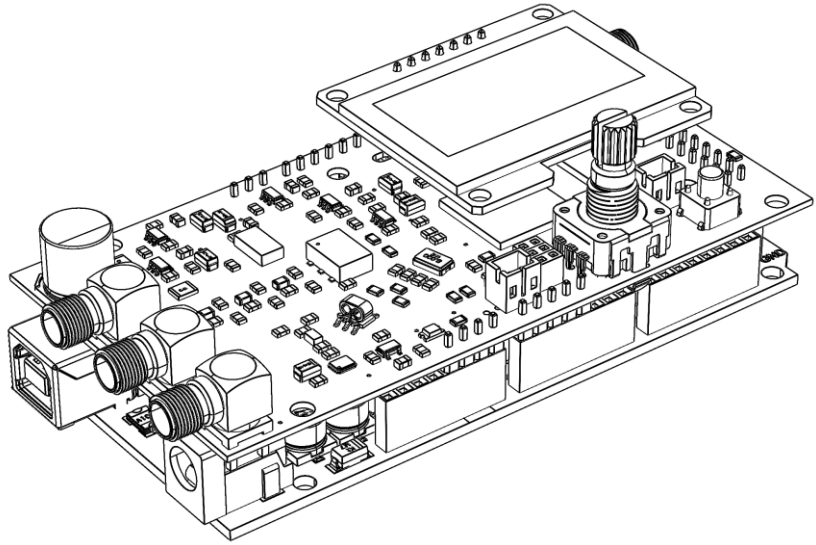
GRA & AFCH



DDS 9910 Arduino Shield

V3.5

OPERATING MANUAL

Firmware v. 3.18

Rev. A

⚠WARNING **Use only a power supply with a voltage rating of 7.5 volts or USB to power this device!**

GENERAL GUIDE

The device is an expansion board (shield) for Arduino Mega based on the ATmega2560 microcontroller with **5-volt** logic levels, since the board has logic signal level converters from **3.3V to 5V**.

Power is supplied to the device through the Arduino, and connection is made through the power jack **(7.5 volts only!)** or through the USB connector.

To fully operate the device, an I²C OLED **display** of **0.96** or **1.54 inches** is required (optional and not included). The display is powered by **5 volts** from the **5v pin** on the Arduino.

The device is controlled by an **encoder** and a **OUTPUT** ON/OFF **push-button**.

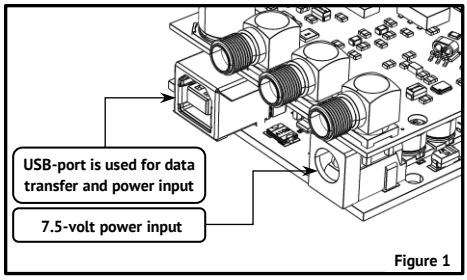


Figure 1

An **external encoder** and **push-button** can be connected to the **ExENC** (PH2.0-4p) and **ExON/OFF** (PH2.0-2p) connectors, if needed.

The AD9959 **clocking** can be done in four ways:

- Using On Board **XO** - Crystal 25MHz ±20ppm with built-in **PLL** at **1GHz.** Refer to **(Figure 2)** and **(Table 1);**
- Using On Board **TCXO** – 5 - 62.5MHz ±1 ppm with the built-in **PLL** at **1GHz** (Overclocking up to **1.5GHz**);
- Using an External **TCXO/OCXO** – 5 - 62.5MHz with the built-in **PLL** at **1GHz** (Overclocking up to **1.5GHz**);
- Using an External **Oscillator** with frequency range: **60MHz** to **2000MHz. PLL** is **DISABLED**.

The type and frequency of the clock source **must** be **correctly set** in the device settings (at "**SETUP**" menu). All settings are saved in non-volatile memory.

The **output signal** is taken from the SMA connector labeled "**RF OUT**" on the board.

