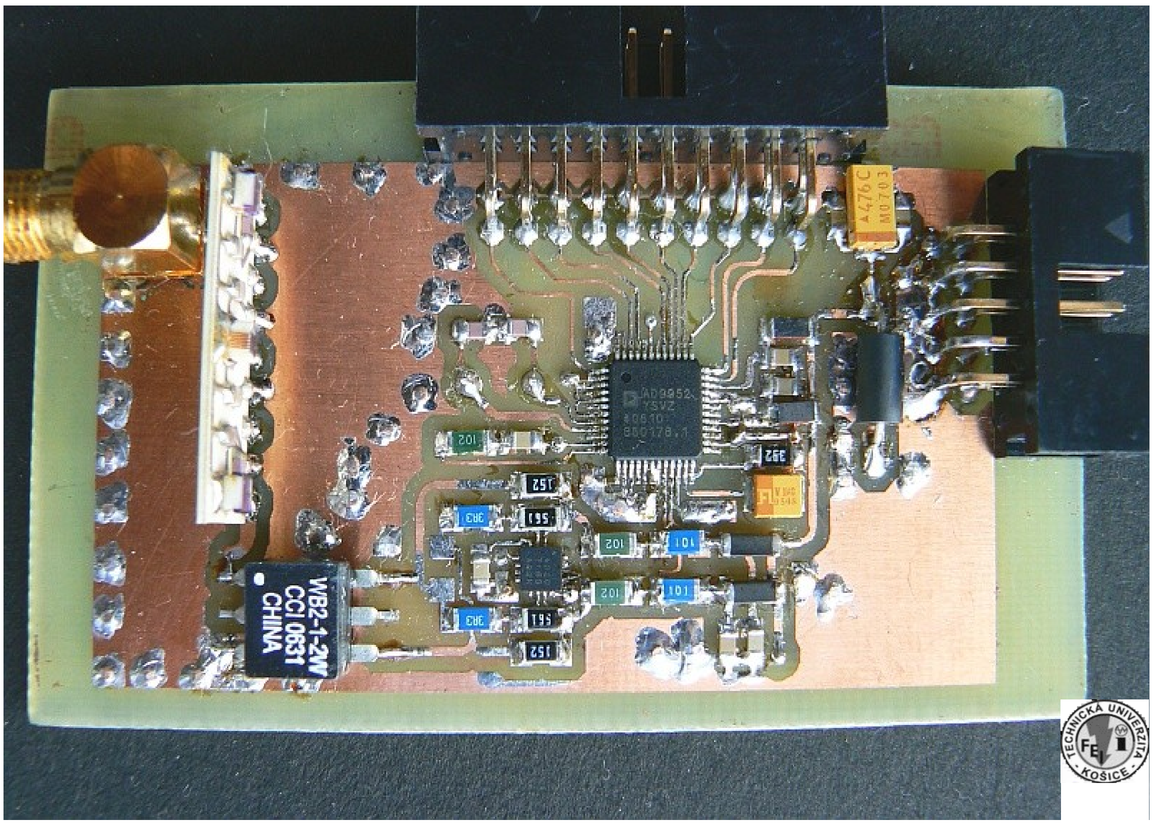
Evaluation board for DDS frequency synthesizer from ANALOG DEVICES, INC.

EVAL-AD9952-kemt07



Designed on
Faculty of Electrical Engineering and Informatics
Department of Electronics and Multimedia communications
Technical University of Kosice
2007
Semestral project

EVAL-AD9952-kemt07

FEATURES

Board includes DDS synthesizer, wideband differential amplifier, wideband transformer and LPF 150MHz for generating frequencies up to 150 MHz
Supply 3.3V with onboard voltage regulator 1.8V
Connectors for control of synthesizer functions from controller
Typical consuming 3.3V 90mA
Output 0dBm up to 120 MHz

GENERAL DESCRIPTION

This board is designed to allow students to evaluate the performance of AD9952 Digital Direct Synthesizer. It contains the AD9952 DDS,crystal 20MHz, wideband differential amplifier THS4520, wideband transformer WB2-1-2, Low pass filter 150MHz, SMA connectors for output, connector for control of DDS from controller,power connectors and voltage regulator 1.8V TL3021 [3]

