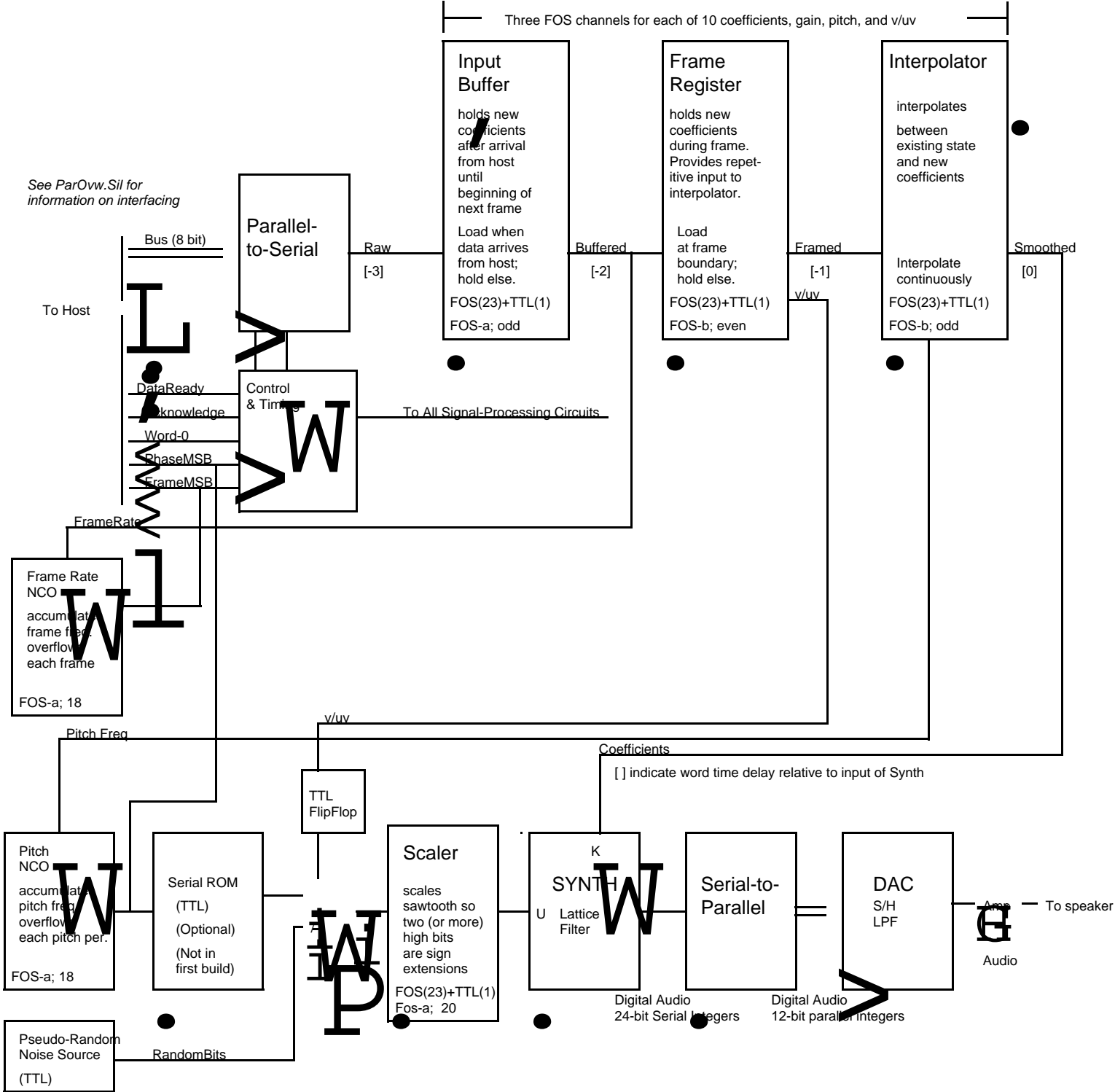


# Parrot Box A Talking Peripheral for Alto, Apple, etc.

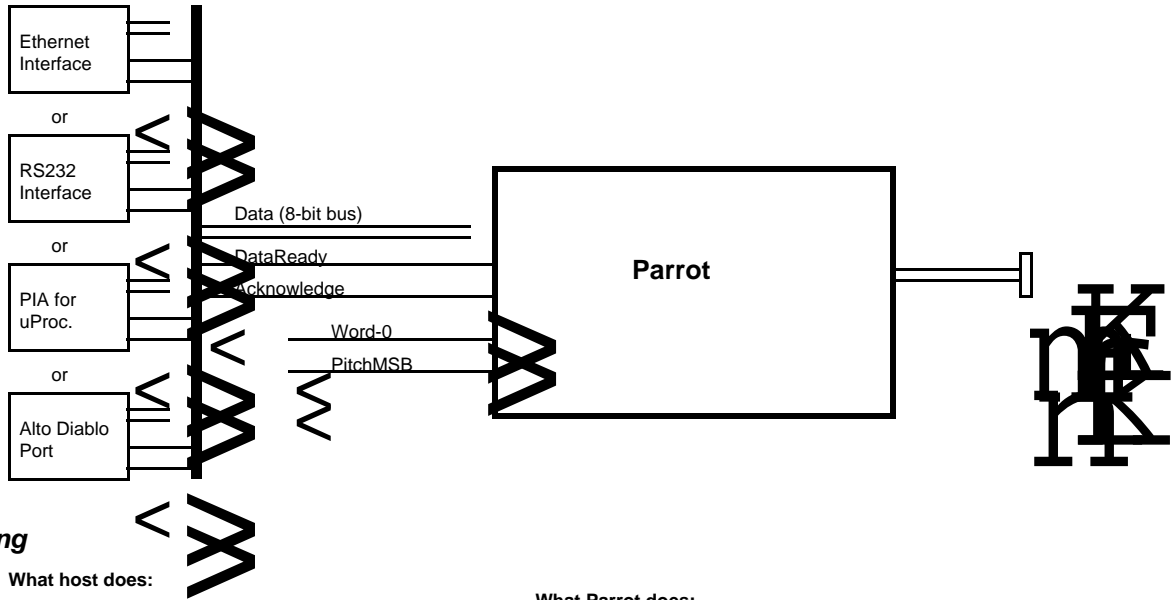
## Coefficient Path

Raw coefficients are loaded into buffer upon random arrival from host. Buffered coefficients are copied to Frame register upon receipt of "Frame" command. Framed coefficients are low-pass-filtered by Interpolator with a time constant set by the "Frame" command. Smoothed coefficients from Interpolator drive Synth.



Synth requires: 22 timeslots x 24 bits = 528 clocks/sample.  
Fsamp = 16 kHz implies Fclock = 8.448 MHz.