A software-controlled **RF switch** has been added to select **External/Internal** clock sources, eliminating the need to manually resolder capacitors. When using an **external clock source**, the signal is fed to the SMA connector labeled "**REF CLK IN**"(Figure 2).

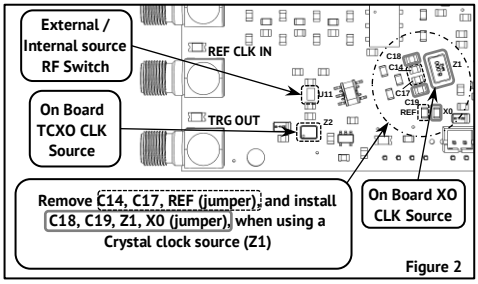


Figure 2

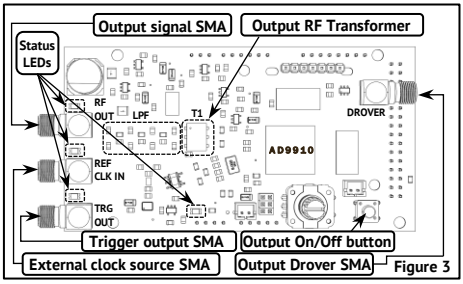


Figure 3

The level of the external clock signal must be within the range of **-10** dBm to **+10** dBm for a sinusoidal signal. For example, if the signal level from an external generator is +16 dBm, it is necessary to connect it only through an attenuator of at least **6** dBm (16 - 6 = 10). For signals of other waveforms, such as a clipped sine or square wave, the level must be **0.2 – 1 Vpp**.

The device contains an output low-pass filter and a matching output transformer, therefore a software limit of 100 kHz is applied to the minimum output frequency of the device **(Figure 3)**.

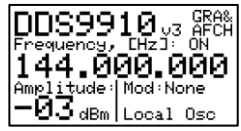
Two SMA outputs have been added: **TRG OUT** for oscilloscope synchronization in S-Curve mode, and **DROVER** to indicate when the **Sweep** function completes.

To visually indicate operating modes, in addition to the display, the shield contains four LEDs **(Figure 3)**:

- LED**RF OUT** - Lights when the radio frequency **output** is **activated** by the OUTPUT ON/OFF button or by command via the serial port. Located next to the RF OUT SMA connector;
- LED**REF CLK IN** - Lights up when the DDS **external clock source** is selected in the settings. Located next to the REF CLK IN SMA connector;
- LED**TRG OUT** - Lights up when **S-Curve** mode is selected in the settings. Indicates that the trigger output has a synchronization signal with the oscilloscope. Located next to the TRG OUT SMA connector;
- LED**PLL LOCK** - Lights up when phase-locked loop is **enabled**.

OPERATION

Main menu:

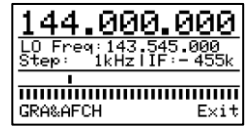


Rotating the **encoder knob** moves the cursor through menu items or changes the value of the selected item. Pressing the encoder knob activates or deactivates the parameter editing mode, or enters a submenu (depending on the context). Fast rotation of the knob allows jumping through **10** values at a time.

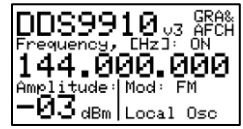
Frequency [Hz]: The maximum output frequency is limited to **600 MHz**, but it is important to note that the maximum output frequency that can be obtained is half of the frequency of the AD9910 core. For example, with a core frequency of 1 GHz, the maximum output frequency cannot exceed **500 MHz**. The core frequency can be changed in the "**Setup**" menu.

Amplitude: [dBm] The signal level can be adjusted from -72 dBm to 0 dBm, or up to +4 dBm if the "**DAC current**" option in the "**Setup**" menu is set to "**Hi**".