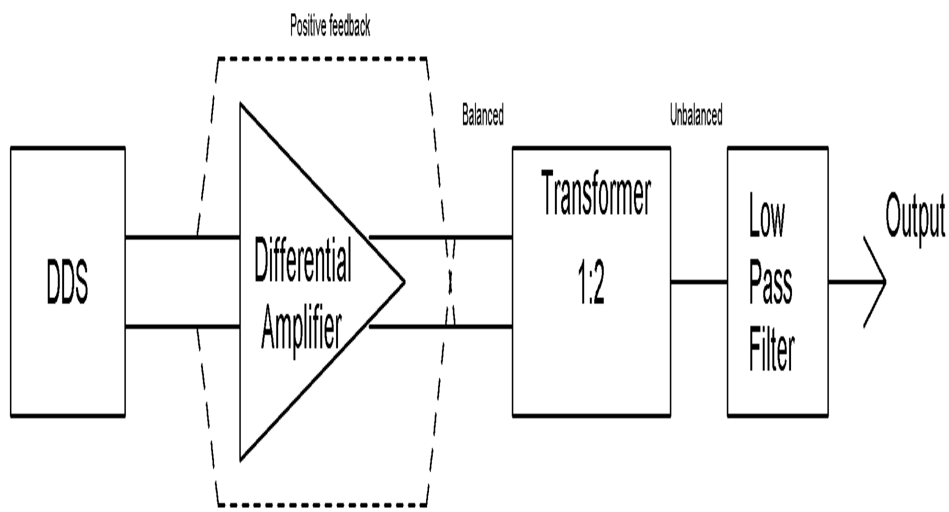


Figure 1. Block diagram of EVAL board

THEORY OF OPERATION

DDS DESCRIPTION

The AD9952 [1] is fully integrated direct digital synthesis (DDS) chip featuring a 14 - bit DAC and operating up to 400 MSPS it is capable of generating a frequencies up to 200MHz. The AD9952 is designed to provide fast frequency hopping and fine tuning resolution (32 - bit frequency tuning word). All control words are loaded into the AD9952 via a serial I/O port.
The internal circuits of the AD9952 consist of the following main sections (Fig.2): a buffered oscillator input, PLL multiplier, frequency and phase modulators, COS ROM, a digital -to- analog converter, a fast comparator and I/O buffer.

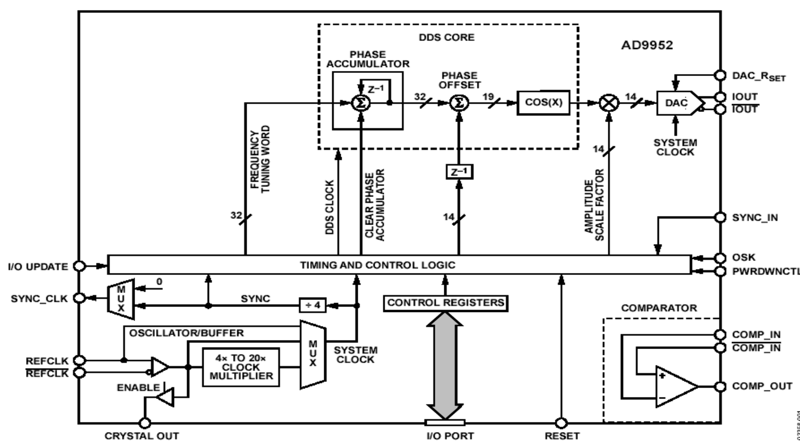


Figure 2. Functional block diagram for AD9952

THEORY OF OPERATION

Sine waves are typically thought of in terms of their magnitude form a(t) = sin(t). These harmonics signals are nonlinear but the angular information is linear function of time. The DDS method uses a phase accumulator, driven by the specified frequency, which accumulates the phase increments. The phase is incremented by each driving frequency clock tick. The size of the phase increment determines the actual output frequency. The binary width of the phase accumulator (accumulator overflows) determines the minimum frequency, which is equal to the frequency step, achievable by the DDS. The minimum frequency is defined by

$$\Delta\omega = \frac{1}{2^n}\omega_v$$

and therefore the output frequency is

$$\omega_0 = \frac{F}{2^n}\omega_v$$

where *F* is a tuning number and *n* is the accumulator width in bits.
Since phase information maps directly into amplitude, the COS ROM uses digital phase information as an address to look-up a table and converts the phase information into amplitude. This amplitude words are converted in fast digital -to- analog converter into current source. The AD9952 have differential current source output and maximal current is possible to adjust with DAC R_{SET} value.

DIFFERENTIAL AMPLIFIER DESCRIPTION

The THS4520 [4] is wideband, fully differential amplifier with Rail to Rail output. It is optimized for 5V and 3.3V single supply systems. In this project was used positive feedback [7]. The positive feedback makes the value of the output resistor appear larger than what it actually is when viewed from the line. Still, the voltage dropped across the resistor depends on its actual value, resulting in increased efficiency. With standard termination, 36 mW of power is dissipated in the output resistors, as opposed to 13 mW with active termination. That is, 64% less power is wasted with the active termination.

