

Department of Electrical and Computer Engineering

College of Engineering and Applied Sciences

WESTERN MICHIGAN UNIVERSITY



ECE 4510/5530

Microcontroller Applications

Week 7

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MISC Stuff

- Project Progress?
 - Complete by end of next week (Friday)
 - Lab open this Saturday @ noon – thank Lalith
- Lab 5 reports
 - Complete by end of spring break
- Lab 6
 - Code for operating uC/OS-II has been prepared and tested by Lalith Narasimhan. It is on the lab web site as Lab6_Code
- 5x7 Display Code revisited
- Direct Digital Synthesis

Optional Required Reading

Reminiscences of the VLSI Revolution:

How a series of failures triggered a paradigm shift in digital design

By Lynn Conway

IEEE SOLID-STATE CIRCUITS MAGAZINE, vol.4, no.4, pp.8-31,
Dec. 2012

- <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6393023>

5x7 Display Revisited

Text Keypad Code Function

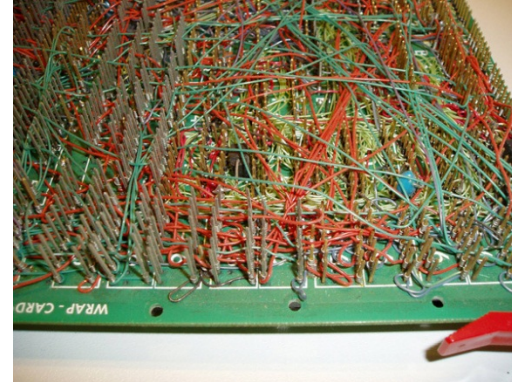
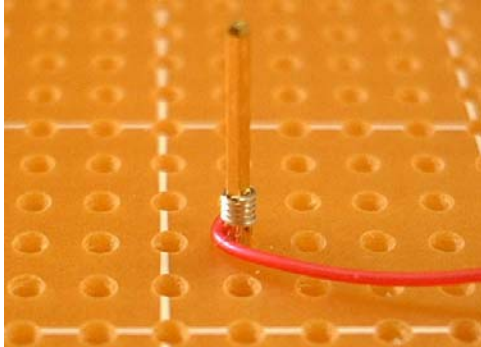
```
if(display5x7_advance_flag)
{
    display5x7_advance_flag = FALSE;
    PORTA |= 0x08;           // Output disable row source
    switch(display_count)
    {
        case 0:
            PORTA |= 0x10;    // Set one into the first shift register
            PORTA |= 0x20;    // shift register clock rise
            PORTA &= ~(0x30); // shift register clock fall, remove input data
                                // The next clock will cause the 1st column to be active
            display_count++;  // increment counter
            break;
        case 1:case 2:case 3:case 4:case 5:case 6:case 7:case 8:case 9:
        case 10:case 11:case 12:case 13:case 14:case 15:
            row_location = display_count + offset - 1; // row index
            row_load(row_data_array[row_location]);    // load the row value
            PORTA |= 0x20;                             // shift register clock rise
            PORTA &= ~(0x08);                          // Output enable row source
            PORTA &= ~(0x20);                          // shift register clock fall
            display_count++;                            // increment counter
            break;
        default:
            PORTA |= 0x20; // shift register clock rise
            PORTA &= ~(0x20); // shift register clock fall
            display_count = 0;
            break;
    }
} // end display5x7_advance
```

C-Library

- Tested and corrected code from the keypad and 5x7 display has been added to the C-library zip file on the course web site.
 - Thanks to Lalith for testing and correcting my original musings.

