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ADF4351 and ADF5355 Update

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Agenda

- ADF4351 NTMS 432.380 MHz beacon
- Orion ADF4351 Board
- ADF5355 Arduino Due Controller

432.380 MHz NTMS Beacon

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- ADF4351 LO
- Arduino Uno sets frequency, sends beacon message and controls on-off keying of RF via the ADF4351
- Message
  - W5HN/B EM13kf Denton, TX
  - 432.380 MHz
  - Temp xxxx (amplifier temp in degrees F)
- Real-time temperature telemetry w/LM34
- LED keying indicator
- LCD Shield displays call sign and frequency

432 MHz Beacon Block Diagram

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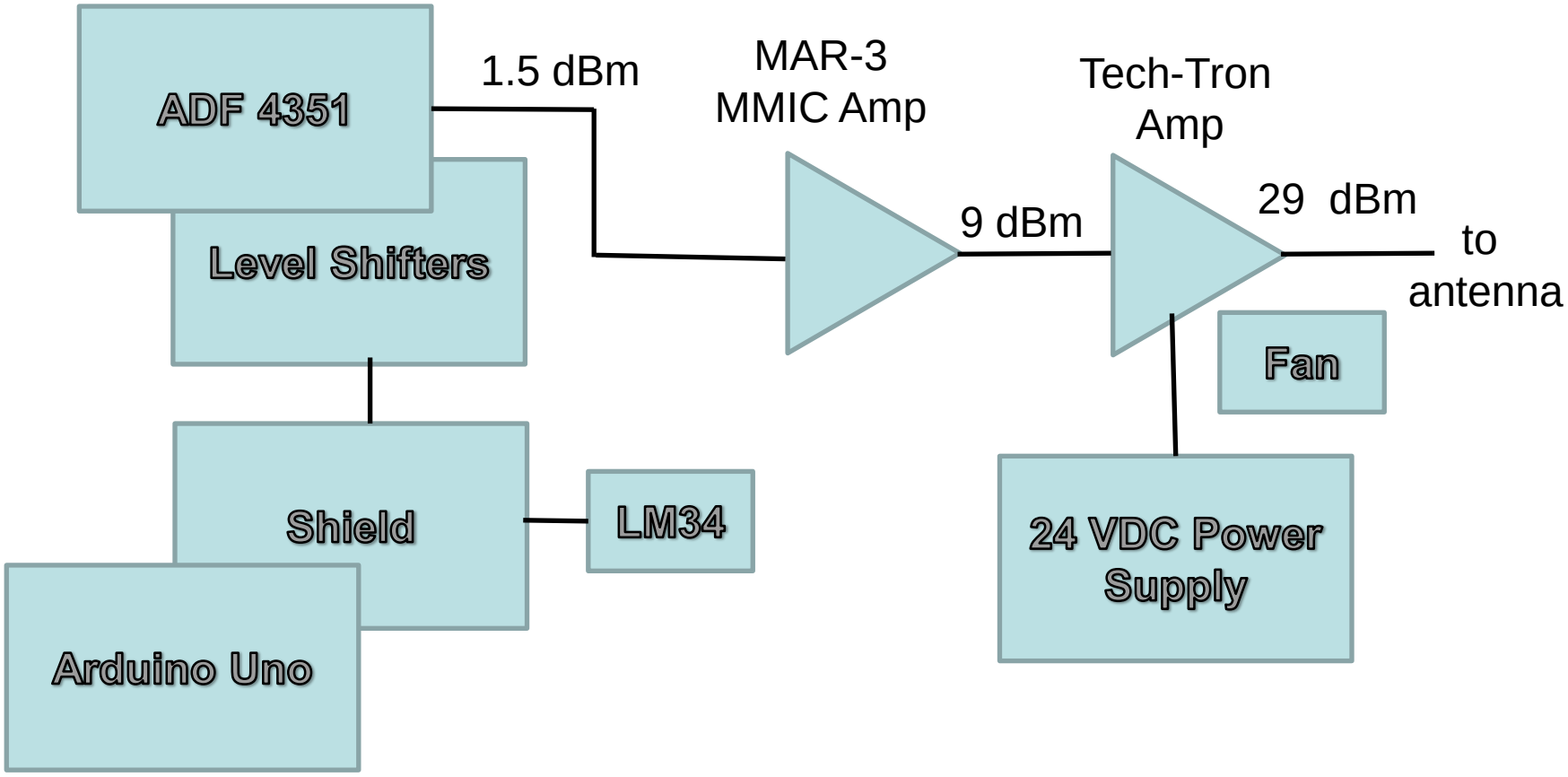