**Environment**



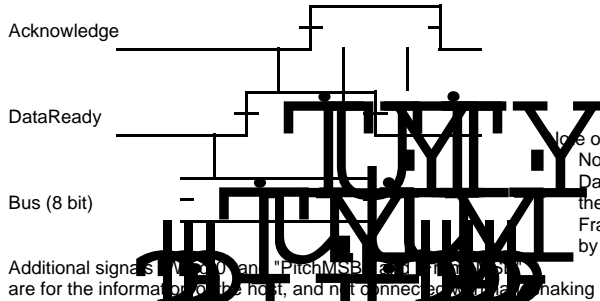
**Interfacing**

**What host does:**

- Places data on Bus and waits for Acknowledge to be low.
- When Acknowledge is low and bus is stable, raises DataReady.
- Waits for Acknowledge to go high.
- Removes data (optional) and lowers Data Ready.

**What Parrot does:**

- Lowers Acknowledge and waits for DataReady to go high.
- When DataReady is high, reads data from bus.
- Raises Acknowledge and waits for DataReady to go low.
- Lowers Acknowledge.



Note:  
Similar to Versatec, except for timing.

|               |                 |
|---------------|-----------------|
| <b>Parrot</b> | <b>Versatec</b> |
| data ready    | PICLK           |
| acknowledge   | READY'          |

Note on timing:

Normally, "Acknowledge" is returned within a few microseconds of DataReady, *except* for the Frame command, which is deferred by Parrot until the next low-to-high transition in the MSB of either the Pitch NCO or the Frame NCO, depending on the state of the SyncMode bit s, which is set by the Frame command (see below).

Additional signals Word-0 and "PitchMSB" are for the information of the host, and not connected to any making circuits.

**Instruction Set**

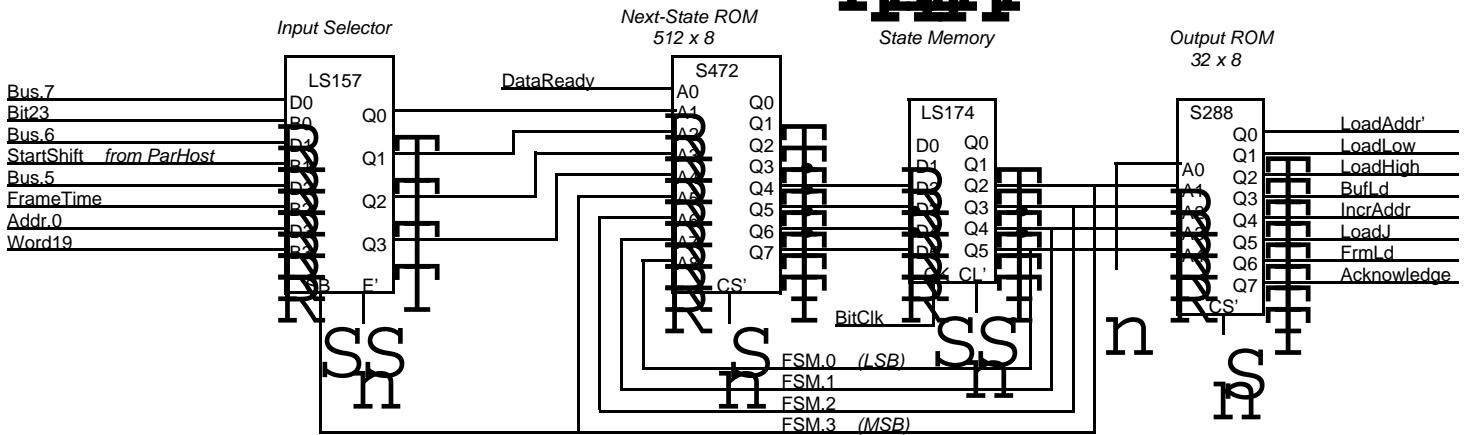
| Mnemonic | Format   | Meaning/effect |      |         |   |   |  |  |   |   |
|----------|--|----------------|------|---------|---|---|--|--|---|---|
| LoadData | <table border="1"> <tr> <td>MSB</td> <td>7</td> <td>1</td> <td>data</td> <td>0</td> <td>LSB</td> </tr> </table>                | MSB            | 7    | 1       | data  | 0 | LSB  | store this data into the buffer field addressed* by the Address Register; then increment the Address Register. |   |   |
| MSB      | 7  | 1              | data | 0       | LSB   |   |  |  |   |   |
| LoadAddr | <table border="1"> <tr> <td>1</td> <td>0</td> <td>address</td> </tr> </table>  | 1              | 0    | address | set the address register to the indicated address |   |  |  |   |   |
| 1        | 0  | address        |      |         |   |   |  |  |   |   |
| Frame    | <table border="1"> <tr> <td>1</td> <td>1</td> <td>0</td> <td>s</td> <td>j</td> </tr> </table>                                  | 1              | 1    | 0       | s   | j | <ul style="list-style-type: none"> <li>Copy coefficients from Buffer to Frame register, and set interpolation pole to <math>z = 1 - 2^j</math>.</li> <li>s=0 =&gt; pitch synchronous; s=1 =&gt; fixed frame rate.</li> </ul> |  |   |   |
| 1        | 1  | 0              | s    | j       |   |   |  |  |   |   |
| NoOp     | <table border="1"> <tr> <td>1</td> <td>1</td> <td>1</td> <td>x</td> <td>x</td> <td>x</td> <td>x</td> <td>x</td> </tr> </table> | 1              | 1    | 1       | x   | x | x  | x  | x | No operation. (reserved for future expansion) |
| 1        | 1  | 1              | x    | x       | x   | x | x  |  |   |   |

\* Address 2n-2 represents the low-order 7 bits of what enters FOS-A during word time n (see ParFOS.Sil for explanation). Address 2n-1 represents the high-order 7 bits of what enters FOS-A during word time n. A LoadData command into an even address simply sticks the low 7 bits into a temporary register (not shown above), but a LoadData command into an odd address causes the high 7 bits presented, along with the low 7 bits previously loaded, into the Buffer.

**Formats for data entries**

|                                 | High 7 | Low 7 |   |
|---------------------------------|--------|-------|---|
| Reflection Coefficients & Gain: | S      |       | Two's complement, in [ 2,+2). = radix point             |
| Pitch & FrameRate:              |        |       | As a fraction of sample rate; MSB = fs/16. S = sign bit |
| Voice/Unvoiced                  | V      |       | V=1 => Voiced<br>V=0 => Unvoiced                        |

| Present State     | Outputs (depend only on state) | Inputs   | Next State   |
|-------------------|--------------------------------|--|--|
|                   |                                |  |  |
| 0000 Idle         | 1 0 0 0 0 0 0 0                | 0 x x x x<br>1 0 x x 0<br>1 0 x x 1<br>1 1 0 x x<br>1 1 1 0 x<br>1 1 1 1 x | Idle<br>LoadLow<br>LoadHigh<br>LoadAddr<br>WaitForFrame<br>Acknowledge |
| 0001 LoadAddr     | 0 0 0 0 0 0 0 0                | x x x x x  | Acknowledge  |
| 0010 LoadLow      | 1 1 0 0 0 0 0 0                | x x x x x  | IncrAddr   |
| 0011 LoadHigh     | 1 0 1 0 0 0 0 0                | x x x x x  | WaitForShift   |
| 1000 WaitForShift | 1 0 0 0 0 0 0 0                | x x x x x  | WaitForShift<br>WaitForShift<br>PSShift                                |
| 1001 PSShift      | 1 0 0 1 0 0 0 0                | x x x x x  | PSShift<br>IncrAddr  |
| 1010 IncrAddr     | 1 0 0 0 0 1 0 0                | x x x x x  | Acknowledge  |
| 1011 WaitForFrame | 1 0 0 0 0 0 0 0                | x x x x x  | LoadJ<br>WaitForFrame  |
| 1100 LoadJ        | 1 0 0 0 0 0 1 0                | x x x x x  | Frame  |
| 1101 Frame        | 1 0 0 0 0 0 0 1                | x x x x x  | Frame<br>Frame<br>Acknowledge  |
| 1111 Acknowledge  | 1 0 0 0 1 0 0 0                | 0 x x x x<br>1 x x x x   | Idle<br>Acknowledge  |