Wire Wrap Prototypes

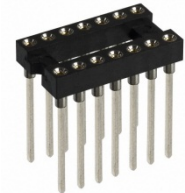
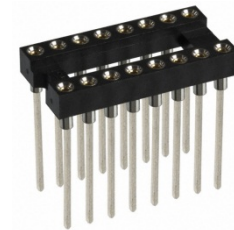
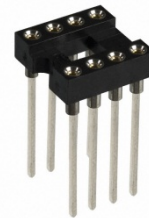
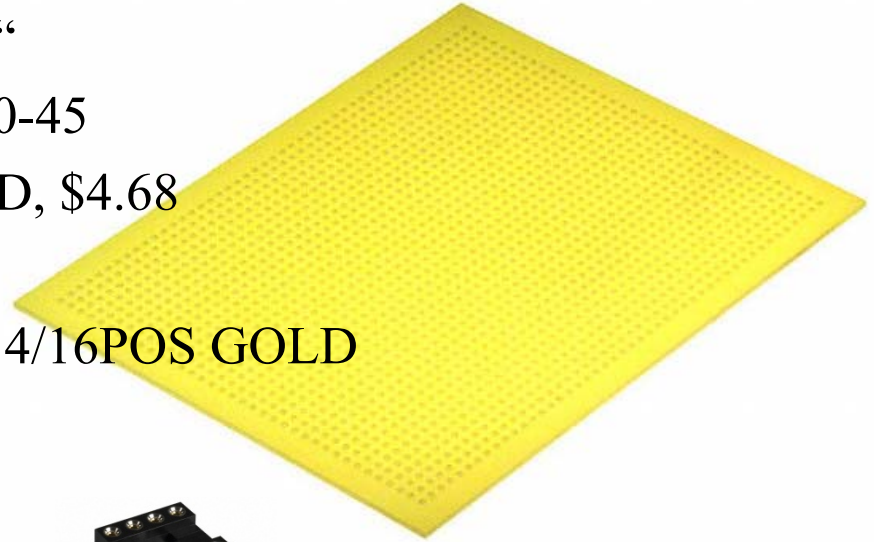
- Lost Knowledge: Wire-wrapping
- By Gareth Branwyn , 2009/07/27 @ 3:16 pm
- <http://blog.makezine.com/2009/07/27/lost-knowledge-wire-wrapping/>



- For a nice wire wrap job, see
- <http://blog.imakecircuits.com/category/breadboard-freaks/>

PC Board and Wire Wrap Sockets

- PC BOARD 4"X5" UNCLAD 0.1"
- Twin Industries, Part Number 7100-45
- Digikey Part Number 438-1019-ND, \$4.68
- IC SOCKET MACH PIN WW 8/14/16POS GOLD
- Assmann WSW Components
 - AR08-HZW/T-R
 - AR14-HZW/T-R
 - AR16-HZW/T-R
- Digikey Part Number
 - AE10046-ND, \$1.45
 - AE10047-ND, \$2.55
 - AE10048-ND, \$2.69



Wire Wrap Tool and Wire

- TOOL WRAP/STRIP/UNWRAP MOD 30AWG
- OK Industries/Div of Jonard Ind Corp, WSU-30M
- Digikey Part Number K105-ND
- \$31.85
- Wire Wrap Wire – 30 Gauge
- Digikey Part Number K229-ND
- 30 foot roll for \$9.65

