Pong in colour

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Introduction

I do like vintage arcade games, i love their simplicity, how a picture can be built up purely by using mundane logic gates in the right combinations. Back in the day when these things were new, it was enough of a wow factor just to have something that you could play and control - moving about on a TV screen, of which the vast majority were black and white. It was natural therefore that videogames were not born into a colour world, for many reasons including reducing complexity but more importantly for the cost factor of the monitors. In 1972, colour TV sets and monitors were prohibitively expensive, and the coin-operated industry was driven by the bottom line, there wasn't room for being fancy at this early stage, that was to happen in waves of prosperity later on through videogame history.

So, you can't get more simple than the game of PONG, but i always thought about how it might have looked, or may have been developed should colour TV's and monitors have been much more commonplace.

Nearly 40 years after its inception i decided to see how easy and effective adding colour to the game of PONG might be.

So - first i need to find a suitable game PCB to have my wicked way with...

PONG clone pcbs are fairly common, and don't get any love amongst collectors. I have a whole bunch of them that i have acquired along the way. I looked through what I had and settled on the one shown opposite, its a Chicago Coin 'TV Tennis'.

I've had this pcb for a long time, only partially tested. I decided that nobody is ever going to want it as it is.

I was given this pcb by another collector (Joe Magiera) when i was working in Chicago in about 2005. It has languished in a box in storage pretty much since then. He said he had removed it from a whole machine that got scrapped and it was probably working, sure enough, it looked like it actually was. Later on I found it had a few minor faults that weren't immediately noticeable as most TTL games do, but these were easy to fix quickly and too boring to document here :-)

Sales Flyers for TV Tennis

Chicago Coin

US Billiards

It is highly likely that the pcb i have was the same one used in both machines. The only identifying marks on the pcb is that its marked with 'C.D.I'.

Firstly, this pcb is a lot like PONG but is for 2 or 4 players. The pcb is not however based on Pong Doubles from Atari, its just an extension of a regular Pong pcb with a few more chips for the extra paddles and changing some 3-input gates to 4 inputs to cope with the extra logic needed.

This could be a unique redesign by Chicago Coin, but I have subsequently found out that it directly matches Midway's 1973 game 'Winner IV'. (I have a Winner IV pcb and its identical). The chips on this pcb date from mid 1973, and Winner IV is marked as coming out in October '73 so maybe Midway cloned this design. I don't know for sure.

Sadly, I can't currently find any schematics for Winner IV, so for following the technical part below, you will have to refer to the 'Pong' schematics (found here) and just get the gist of it, they're very similar but not identical of course, most

things match up.

Here is what the game screen looks like currently. BORING black and white.. lets bling it up!

I have several aims for this pcb:
A) make this 2 player (PONG STYLE) or 4 player (PONG DOUBLES) style
Solution to A) I have found that holding the 'serve' button in and then coining the game will actually start a 2 player only game, so for now thats this sortof answered at least.

B) Make the sound work like pong, driving a speaker directly
I found a cap and a resistor near A2, hooked to the TTL chip sound output, I simply removed this and wired it direct to the speaker, and I got sound...

C) Make the game in output in nice RGB colour so it can be played on a JAMMA setup.

D) Add the game features described by Atari as 'Super Pong'

E) Convert the coin and start buttons from N.C/N.O to regular active low inputs.

C) this ones the biggie...

The screenshot mockup opposite is my idea of what I want the game screen to look like, I asked friends online about which direction to go in, and this was about the 8th iteration of trying different colours in different places. I think it definitely spruces it up, while in both 2 player and 4 player mode, provides enough contrast where it matters to make the game still playable.

Now, in order to achieve this, this means grabbing each element of the game as it is made up in TTL and combining it with the relevant RGB signals in the right combination to achieve the colours we want.

So, in order to achieve this, we need to define how we build up this picture above... I came up with a rough diagram , writing the elements on one side, colours on the other and drawing it like a circuit, finding out what needed to be connected to what.

PADDLE numbers are taken from left to right in the screenshot.

From this diagram above, it makes it easier to see what needs to be connected where.

RED:
NET/BOUNDARIES
BALL
PADDLE 1
PADDLE 3

GREEN
SCORES
NET/BOUNDARY
BALL
PADDLE 2

BLUE
NET/BOUNDARY
PADDLE 2
PADDLE 4
PADDLE 3

In combination of course, NET/BOUNDARY goes to all 3 colours and makes white. The BALLgoes to just red and green, this makes yellow, PADDLE 2 goes to green and blue making cyan... and so on and so on...
You can see quite neatly this means we have 4 elements for each channel of colour to combine. This will be quite crucial a bit later on...