432 MHZ Beacon LO & Keyer

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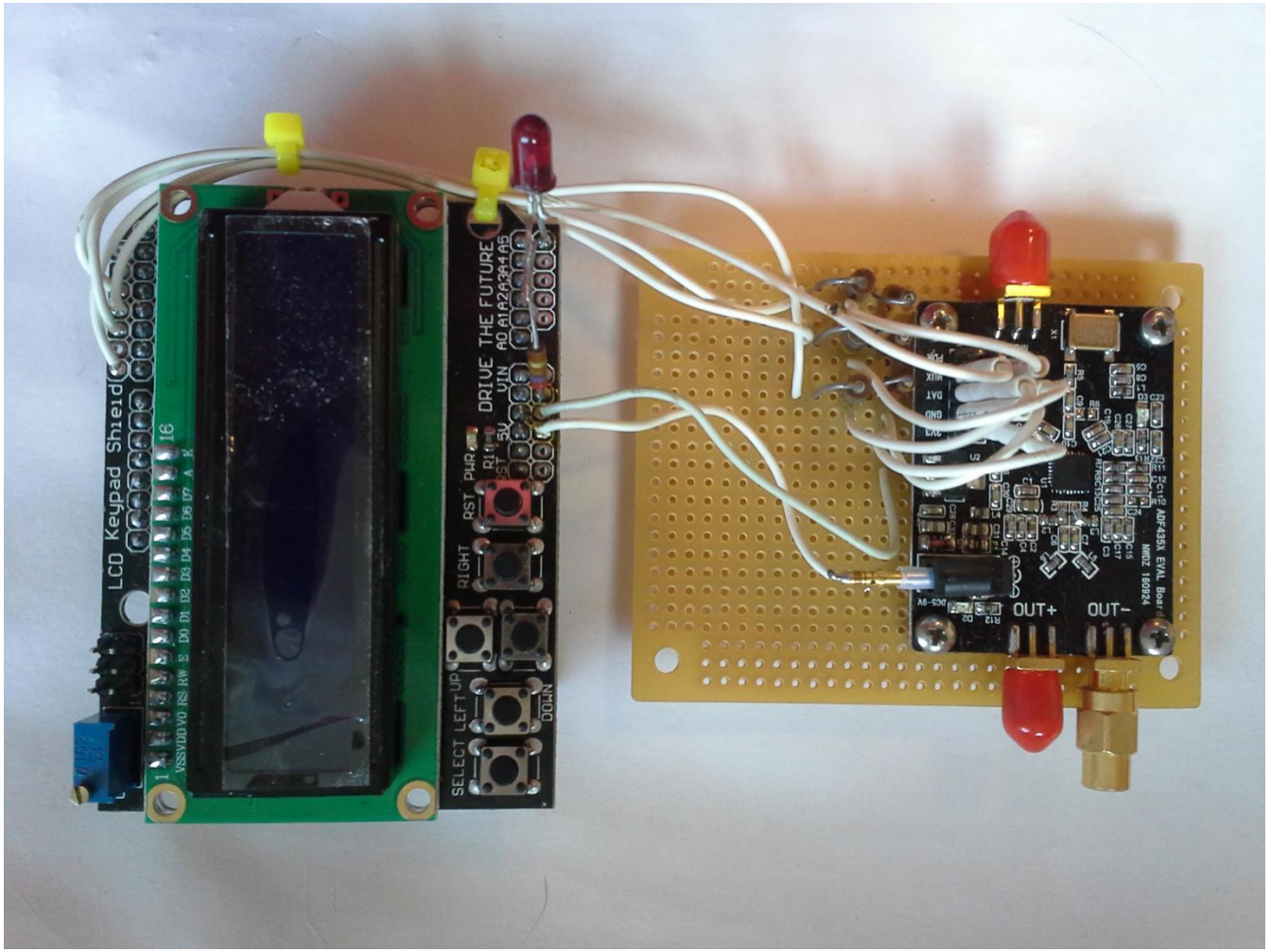

NTMS 432 MHz Beacon Status and Plans

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- Status
  - Completed ADF4351 LO/Keyer
  - Built MAR-3 amp to go between ADF4351 and Tech-Tron amp
  - Tested RF chain
  - Ordered LM34
- Plans
  - Order Bud box for a chassis
  - Add regulator to power Arduino and MMIC amp off 12V supply
  - Add fan for Tech-Tron amp
  - Integrate components
  - Burn-in/test from AA5C

Orion ADF4351 Board

Orion Board

- RMG project headed by Joe Haas, KE0FF
- ADF4351 VCO/PLL 35 MHz – 4.4 GHz
- SiLABS C8051F531 Microcontroller Unit
  - Handles SPI bus communications with ADF4351
  - Programmed with a command set for user interface
- GVA-62 RF amp
  - +15 dBm +/- 2 dB output at 2 GHz
- On-board 10 MHz crystal or select external reference with jumper to RF switch
- On-board voltage regulator
  - Thermally limited to about 7.5 VDC input unless heat sunk

Orion Board (2)

- Can be programmed for up to 100 frequencies
  - 10 lines to select channel
  - BCD encoded
- Includes a prototyping area that can be snapped off
- Support information and manual at: http://www.rollanet.org/~joeh/projects/Orion/