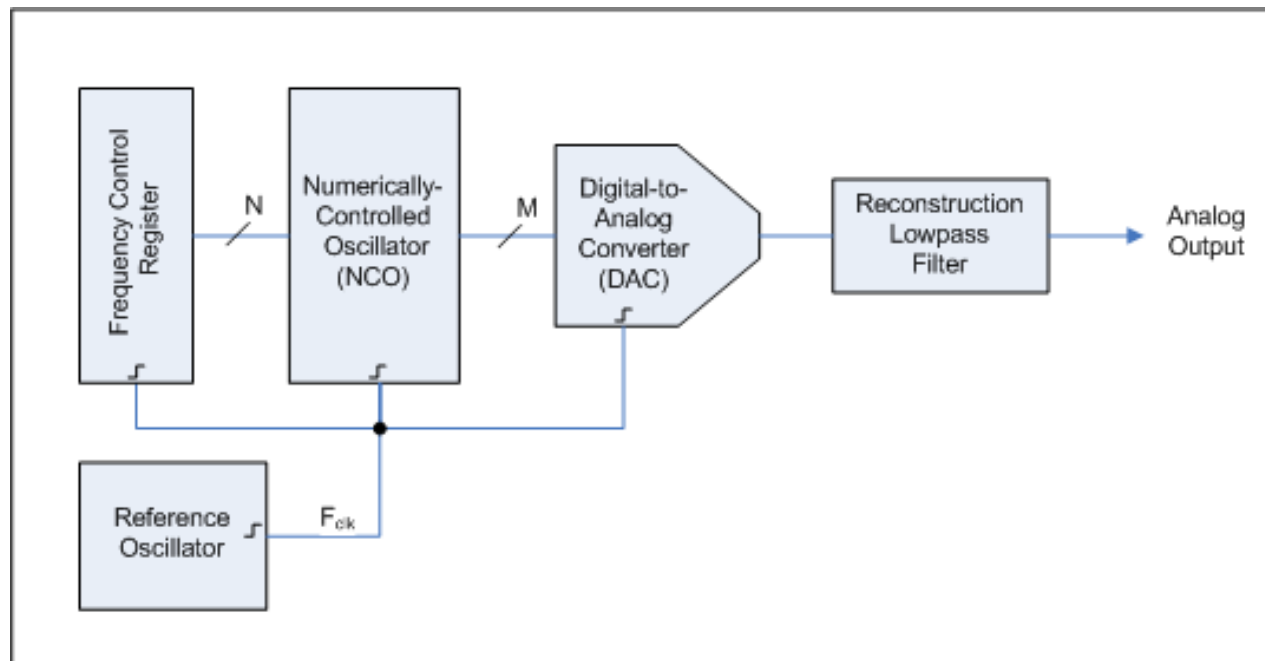


Direct Digital Synthesis

- something to do with DACs

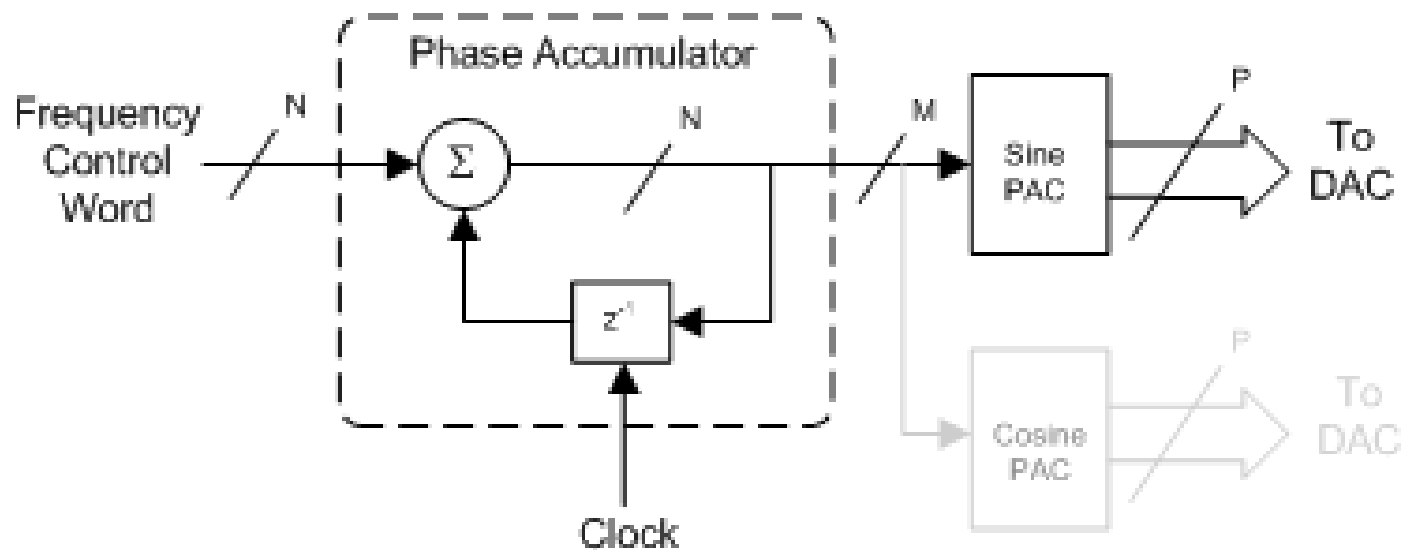
Direct Digital Synthesis

- From Wikipedia, the figure works great ...
 - http://en.wikipedia.org/wiki/Direct_digital_synthesizer
 - Implementation: digital logic, DAC and analog filter.



Numerically Controlled Oscillator

- The NCO forms time samples of the waveform desired.
 - Wikipedia again: http://en.wikipedia.org/wiki/Numerically_controlled_oscillator



- A phase accumulator/summer: generate θ
- Sinusoidal output generators/ROM: $\sin(\theta)$ or $\cos(\theta)$

Drawback of Microprocessors

- The sound is subject to the periodicity of the outputs
 - The sample rate should be constant.
 - The loading of the DAC should be periodic ... using a counter/timer channel at a constant output frequency
 - The waveform samples are loaded into the DAC and then output using the periodicity of the timer channel.
- Alternative: A Xilinx device makes an excellent NCO and sin/cos table lookup with clock based periodicity.
 - Microcontroller adjusts the frequency control word or instantaneous phase that will be accumulated.