### Fos, Section A

| Input Word Time | Data Input Name | Data Input Source | Control Bus Input Function | Data Output Name | Data Output Dest.      | Output Word Time |
|-----------------|-----------------|-------------------|----------------------------|------------------|------------------------|------------------|
| 0               |                 |                   |                            |                  |                        | 1                |
| 1               | k1              | raw               | Input                      | Buffer           | k1 buffered Fos-B      | 2                |
| 2               |                 |                   |                            |                  |                        | 3                |
| 3               | k2              | raw               | Input                      | Buffer           | k2 buffered Fos-B      | 4                |
| 4               | v/uv            | raw               | Input                      | Buffer           | v/uv buffered TTL 1WD  | 5                |
| 5               | k3              | raw               | Input                      | Buffer           | k3 buffered Fos-B      | 6                |
| 6               | v/uv            | buffered          | TTL 1WD                    | Frame            | v/uv framed FlipFlop   | 7                |
| 7               | k4              | raw               | Input                      | Buffer           | k4 buffered Fos-B      | 8                |
| 8               | FR              | raw               | Input                      | Buffer           | FR buffered            | 9                |
| 9               | k5              | raw               | Input                      | Buffer           | k5 buffered Fos-B      | 10               |
| 10              | FR              | buffered          | TTL 1WD                    | NCO              | FrameTime ParCont      | 11               |
| 11              | k6              | raw               | Input                      | Buffer           | k6 buffered Fos-B      | 12               |
| 12              | Pitch           | raw               | Input                      | Buffer           | Pitch buffered TTL 1WD | 13               |
| 13              | k7              | raw               | Input                      | Buffer           | k7 buffered Fos-B      | 14               |
| 14              | Pitch           | buffered          | TTL 1WD                    | Frame            | Pitch framed TTL 1WD   | 15               |
| 15              | k8              | raw               | Input                      | Buffer           | k8 buffered Fos-B      | 16               |
| 16              | Pitch           | framed            | TTL 1WD                    | Interpolate      | Pitch smoothedTTL 1WD  | 17               |
| 17              | k9              | raw               | Input                      | Buffer           | k9 buffered Fos-B      | 18               |
| 18              | Pitch           | smoothed          | TTL 1WD                    | NCO              | Phase TTL 1WD          | 19               |
| 19              | A               | raw               | Input                      | Buffer           | A buffered Fos-B       | 20               |
| 20              | Phase           | Fos-A/Random      |                            | Scale/4          | Glottal TTL 1WD        | 21               |
| 21              | k0              | raw               | Input                      | Buffer           | k0 buffered Fos-B      | 0                |

NBote: FR = FrameRate

### Synth

| Word Time | K-Input Name | Source         | Glottal Input Name | Source  |
|-----------|--------------|----------------|--------------------|---------|
| 0         | A            | smoothed Fos-B | Glottal            | TTL 1WD |
| 1         |              |                |                    |         |
| 2         | k0           | smoothed Fos-B |                    |         |
| 3         |              |                |                    |         |
| 4         | k1           | smoothed Fos-B |                    |         |
| 5         |              |                |                    |         |
| 6         | k2           | smoothed Fos-B |                    |         |
| 7         |              |                |                    |         |
| 8         | k3           | smoothed Fos-B |                    |         |
| 9         |              |                |                    |         |
| 10        | k4           | smoothed Fos-B |                    |         |
| 11        |              |                |                    |         |
| 12        | k5           | smoothed Fos-B |                    |         |
| 13        |              |                |                    |         |
| 14        | k6           | smoothed Fos-B |                    |         |
| 15        |              |                |                    |         |
| 16        | k7           | smoothed Fos-B |                    |         |
| 17        |              |                |                    |         |
| 18        | k8           | smoothed Fos-B |                    |         |
| 19        |              |                |                    |         |
| 20        | k9           | smoothed Fos-B |                    |         |
| 21        |              |                |                    |         |

### Fos, Section B

| Input Word Time | Data Input Name | Data Input Source | Control Bus Input Function | Data Output Name | Data Output Dest. | Output Word Time |
|-----------------|-----------------|-------------------|----------------------------|------------------|-------------------|------------------|
| 0               | k0              | buffered          | Fos-A                      | Frame            | k0 framed Fos-B   | 1                |
| 1               | k0              | framed            | Fos-B                      | Interpolate      | k0 smoothed Synth | 2                |
| 2               | k1              | buffered          | Fos-A                      | Frame            | k1 framed Fos-B   | 3                |
| 3               | k1              | framed            | Fos-B                      | Interpolate      | k1 smoothed Synth | 4                |
| 4               | k2              | buffered          | Fos-A                      | Frame            | k2 framed Fos-B   | 5                |
| 5               | k2              | framed            | Fos-B                      | Interpolate      | k2 smoothed Synth | 6                |
| 6               | k3              | buffered          | Fos-A                      | Frame            | k3 framed Fos-B   | 7                |
| 7               | k3              | framed            | Fos-B                      | Interpolate      | k3 smoothed Synth | 8                |
| 8               | k4              | buffered          | Fos-A                      | Frame            | k4 framed Fos-B   | 9                |
| 9               | k4              | framed            | Fos-B                      | Interpolate      | k4 smoothed Synth | 10               |
| 10              | k5              | buffered          | Fos-A                      | Frame            | k5 framed Fos-B   | 11               |
| 11              | k5              | framed            | Fos-B                      | Interpolate      | k5 smoothed Synth | 12               |
| 12              | k6              | buffered          | Fos-A                      | Frame            | k6 framed Fos-B   | 13               |
| 13              | k6              | framed            | Fos-B                      | Interpolate      | k6 smoothed Synth | 14               |
| 14              | k7              | buffered          | Fos-A                      | Frame            | k7 framed Fos-B   | 15               |
| 15              | k7              | framed            | Fos-B                      | Interpolate      | k7 smoothed Synth | 16               |
| 16              | k8              | buffered          | Fos-A                      | Frame            | k8 framed Fos-B   | 17               |
| 17              | k8              | framed            | Fos-B                      | Interpolate      | k8 smoothed Synth | 18               |
| 18              | k9              | buffered          | Fos-A                      | Frame            | k9 framed Fos-B   | 19               |
| 19              | k9              | framed            | Fos-B                      | Interpolate      | k9 smoothed Synth | 20               |
| 20              | A               | buffered          | Fos-A                      | Frame            | A framed Fos-B    | 21               |
| 21              | A               | framed            | Fos-B                      | Interpolate      | A smoothed Synth  | 0                |

