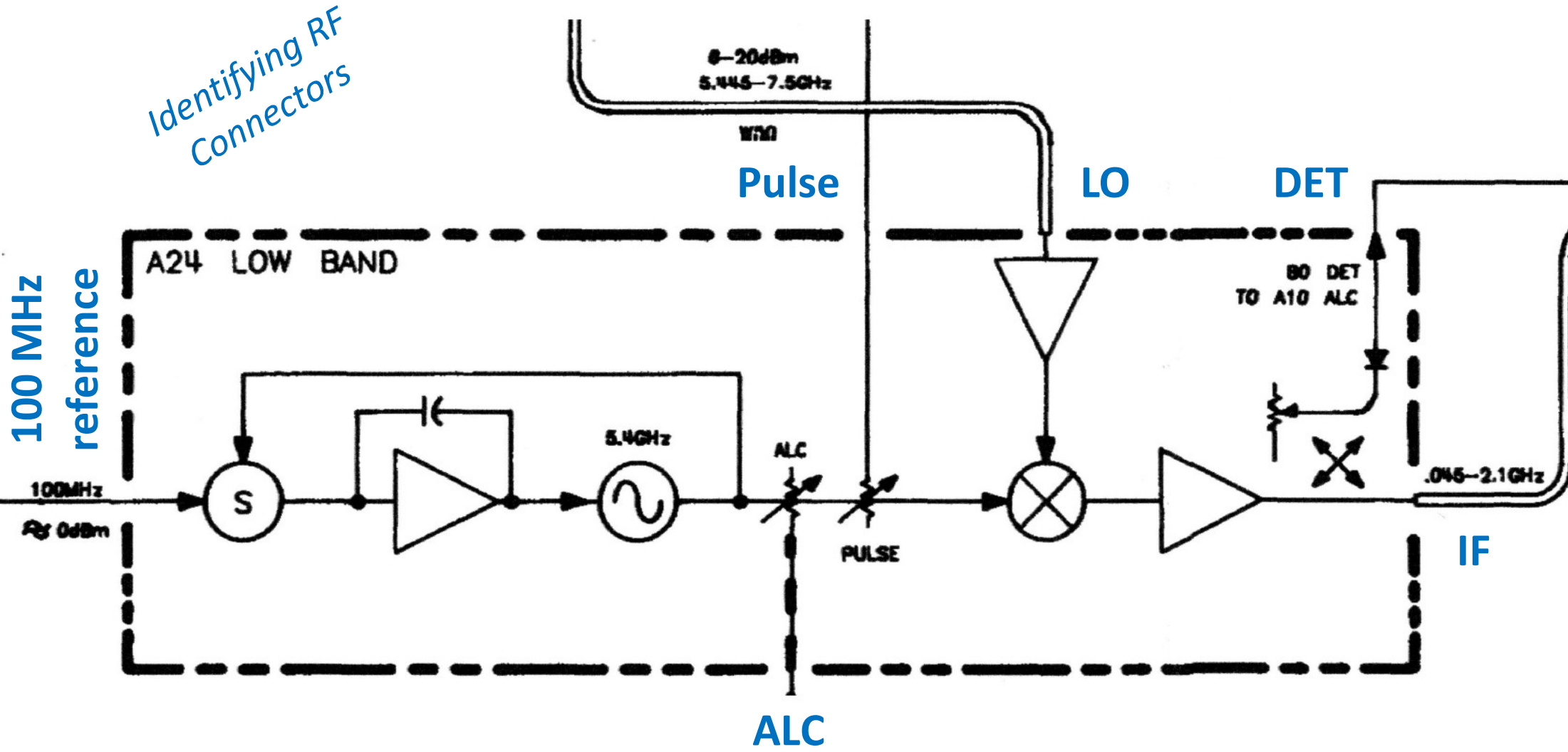
HP83651A Sweeper  
Low Band Module  
*Publicly available Information*



Image from Ebay

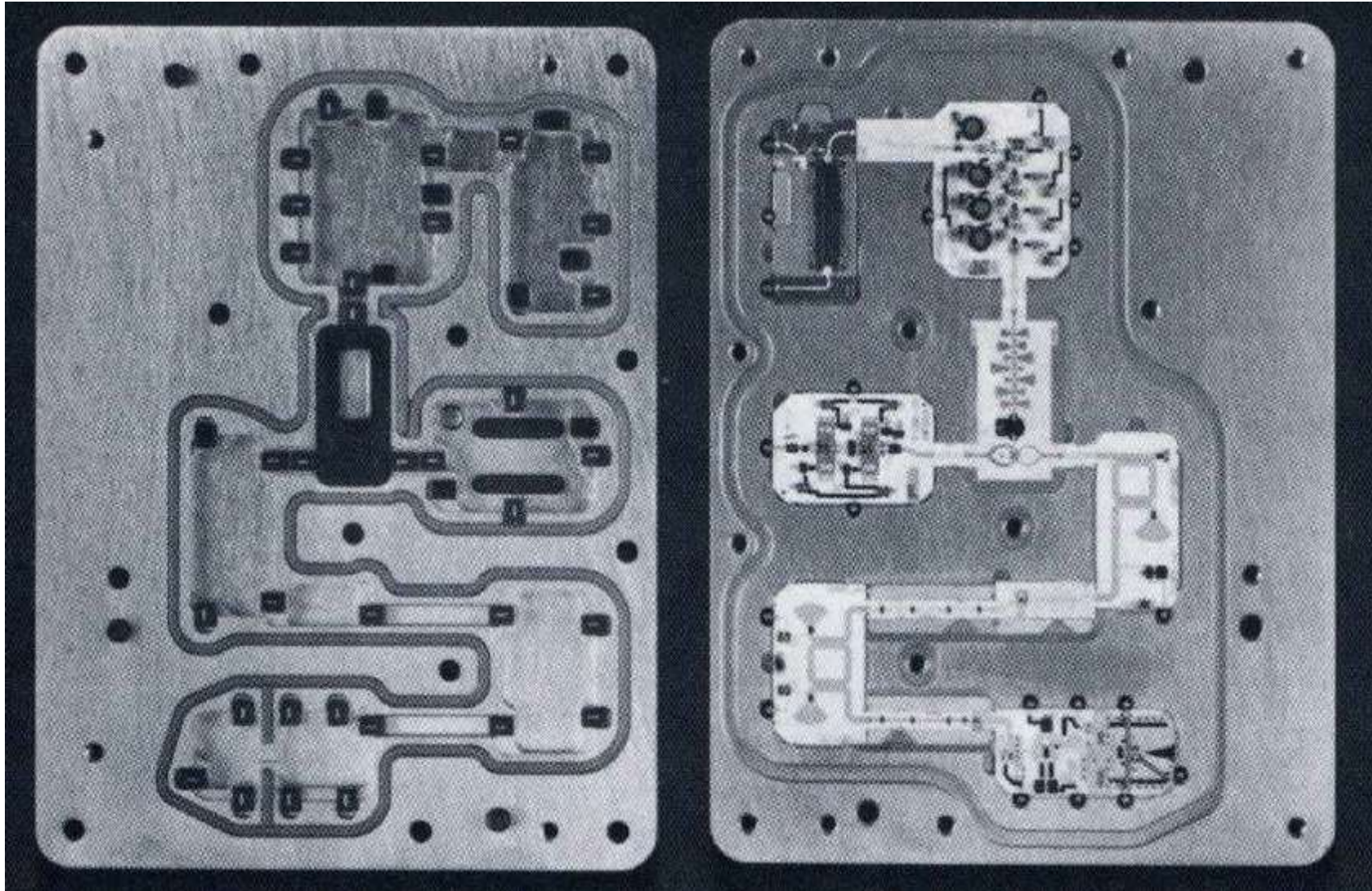
# Block Diagram Low-Band Module

from HP8360 Service Manual



# Low-Band Microcircuit with Cover

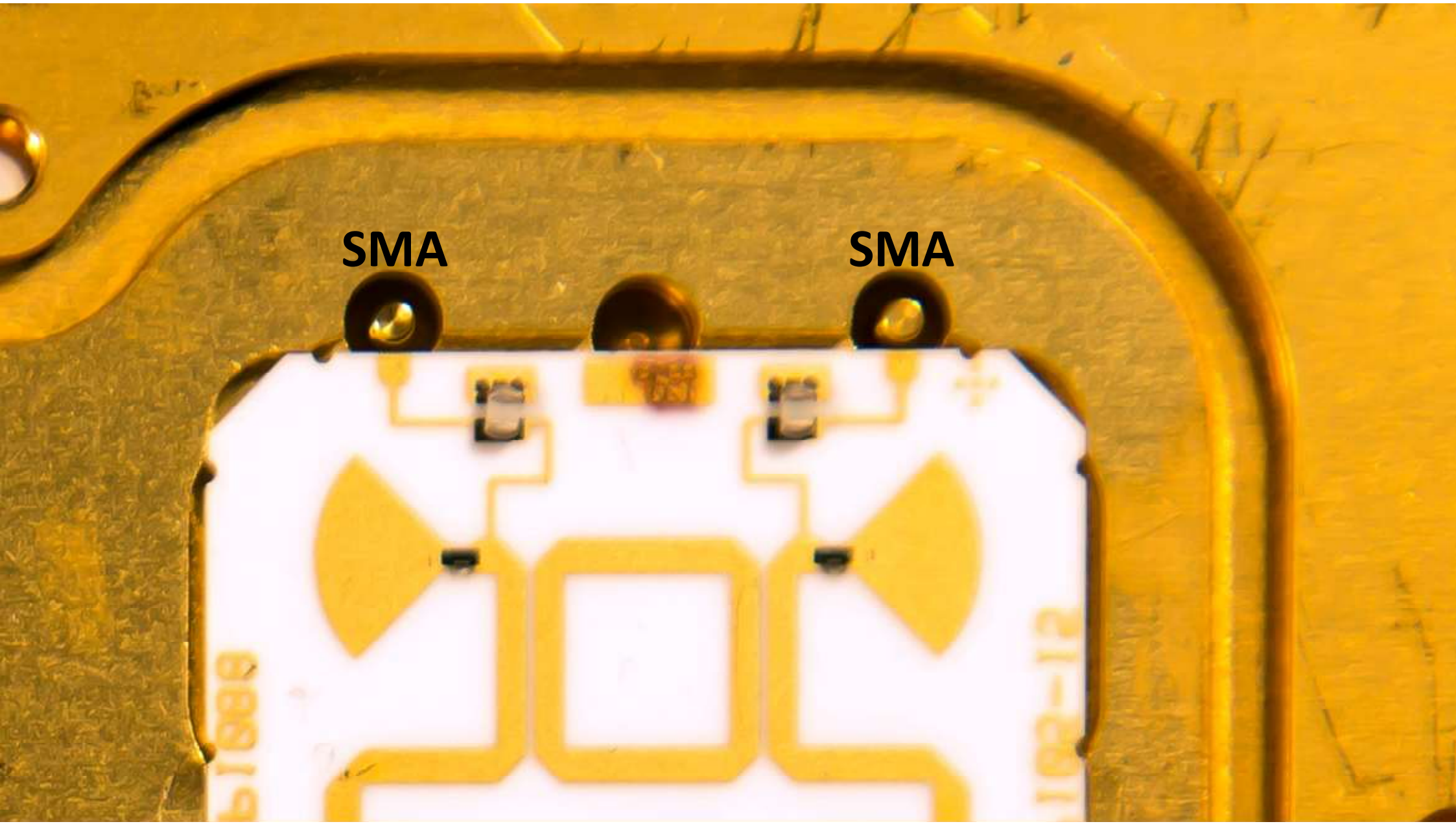
(HP Journal April 1991)