Local oscillator menu - "Local Osc": This mode will be particularly appreciated by HAM radio enthusiasts, as the DDS is an ideal solution for use as a local oscillator in superheterodyne radio receivers due to its very low phase noise and high frequency stability. A separate operating mode was created to eliminate the need to recalculate the output frequency each time. Instead, you can simply set the "**IF"** (Intermediate Frequency): **450kHz, 455kHz, 465kHz, 5.5MHz, 6.5MHz, 10.7MHz, 21.4MHz, 21.7MHz, 38.4MHz, 70MHz, 90MHz, 100MHz;** and the tuning **"Step"**: **1kHz, 5kHz, 25kHz, 50kHz, 100kHz)**. In the settings, you can choose to either add **"+"** or subtract **"-"** the **intermediate** frequency from the **carrier** frequency.



Modulation menu - "Mod":



This menu allows you to enable amplitude modulation (**AM**), frequency modulation (**FM**), "**Sweep**" mode for frequency or "**S-Curve"** mode. Changes to the parameters take effect immediately after releasing the encoder knob, and the "**SAVE**" menu item is used to save the selected mode and all its parameters to **non-volatile** memory. The carrier frequencies can be changed in the "**Main**" menu, and the "**EXIT**" option is used to return to the "**Main**" menu.

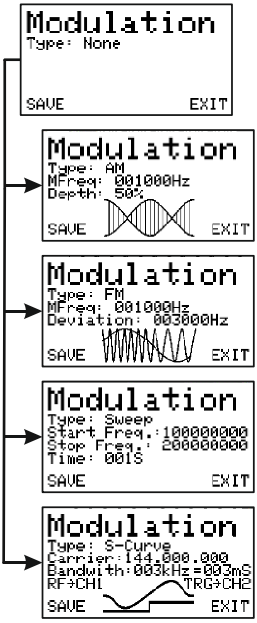
Type: None – To disable modulation or the "**Sweep**" mode, set the "**Type**" parameter to "**None**".

Type: AM – Amplitude Modulation: The "**MFreq**" parameter allows for adjustment of modulation frequency from **10** to **100999 Hz** with a step size of **1 Hz**, while the "**Depth**" parameter allows for setting **modulation depth**, also known as **modulation index**, within the range of **0** to **100%** with a step size of **1%.**

Type: FM – Frequency modulation: The "**MFreq**" parameter allows for adjustment of modulation frequency from **10** to **100999 Hz** with a step size of **1 Hz**, while the "**Deviation**" parameter allows for setting **frequency deviation** of the carrier wave within the range of **1 Hz** to **100999 Hz** with a step size of **1 Hz**.

Type: Sweep – Frequency Sweep: The "**Start Freq.**" and "**Stop Freq.**" parameters set the initial and final frequencies within the range of 1 Hz to 600 MHz with step sizes of 1 Hz. It is not allowed to set the initial frequency higher than the final frequency. The "**Time**" parameter sets the time for the frequency to change from the "**Start Freq**." value to the "**Stop Freq**." value. This parameter can take values from **1** to **999**, and the units of measurement can be selected from "**S**" for seconds, "**mS**" for milliseconds, and "**uS**" for microseconds. In this mode, the frequency will change first from a lower value to a higher value, and then in the reverse direction - from a higher value to a lower value, and so on until the sweep mode is turned off (**NO-DWELL** mode). Each time the frequency reaches the upper or lower limit ("Start Freq." or "Stop Freq."), a short positive pulse of **3.3 V** with a duration of **two cycles** of the DDS clock will appear on the "**DROVER**" pin.

Type: S-Curve – This mode is essential for optimal tuning of a **quadrature coil** or for testing a **ceramic discriminator** in an FM detector. To use this mode, you need to connect the RF output to the receiver input through a **70 dB** attenuator.