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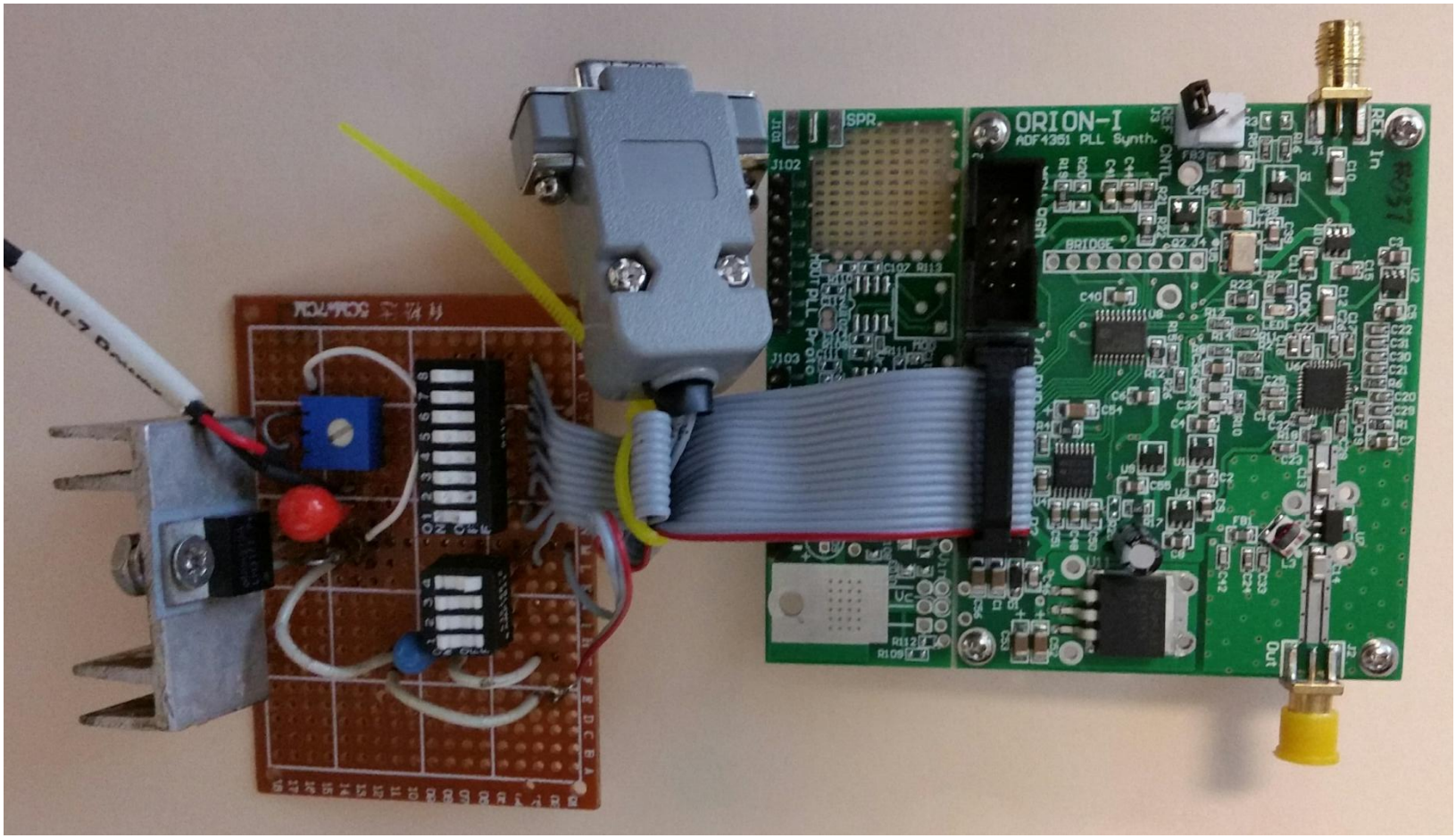
AA5C Orion Configuration



AA5C Orion Board Setup

- Used a LM317 to set voltage to Orion board to 7.5 VDC
- DIP switches (one 8 and one 4) to select channel
- Use the puTTY terminal emulator program to talk to the MCU
  - Freeware
  - Use RS232 to USB cable converter
- Use the Analog Devices ADF4351 tool to compute the six 32-bit register values
- Load register values into the MCU via terminal emulator
  - Lots of data to hand enter unless you write code
  - Make a mistake and that channel is unusable
  - Only erase/clear function erases all channels
  - Not too much a limitation given 100 channel capacity

ADF5355 Arduino Due Controller

ADF5355

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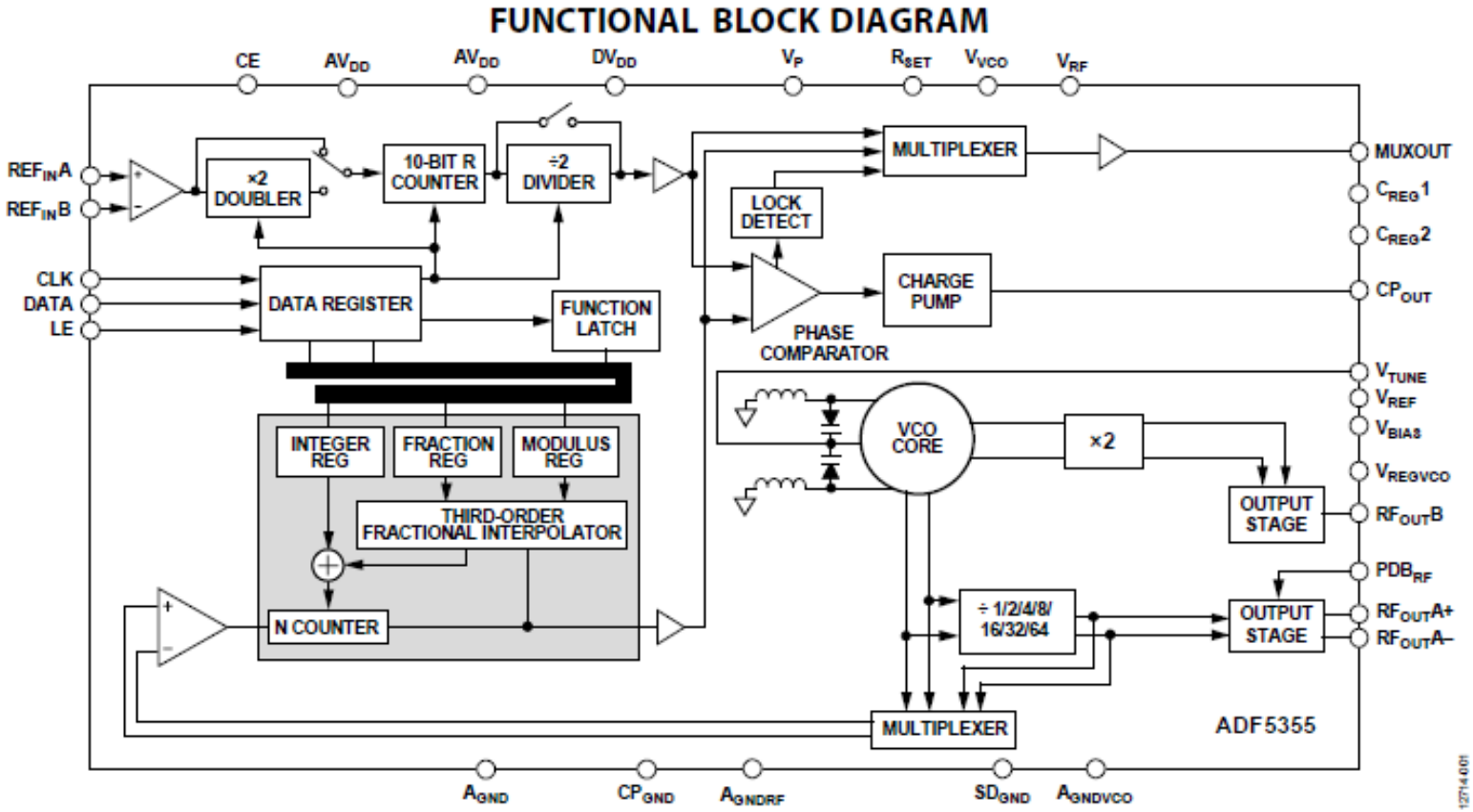