TRANSFORMER DESCRIPTION

The WB2-1-2WSL [6] is wideband transformer with impedance ratio 1:2. In this project was used on transformed output impedance (25Ω) from amplifier to 50Ω for low pass filter. Also for conversion of balanced signals to unbalanced one.

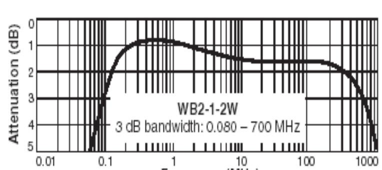


Figure 3. Typical frequency response

LOW PASS FILTER DESCRIPTION

The Low pass filter P7LP-157 [5] used in this project eliminated harmonics product from signal. This filter is 7th order elliptical alignments and it frequency response is on Fig.4

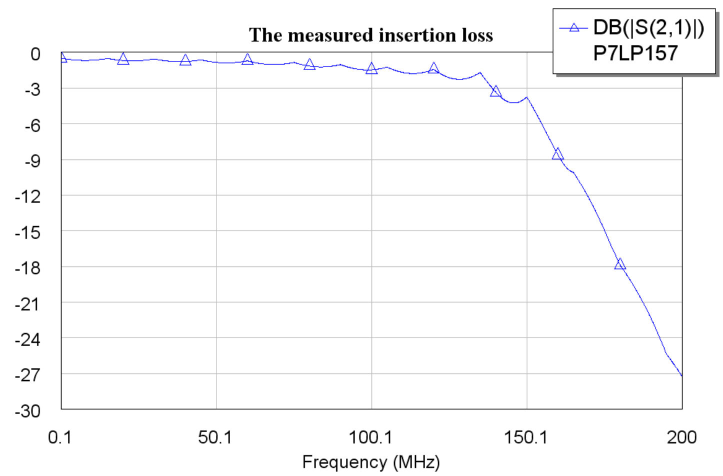


Figure 4. Measured insertion loss

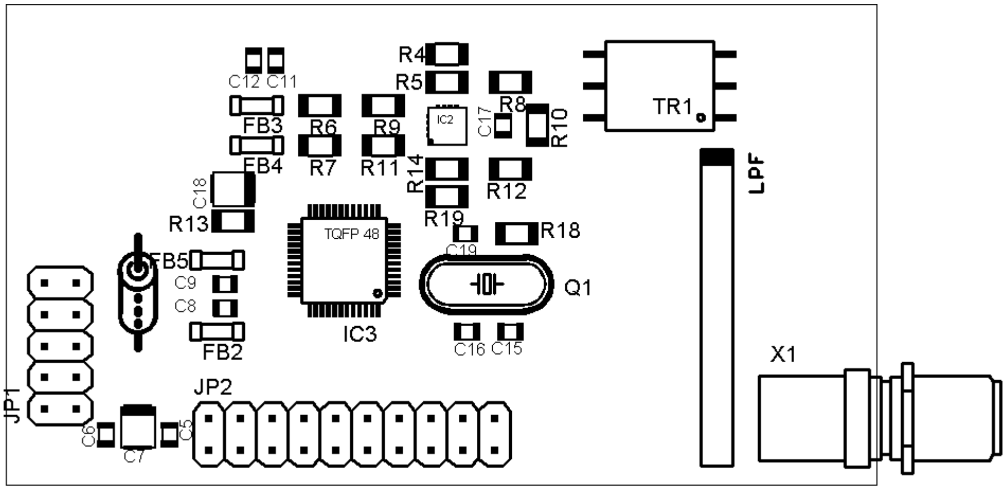


Figure 5.EVAL - Component side view - Silkscreen

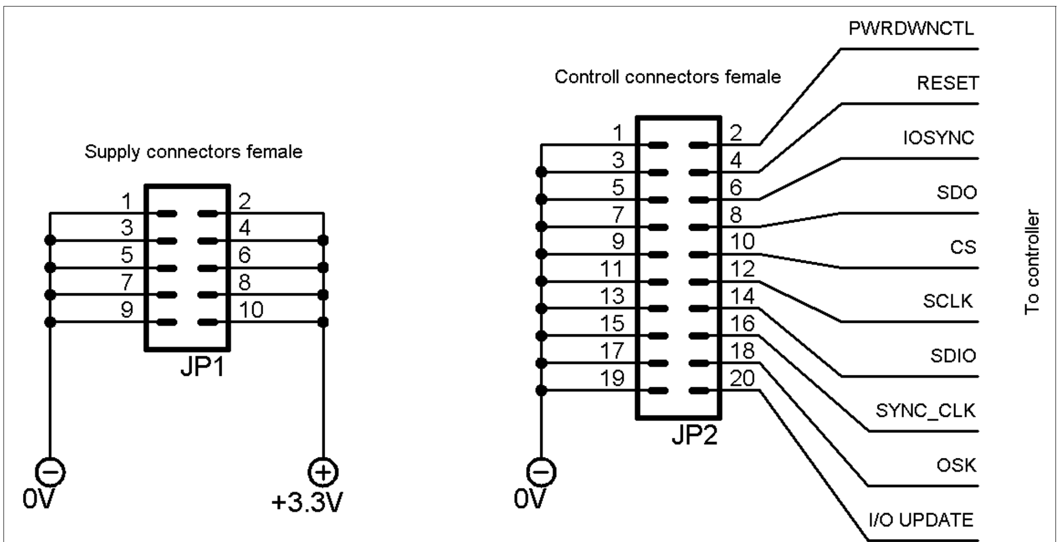


Figure 6. Cable diagram

Hardware description

For connecting controller and supplying with evaluation board required the female connectors FL10EC for supply and FL20EC for controller. Both connectors have to be with flat cable AWG28-10G and AWG28-20G.

