Scanfish Technical Description

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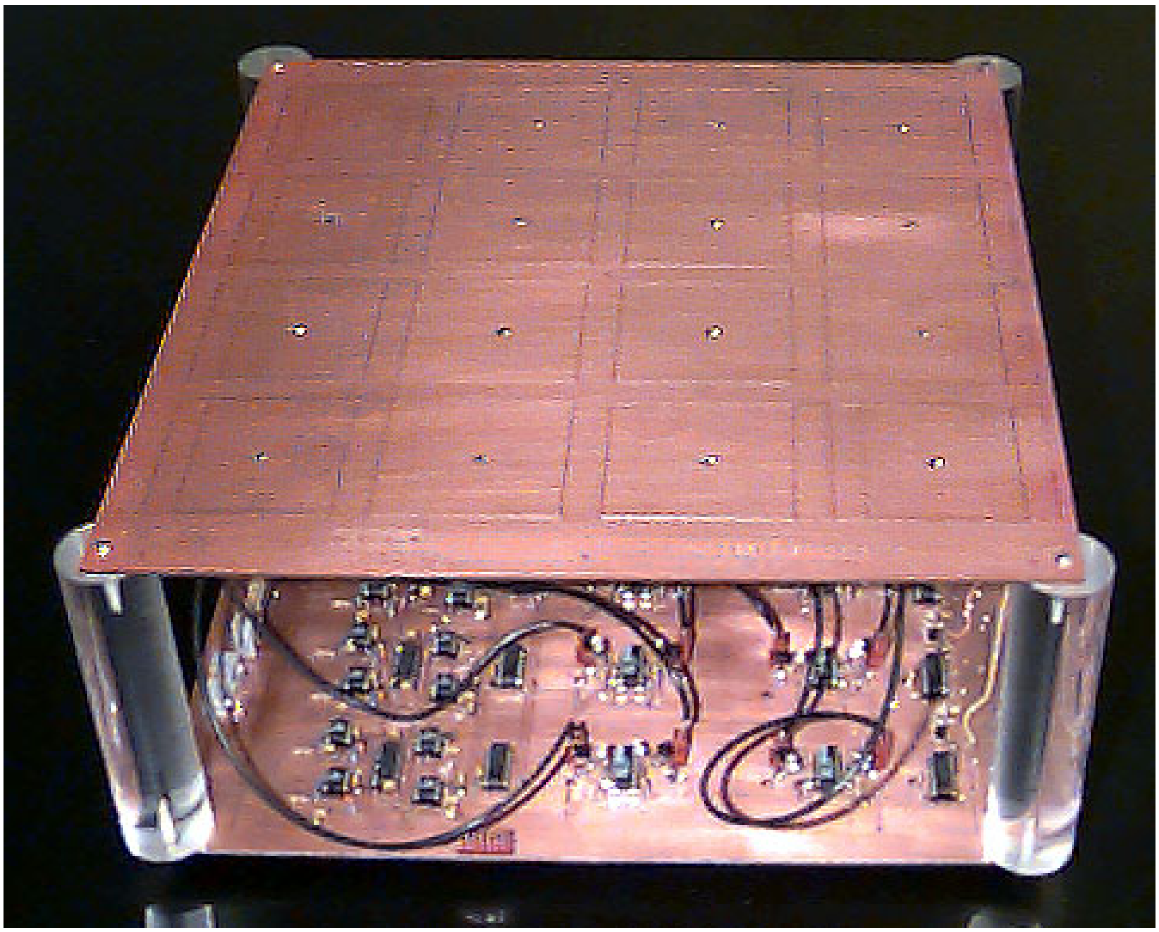


CONNECTORS

The card is equipped to manage an 8 x 8 antenna array. Due to space limitations (and needless complexity at this point), a 4 x 4 array is implemented. Each of the antennas connects to a two-pin header; there are 16 of them, numbered appropriately. The right pin is ground (shield); left is signal.

The card has 4 connectors that enable it to be extended in blocks of 4 x 4; right now, these should be ignored. The only connections required at the moment are the large IDC that goes into the AT-MIO-16 National Instruments DAQ card, and the power connector (the circuit is currently jumpered to use the National Instruments 5 Volt supply; only /- 15 Volts are required, don't connect the +5 Volt lead to anything if the AT-MIO-16 card is used!!).

ADJUSTMENTS

Currently, the master offsets and gain factors are programmed through the DAC's on the AT-MIO-16. The master frequency is also voltage programmable, but there weren't enough DAC outputs on the AT-MIO-16 to incorporate direct oscillator tuning (although a connector is provided that can be driven by another DAC if this feature is desired).