Figure 1.

ADF5355 Features

FEATURES

RF output frequency range: 54 MHz to 13,600 MHz
Fractional-N synthesizer and integer-N synthesizer
High resolution 38-bit modulus
Phase frequency detector (PFD) operation to 125 MHz
Reference frequency operation to 600 MHz
Maintains frequency lock over −40°C to +85°C
Low phase noise, voltage controlled oscillator (VCO)
Programmable divide by 1, 2, 4, 8, 16, 32, or 64 output
Analog and digital power supplies: 3.3 V
Charge pump and VCO power supplies: 5.0 V, typical
Logic compatibility: 1.8 V
Programmable dual modulus prescaler of 4/5 or 8/9
Programmable output power level
RF output mute function
Analog and digital lock detect
Supported in the ADIsimPLL design tool

APPLICATIONS

Wireless infrastructure (W-CDMA, TD-SCDMA, WiMAX, GSM, PCS, DCS, DECT)
Point to point/point to multipoint microwave links
Satellites/VSATs
Test equipment/instrumentation
Clock generation

GENERAL DESCRIPTION

The ADF5355 allows implementation of fractional-N or integer-N phase-locked loop (PLL) frequency synthesizers when used with an external loop filter and an external reference frequency. The wideband microwave VCO design permits frequency operation from 6.8 GHz to 13.6 GHz at one radio frequency (RF) output. A series of frequency dividers at another frequency output permits operation from 54 MHz to 6800 MHz.

The ADF5355 has an integrated VCO with a fundamental output frequency ranging from 3400 MHz to 6800 MHz. In addition, the VCO frequency is connected to divide by 1, 2, 4, 8, 16, 32, or 64 circuits that allow the user to generate RF output frequencies as low as 54 MHz. For applications that require isolation, the RF output stage can be muted. The mute function is both pin and software controllable.

Control of all on-chip registers is through a simple 3-wire interface. The ADF5355 operates with analog and digital power supplies ranging from 3.15 V to 3.45 V, with charge pump and VCO supplies from 4.75 V to 5.25 V. The ADF5355 also contains hardware and software power-down modes.

ADF5355 Phase Noise and Harmonics

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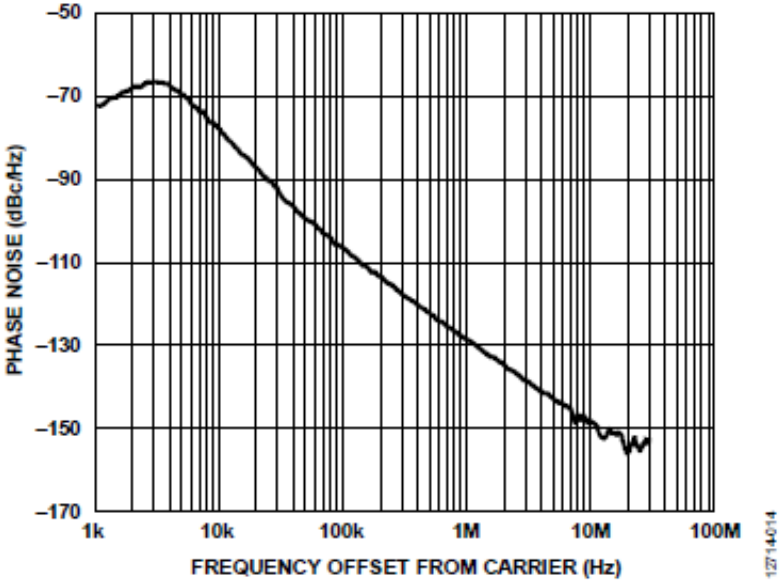