The silk screen and the cable diagram for evaluation board are shown above. The board schematic is shown on pages 11.

MEASURED PERFORMANCE OF THE EVAL-AD9952-kemt07

These data were measured with RF milivoltmeter BM495A. Output was terminated with 50 ohm.
Output power for low frequencies is around 13dBm and slowly decreases to 0 dBm at 120 MHz

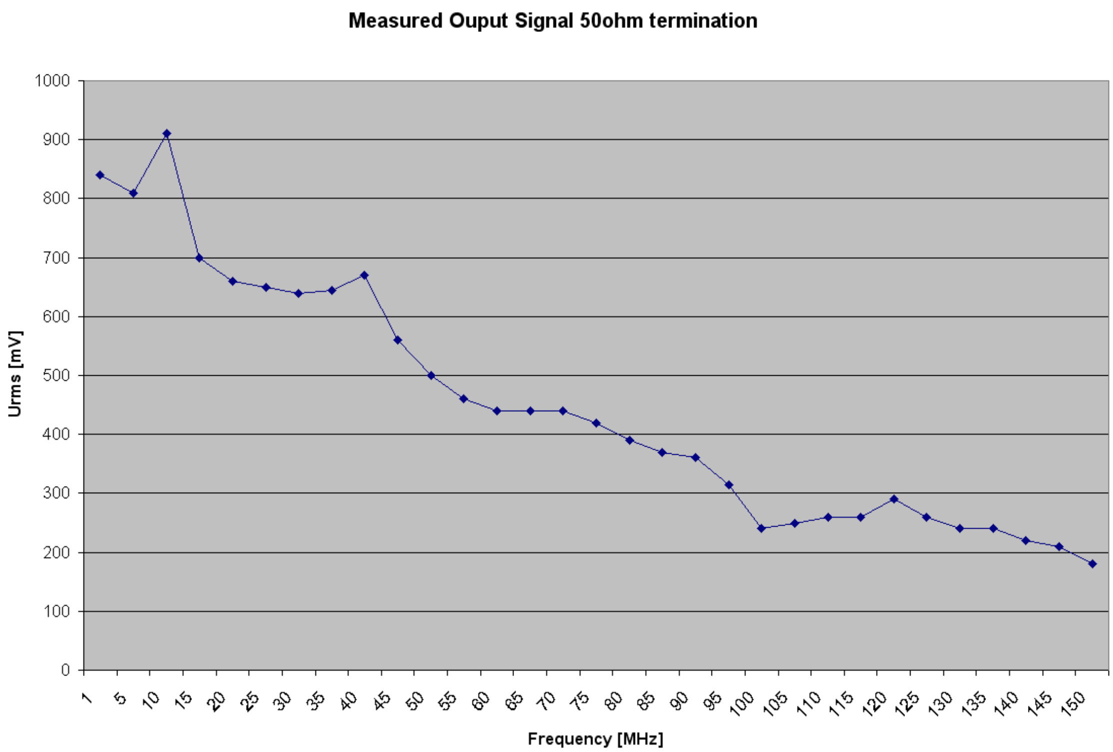


Figure 7. Measurements show output voltage

EXAMPLE OF APPLICATION

This EVAL-BOARD was used on application for simple AM/FM transmitter. For the conversion of signal from microphone to digital signal and transforming this signal on frequency word or amplitude word was used controller. The signal was received with correct antena at radius few tens meters.

Principles for transmitting signal for other band like up to 150 MHz is shown on Fig.9. Modulated signal goes to up-convert mixer and is translated around local oscillator frequencies. After this operation the signal is filtered in LPF or HPF and is amplified.