There are 6 trimpots on this card. All are located at the left edge. Only two of them (Xmit drive and Frequency) are potentially needed, but I'll run through them all (all but one are labeled on the card).

The top pot is the transmit amplitude. It works over all antennae, and serves the same purpose as in our original fish. Right now, it's tuned to give something between 20 and 30 Volts P-P.

Right below this is the Quadrature Oscillator input drive. This should never need tweaking. It is adjusted for minimum distortion on the sine and cosine quadrature demodulation waveforms (the sine is at pin 14 of the leftmost AD639 and the cosine is at pin 7 of the nearby AD633 that's been kludged onto the board). Ignore the message (adjust to 3.6 V P-P) that's written near the pot; this is only approximate.

To the left of the XR8038A is a sine symmetry adjustment. This is currently set properly, so leave it alone. Nominally, one adjusts this until the sine waves (demod or xmit; it doesn't matter) look symmetric.

Below the 8038A is the frequency adjustment for the xmit/demod oscillator. Currently, this runs between 30 and 100 Khz. Adjust it appropriately. Because of the quadrature demodulation, no phase adjustments are needed here.

Slightly below the middle of the board, a pot has been kludged into place without labeling. This adjusts the amplitude of the in-phase oscillator in order to make it match the quadrature output. This pot has been set, and should require no adjustment. If adjustments are needed, look at both in-phase and quadrature outputs (located as described above), and tweak this until the amplitudes are nearly identical.

At the bottom of the board is the Demodulation level adjustment. This has been roughly set appropriately and should be fine (plus it can be adjusted over a wide range through the AT-MIO-16). If tweaking is in order, output a ground on the AT-MIO-16 DACs, look at the sine or cosine outputs, and adjust this to give something on the order of 10 V p-p.

LED's

The row of LED's at the top of the card illuminate when a particular column (when selecting xmit/receive status) or row (on receive) is addressed. The two LED's near the quadrature oscillator labeled "trouble" were intended to light up when the quadrature chips were overdriven; the chips don't work as anticipated, however, hence these LED's stay off. Basically ignore them. The small LED located at each transceiver channel is illuminated when that channel is moded to transmit; these can be used for crosschecking when setting up transmit/receive array patterns.

PROGRAMMING AND OPERATION

The Scanfish uses the three accessible timers on the AT-MIO-16 and the four low bits on the digital output port (ADIO 0-3). One of the timers advances the row/column counter, another writes the four ADIO bits into the addressed column to set xmit/receive operation, and the third can be used to reset the output filter. These pulses should be set to be on the order of 10 microseconds or so (longer is fine, shorter may be OK). If the scanfish is expanded into 8 columns, the 4 high bits (BDIO) will be used to determine xmit/receive status of the other 4 columns. The timers should be set to be quiescently low and pulse high (which is I suspect the AT-MIO-16 default).

When the ScanFish is first powered, it addresses row/column 1. With each pulse on the OUT5 timer, the next row/column is addressed. On the 4'th pulse, the counter is auto-reset to again point at column one (this is strap selectable on the card; if 8 columns are used, the strap is inserted as labeled). It is important that the software track which column is addressed, as there is no way to internally reset the address counter. When debugging, it may be useful to observe the LED's and insure that they track the program's assumptions. Remember that the ScanFish doesn't buffer fast commands; you must structure the driving software to wait until the OUT5 pulse is finished before issuing other commands (including other OUT5's). A reset button is provided on the Scanfish to force the counter to point at column one, in order to accommodate restarting from software lockup.

Any of the antennas can be programmed to be a transmitter or receiver. In order to mode a column of transceivers, the counter is advanced to address the desired elements. A bit pattern is then written into ADIO0 - ADIO3 (with ADIO0 corresponding to the top transceiver and ADIO3 the bottom). A "1" written into a transceiver turns it into a transmitter; a "0" turns it into a receiver. A pulse must then be generated on the OUT2 timer, which latches the ADIO values into the addressed column. The ADIO values must be held until the OUT2 pulse finishes, after which they can be changed, another column addressed, etc. If OUT2 is not asserted, nothing is written into the addressed transceivers (this is the normal readout mode).