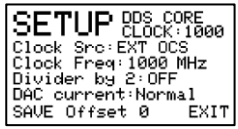


Then, connect the **receiver output** to the **1-st** channel of the oscilloscope. It is recommended to capture the signal before the output filter. Additionally, connect the **TRG** output to the **2-nd** channel of the oscilloscope and set the trigger to capture the **rising edge** on this channel. The "**Carrier**" parameter set the carrier frequency within the range of **1 Hz** to **600 MHz** with step sizes of 1 Hz. The "**Bandwidth**" parameter allows you to adjust the deviation frequency from **3** to **300 kHz** with a step of **1 kHz**. By changing the horizontal sweep time of the oscilloscope, as well as the vertical sensitivity, achieve a convenient scale for displaying the **S-curve**, taking into account that **1 kHz** of the DDS deviation frequency corresponds to **1 ms** of the oscilloscope sweep time.

Setup menu:

To enter the settings menu, **press** and **hold** the **encoder knob** for **1 second.**

Clock Src: Allows selecting the clock source, with **four** options available: "**XO**", "**TCXO**", "**Ext. TCXO/OCXO**", "**EXT OSC**" - External clock source. In addition to selecting the clock source in the menu, it is also necessary to ensure that the components listed in the Table 1 are set to the position corresponding to the selected clock source.



Clock source (only one at a time)	Capacitors (0805)		Resistors (0R 0805)	
	C18, C19 33pF	C14, C17 100nF	XO	REF
XO - Crystal Oscillator (20, 25 MHz)	✓	✖	✓	✖
TCXO, Ext. TCXO/OCXO, Ext OSC	✖	✓	✖	✓

Table 1 ✓ means that the component must be installed,
✖ means that the component must be removed.

Clock Freq: Allows setting the frequency of the clock source, with different frequencies available for each source:

- For "**XO**", frequencies of **20 MHz** and **25 MHz** are available;
- For "**TCXO**", frequencies of **5**, **10**, **20**, **25**, **40**, **50** and **62.5 MHz** ±1ppm are available;
- For "**ExtTCXO/OCXO**", frequencies of **5**, **10**, **20**, **25**, **40**, **50** and **62.5 MHz**;
- For "**EXT OSC**", it is possible to manually set the frequency in the range of **60 MHz** to **2000 MHz** with a step of **1 MHz**. In addition, an additional parameter "**Divider by 2**" is available for this source, which allows activating the built-in **AD9910 divider** by **2** on the signal path from the clock source.

DAC current: The parameter can take two values, "**HI**" - increases the output signal power by **+4 dBm** but results in increased harmonic levels and phase noise; "**Normal**" - reduces the maximum power to **0 dBm** but lowers harmonic levels and phase noise.

DDS Core Clock: Allows changing the core frequency. When clocked by "**XO**", "**TCXO**" or "**ExtTCXO/OCXO**", the core frequency can be set from **1000 MHz** to **1520 MHz**, with the adjustment step depending on the clock source frequency. When clocked by an external oscillator, the core frequency can be set in the range of **60 MHz** to **3000 MHz** (by setting the clock source frequency and, if necessary, activating the "**Divider by 2**" parameter). The nominal **AD9910** core frequency is **1000 MHz**, setting a higher frequency is overclocking, and operation at such a frequency is not guaranteed.

⚠WARNING **It is not recommended to set the core frequency above 1520 MHz**

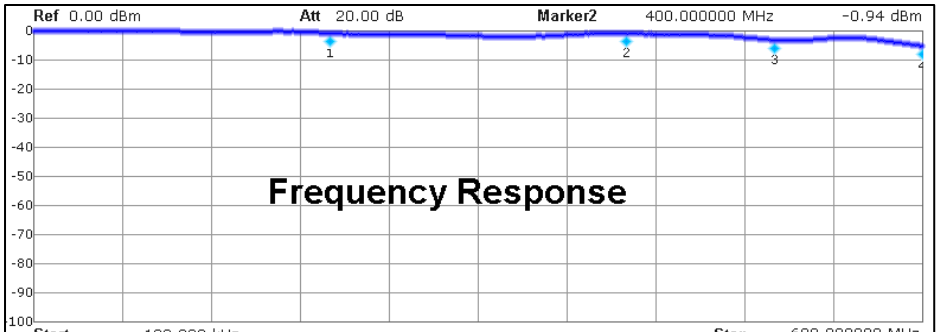
Divider by 2: The parameter is activated when selecting "**EXT OSC**" - External clock source in the **Clock Src**: item. It takes the values **ON** / **OFF**. When the frequency of the external clock source is higher than **1500 MHz**, the frequency divider should **ALWAYS** be turned **ON**!