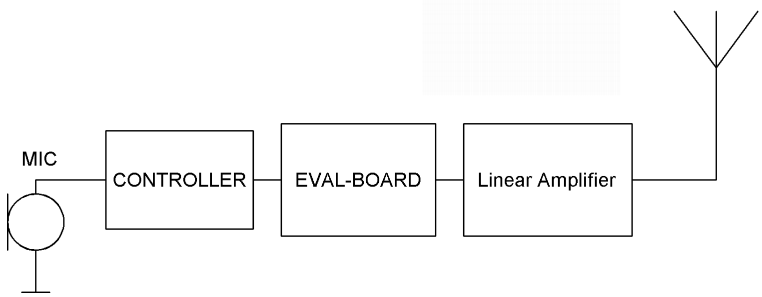


Figure 8. Block diagram - Simple AM/FM transmitter

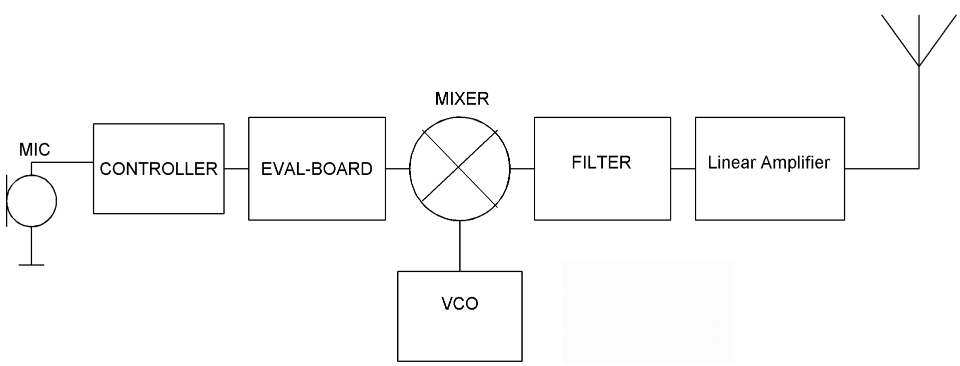


Figure 9. Block diagram - Transmitter for other frequency band

KNOWN PROBLEMS

For this project was chosen dual layer PCB board with photo sensitivity film. Schema and board was drawing in EAGLE Light software.
The soldering parts on board were made with hands. It is necessary to have not shivery hands. The placing and soldering of amplifier seemed to be difficult but it is possible. This package is only 3 mm width and has four pins at every side.
The peak around 8MHz (Fig.7) is caused probably by parasitic capacity loop or maybe by bad placement of parts around OpAmp chip. The power decreasing is caused by insertion loss on transformer and on filter. The influence must be inspect on OpAmp.
Thermal pad was soldering from bottom side via AgCu wire. Low melting-point alloys were used for soldering.