Figure 17. Closed-Loop Phase Noise, $RF_{OUT}B$ = 10 GHz, 2× VCO, VCO = 5.0 GHz, f_{PFD} = 61.44 MHz, Loop Bandwidth = 2 kHz

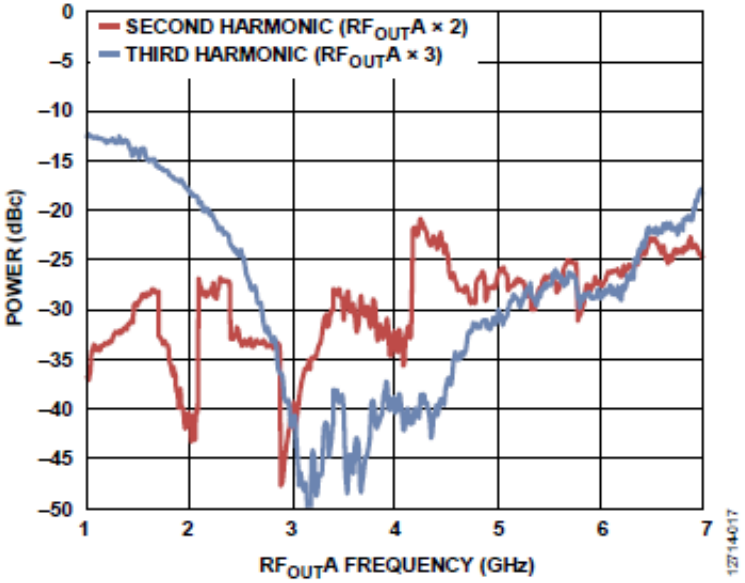

Figure 20. $RF_{OUT}A+/RF_{OUT}A–$ Harmonics vs. Frequency (7.5 nH Inductors, 10 pF Bypass Capacitors, Board Losses De-Embedded)

ADF5355 and Arduino Uno

- Uno uses an 8-bit ATMEL processor
- 16 MHz clock
- 5V logic
  - Requires level shifters for the SPI bus lines
- Insufficient resolution to accurately calculate the 24-bit frequency values needed by the ADF5355
- Does have integrated EEPROM
- The Arduino Uno works well to load ADF5355 register values at power up.
  - Fine for a single frequency LO, for example

Arduino Due

- 32-bit processor
- 84 MHz clock
- Has FLASH memory but does NOT have EEPROM
- 3.3V logic
- LCD Button Shield that works with the Uno works on the Due – as long as you properly align to the right pins! Be cautious!
- A lot more I/O and features than the Uno
- About $20 on eBay

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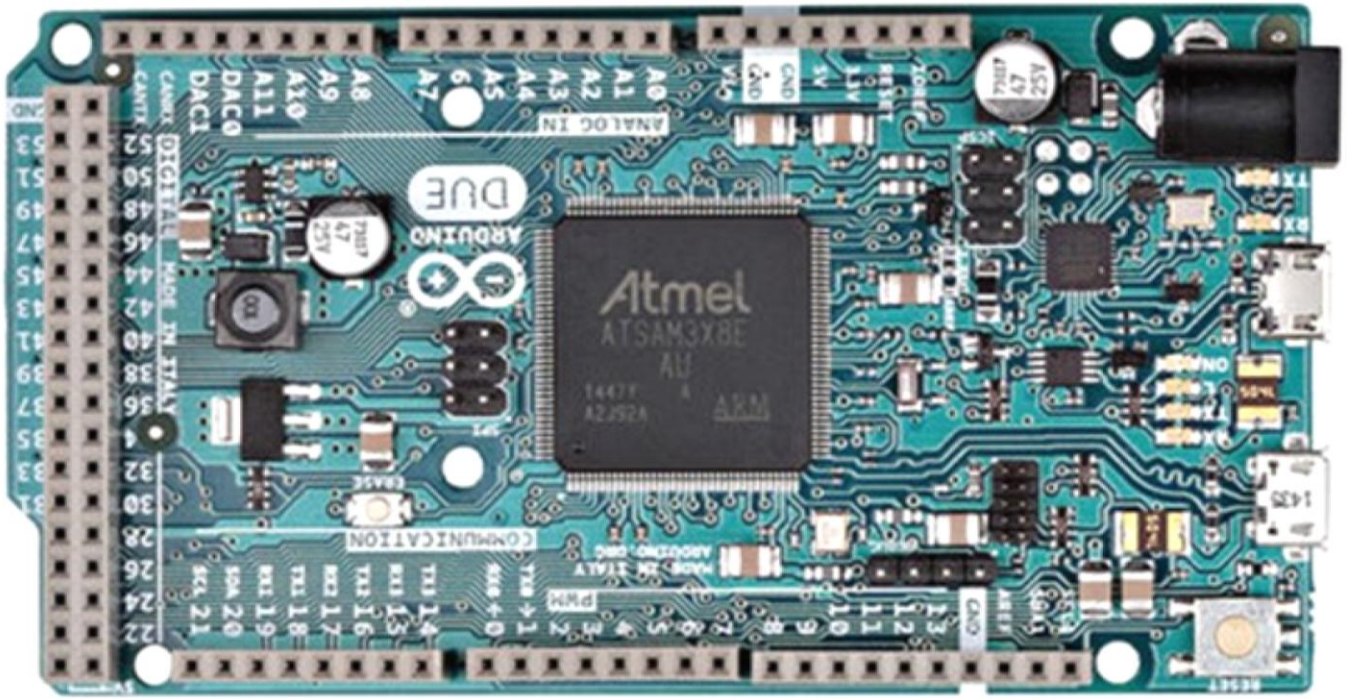
Arduino Due