The OUT1 timer is used to force a reset of the output low-pass filters. In the standard analog fish output, there is a low-pass filter with a cutoff placed below 100 Hz, to attenuate out-of-band noise. This produces a long transient, however, whenever anything is changed (i.e. scanfish remoded or addressed to output another channel), which can slow the scanfish readout. The scanfish has been built with a fast filter reset function, however, which initializes the filter state to quickly acquire a new voltage level, thereby narrowing the transient to 100 microseconds or so. The filters are automatically reset with an OUT5 pulse (counter advance to another row/col) or an OUT2 pulse (write I/O state). The OUT1 pulse, however, will explicitly force a filter reset without changing the row/col address or I/O setup. This is useful in cases where the global gains or biases have been changed; issuing an OUT1 thereafter will cause the filter outputs to quickly acquire the new levels. Remember that the reset lasts a bit over 100 microseconds; after issuing it, wait circa 200 microseconds before reading the output data.

The readout uses the address counter to define the row which is presented to the A/D converter of the AT-MIO-16. Signals from all 4 transceivers in a row are simultaneously available. These appear at ACH0-ACH7 in quadrature pairs (odd channels are in-phase, even are quadrature; ACH0/1 are the rightmost column). After the output filters settle, these can be digitized as rapidly as desired. To get the phase-free magnitude, take the quadrature sum of in-phase and quadrature signals for a given channel. To obtain the tangent of the phase angle, take their ratio. The 90 deg phase shift from the intrinsic differentiation has been accounted for; the quadrature signal defined above is actually the in-phase demodulation, while the in-phase signal is actually the inverted quadrature demodulation. This doesn't really matter; the squared magnitude is unaffected, and the phase reference is unvarying. The output signals can now run between +/- 13 Volts or so; they are no longer clamped positive. The input range of the AT-MIO-16 should thus be set to accept this span (i.e. define unity gain). Reading the outputs of a channel defined to transmit is allowed; this will produce large values from the saturated front-end. If the scanfish is extended into 8 columns, the 4 additional columns would appear at ACH8-15.

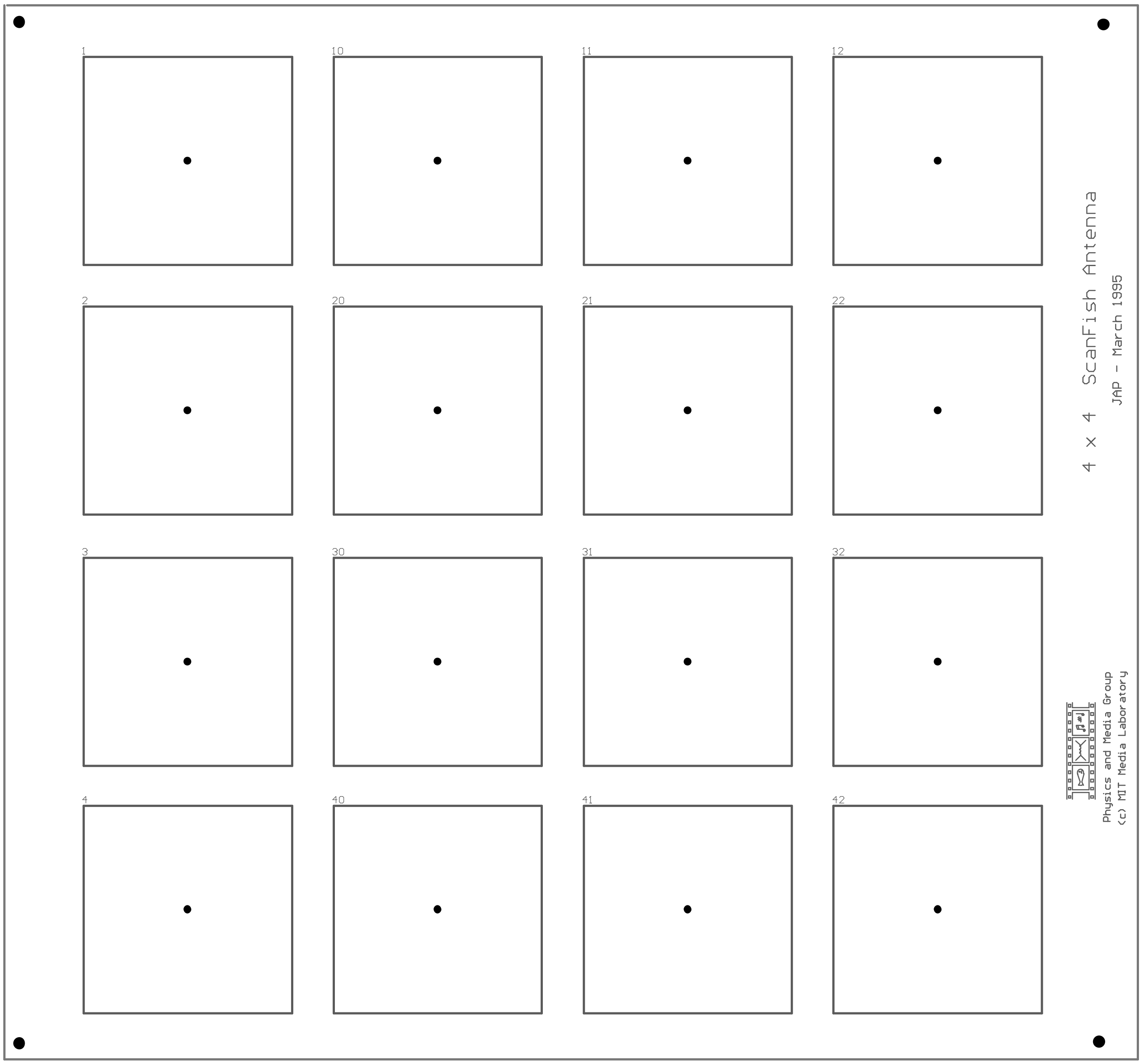
The offset and gains of the output stages (as in the old-style fish) can be set from the AT-MIO-16 analog outputs. To keep things simple, however, only one offset and gain setting are available; these are used to set parameters for all outputs together. Offset is set by DAC0, and gain is set by DAC1 (the gain here is actually the magnitude of the demodulation waveform). The DAC outputs should be set to range between +/- 10