### TTL 1-Word Delay

| Input Word Time | Data Input Name | Source | Output Dest. | Output Word Time |
|-----------------|-----------------|--------|--------------|------------------|
| 0               |                 |        |              | 1                |
| 1               |                 |        |              | 2                |
| 2               |                 |        |              | 3                |
| 3               |                 |        |              | 4                |
| 4               |                 |        |              | 5                |
| 5               | v/uv buffered   | Fos-A  | Fos-A        | 6                |
| 6               |                 |        |              | 7                |
| 7               |                 |        |              | 8                |
| 8               |                 |        |              | 9                |
| 9               | FR buffered     | Fos-A  | Fos-A        | 10               |
| 10              |                 |        |              | 11               |
| 11              |                 |        |              | 12               |
| 12              |                 |        |              | 13               |
| 13              | Pitch buffered  | Fos-A  | Fos-A        | 14               |
| 14              |                 |        |              | 15               |
| 15              | Pitch framed    | Fos-A  | Fos-A        | 16               |
| 16              |                 |        |              | 17               |
| 17              | Pitch smoothed  | Fos-A  | Fos-A        | 18               |
| 18              |                 |        |              | 19               |
| 19              | Phase           | Fos-A  | Fos-A        | 20               |
| 20              |                 |        |              | 21               |
| 21              | Glottal         | Fos-A  | Synth        | 0                |

### Explanation of FOS Control Bus Functions Referenced Above

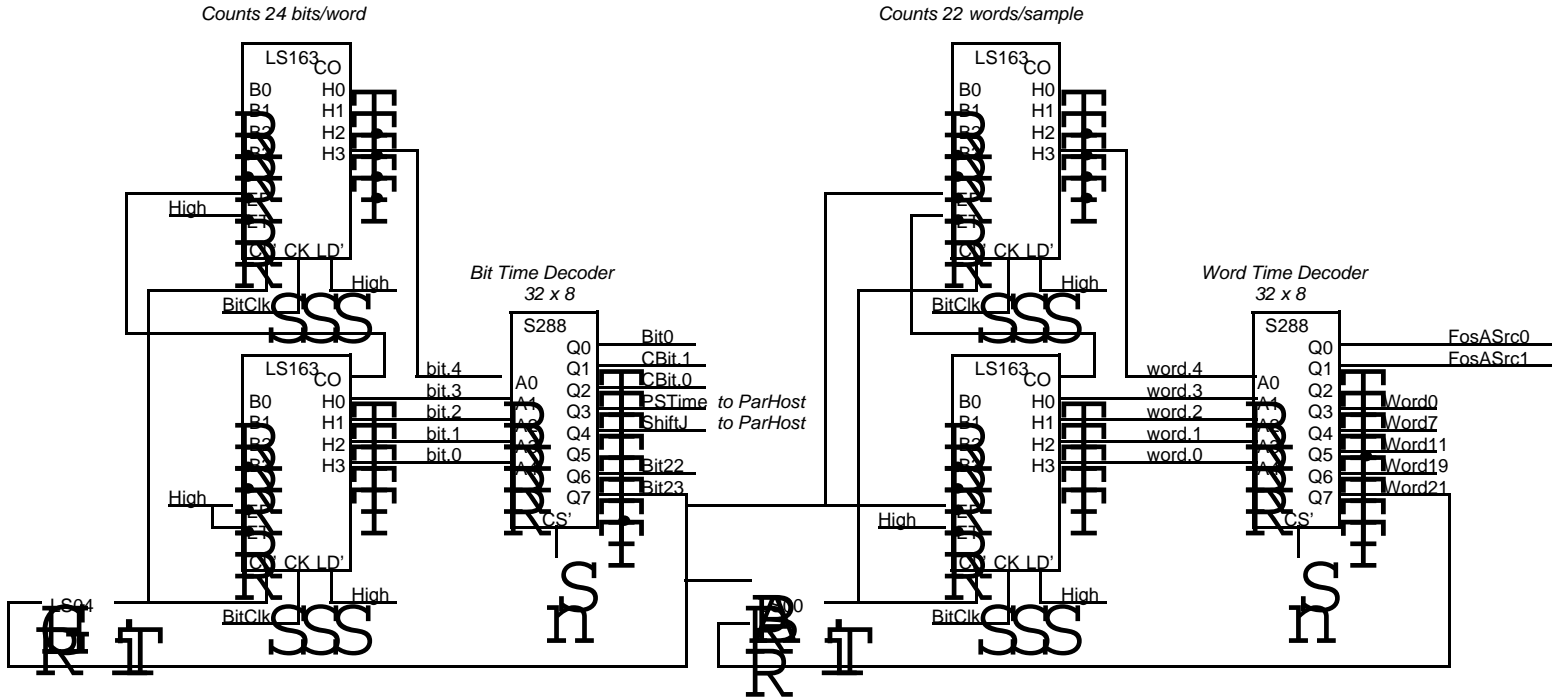
| Control Bus |             |      |      | Function |   |       |        |   |       |                 |    |   |     |   |   |         |   |   |   |
|-------------|-------------|------|------|----------|---|-------|--------|---|-------|-----------------|----|---|-----|---|---|---------|---|---|---|
| Bit Time    | Signal Name |      |      | Buffer   |   |       | Frame  |   |       | Interpolate/128 |    |   | NCO |   |   | Scale/4 |   |   |   |
|             | 2           | 1    | 0    | 2        | 1 | 0     | 2      | 1 | 0     | 2               | 1  | 0 | 2   | 1 | 0 | 2       | 1 | 0 |   |
| 0           | DI          | ASF  | DSF  | BufLd'   | H | BufLd | FrmLd' | H | FrmLd | L               | L  | L | L   | x | H | L       | x | H |   |
| 2           |             | j0   | k0   |          | L | x     |        | L | x     |                 | J0 | H |     | L | x | L       | L | x |   |
| 5           |             | j1   | k1   |          | L | x     |        | L | x     |                 | J1 | H |     | L | x |         | H | x |   |
| 10          |             | j2   | k2   |          | L | x     |        | L | x     |                 | J2 | H |     | L | x |         | L | x |   |
| 19          |             | j3   | k3   |          | L | x     |        | L | x     |                 | J3 | L |     | L | x |         | L | x |   |
| 20          |             | ADF  | DDF  |          | x | H     |        | x | H     |                 |    | H | L   |   | H | L       |   | x | H |
| 21          | DDiO        | ADeO | DDeO | L        | x | H     | L      | x | H     | H               | x  | H | L   | x | H | L       | x | H |   |
| 22          |             | ASO  | DSO  |          | x | H     |        | x | H     |                 |    | H | L   |   | x |         | x | H |   |

Note: NCO could scale its own output, but we need separate scaler for RandomBits, so we use it for Phase-to-Glottal, too. Interpolator divides its output by 2^7 = 128.