Programming Mini-USB

Native Mini-USB

Arduino Due

Microcontroller	AT91SAM3X8E
Operating Voltage	3.3V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-16V
Digital I/O Pins	54 (of which 12 provide PWM output)
Analog Input Pins	12
Analog Output Pins	2 (DAC)
Total DC Output Current on all I/O lines	130 mA
DC Current for 3.3V Pin	800 mA
DC Current for 5V Pin	800 mA
Flash Memory	512 KB all available for the user applications
SRAM	96 KB (two banks: 64KB and 32KB)
Clock Speed	84 MHz
Length	101.52 mm
Width	53.3 mm
Weight	36 g

Chinese ADF5355 Eval Boards

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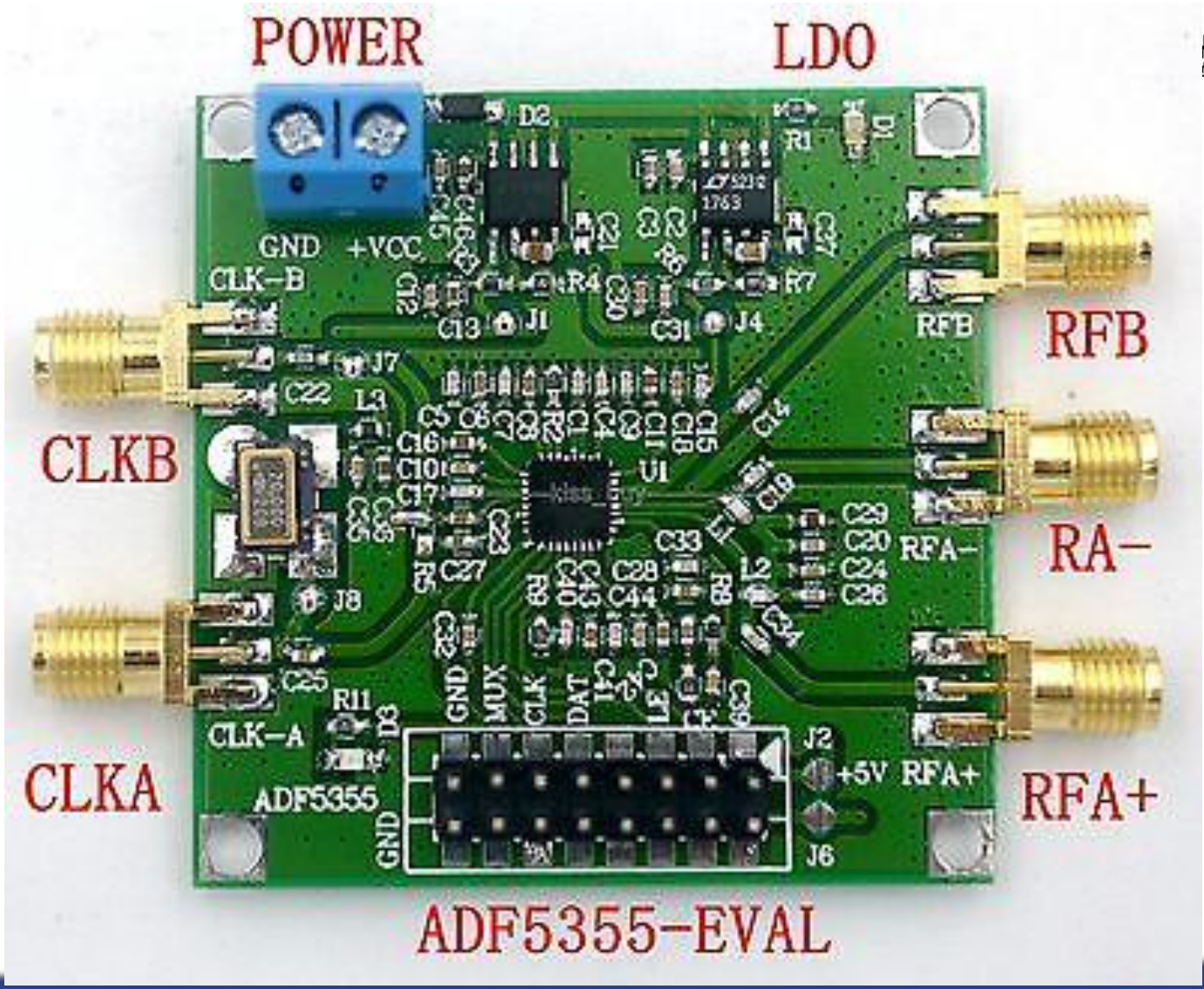

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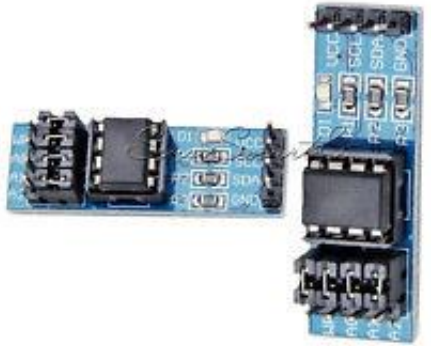
Hardware