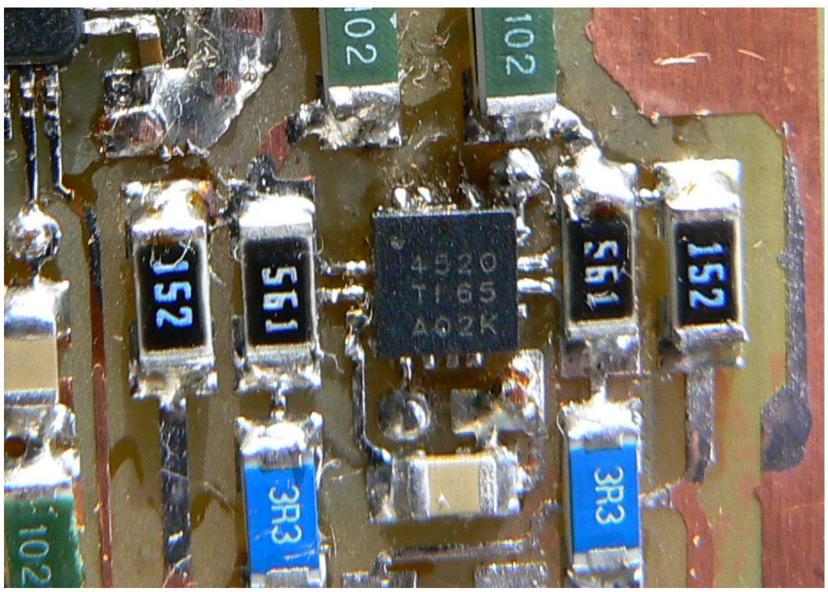


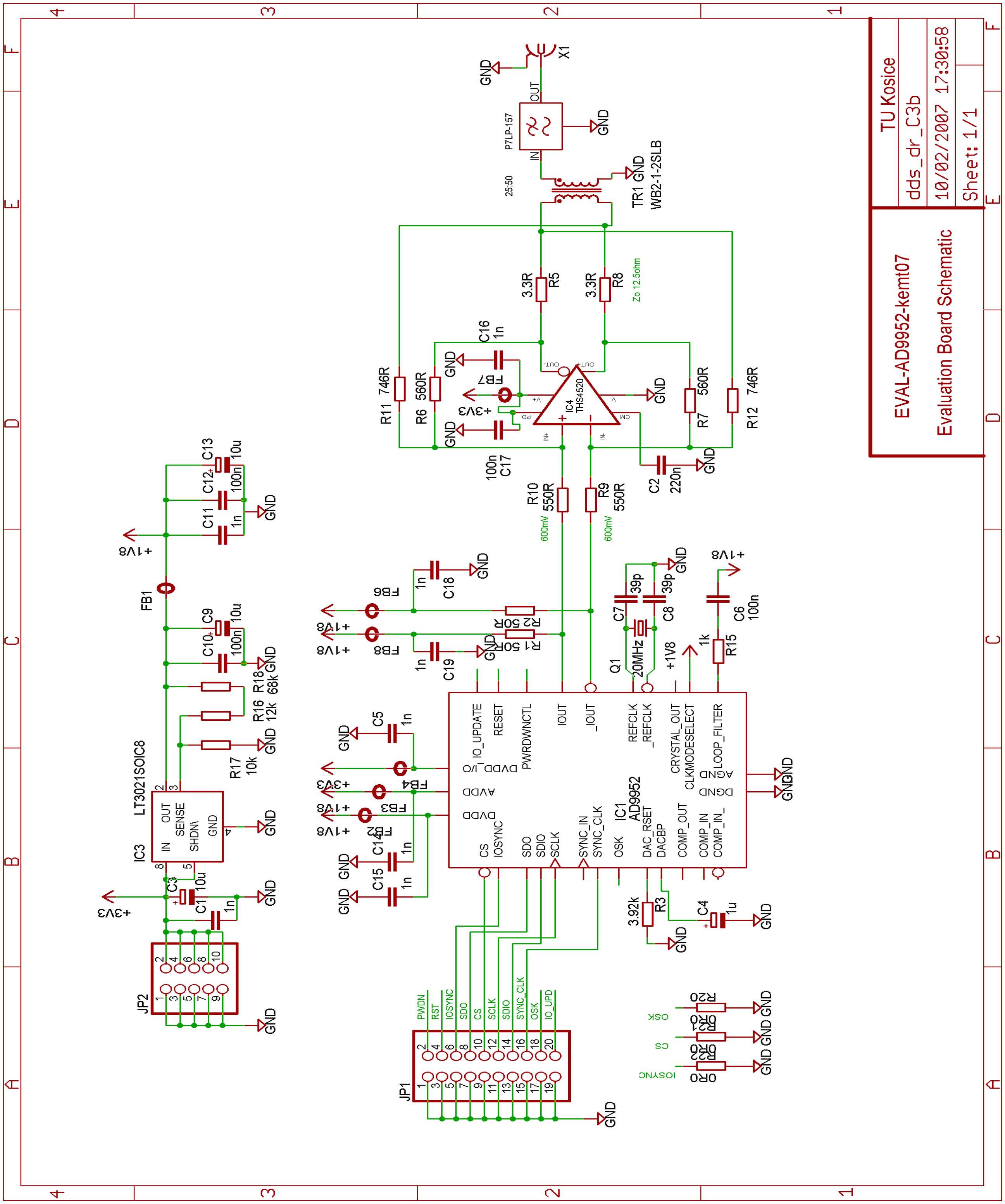
Figure 10. The detail of hand made soldering amplifier