Volts. With DAC0 at ground, there is no offset applied. If a different offset/gain is desired for each output, the DAC's will have to be written (and filters reset thorough OUT1) before each output is read. Again, the AT-MIO-16 inputs have 12-bit resolution, thus the offset/gain adjustments should be much less critical than in our old 8-bit fish.

The scanfish uses quad operational amplifiers for the transceivers, and shares them among two adjacent channels in a column (i.e. top and second down share a package, as do bottom and next up). This can cause some small crosstalk (i.e. 200 mV or so) if one transceiver in a package transmits and the other receives. This crosstalk is constant, however, and can be calibrated out. One suggestion of doing this is to run the scanfish through all desired transmit/receive configurations as soon as the software is brought up (and hands are away from the antenna array). The values thus obtained can be used as fixed offsets for processing later data. This has to be performed regardless to calibrate out effects from antenna spacing.

Because of the design of these transceivers, diode clamps can't be placed between their input and ground to protect directly against static on the antennas. The diodes placed in feedback, however, may afford adequate protection; time will tell. These feedback diodes produce another effect; the maximum front-end output before clipping ranges around +/- 6 Volts (this isn't seen at the demodulated output; these can still range up to the full +/- 13 volts allowed by the power supply). The front-end gain is broken into two stages; the head amplifier is a current-input stage with a 100K resistor in feedback (an order of magnitude lower in gain than used in the original fish, to avoid hitting Op-Amp rolloff and to accommodate the feedback diodes needed by the transceiver), followed by a X10 voltage amplifier (bringing the sensitivity up to the level attained by the standard fish with the single-stage 1 Meg feedback).