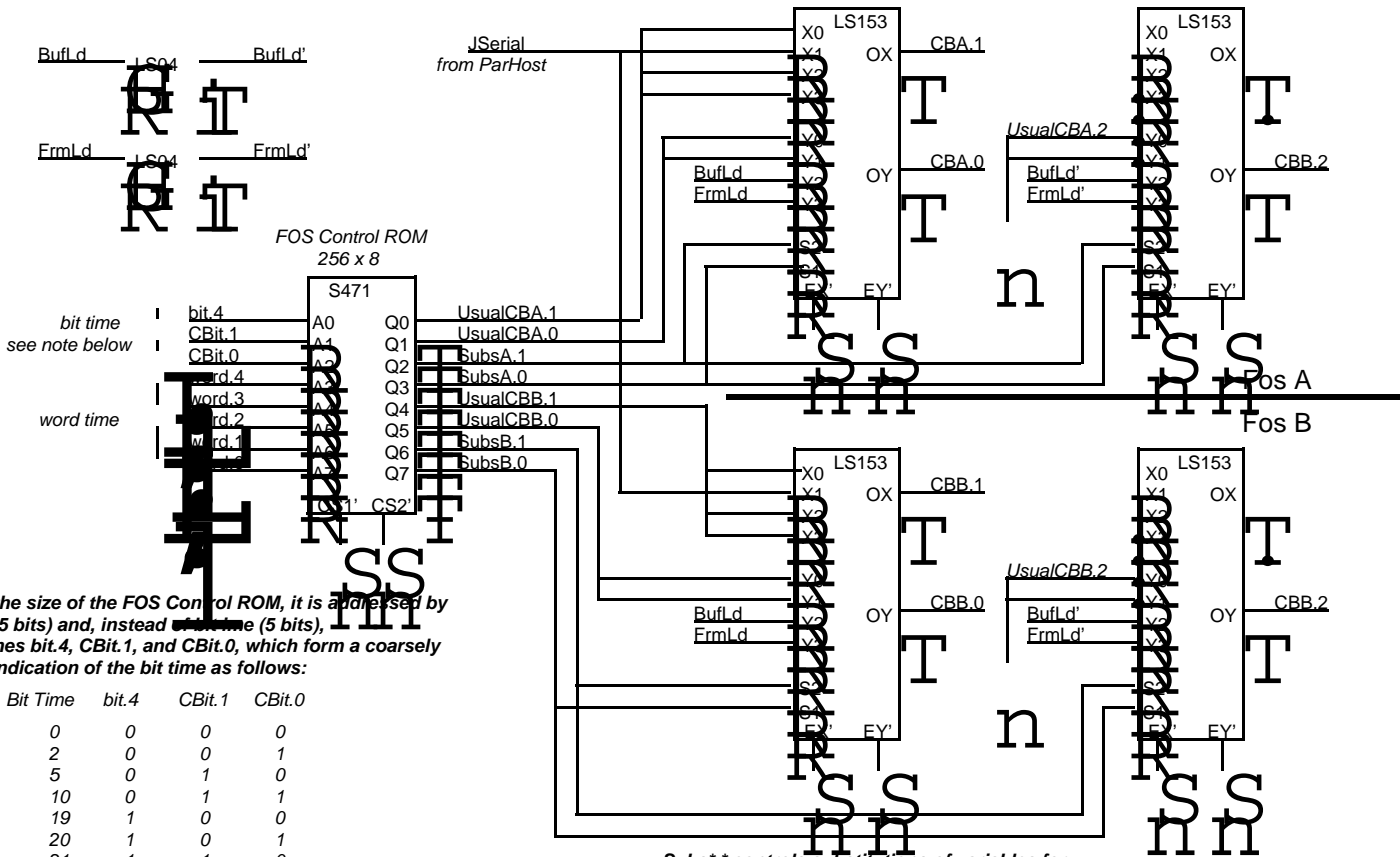
TTL FlipFlop takes v/uv framed from FOS-A during Word Time 7.

|                      |                   |                                 |                    |                   |          |                 |            |
|----------------------|-------------------|---------------------------------|--------------------|-------------------|----------|-----------------|------------|
| <b>XEROX</b><br>PARC | Project<br>Speech | Reference<br>Parrot-FOS Control | File<br>ParFOS.Sil | Designer<br>Pasco | Rev<br>A | Date<br>6/22/81 | Page<br>04 |
|----------------------|-------------------|---------------------------------|--------------------|-------------------|----------|-----------------|------------|

## Timing Counters



## FOS Control Bus Signal Generators



To reduce the size of the FOS Control ROM, it is addressed by word time (5 bits) and, instead of bit time (5 bits), the three lines bit.4, CBit.1, and CBit.0, which form a coarsely quantized indication of the bit time as follows:

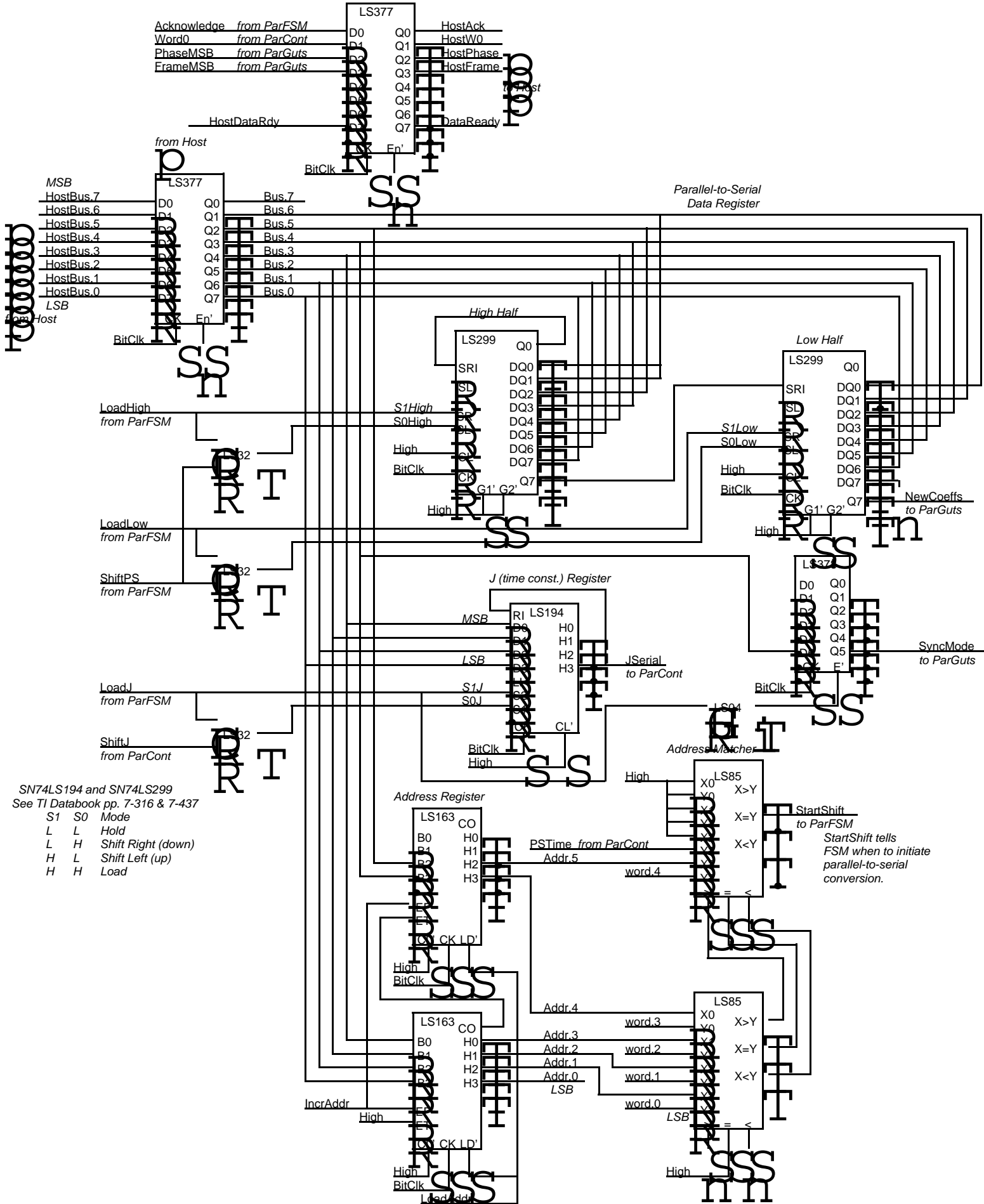
| Bit Time | bit.4 | CBit.1 | CBit.0 |
|----------|-------|--------|--------|
| 0        | 0     | 0      | 0      |
| 2        | 0     | 0      | 1      |
| 5        | 0     | 1      | 0      |
| 10       | 0     | 1      | 1      |
| 19       | 1     | 0      | 0      |
| 20       | 1     | 0      | 1      |
| 21       | 1     | 1      | 0      |
| 22       | 1     | 1      | 1      |
| other    | x     | x      | x      |