Offset: Allows adjusting the clock frequency if the deviation from the specified value is known. If the signal frequency at the DDS output differs from that set in the menu, then the actual frequency of the clock source deviates from the nominal value. This parameter allows you to adjust the frequency of the clock source in **1 Hz** increments to correctly display the output frequency.

The clock settings are applied only after selecting the "**SAVE**" option. The "**EXIT**" option allows exiting without saving the settings.

FACTORY RESET

To reset all settings to factory defaults, you should hold down the **encoder knob** and apply power to the device while keeping the **knob** pressed.



Marker	Trace	Readout	X Axis	Ampt
M1	A	Frequency	200.000000 MHz	-0.96 dBm
M2	A	Frequency	400.000000 MHz	-0.94 dBm
M3	A	Frequency	500.000000 MHz	-3.21 dBm
M4	A	Frequency	600.000000 MHz	-5.33 dBm

Figure 4

SPECIFIACTIONS

Frequency Range:	**100 kHz to 600[(1)] MHz, with 1 Hz frequency step**
Output Power:	**+4[(2)] dBm to -84 dBm (on 50 Ohm load)**
Output Level Up To:	**1 Vpeak-to-peak (+4 dBm 50 Ohm at 100 MHz)**
Flatness:	**±1dB from 100kHz to 400MHz, full scale (referred to Figure 4)**
Spectral Purity:	**Spurious: <-60dBc below 400MHz / Harmonic: <-60dBc below 400MHz**
Phase Noise:	**-142 dBc/Hz @ 10 kHz offset (100 MHz Carrier)**
Output Filter:	**LPF LC 7-th order, 600 MHz cut-off (-3 dB)**
Reference Clock Input (SMA):	**0.2 to 2 Vpeak-to-peak, -10 dBm to +10 dBm; Impedance: 50 Ohm**
On Board Reference Clock Sources *(On Choice)*:	**TCXO 50 MHz 1ppm Oscillator (default), XO 25 MHz 20ppm Oscillator (alternative) or External Oscillator up to 2000 MHz (if using built-in PLL then DDS clock is limited to 1500MHz)**
Local Oscillator Mode:	**100 kHz to 600[(1)] MHz, with 1 Hz (1kHz, 5kHz, 25kHz, 50kHz, 100kHz) frequency step; IF (Intermediate Frequency) can be set: (450kHz, 455kHz, 465kHz, 5.5MHz, 6.5MHz, 10.7MHz, 21.4MHz, 21.7MHz, 38.4MHz, 70MHz, 90MHz, 100MHz)**
AM (Amplitude Modulation):	**Modulation Frequency: 10 Hz to 100 kHz in 1 Hz step; Modulation Depth: 0% to 100% in 1% step**
FM (Frequency Modulation):	**Modulation Frequency: 10 Hz to 100 kHz in 1 Hz step; Modulation Deviation Frequency: 0 Hz to 100 kHz in 1 Hz step**
Frequency Sweep Mode:	**Frequency Range (Start - Stop): 1 Hz to 600 MHz in 1 Hz step; Sweep Time: 1-999; "*S*" for seconds, "*mS*" for milliseconds, and "*uS*" for microseconds**
S-Curve (For FM-Detector Tunning):	**Carrier (Carrier frequency): 1 Hz to 600 MHz in 1 Hz step; Bandwidth (Modulation Frequency): 3 to 300 kHz in 1 kHz step;**
TRIGGER OUT (SMA)	**S-Curve Measure Sync; 5 Volt 20mA (TTL Compatible)**
DROVER OUT (SMA)	**Digital Ramp Over; 3.3 Volt 20mA (TTL Compatible)**
Outputs Types (SMA):	**1 Channel; Impedance: 50Ω**
Power Supply:	**By USB or External Power Supply DC 7.5V, 1A**
Display *(On Choice)*:	**OLED 0.96 or 1.54 inches I²C**
Size:	**53 x 115 x 47 mm (W x L x H)**
Weight:	**46 g (without Arduino and display) / 105 g (with Arduino and display)**