SMA

SMA



888919

100-12

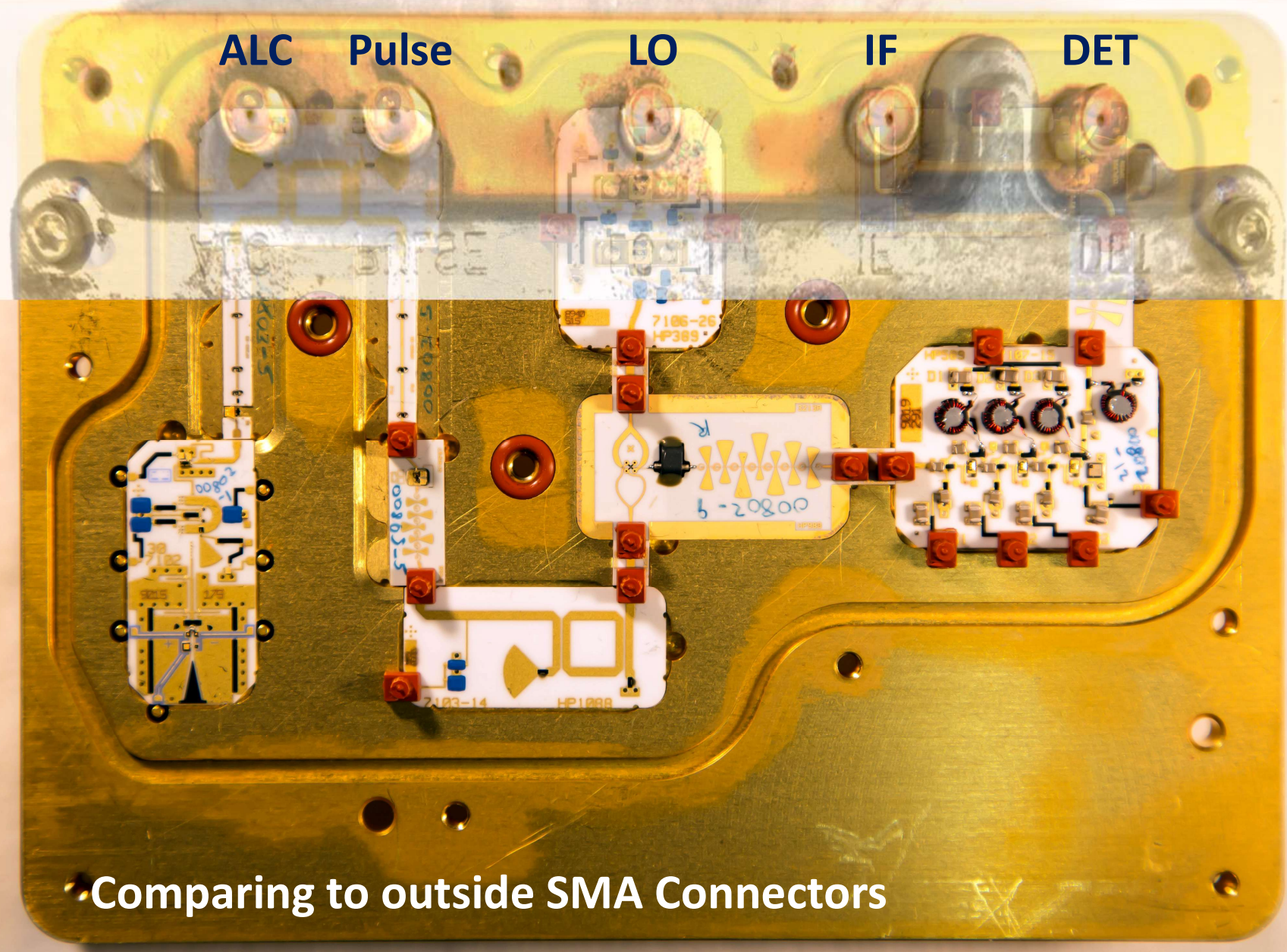
ALC Pulse

LO

IF

DET

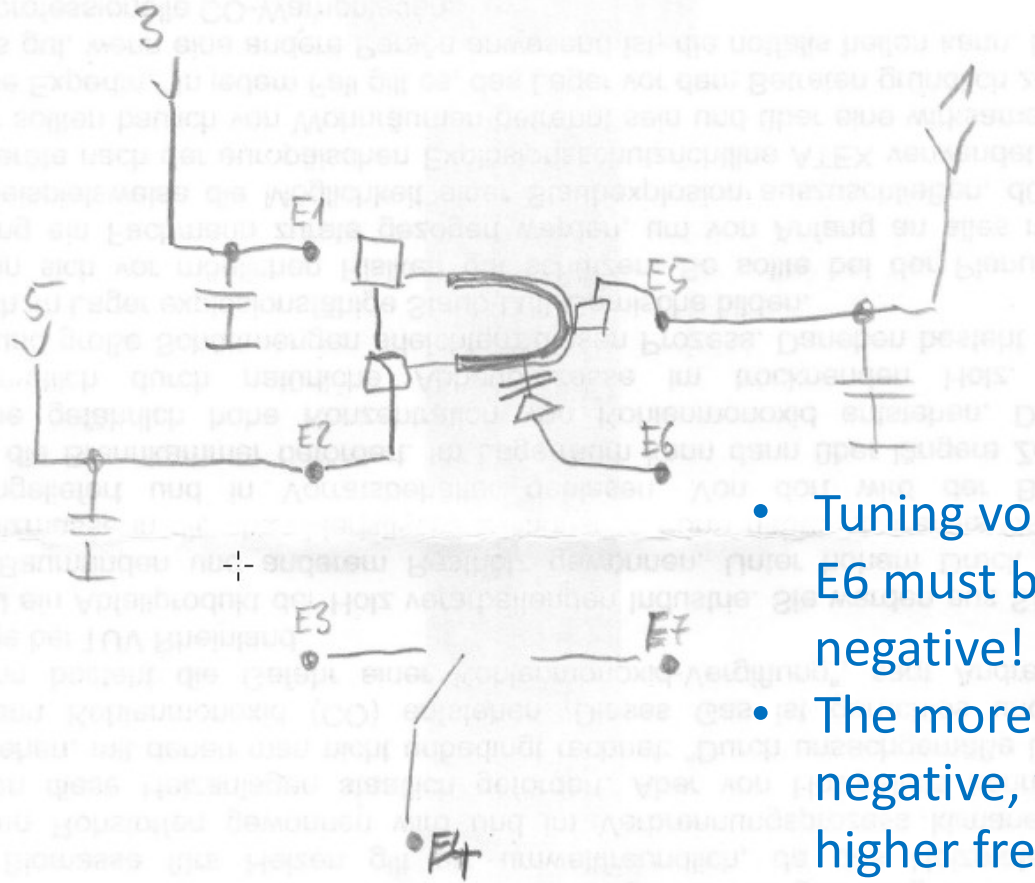
• Comparing to outside SMA Connectors





# VCO

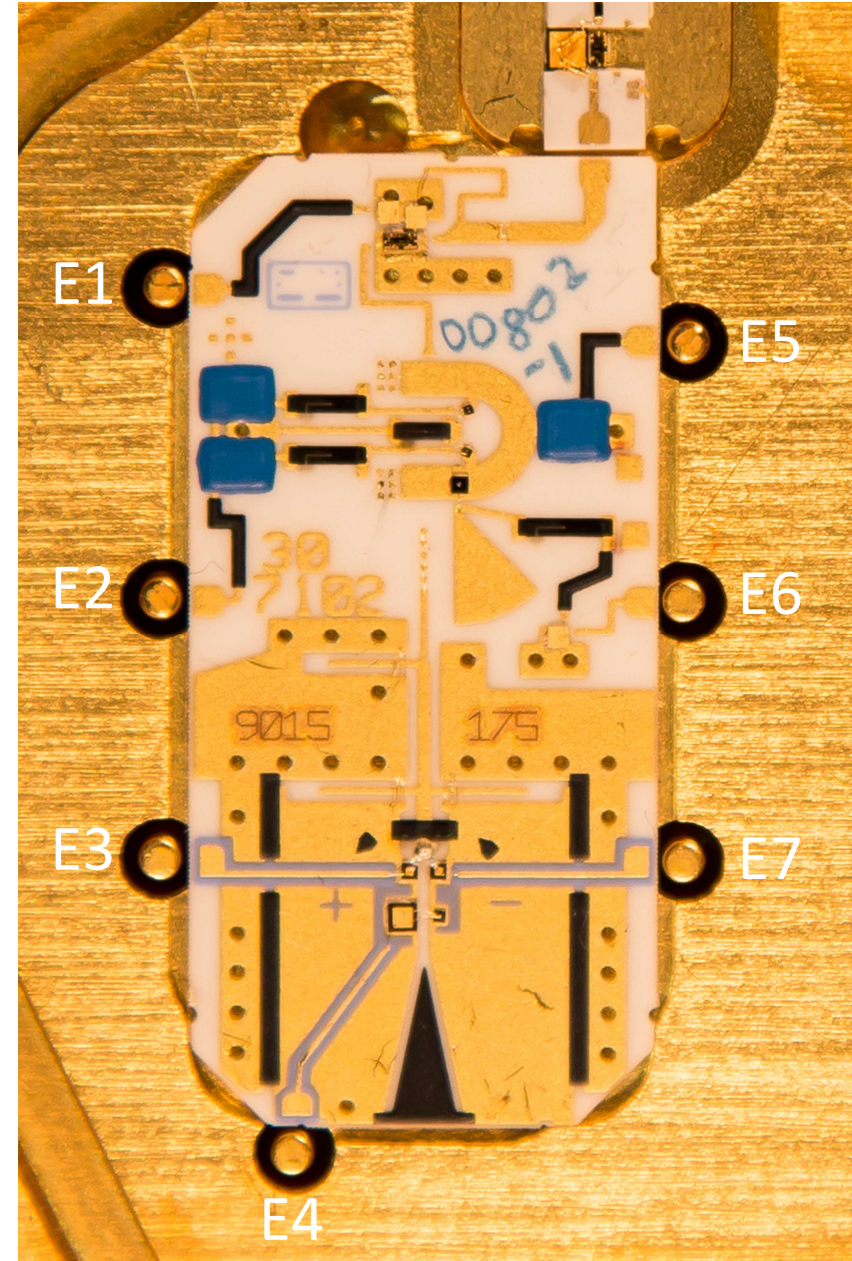
reverse engineered by hp70000freak



- Tuning voltage on E6 must be negative!
- The more negative, the higher frequency