Example for software control

This source code is for ATmega8 [2] controller, including SPI interface and many pins necessary for full control function AD9952. This simple code shows the sending of address and data words from controller to DDS chip.

```
.equ    cs        =    PB2 ;default 0..enabled io
.equ    sclk        =    PB5
.equ    sdo        =    PB4
.equ    sdi        =    PB3
.equ    osk        =    PC1 ;default 0
.equ    iosync        =    PC2 ;default 0
.equ    reset        =    PC3 ;default 0  reset je 0-1-0
.equ    pwdown        =    PC4 ;default 0
.equ    ioupdate    =    PC5 ;default 0

        sbi        portc,reset;do 1
        rcall    wait
        cbi        portc,reset;do 0
        rcall    SPI_init

        ldi    R16,0x00    ;DDS adress word first
        rcall    SPI_transmit
        ldi    zh,high(ad9952_0*2);adress in EEPROM - including first data word
        ldi    zl,low(ad9952_0*2)
        ldi    R17,0x04    ;number data word
        rcall    send

        ldi    R16,0x01    ;DDS adress word
        rcall    SPI_transmit
        ldi    zh,high(ad9952_1*2);adress in EEPROM - including second data word
        ldi    zl,low(ad9952_1*2)
        ldi    R17,0x03    ;number data word
        rcall    send
        .......
        .......

;now send  ioupdate
        rcall    io_update

;-------------------------------------------------------------------------
send:
        lpm    R16,z+     ;move byte from EEPROM
        rcall    SPI_transmit
        dec    R17
        brne    posli        ;repeat while R17 not zero
        ret
;------------------------------------------
SPI_Init:
; Enable SPI, Master, fck/128
        ldi R16,(1<<SPE)|(1<<MSTR)|(0<<SPR0 | 0<<SPR1);fclk/2
        out SPCR,R16
        ret
SPI_transmit:
; Start transmission of data (r16)
        out SPDR,R16
Wait_Transmit:
    ; Wait for transmission complete
        sbis SPSR,SPIF
        rjmp Wait_Transmit
        ret
io_update:
;at 8MHz..125ns
        sbi    portc,ioupdate
        cbi    portc,ioupdate
        ret

;data for AD9952
ad9952_0:
        .db 0x02,0x00,0x02,0x42 ;adress 0x00 bit 0-7,osk enabled
ad9952_1:
        .db 0x00,0x00,0xA4,0x00 ;adress 0x01 bit 16-0
ad9952_2:
        .db 0x3f,0xff         ;adress 0x02 bit 7-0 asf amplitud full
ad9952_3:
        .db 0x00,0x00         ;adresa 0x03 bit 7-0   ARR register
ad9952_4:
        .db 0x03,0x33,0x33,0x34 ;adress 0x04 bit 0-31 freq.register 5MHz
ad9952_5:
        .db 0x00,0x00         ;adress 0x05 bit 15-0     POW register

ad9952_f12:
        .db 0x01,0xFF         ;adress 0x02 bit 7-0 asf 1000 0000 0000 00..half 320mV amplitud
ad9952_f13:
        .db 0x10,0x00         ;adress 0x02 bit 7-0 asf 1000 0000 0000 00..quarter 160mV
ad9952_f14:
        .db 0x3f,0xff         ;adress 0x02 bit 7-0 asf 1000 0000 0000 00..full 640mV
```