- Added an AT24C256 32k x 8-bit EEPROM
  - 2-pin I2C data interface
  - Power with 3.3V from Due to get correct interface levels for the Arduino Due
    - 3.3V and GND from the LCD Button Shield
  - Two I2C interfaces on the Due
  - EEPROM boards with ICs are about $1 each (qty 5) on eBay from China



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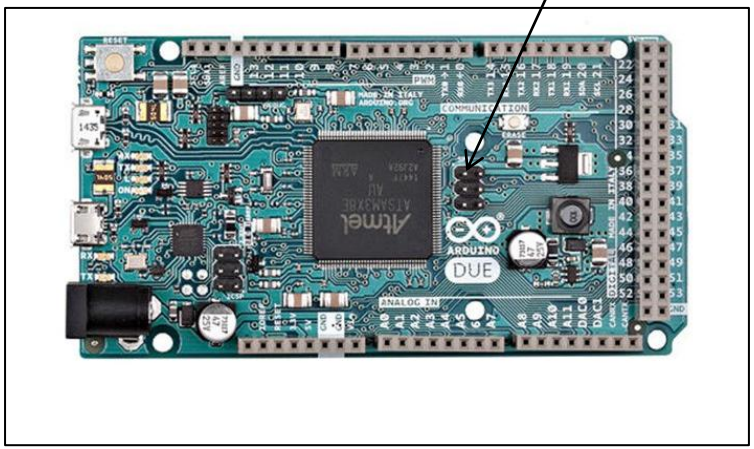
Hardware (2)

- SPI bus pins are different on the Due vs. Uno
  - Separate SPI bus header
    - SCLK – pin 3
    - MOSI – pin 4
    - GND – pin 6
  - LE and MUXOUT from LCD Button Shield
  - No level shifters required



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Software

- Math to calculate frequency values is more complicated than for the ADF4351

$$N = INT\left[\frac{FRAC1 + FRAC2/MOD2}{MOD1}\right]$$

- INT = 16-bit
- FRAC1 and MOD1 = 24-bit
- FRAC2 and MOD2 = 14-bit
- Double precision words (64-bit) used to calculate the larger values

Software (2)

- Added the EEPROM
  - An Arduino library function for the I2C bus is available (Wire)
  - EEPROM is byte wide so had to write the code to pack/unpack 32-bit values
  - Up to 100 output frequencies can be stored
    - Much more capacity but field size on LCD limited
  - 2 reference frequencies can be stored

Software (3)

- LCD Button Shield
  - The six buttons are across a resistor string on the A0 ADC input
  - Threshold values needed to be rescaled compared to those used with either V1.0 or V1.1 of the shield and the Uno.
- Added code to calculate the divide ratio and enable/disable the RF-A and RF-B outputs

ADF5355 and Arduino Uno Controller

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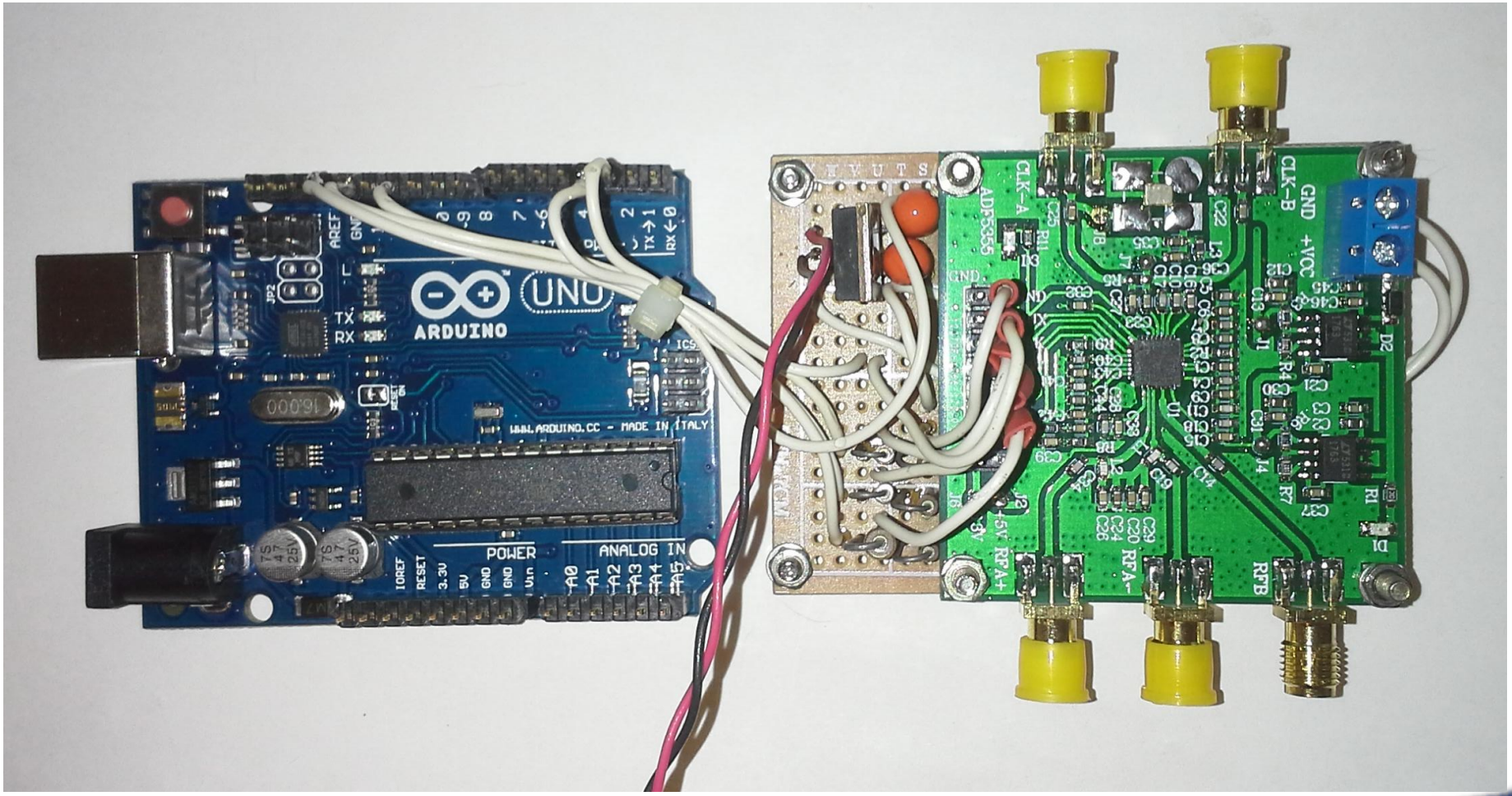