L Band converter 5086-F463 HP 83631

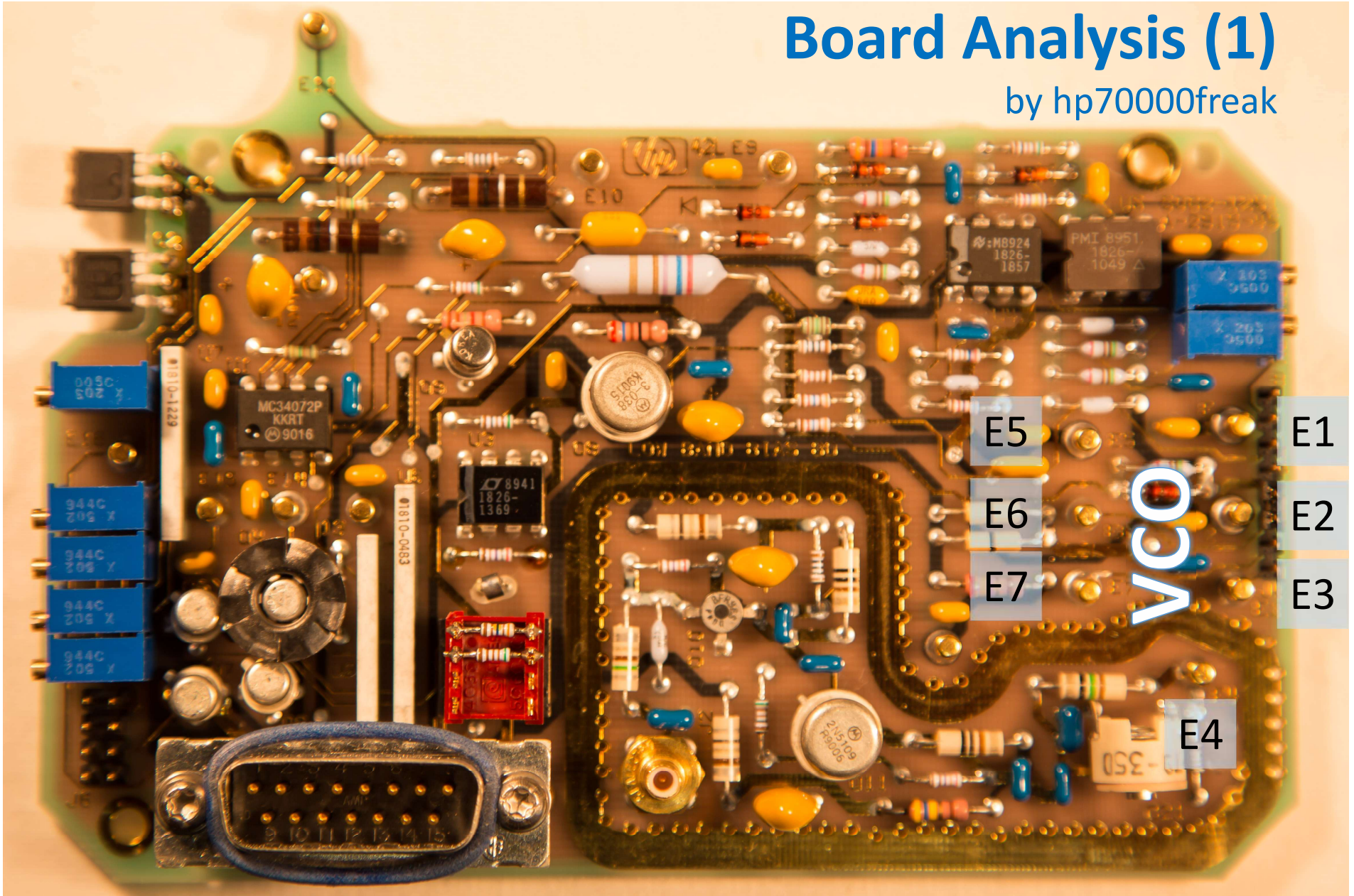
5.4GHz oscillator 5062





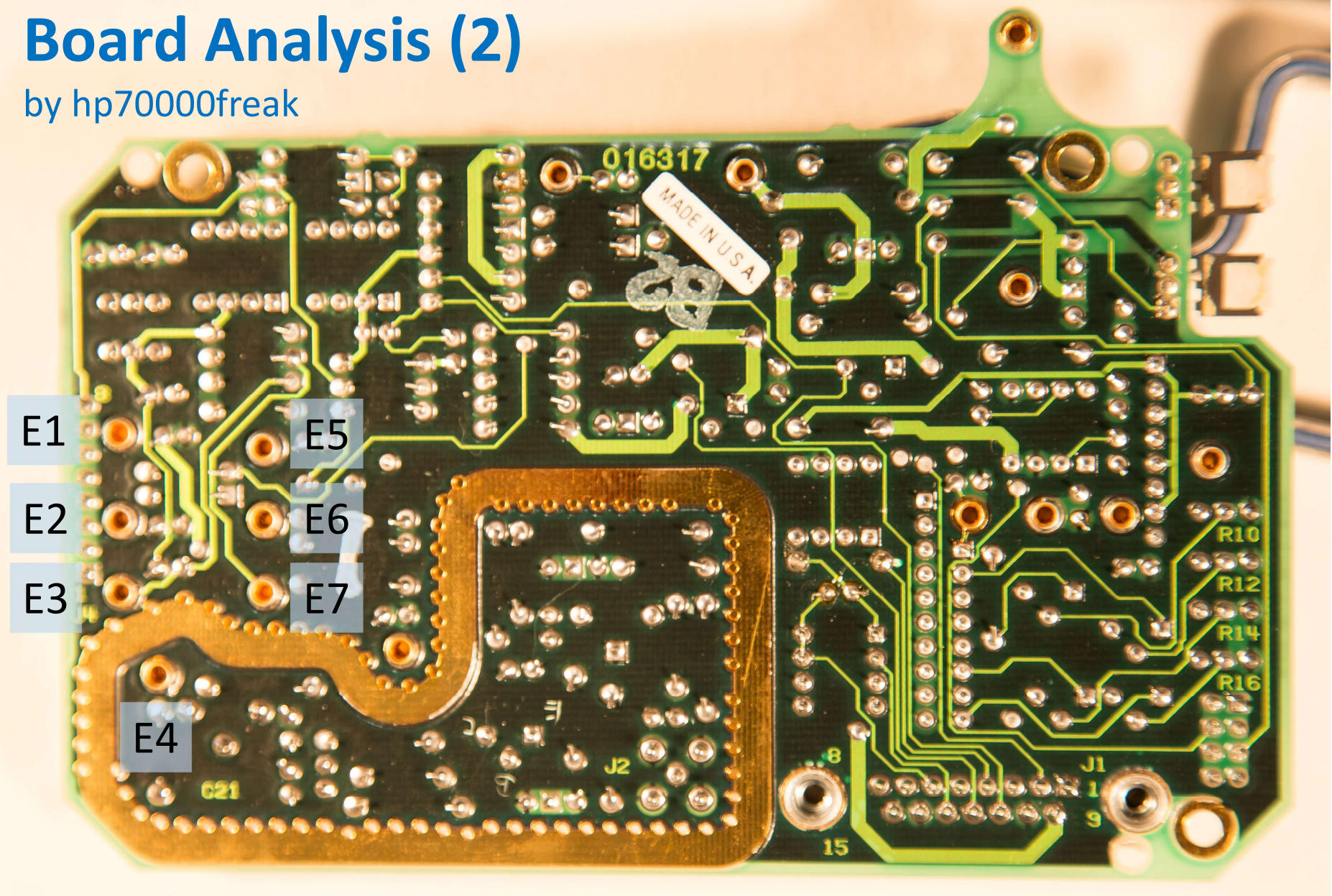
# Board Analysis (1)

by hp70000freak



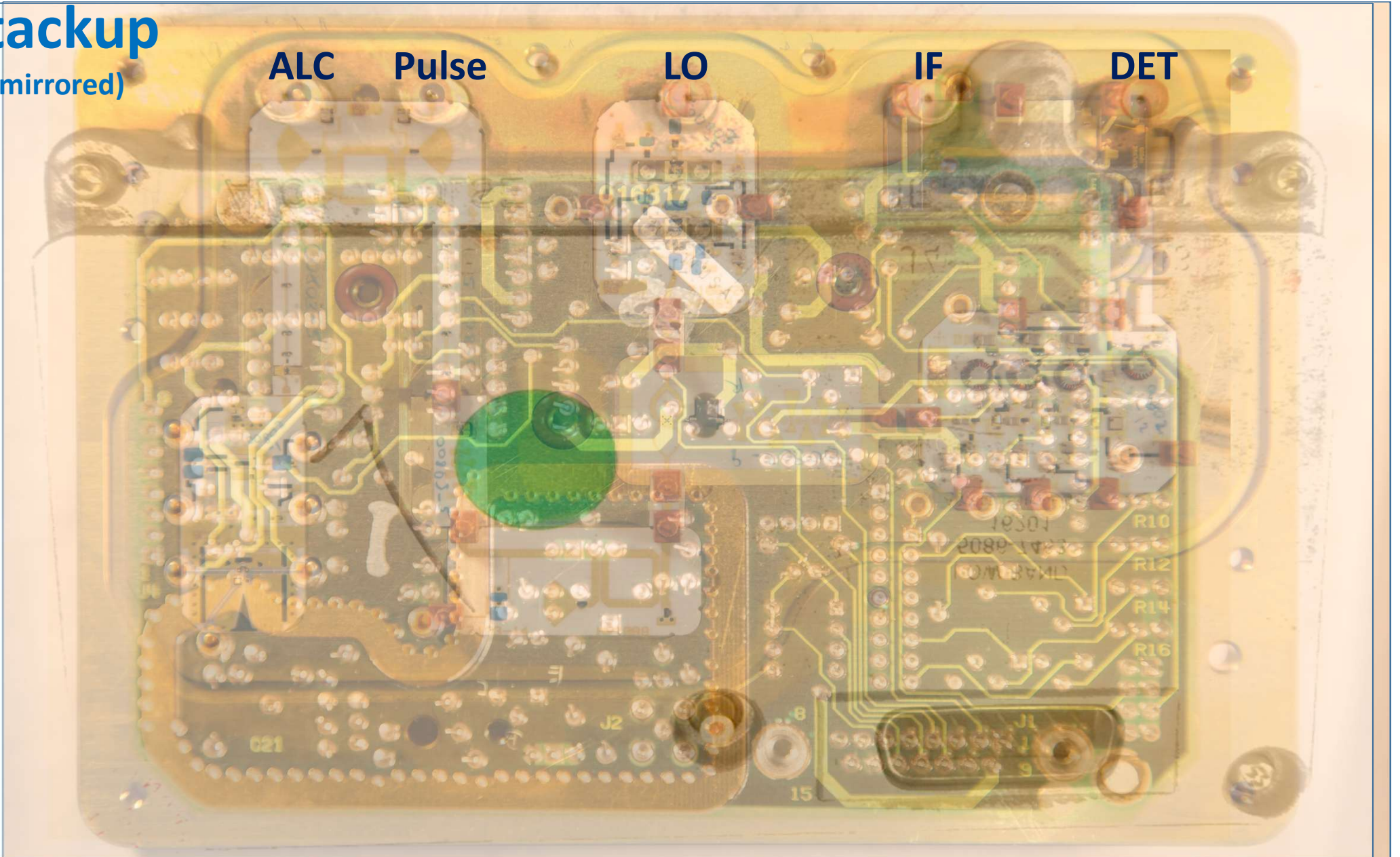
# Board Analysis (2)

by hp70000freak



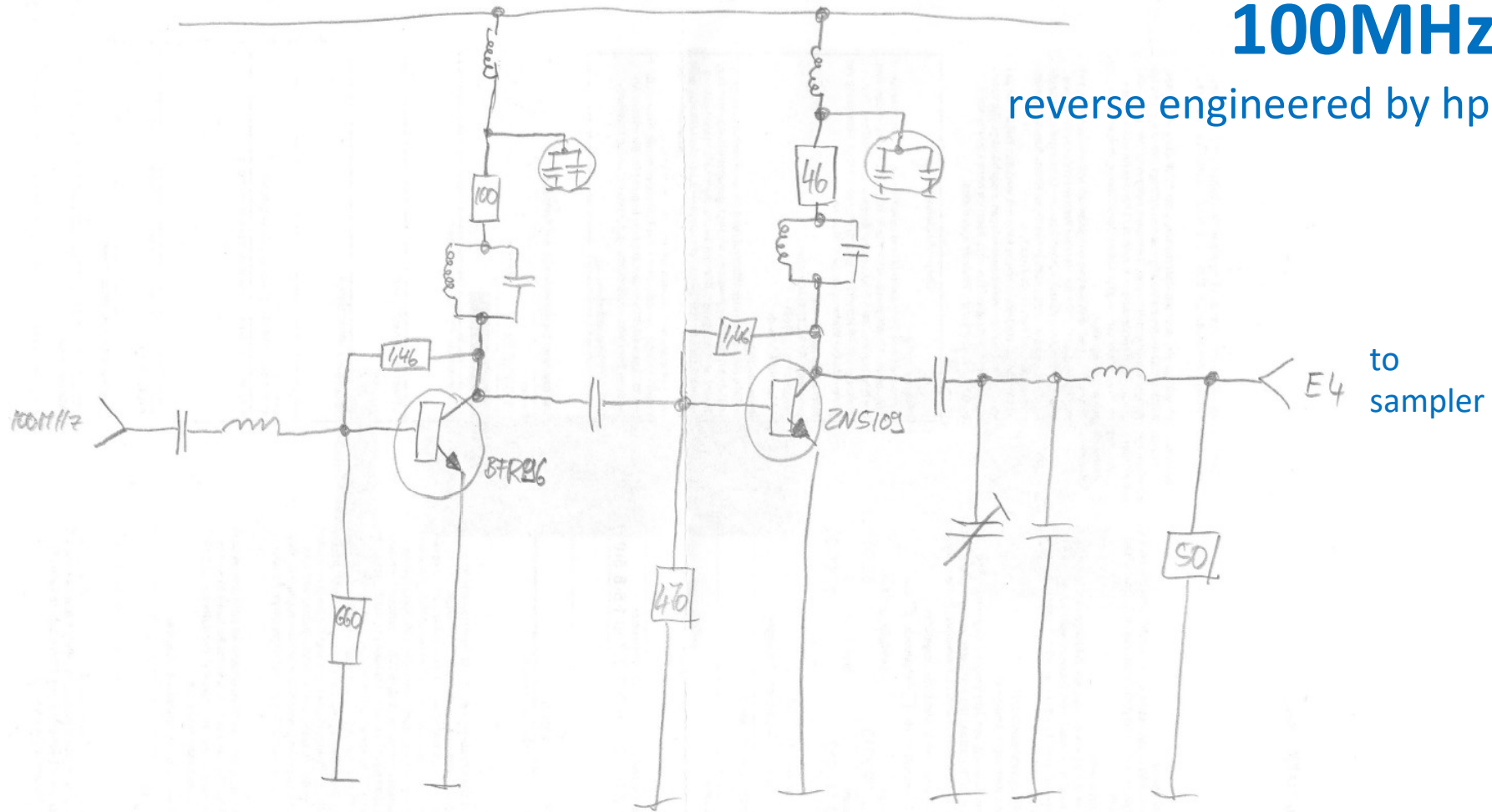
# Stackup

(mirrored)