ShiftJ is true during bit times 3,6,11,20

Subs\* controls substitutions of variables for constants on FOS control bus lines as follows:

| Function     | Subs*<br>.10 | For* in {A,B} | CB*.2 | CB*.1 | CB*.0 |
|--------------|--------------|---------------|-------|-------|-------|
| NCO or Scale | 00           | Low           | Usual | Usual |       |
| Interpolate  | 01           | Low           | J     | Usual |       |
| Frame        | 10           | BufLd'        | ROM   | BufLd |       |
| Buffer       | 11           | FrmLd'        | ROM   | FrmLd |       |

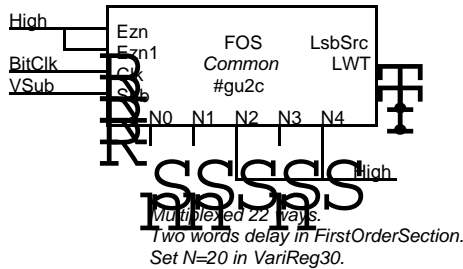
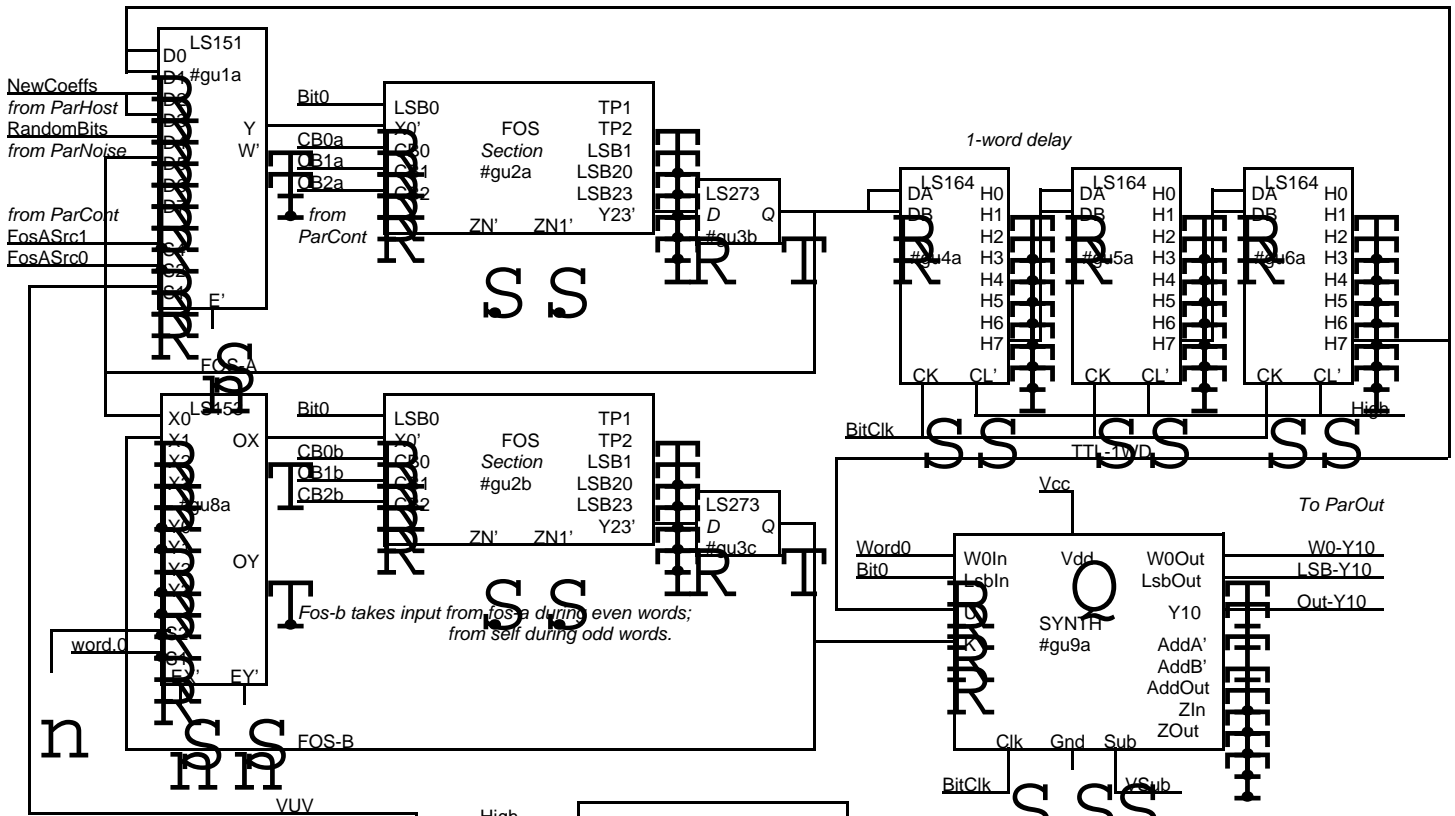
Synchronizers/Buffers