Xilinx DDS

- DDS V5.0, DS246, April 28, 2005
 - http://www.xilinx.com/support/documentation/ip_documentation/dds.pdf

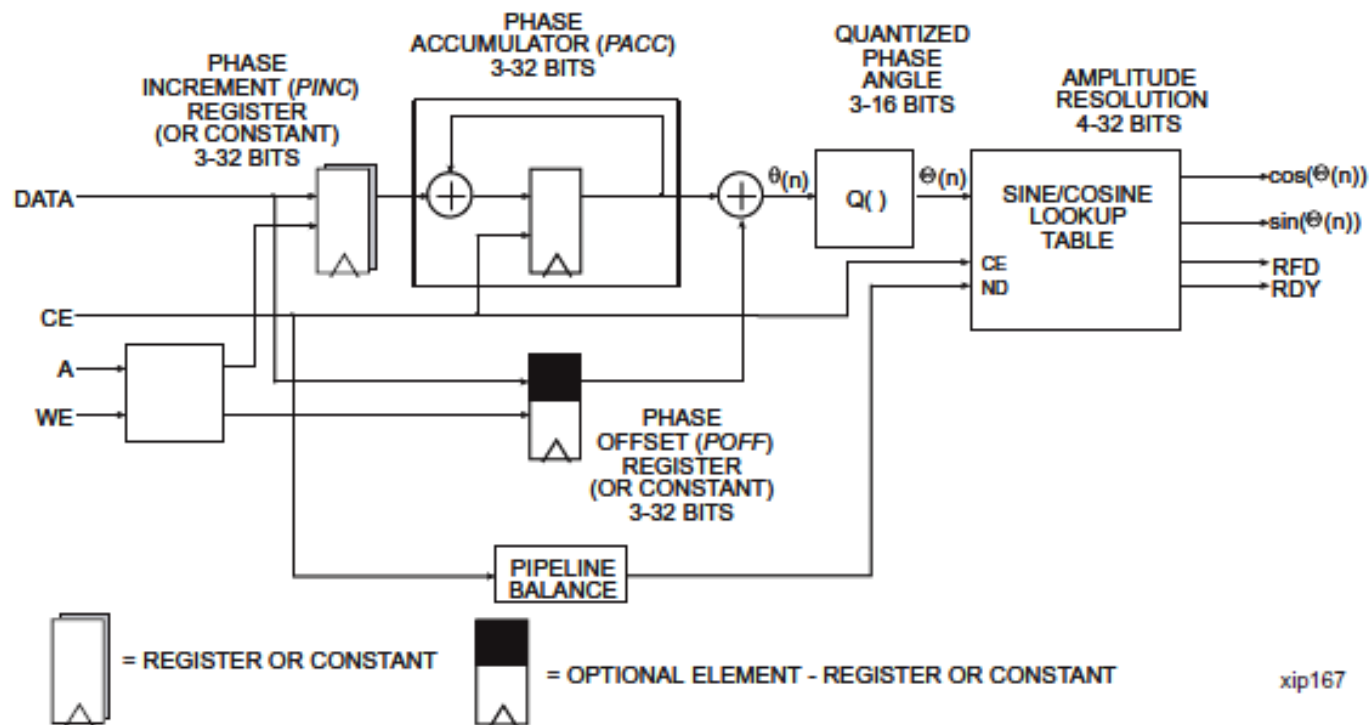


Figure 16: DDS Core (Detailed View)