# 100MHz driver

reverse engineered by hp70000freak



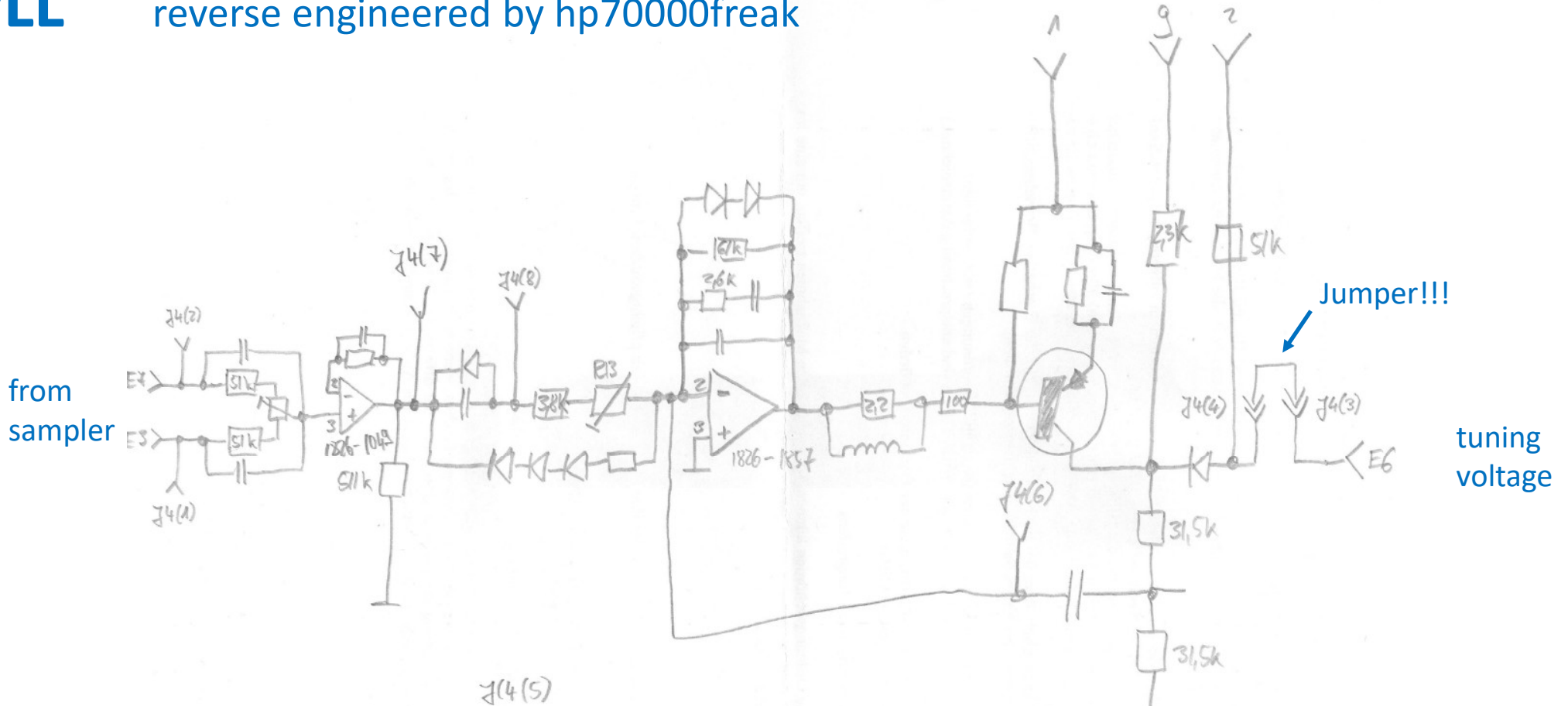
L Band converter  
5086 - 7463

HP83631

L Band control band 5062-1251  
100 MHz sample pulse generation

# PLL

reverse engineered by hp70000freak



from sampler

Jumper!!!

tuning voltage

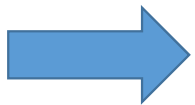
L Band converter 5086-7463  
HP 83631  
L Band control board  
5062-1251  
PLL for 5.4GHz LO

J4(5)

# **Analyzing PLL and VCO in Operation**

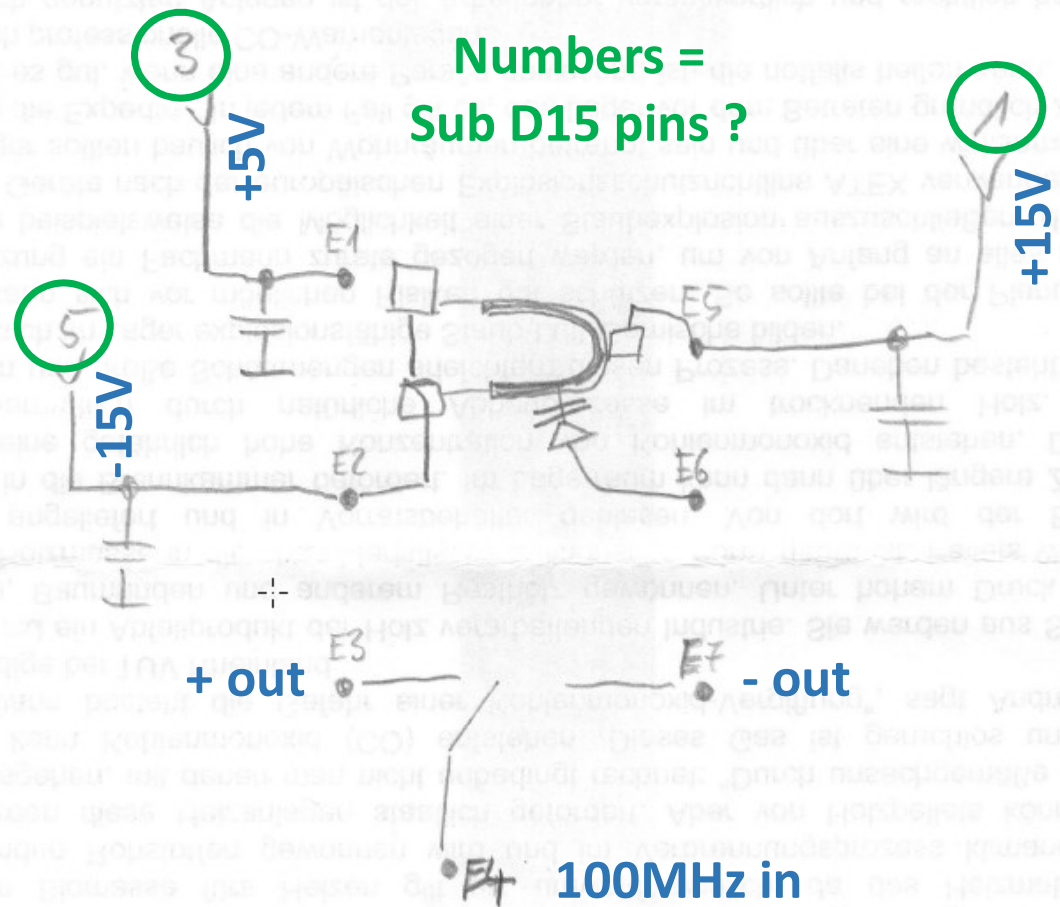
## Measuring VCO Voltages

VCO Pin	RF = 2,2GHz <u>lowband active</u>	RF = 3GHz <u>lowband inactive</u>	Interpretation
VCO E1	5,14 V	5,14 V	<u>V<sub>bias</sub></u>
VCO E2	-14,91V	-14,91 V	<u>V<sub>ee</sub></u>
VCO E3	0,77 V	0,77 V	
VCO E4	-0,02 V	-0,02 V	
VCO E5	14,98 V	14,98 V	<u>V<sub>cc</sub></u>
VCO E6	-6,75 V	-6,75 V	<u>V<sub>tune</sub></u>
VCO E7	-0,94 V	-0,94 V	