The PCB Layouts and Schematic Diagrams are presented in the following pages


1
10
11
12
2
20
21
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3
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31
32
4
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42
4 x 4 ScanFish Antenna
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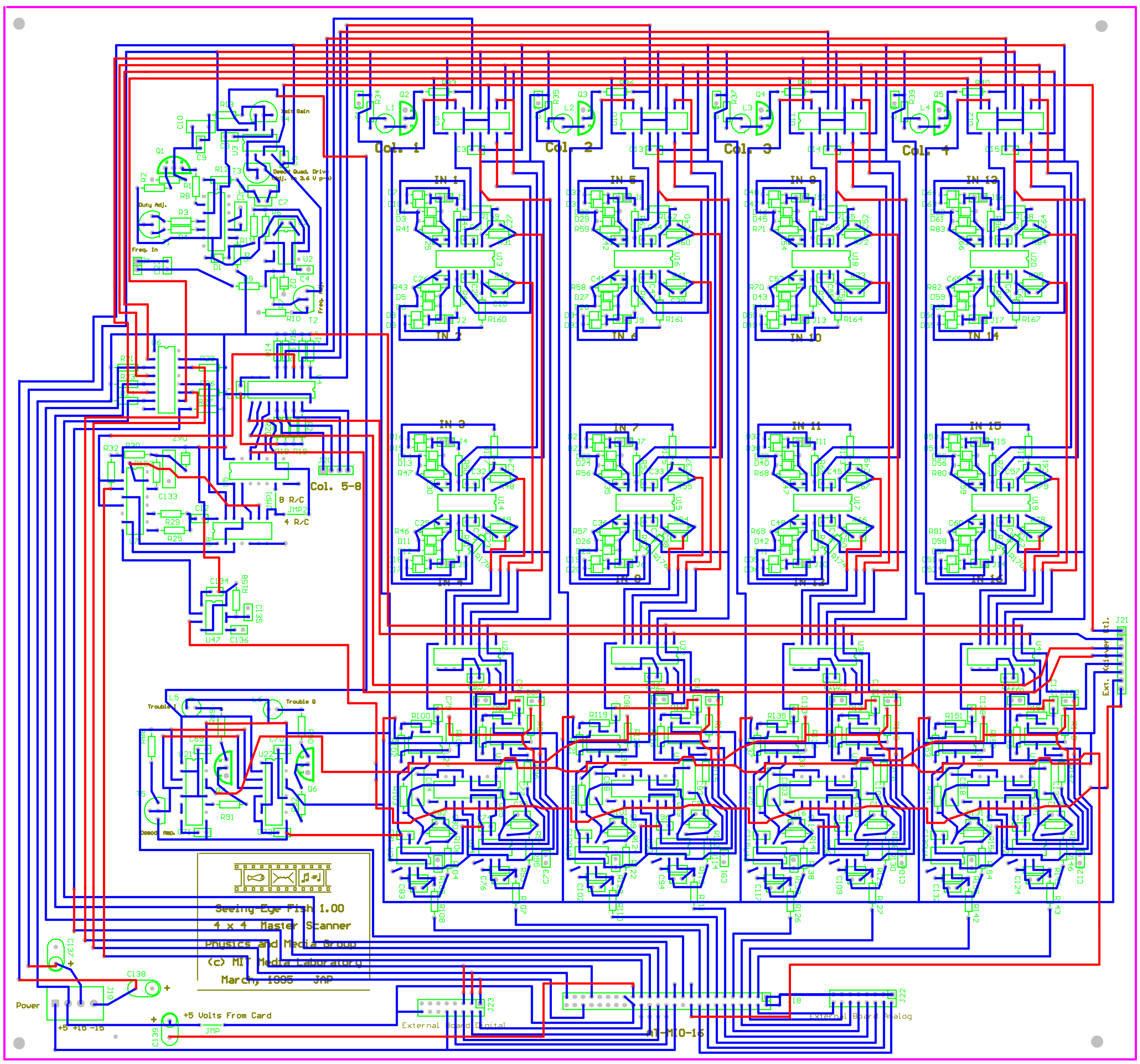
Col. 1
Col. 2
Col. 3
Col. 4
IN 1
IN 5
IN 9
IN 13
IN 3
IN 7
IN 11
IN 15
Col. 5-8
8 R/C
4 R/C
Seeing Eye Fish 1.00
4 x 4 Master Scanner
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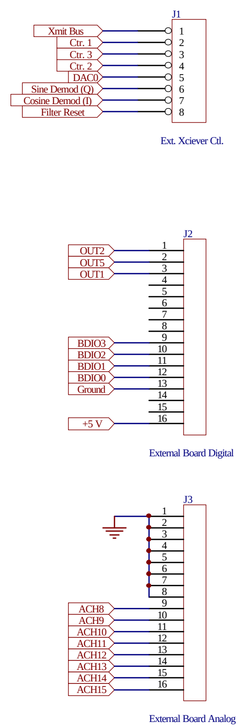
Power
+5 +15 -15
+5 Volts From Card
JMP
Demod. Amp.
AT-MIO-16
Ext. Receiver Ctl.