ADF5355 and Arduino Due Controller

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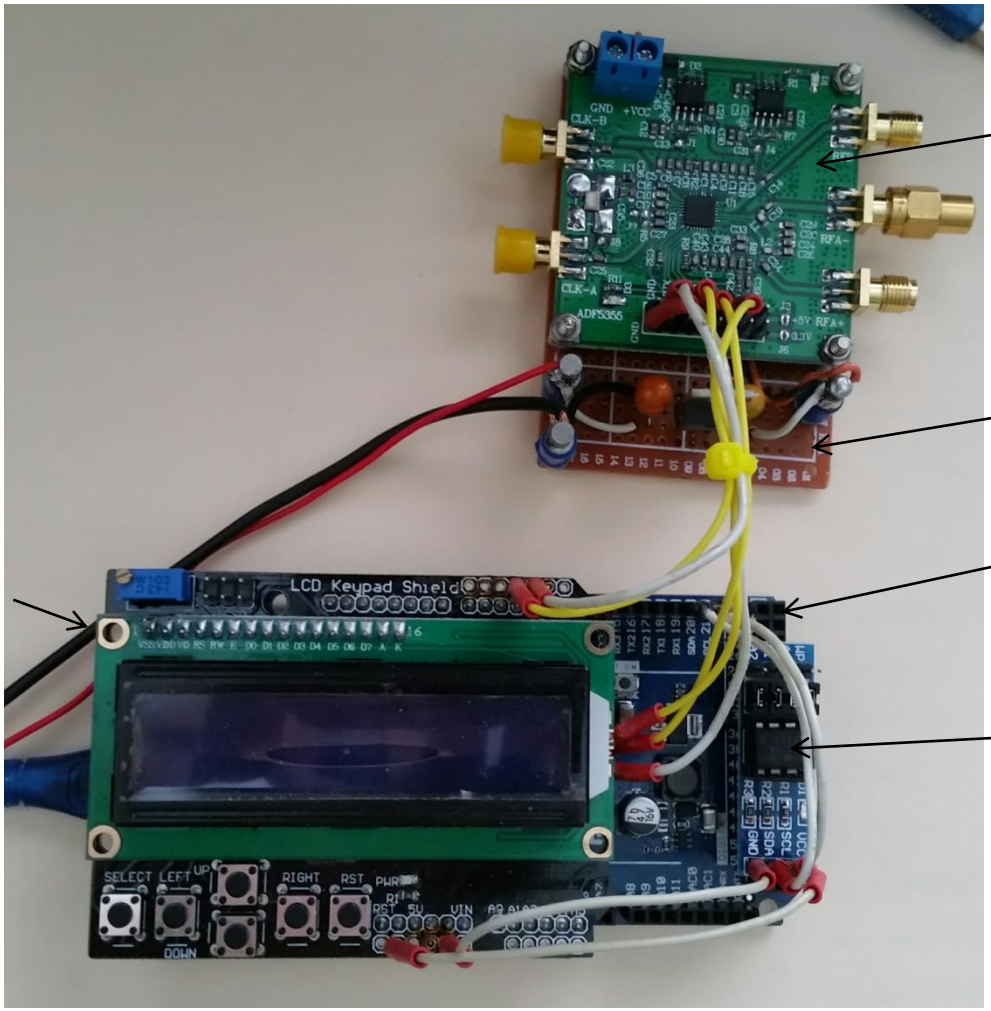

Notes

- The ADF5355 runs warm – make sure there is adequate cooling air for the board
  - First hand experience from 10 GHz and up contest
  - Maybe able to solder copper heat spreader to ground pad on back of board, with caution!

Summary

- Now have dynamic controllers for:
  - ADF4351using the Arduino Uno
  - ADF5355 using the Arduino Due
  - 10 kHz frequency resolution
- On-board or external 10 MHz reference
  - ADF4351 25 MHz on-board crystal
  - ADF5355 26 MHz on-board crystal
  - On-board crystal OK for test has frequency offset and drifts
  - Recommend using a good external 10 MHz reference
- Low cost static controllers for LO applications using the Arduino Uno – at AA5C:
  - ADF4351 for 3312 MHz LO
  - ADF5355 for 5616 MHz LO
  - ADF5355 for 10224 MHz LO

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Arduino LCD Button Shield

- Plugs directly into the Arduino Uno
- ~$7.50 for two from China including shipping