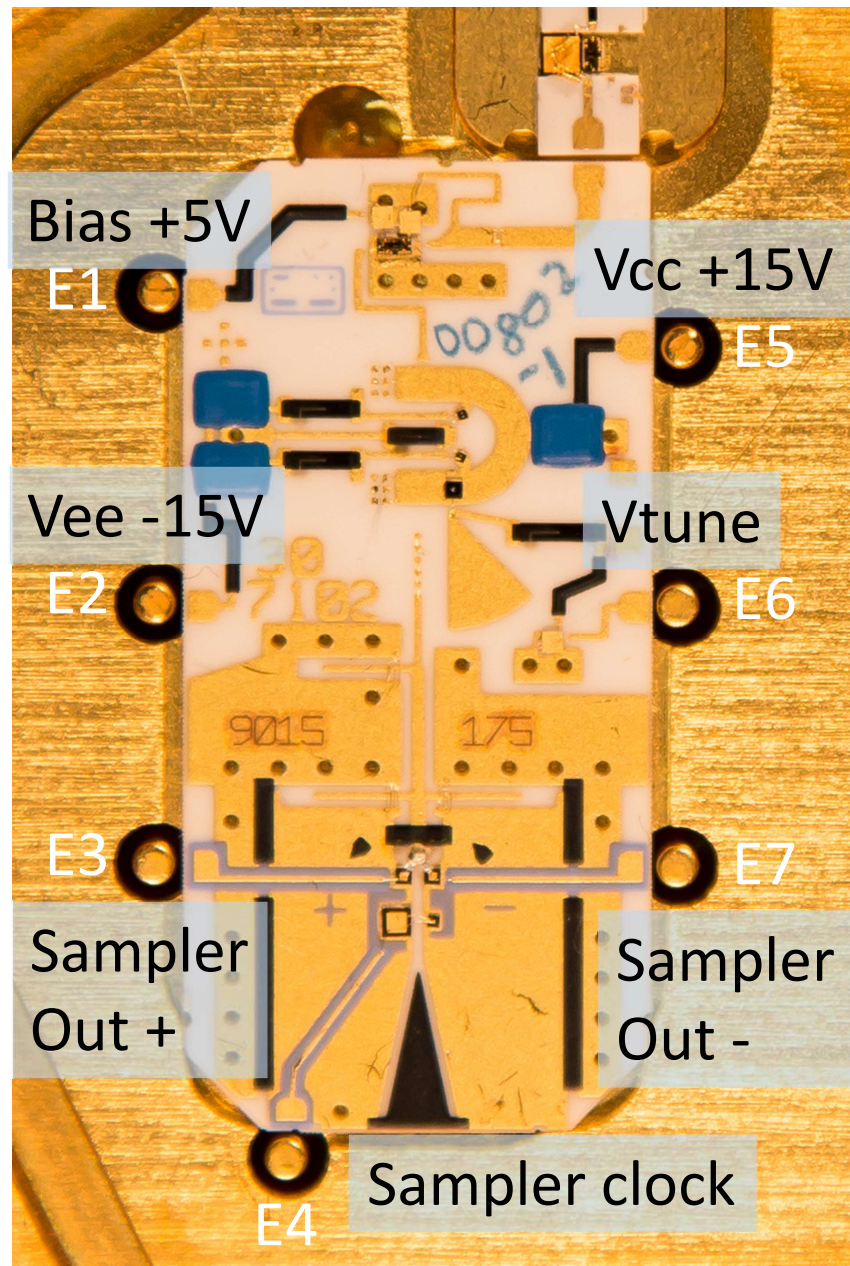


**5,4 GHz VCO is always ON even if not needed!**

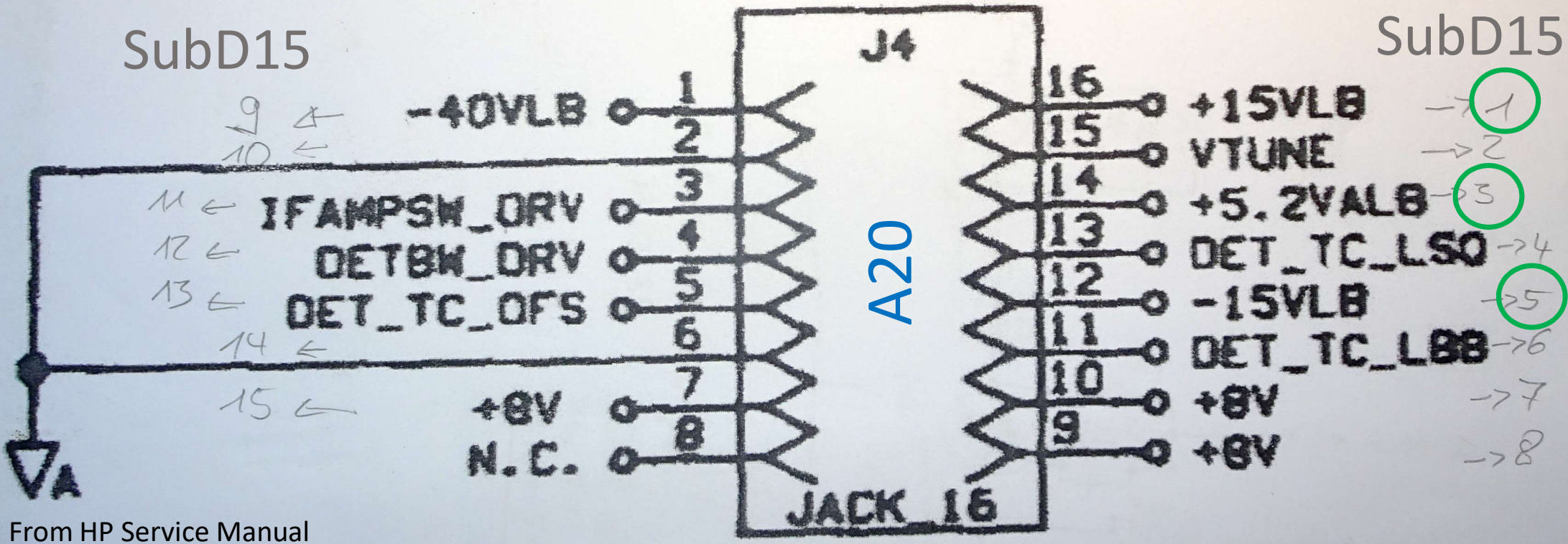
# VCO



L Band converter 5086-F463 HP 83631  
5.4GHz oscillator 5062



# A20 / J4 to PLL - SubD15 Cable Pinning



From HP Service Manual

Numbers = Sub D15 pins ?

**YES !!!**

# PLL

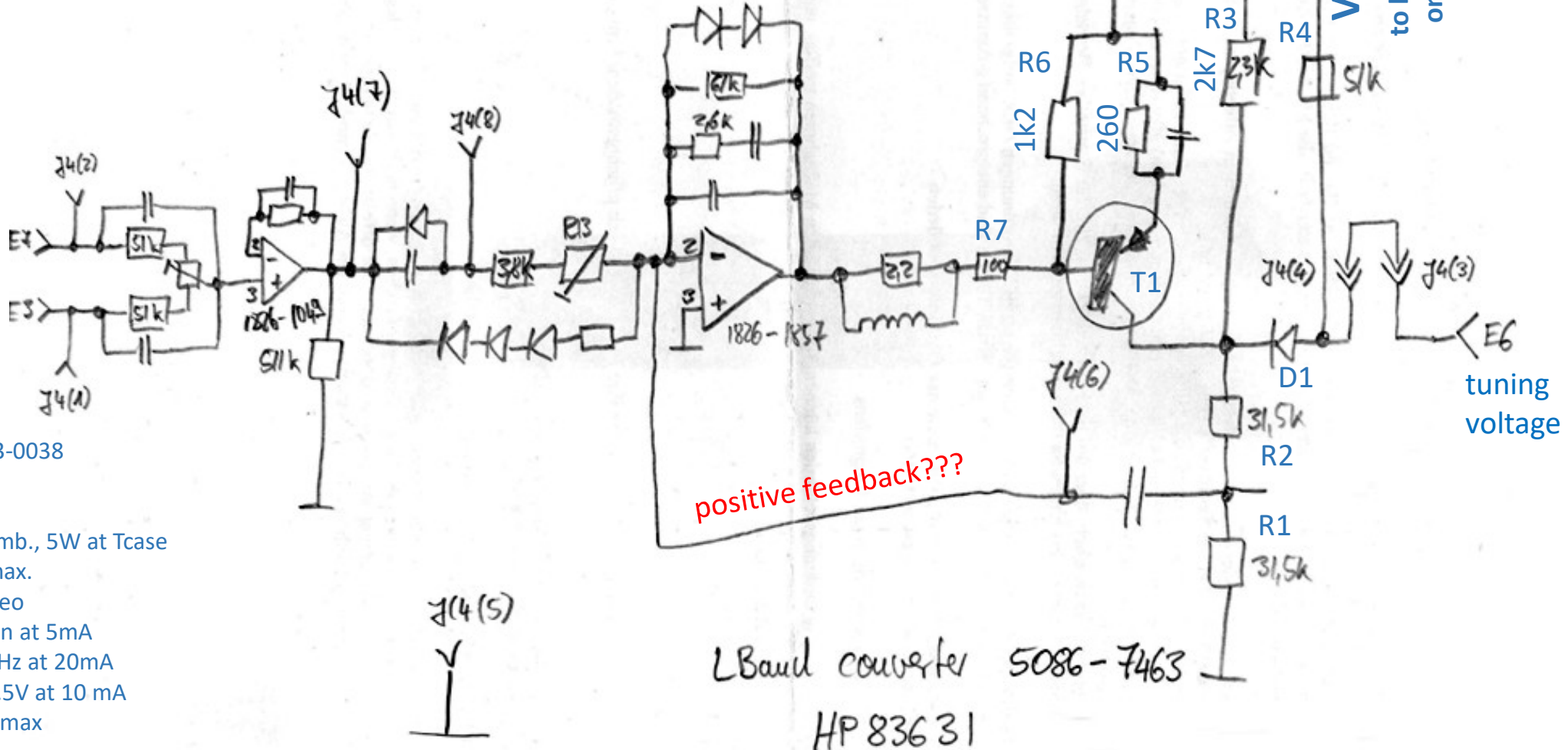


Sub D15



V<sub>tune-sense</sub>  
to lock detector  
on A20 board

from  
sampler



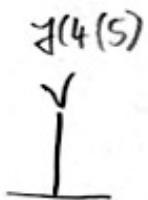
T1 = 1853-0038  
PNP  
TO-39  
1W at Tamb., 5W at Tcase  
500mA max.  
120V Bvceo  
hfe 35 min at 5mA  
Ft 150 MHz at 20mA  
Vce sat 0.5V at 10 mA  
Cob 8 pF max

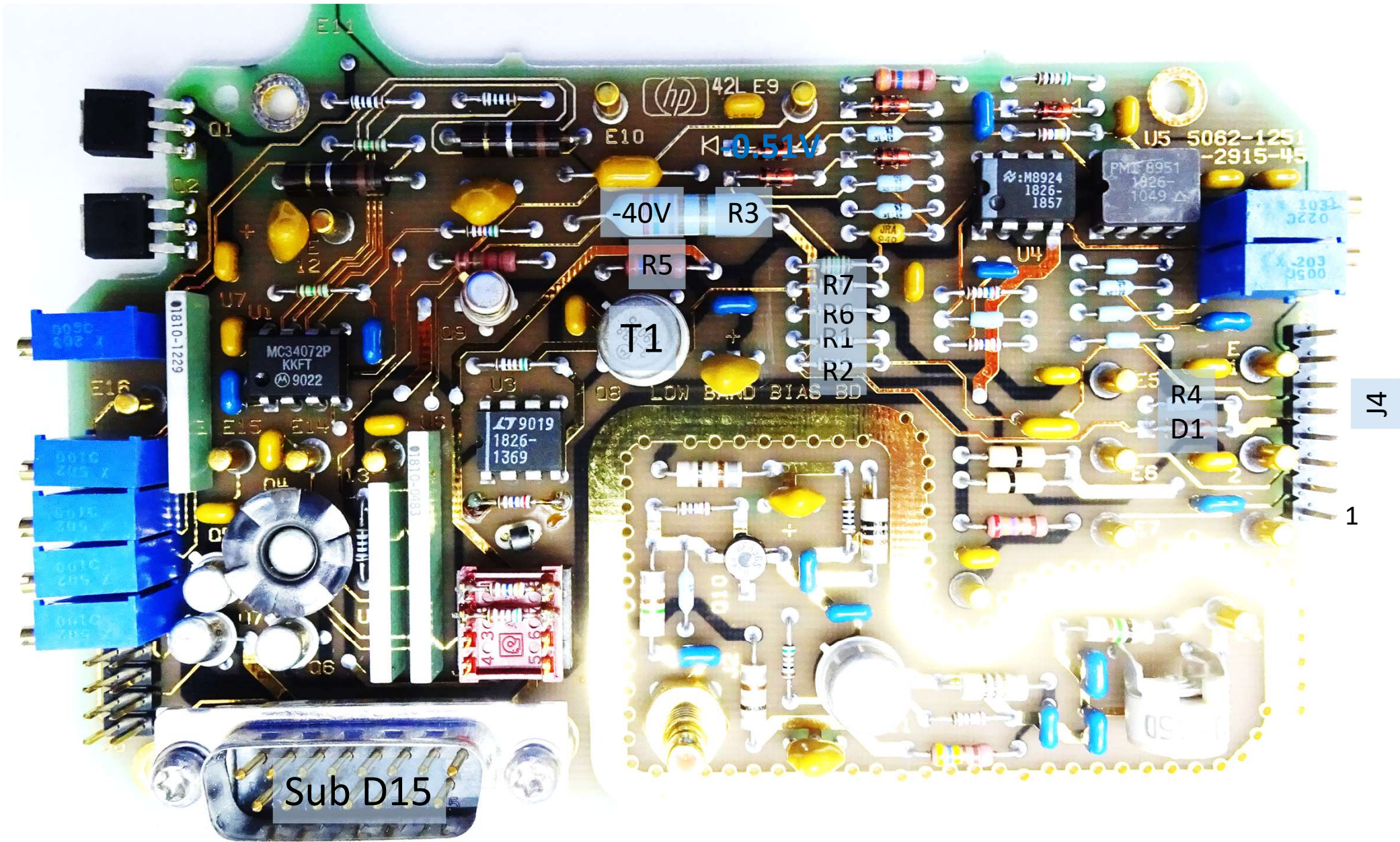
positive feedback???