Example Output

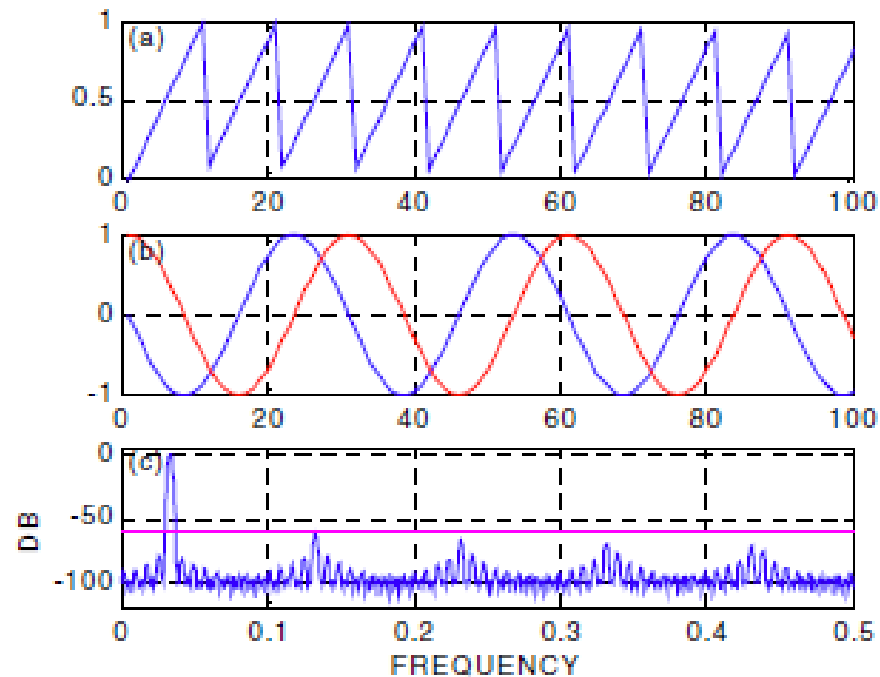


Figure 17: DDS plots showing (a) phase error time series, (b) complex output time series, (c) output spectrum. 1024 deep lookup table, 16-bit samples, output frequency is 0.333 Hz.

Frequency Modulated Waveform

- If the phase increment register is constant
 - A single frequency results
- If the phase increment register is linearly incremented
 - A chirp waveform is generated
- If the phased increment register changes with the input from a microphone with a constant offset
 - A frequency modulated waveform results
 - This is a simple way to make FM

Wavetable Synthesis

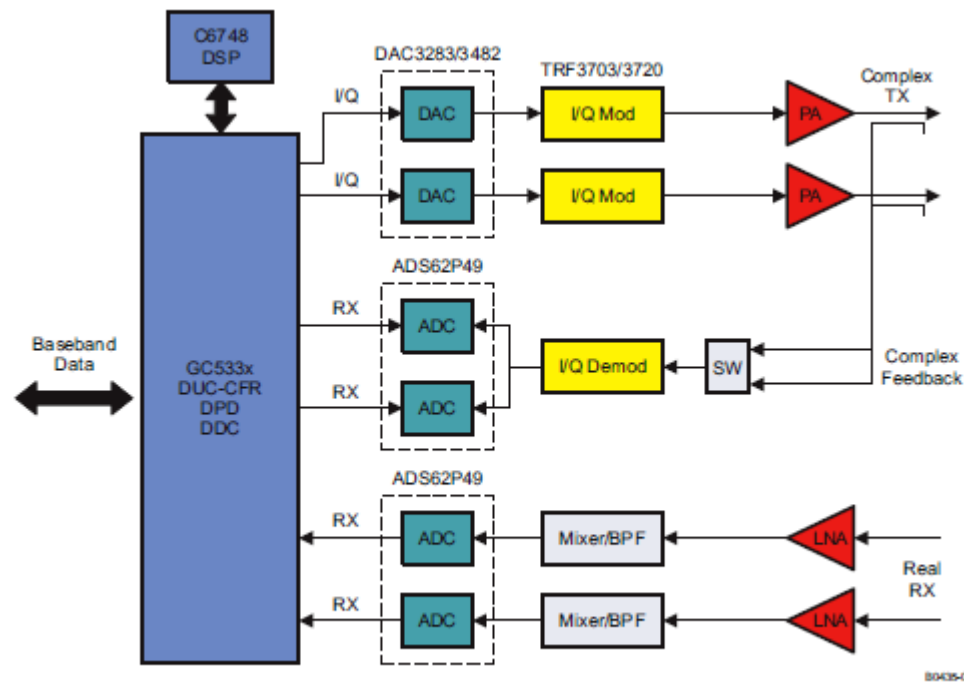
- another way to make sound

Generate a Waveform Table

- Collect one cycle of a waveform desired.
We did not have to use a sine or cosine table!
 - Imagine that it is stored in a circular buffer that can be continuously read out ... a continuous waveform results.
 - It can be played back at any desired sample rate resulting in different frequencies of the same waveform.
 - If the waveform was sampled at a very high sample rate, not all samples need to be produced you could “step across” the waveform with different “time steps” to increase or decrease the output frequency.
- Multiple waveforms can be summed and “processed” using DSP