Notes: **1.** When overclocking the core to **1.3 GHz** or above (Refer to **Setup menu** -> **DDS Core Clock**).
2. When the "**DAC Current HI**" function is activated (Refer to **Setup menu** -> **DAC current**).

REMOVING 100 KHz MINIMUM FREQUENCY LIMIT

For experienced users only. All actions are performed at your own risk.

Remove transformer **T1** and replace it with one capacitor and two resistors (**Figure 5**), and in the file "**DDS-AD9910-Arduino-Shield_HW3.x.ino**" set the desired value in Hertz in the line **`#define LOW_FREQ_LIMIT 100000`**.

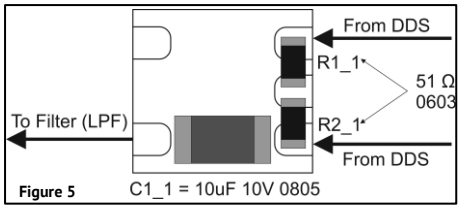


Figure 5

Installing a capacitor **C1_1** with a value of **10 uF** will reduce the lower frequency limit to **10 Hz**, if you want to reduce the limit even more, then the value of the capacitor should be increased. These modifications will lead to a degradation in the performance of the **DDS**: the output level will decrease by **3 dBm**, and the level of harmonics will increase as the current mirror and a balanced transformer not be used.

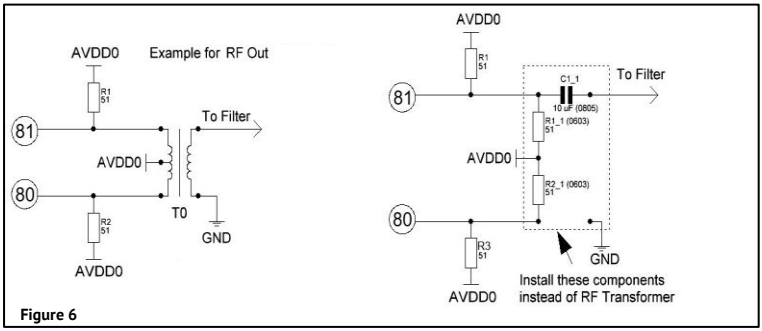


Figure 6

The diagram shows changes in the electrical schematic to reduce the minimum operating frequency of the output signal (see **Figure 6**):

List of Serial Port Commands:

Starting with version **2.14**, the ability to control via the serial port has been added.

COMMANDS	DESCRIPTION
F	Set Frequency in **Hz** (**100 000 — 600 000 000**)
P	Set Output Power in **dBm** (**-72 — 0** or **-68 — +4**, depending on "DAC current")
E	Enable Output
D	Disable Output
M	Get Model
V	Gets Firmware Version
H	This Help
;	Commands Separator

Example: **F100000;P-2 (**Sets the Frequency to **100** kHz, and Output Power (Amplitude) to **-2** dBm on **RF OUT)**
Any number of commands in any order is allowed.

Serial Port Settings: **Speed** – 115200 Bouds, **Data Bits** – 8, **Stop Bits** – 1, **Parity** – No, **DTR** – OFF.

website:
www.gra-afch.com

firmware:
www.github.com/afch/DDS-AD9910-Arduino-Shield

video compilation of firmware:
https://youtu.be/ipIgBvlwRc0