LBaud converter 5086-7463

HP 83631

tuning  
voltage





(hp) 42L E9

-40V R3

R5

T1

R7  
R6  
R1  
R2

R4  
D1

J4

1

Sub D15

LOW BAND BIAS BD

0.51V

MC34072P  
KKFT  
9022

LT9019  
1826-  
1369

M8924  
1826-  
1857

PMT 8951  
1826-  
1049

U5 5062-1251  
-2915-45

01810-1229

01810-0683

4030  
5060

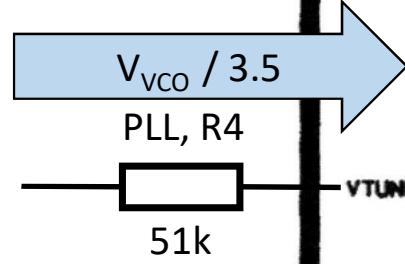
1031  
0220  
203  
0500

SD

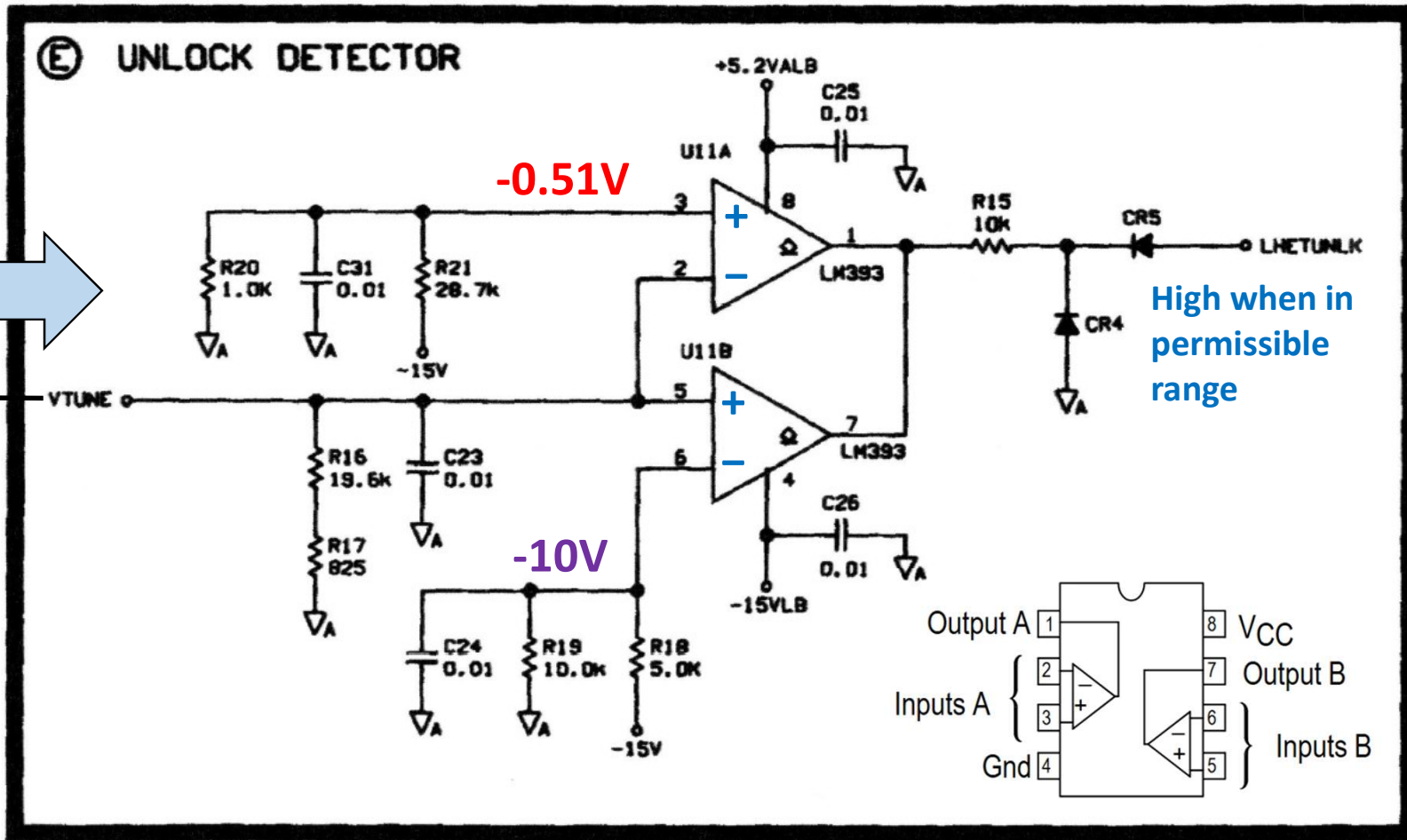
# VCO Unlock Detector

(on A20 board)

Presents load of 71,4 kΩ for VCO tuning voltage



OK, when  $-35V < V_{VCO} < -1,8V$   
 $V_{VCO}$  must be negative!!!

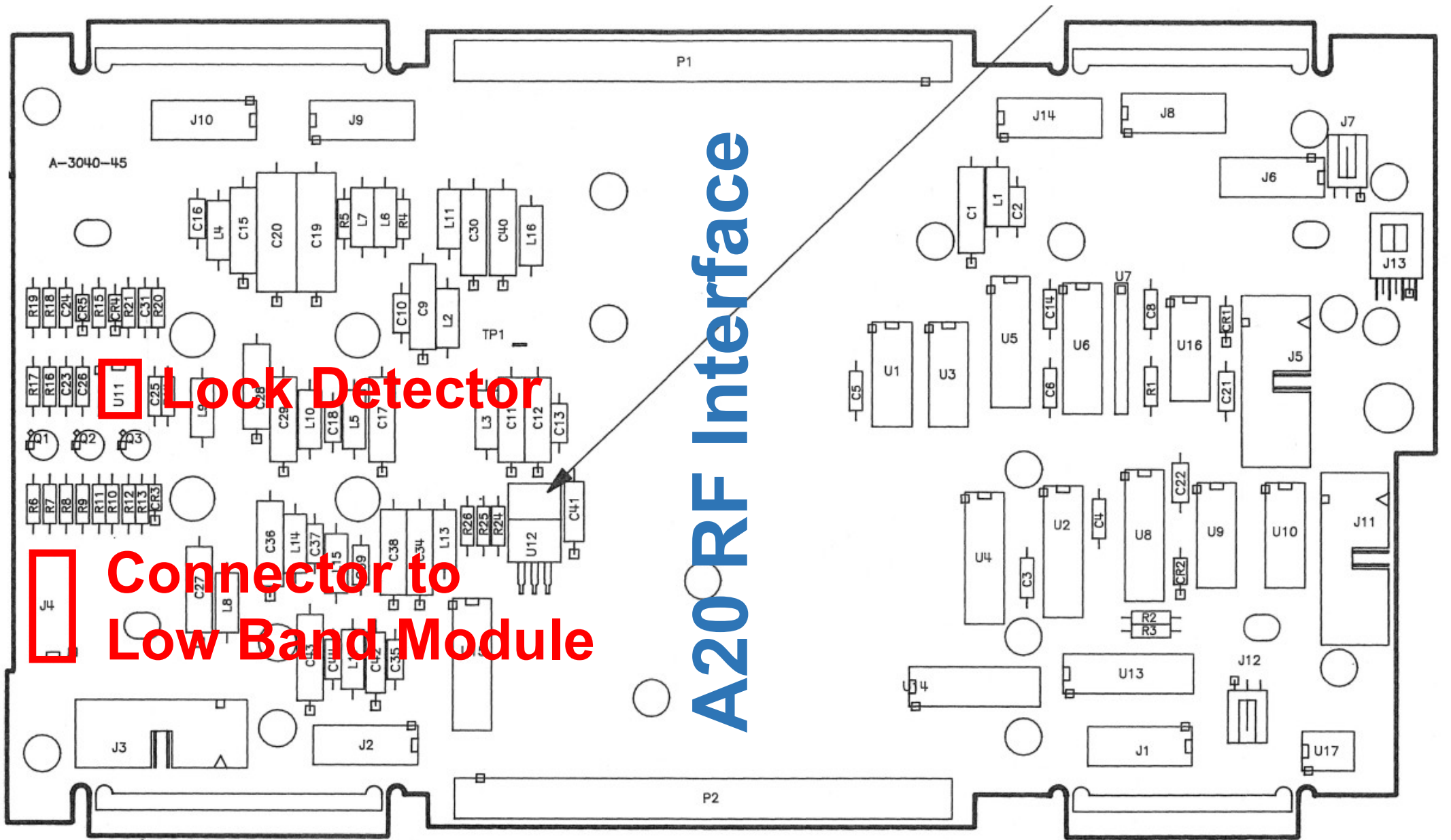


A20U11	1826-0412	1	IC COMPARATOR PRON DUAL 8 PIN DIP-P	03406	LM393N
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## Working Reference Unit GPIB Diagnostics:

268.000) RF : LOBAND Tuning Voltage : V-Tune [mV]	actual	min.	max.
My unit: $-6,75V/3,5=-1,93V$	-3675	-11000	-400

Thanks for this, Staffan!



# A20 RF Interface

**Lock Detector**

**Connector to Low Band Module**



# Troubleshooting (1)

$$\text{nominal } f_{VCO} = 5,4 \text{ GHz}$$

$$\text{YIG } 6 \text{ GHz} \Rightarrow \text{RF} = (6 - 5,4) \text{ GHz} = 600 \text{ MHz}$$

$$\text{actual output at } 600 \text{ MHz nominal} = 500 \text{ MHz}$$

$$\Rightarrow 500 \text{ MHz} = 6000 \text{ MHz} - f_{VCO}$$

$$\Rightarrow f_{VCO} = 6000 \text{ MHz} - 500 \text{ MHz} = 5500 \text{ MHz} = 5,5 \text{ GHz}$$

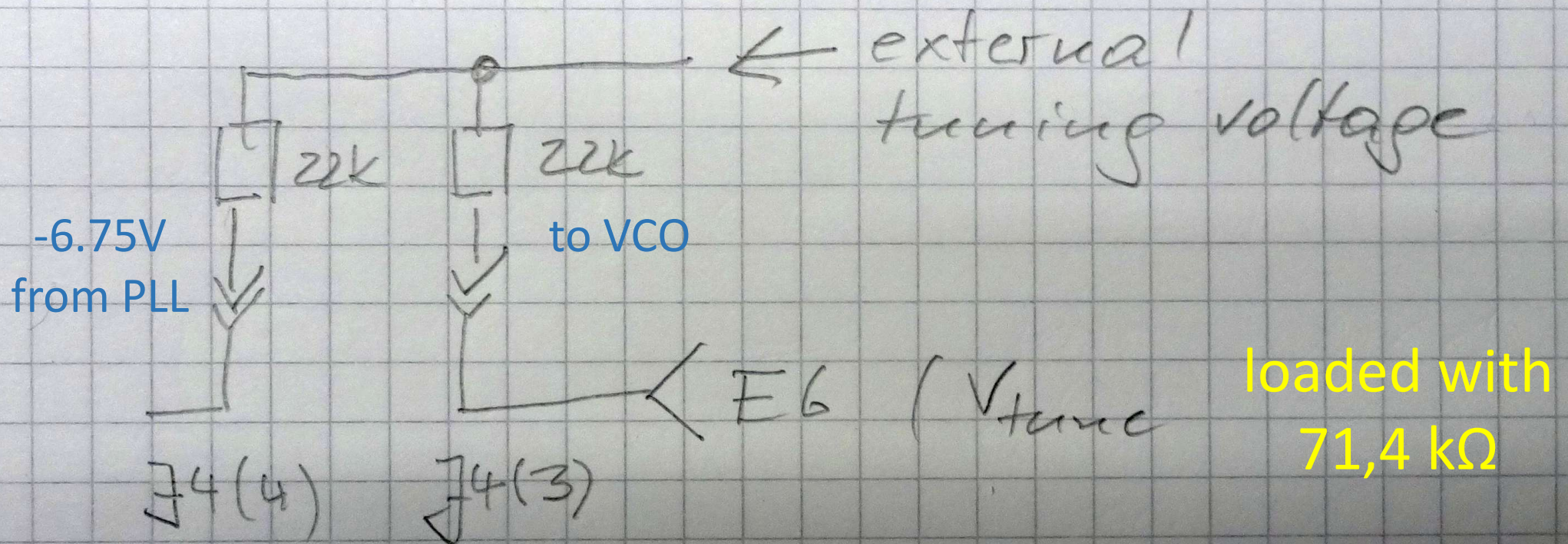
$\Rightarrow$  VCO oscillates 100 MHz too high!