EVAL-AD9952-kemt07



EVALUATION BOARD LAYOUT

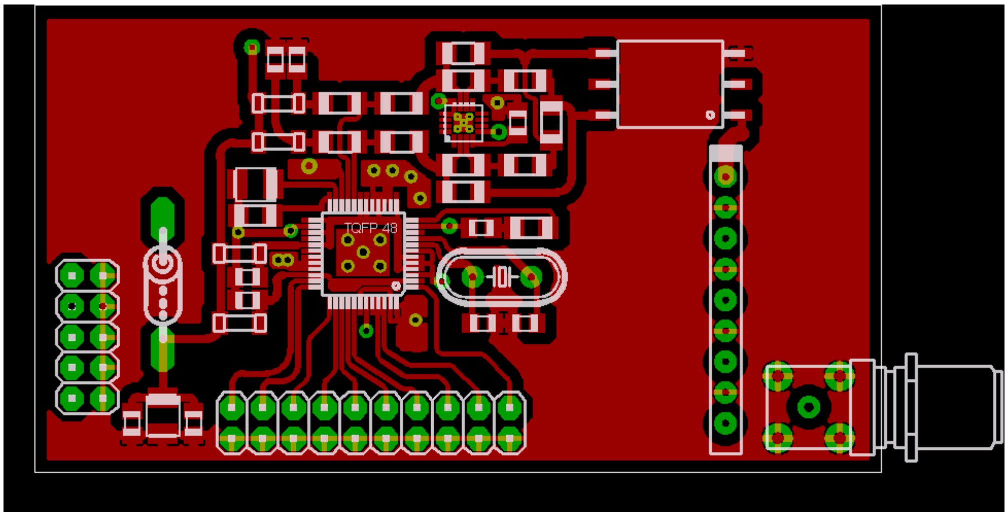


Figure 11. EVAL – TOP Layer

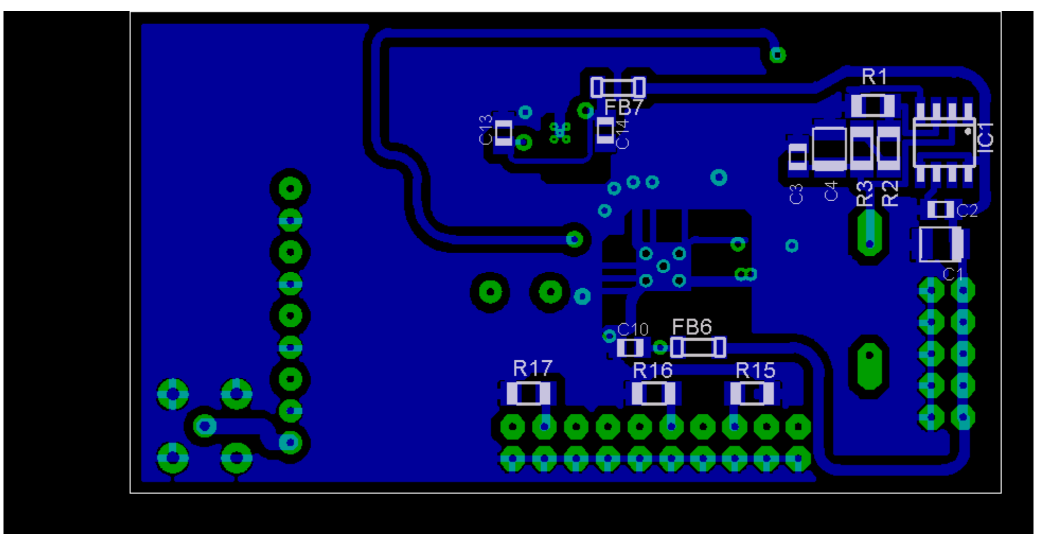


Figure 12. EVAL – BOTTOM Layer – As view on bottom side

References

	Main Parts	Manufacturer	Vendor	Links
[1]	**AD9952YSVZ**	Analog Devices, Inc.	Dialogue s.r.o	http://www.analog.com/UploadedFiles/Data_Sheets/AD9952.pdf
[2]	**ATmega8-16**	ATMEL	S.O.S electronics	http://www.atmel.com/dyn/resources/prod_documents/doc2486.pdf
[3]	**LT3021ES8**	Linear Technology	S.O.S electronics	http://www.linear.com/pc/download
[4]	**THS4520RGTT**	Texas Instruments		http://www.ti.com/lit/gpn/ths4520
[5]	**P7LP-157**	Coilcraft, Inc.		http://www.coilcraft.com/pdfs/lcfilt.pdf
[6]	**WB2-1-2WSL**	Coilcraft, Inc.		http://www.coilcraft.com/pdfs/wb.pdf

[7] Fully-differential Amplifiers, Texas Instruments SLOA054A

Acknowledgments

This project would not have been possible without the support of many manufacturers who have provided samples parts for the development.
I would like to gratefully acknowledge the following organizations : Analog Devices, Inc. for sample AD9952, Texas Instruments for sample THS4520, Linear Technology for sample LT3021 and CoilCraft, Inc. for sample the filter and transformer.
The acknowledgment belong them for contribution development and educations.

I would like to express my sincere thanks and appreciation to my advisor, Assoc. Prof. Milos Drutarovsky, for guidance and technical discussions, and for providing me with excellent facilities to pursue my work .

Table 1. Bill of materials for the EVAL-AD9952-kemt07

Item	Quantity	Reference	Description
1	8	C2 C5 C8 C9 C10 C11 C12 C14	1nF ceramic Capacitor 0805
2	4	C3 C6 C13 C19	100nF ceramic Capacitor 0805
3	2	C15 C 16	39pF ceramic Capacitor 0805
4	3	C1 C4 C7	10uF tantal Capacitor SMC_B
5	1	C18	1uF tantal Capacitor SMC_B
6	1	C17	220nF ceramic Capacitor 0805
7	6	FB2 FB3 FB4 FB5 FB6 FB7	Ferrite Beam 1206
8	1	FB1	Ferrite Beam 10mm
9	1	X1	SMA PCBW Female Connector
10	1	Q1	20MHz HC49 Crystal
11	1	TR1	WB2-1-2SLB Transformer CoilCraft
12	1	IC1	LT3021 SOIC8 Voltage Regulator Linear Technology
13	1	IC2	THS4520 QFN16 Differential Amplifier Texas Instruments
14	1	IC3	AD9952 TQFP48 DDS Analog Devices Inc.
15	1	LPF	P7LP LPF CoilCraft
16	1	JP1	LPH10RA Connector
17	1	JP2	LPH20RA Connector
18	3	R14 R15 R16	0R0 Resistor Optional 1206
19	2	R4 R18	746Ω Resistor 1206
20	2	R5 R13	560Ω Resistor 1206
21	2	R6 R7	50Ω Resistor 1206
22	2	R8 R11	3.3Ω Resistor 1206
23	1	R1	10k Ω Resistor 1206
24	1	R2	12kΩ Resistor 1206
25	1	R3	68kΩ Resistor 1206
26	1	R12	3.9kΩ Resistor 1206
27	1	R17	1kΩ Resistor 1206
28	1	PCB board	Double-sided PCB Made of FR-4 2oz. Copper

EVAL-AD9952-kemt07

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