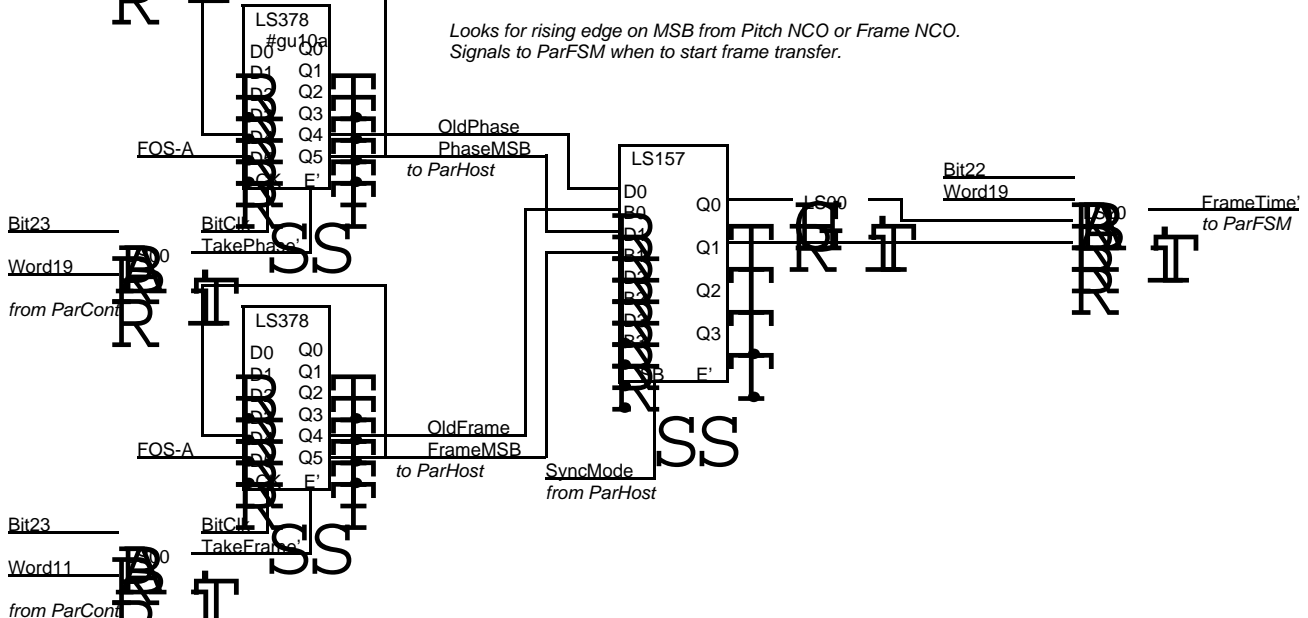
SN74LS194 and SN74LS299  
See TI Databook pp. 7-316 & 7-437

S1 S0 Mode  
L L Hold  
L H Shift Right (down)  
H L Shift Left (up)  
H H Load

FosASrc  
 1 0 Source:  
 0 0 1-word delay  
 0 1 NewCoeffs  
 1 0 RandomBits or FOS-A, depending on VUV  
 1 1 -- unused --



Looks for rising edge on MSB from Pitch NCO or Frame NCO. Signals to ParFSM when to start frame transfer.



## Noise Source Alternatives

White noise <-> Independent, Identically Distributed Samples.

Two special cases of interest are easy to implement and satisfy synth input requirements.

- (1) Random bits, with N sign extensions.  
Uniform on +/- full scale/ $2^N$ .
- (2) Some constant with random signs.  
"Uniform on [-T,T]" has same power as "constant  $T/\sqrt{3}$ ".  
To invert a twos complement constant, invert all bits left of (more significant than) rightmost one.  
Example: Random byte is U[-128,127]; random signs is  $128/\sqrt{3} \sim 74$ .  
74 = 01001010  
-74 = 10110110  
Not very easy to implement in TTL.

Choose method #1, for ease of implementation.

Random bits to come from maximal length linear PN shift register.

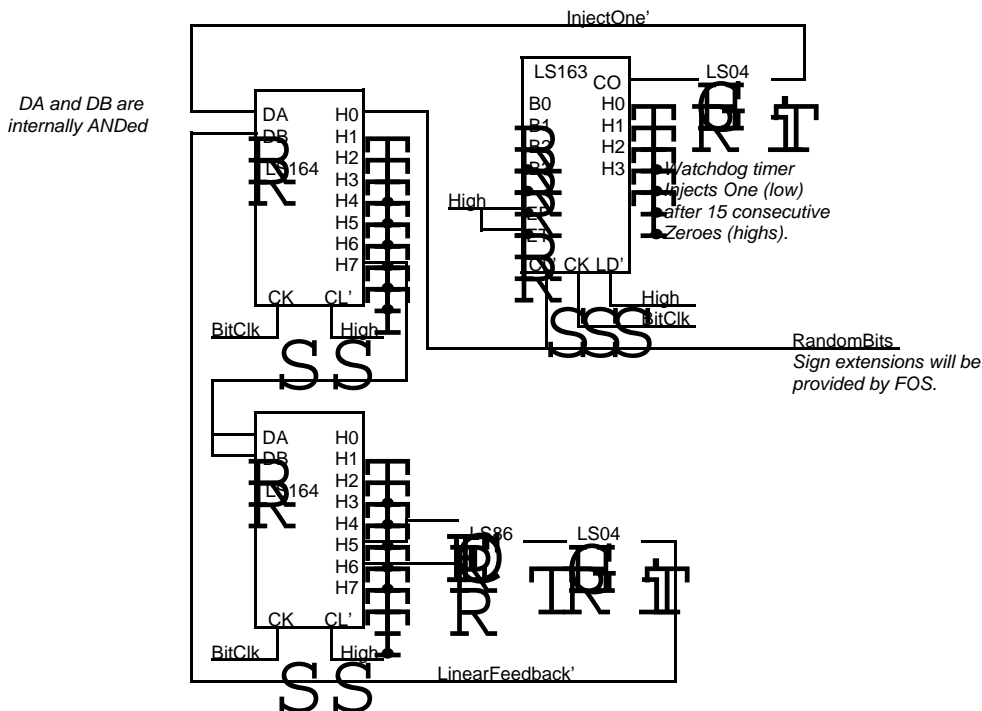
To avoid obvious repetition, epoch of shift register must be longer than longest unvoiced sound (~1/4 second).

Suppose epoch of shift register is  $32767 = 7 \times 31 \times 151$ , which is relatively prime to  $528 = 16 \times 3 \times 11$  bits per sample.

Hence the sample epoch is 32767 samples, over 4 seconds at 8 kHz.