$\Rightarrow$   $V_{tune}$  is too low!

i.e.  $V_{VCO}$  is too negative at -6.75V

## Troubleshooting (2)

Experiment 2



# Troubleshooting (3)

VCO frequency vs. tuning voltage: ( target  $f_0 = 5.4\text{GHz}$  )

Frequency	<u>V<sub>tune</sub></u>	V across 22k	<u>I<sub>tune</sub></u>	Lock Detector
$f_0+100\text{MHz}$	-6,50V	0mV	0	in range
$f_0$	6,87V	0mV	0	outside range
$f_0-100\text{MHz}$	11,27V	3mV	0,14nA	outside range

**Remember:**  $-35\text{V} < V_{\text{tune}} < -1,8\text{V}$  by virtue of Lock Detector

- VCO micro-module is broken, likely varactor diode bias problem
- VCO can still be tuned to correct frequency at zero varactor current
- Output power still correct

 **Work-around should be possible**

# Workaround (1)

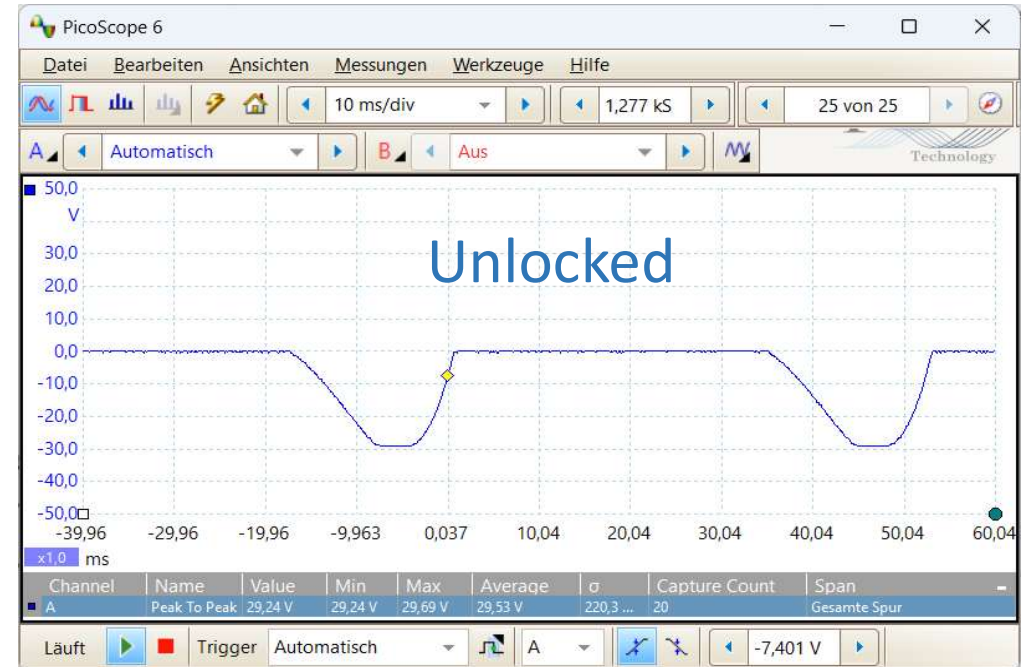
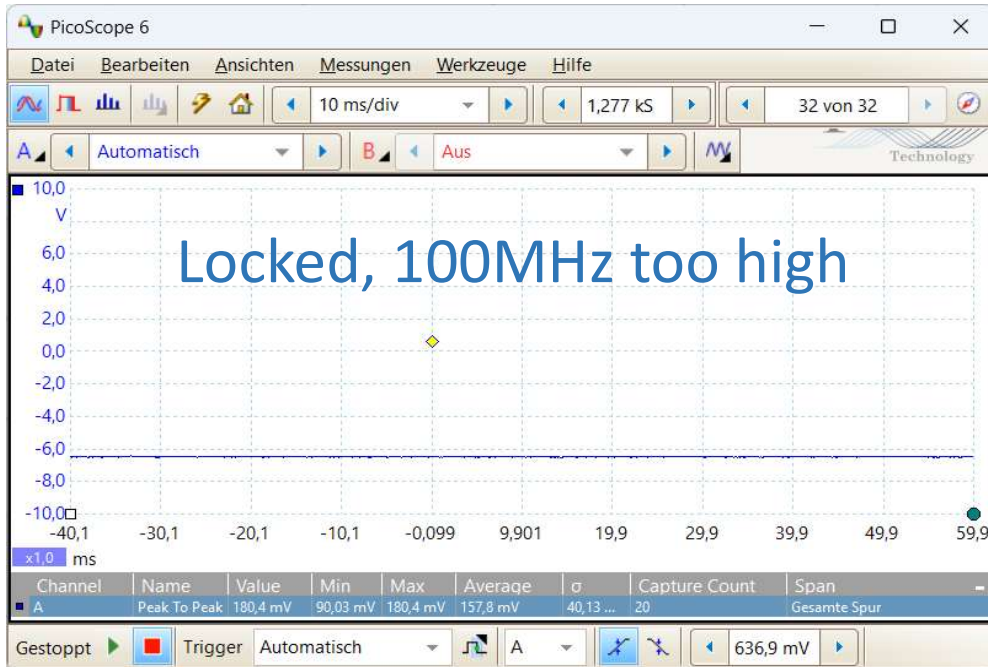
Frequency	<u>V<sub>tune</sub></u>	V across 22k	<u>I<sub>tune</sub></u>
$f_0+100\text{MHz}$	-6,50V	0mV	0
$f_0$	6,87V	0mV	0
$f_0-100\text{MHz}$	11,27V	3mV	0,14nA

## Requirements:

- Shift VCO tuning voltage to +6.9V for locking to correct harmonic
- Make sure VCO tuning voltage never comes close to -6,5V or + 11.3V to prevent locking to wrong harmonic
- Varactor starts leaking at +8,6V, so better keep  $V_{\text{tune}}$  below +8V
- Keep PLL output voltage in permissible range  $-35\text{V} < V_{\text{tune}} < -1,8\text{V}$  to trick lock detector

# Workaround (2)

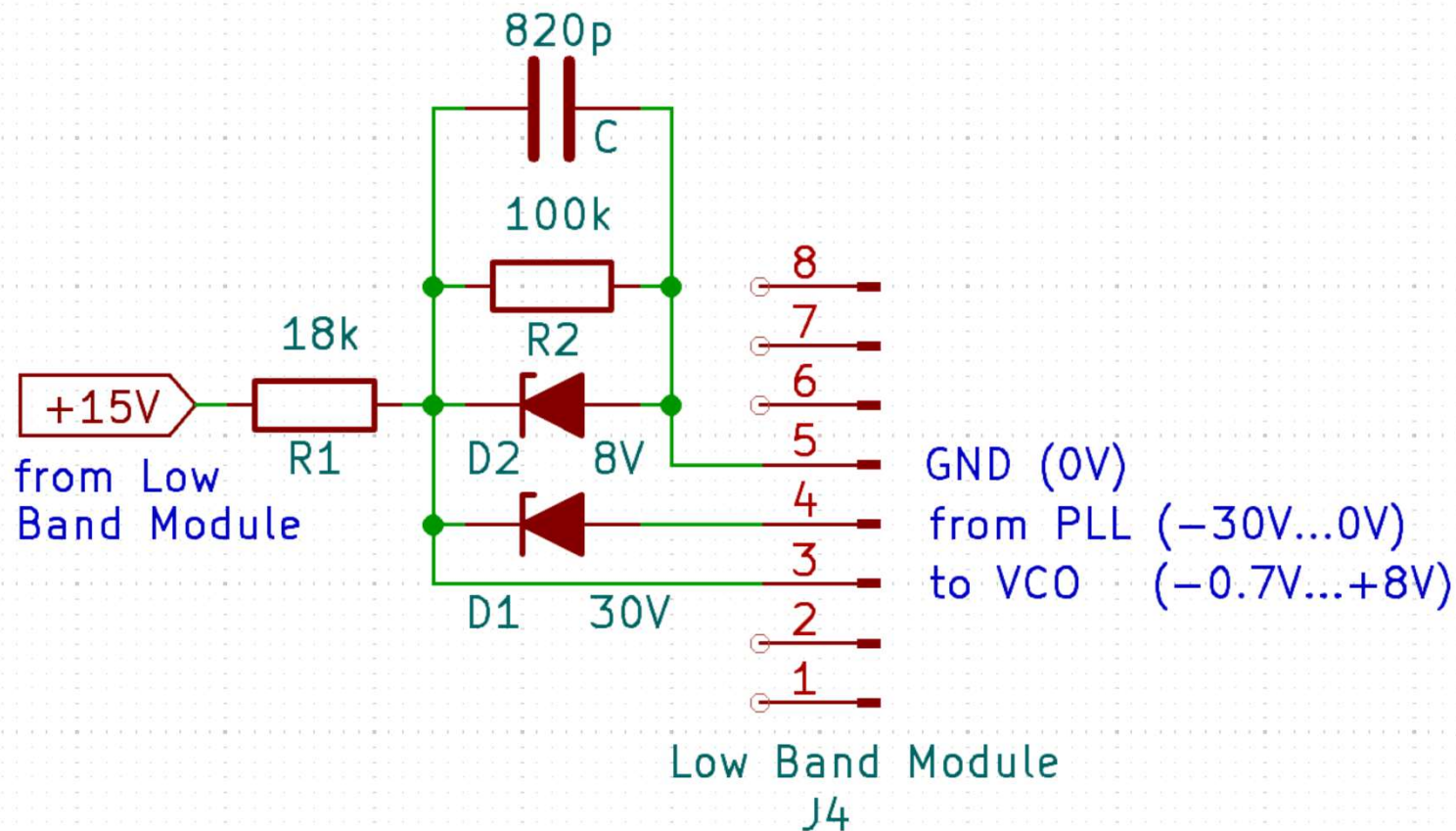
## Output voltage of PLL circuit at J4 (4)



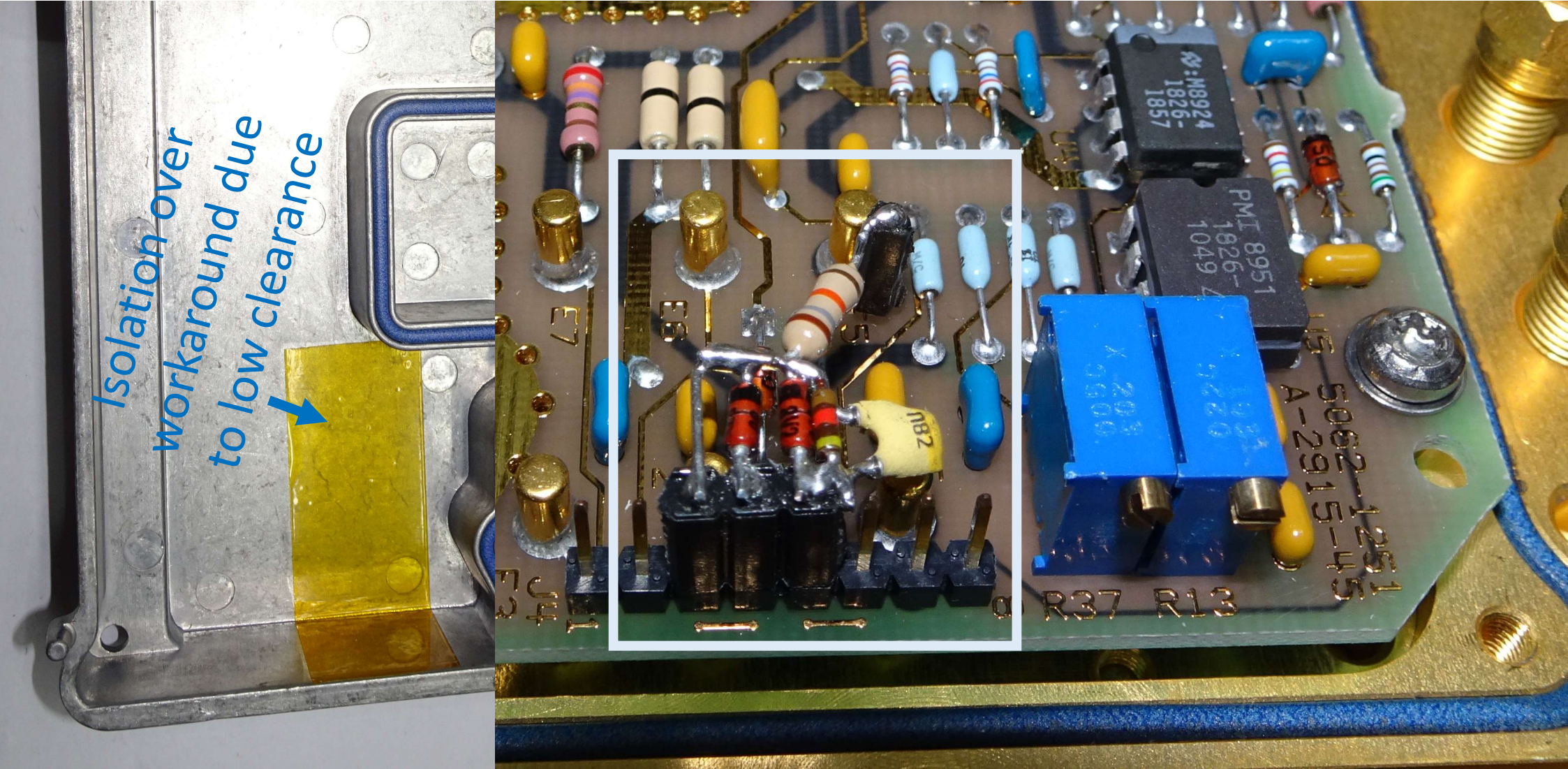
- PLL voltage oscillates at 20Hz if NOT locked ← positive feedback!!!
- $-30V < V_{PLL} < 0V$  under all conditions
- If NOT locked, tuning voltage must sweep through lock condition!