These connectors provide the possibility of adding additional groups of transcievers to the ScanFish

See also the "Col. 5-8" connector in the "Scanfish Control Circuitry"

Title: Scanfish Expansion Ports		
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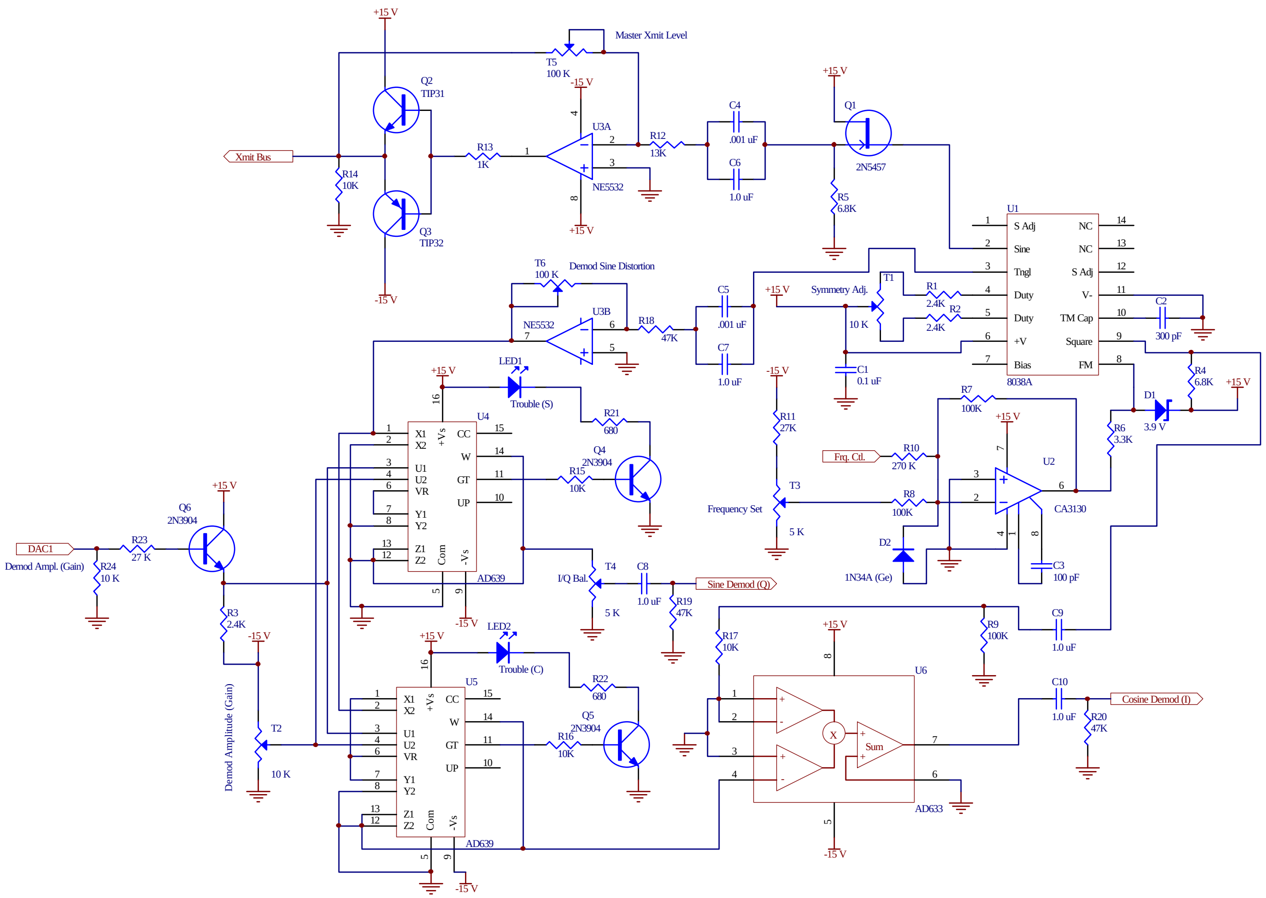
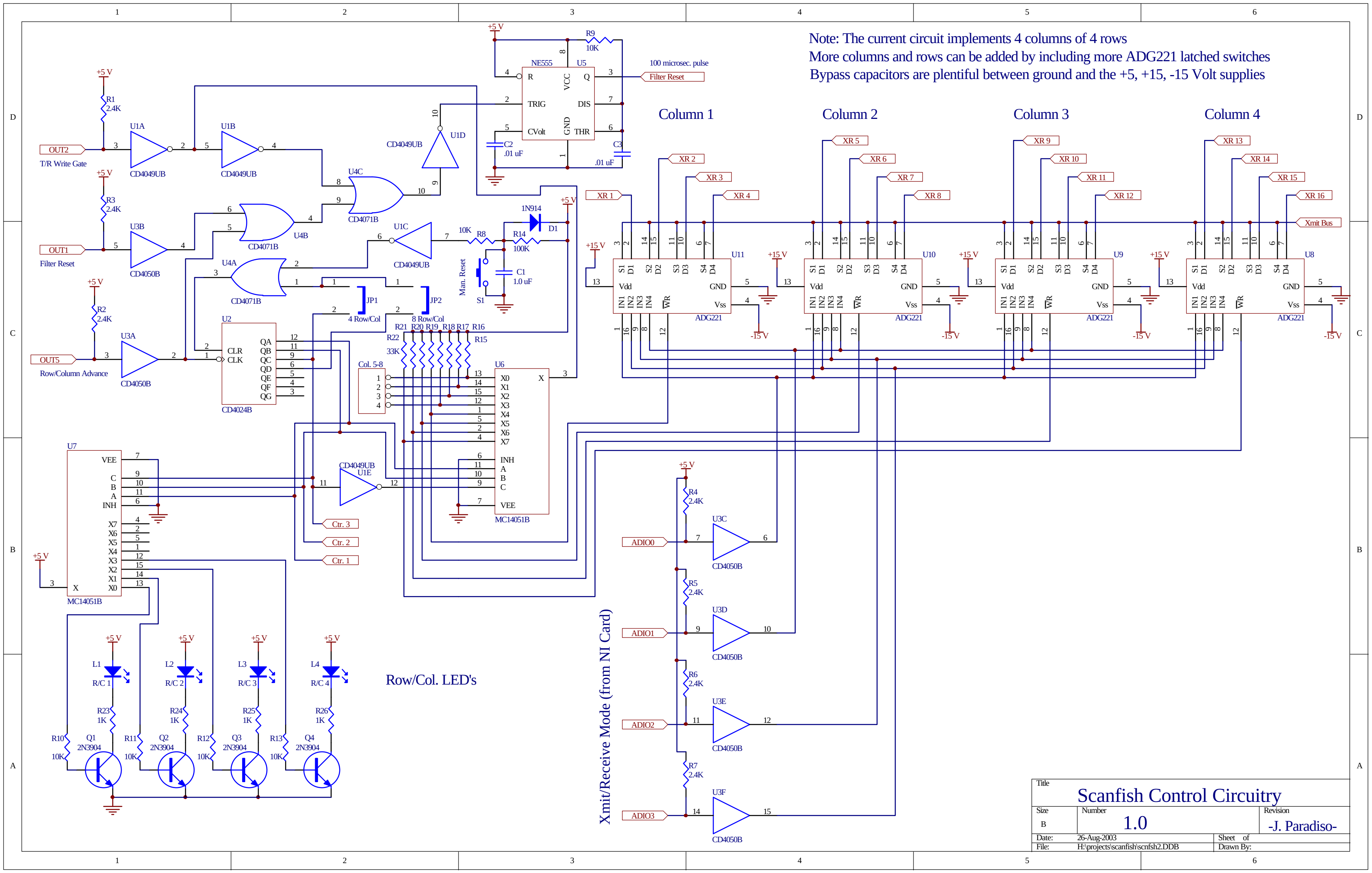
Date: 26-Aug-2003		Sheet of
File: H:\projects\scanfish\scnfsh4.DDB		Drawn By:

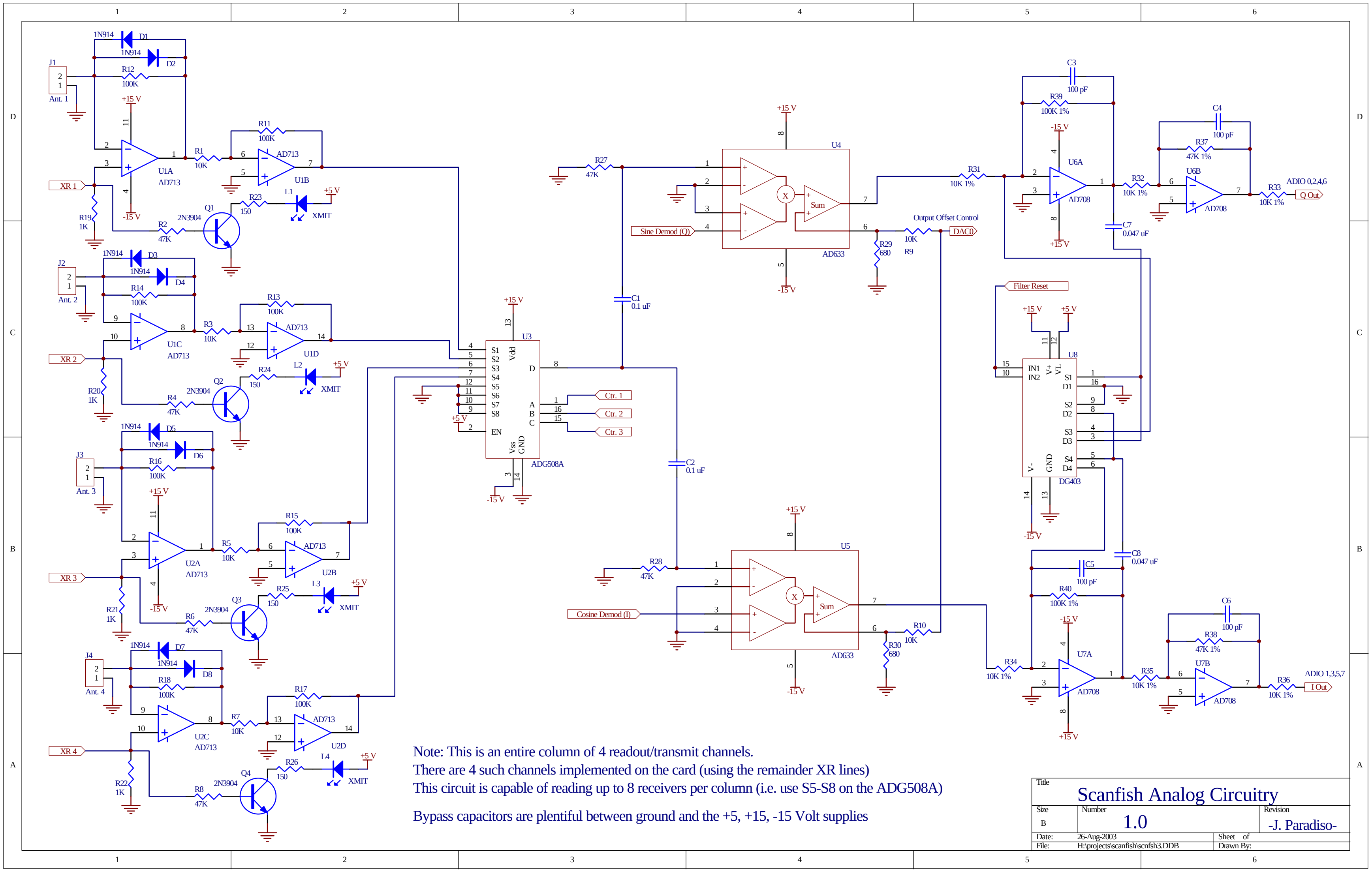


Bypass capacitors are plentiful between ground and the +5, +15, -15 Volt supplies

Title		
Scanfish Oscillator Circuitry		
Size: B	Number: 1.0	Revision: -J. Paradiso-
Date: 26-Aug-2003		Sheet of
File: H:\projects\scanfish\scnfsh1.DDB		Drawn By:



Note: The current circuit implements 4 columns of 4 rows
More columns and rows can be added by including more ADG221 latched switches
Bypass capacitors are plentiful between ground and the +5, +15, -15 Volt supplies
Column 1
Column 2
Column 3
Column 4
OUT2
T/R Write Gate
OUT1
Filter Reset
OUT5
Row/Column Advance
100 microsec. pulse
Filter Reset
NE555
U5
CD4049UB
CD4050B
CD4071B
CD4024B
MC14051B
ADG221
Xmit Bus
XR 1
XR 2
XR 3
XR 4
XR 5
XR 6
XR 7
XR 8
XR 9
XR 10
XR 11
XR 12
XR 13
XR 14
XR 15
XR 16
4 Row/Col
8 Row/Col
Col. 5-8
Man. Reset
Ctr. 3
Ctr. 2
Ctr. 1
ADIO0
ADIO1
ADIO2
ADIO3
Row/Col. LED's
Xmit/Receive Mode (from NI Card)
2N3904
Title
Scanfish Control Circuitry
Size
B
Number
1.0
Revision
-J. Paradiso-
Date: 26-Aug-2003
Sheet of
File: H:\projects\scanfish\scnfsh2.DDB
Drawn By:



Note: This is an entire column of 4 readout/transmit channels.
There are 4 such channels implemented on the card (using the remainder XR lines)
This circuit is capable of reading up to 8 receivers per column (i.e. use S5-S8 on the ADG508A)

Bypass capacitors are plentiful between ground and the +5, +15, -15 Volt supplies

Title	Scanfish Analog Circuitry		
Size: B	Number: 1.0		Revision: -J. Paradiso-
Date: 26-Aug-2003		Sheet of	
File: H:\projects\scanfish\scnfsh3.DDB		Drawn By:	