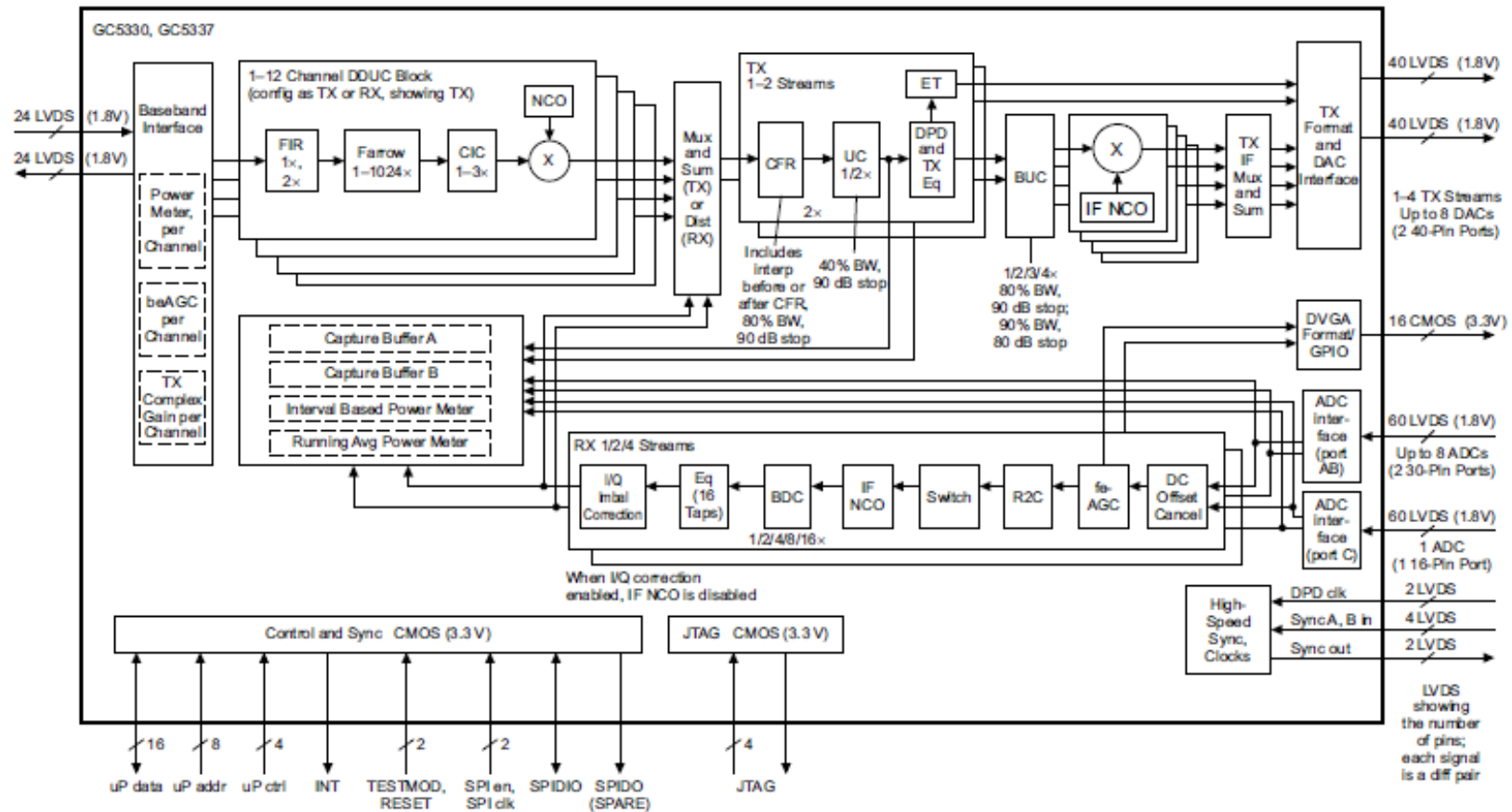
Extending to Radios

- Components of a software radio



Texas Instruments, Wideband Transmit-Receive Digital Signal
Processors, GC5330 and GC5337

GC5330/GC5337



B0445-01

NOTE: UC1 and UC2 are for CFR interpolation; UC2 can only be used if UC1 is also used.

Figure 6. GC533x Block Diagram