## Workaround (3)

- Shift tuning voltage up by 30V with Zener diode D1 and bias resistor R1
- Limit tuning voltage to  $-0.7V \dots +8V$  with 8V Zener diode D2
- R2 and C required for loop stability



# Workaround plugged in



# Some Drawback

13:33:50 27 MAR 2026

REF 10 dBm

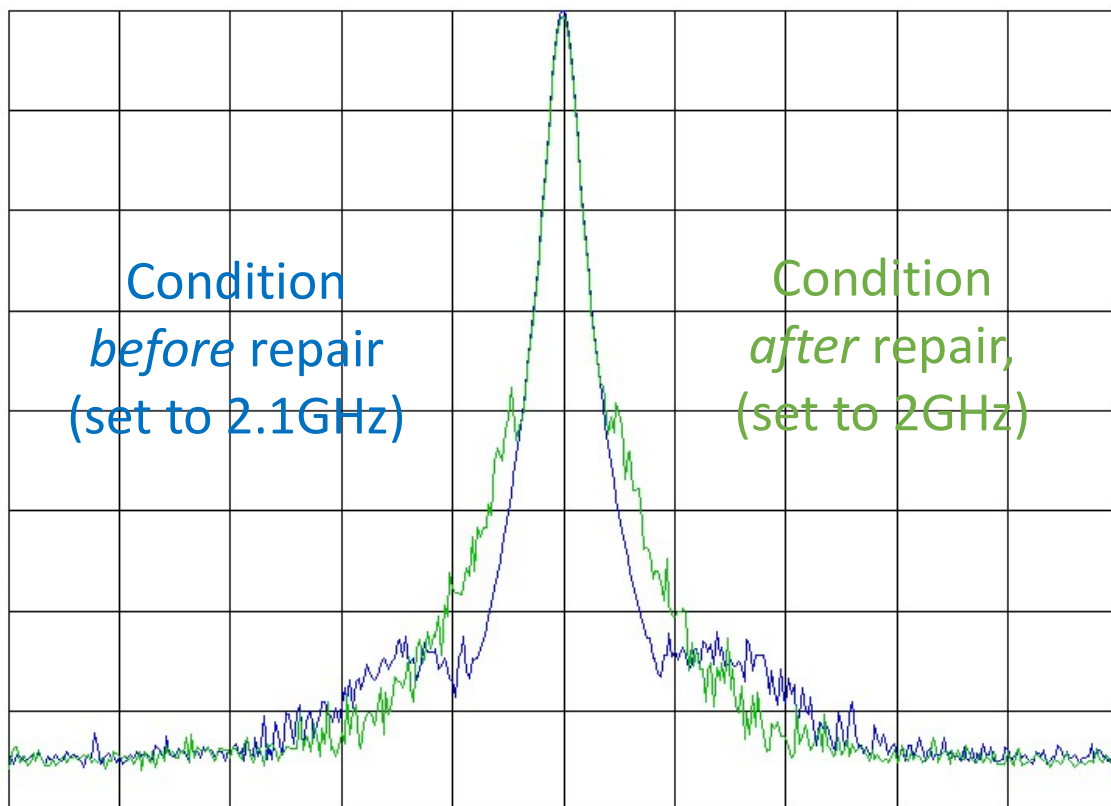
AT 10 dB

PEAK  
LOG  
10  
dB/

Condition  
*before repair*  
(set to 2.1GHz)

Condition  
*after repair,*  
(set to 2GHz)

WA VB  
SC FC  
CORR



CENTER 2.00000 GHz

RES BW 100 kHz

VBW 30 kHz

SPAN 10.00 MHz

SWP 20.0 msec

CLEAR  
WRITE A

MAX  
HOLD A

VIEW A

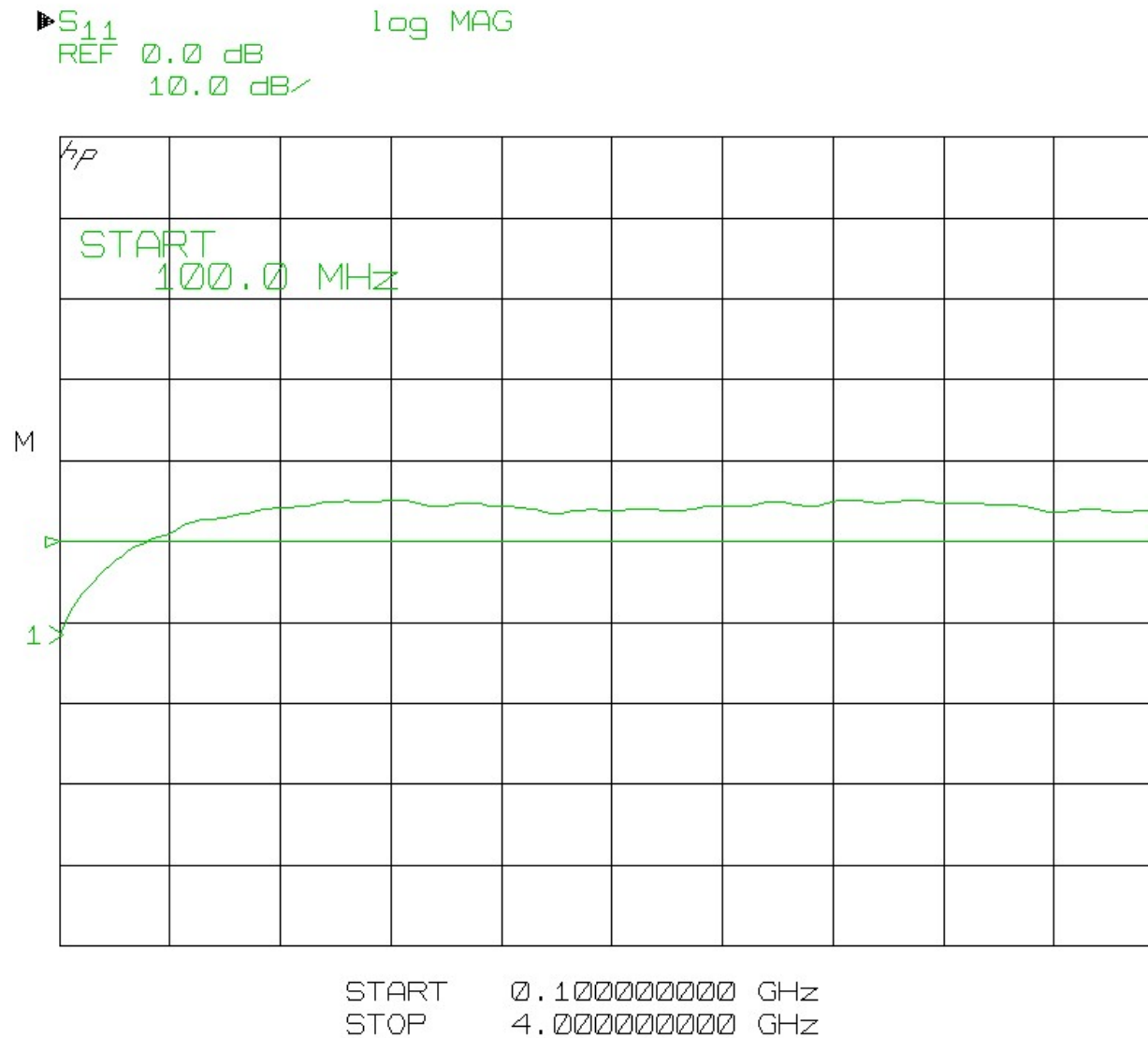
BLANK A

Trace  
A B C

More  
1 of 3

Phase Noise has  
suffered, but still good  
enough for VNA work!

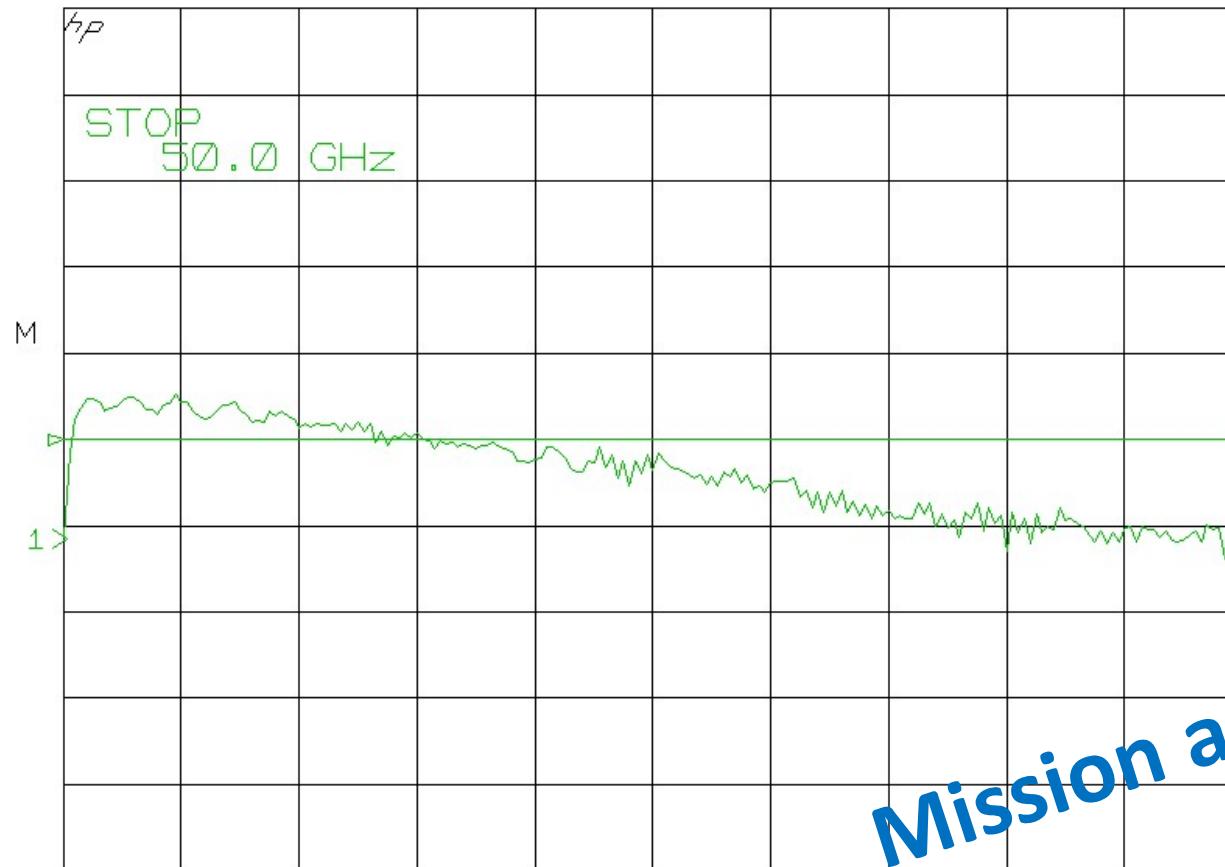
# HP8510C is back alive below 2,4GHz ...



27 MAR 26  
17:08:46

# ... and up to 50GHz

▶ S<sub>11</sub> log MAG  
REF 0.0 dB  
10.0 dB



START 0.100000000 GHz  
STOP 50.000000000 GHz



**Mission accomplished!**

27 MAR 26  
17:09:57

Many thanks for your interest!



## Another repair job

CAUTION



BIOHAZARD

*Why is the satellite dish deaf?!?*