## TTL Implementation

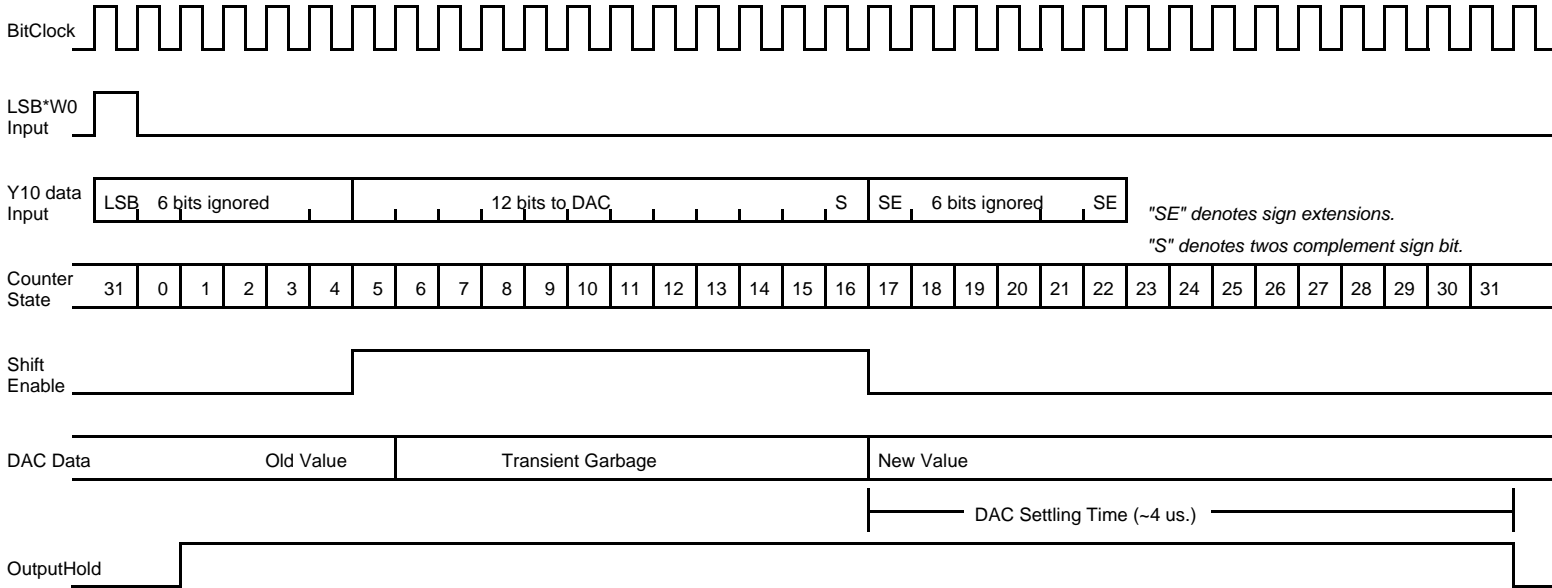
Low-true logic.



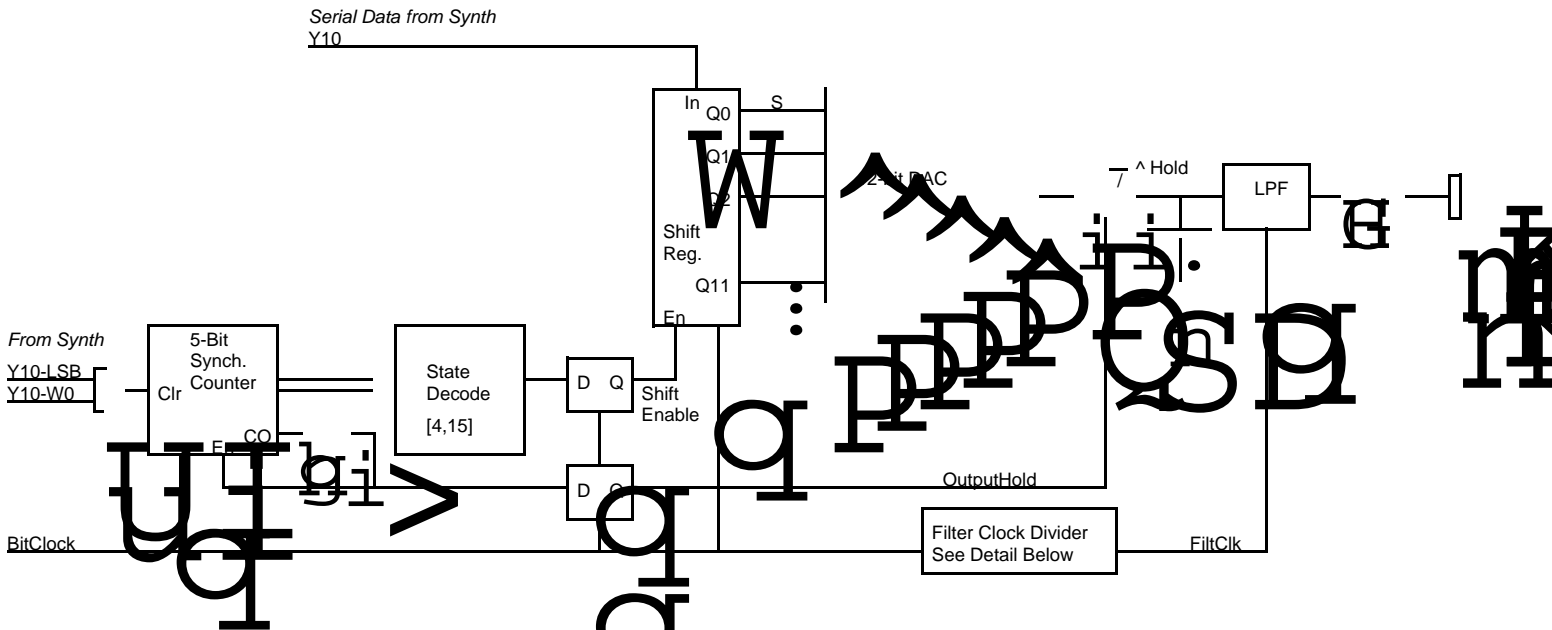


# Parrot Output Section Implementation Concept

The least significant 6 bits of the data word are skipped; the next 12 are sent to the DAC; the high 6 are skipped.

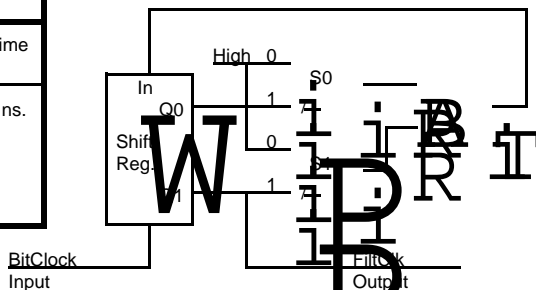


Counter idles in state 31 between samples; Sample/Hold is in Sample mode.  
 Input Y10-LSB with Y10-W0 clears counter and it starts counting.  
 OutputHold is asserted during serial-to-parallel conversion and DAC settling time.  
 Counter stops when it gets to state 31 again.



| Typical Clock Rates       |              |             |
|---------------------------|--------------|-------------|
| BitClock = 528*word rate. |              |             |
| Sample Rate               | BitClock MHz | BitTime ns. |
| 8 kHz                     | 4.224 MHz    | 237 ns.     |

Filter Clock Divider



State Sequences

| S0 S1 =     | 0 1                                | 1 1                         | 1 0                  | 0 0           |
|-------------|------------------------------------|-----------------------------|----------------------|---------------|
| Divide by   | 4                                  | 3                           | 2                    | n/a           |
| Q0 Q1 Cycle | 0 0<br>1 0<br>1 1<br>0 1<br>repeat | 1 0<br>1 1<br>0 1<br>repeat | 1 0<br>0 1<br>repeat | 1 1<br>repeat |