So lets start with the NET and the BOUNDARY (the net is the dashed line in the middle, and the boundary is the line that masks the top and bottom of the screen) We want these to both be white.

Currently when we look at the schematics there are 3 elements combined to create the composite video output, found at area D3/2 on the Pong schematics. VIDEO, SYNC and SCORE are combined through resistors. This already tells us that the SCORE is separate from the VIDEO. However, when you look at this with the video probe, you can see that the SCORE also includes the boundaries. Since we want the score to be green and the boundaries to be white we need to separate these two.

Area B4 on the schems shows the 7430 combining all elements of the score, look at pin 1, it is tied high on PONG, but on TV tennis, this signal is a square wave at the beginning and end of the video raster that gives the bars top and bottom and gets mixed in here. So, in order to isolate this, we snip pin 1 of D3, we have now stopped the boundary from being combined with the SCORE signal.

Since we want the NET and the Boundaries to be white we now need to combine them into one signal that we can squirt out to each colour...

We only have 4 inputs per colour available so it makes economic sense to combine two signals that will be coloured the same, rather than passing them through separately. The boundary signal is currently negative in relation to the NET signal (the 7430 would have inverted its output when it created the SCORE signal). NET is generated at F1 pin 8 on this pcb. We could use a 7404 to invert the signal and a 7402 to combine the signals, however thats getting a bit ugly.

The 7400 (quad NAND gate) is numbered zero zero for a reason, its a building block that can be used to create all other known logic gates. As such we can do both operations needed for combining the two signals properly without using two flavours of IC's (the 7404 and 7402).

Firstly, the inverter, this is essentially a NOT gate... We can make this out of one stage of the 7400...

We need to invert (NOT) the BOUNDARY signal

And then we need to OR the resulting signal with NET : This way we'll end up with a useable signal that is positive going like all the rest.

So, I piggybacked a 7400 over another chip on the pcb (at D1), connecting the Vcc and Gnd to the IC below it. All pins are lifted clear and cut short. Pins 1 and 2 are joined together and connected to the BOUNDARY signal that we detached from D3 pin 1.
Pin 3 on our piggybacked 7400 is now our inverted boundary signal that we now want to pass into one half of an OR gate, so we solder pin 3 to pin 4 and 5, Pin 6 is wired to pin 9 for now. Now we grab the NET signal from the snipped leg of F1 pin 8 and put that onto pins 12+13, we then solder pin 11 to 10. The resulting output from pin 9 of the 7400 is now a combined NET+Boundary signal!

So, in order to make our wonderful game RGB, I need to combine various signals in their respective combinations to each RGB channel. The proper way to do this is to use some more logic. Now, seeing as we are no longer using the composite video signal, I can use the 7425 @ F2 and its inverter at E4 to drive our RED signal. This was previously used to combine NET, BALL and both PADDLES together into the black and white signal. Pin 12 of E4 is our final output, run this through a 33ohm resistor to the edge connector and run that to the RED input to your monitor.

Now we have our NET/BOUNDARY signal, we should snip input pin 10 of F2 and lift it, wire the boundary signal here. We now need the BALL, as luck would have it, this is already wired to pin 13 of F2! (this is why I chose to re-use this gate :) We now need to hunt out PADDLE 1, this is available from D10 pin 11. We snip the leg input to F2 pin 12 and wire this to PADDLE 1. We then find PADDLE 3, this comes from E9 pin 6. We isolate pin 9 from F2 and wire this to E9 pin 6. Et Voila, we now have the RED colour channel wired up and ready to go!

Now we need to build the GREEN and BLUE colour output. We are going to have to use another 7425 (Dual 4-input positive-NOR gates with strobe). So I've bent out all the legs and piggybacked this IC onto a ceramic TTL chip @ C3. We can ignore the 'strobe' input on this chip, well not exactly ignore, but we wont be using its functionality, so we have to tie it high, we do this by joining pin 11 to 14 and 3, this ties both strobes high.

So, looking at our table, we want to add the scores, net/boundary, ball and paddle 2 to it. We can get Net/boundary from pin 8 of the piggybacked chip @ D1, so we hook that to pin 13. We can grab the SCORES from pin 8 of D3, we'll put that on pin 12. Now we need to find BALL, this is from G1 pin 4. Paddle 2 is from D10 pin 12, we wire that to pin 9, and thats the GREEN signal all wired up!

Now for the remaining colour, BLUE, we need to add Net/boundary, paddle 2, 3 and 4. Because we've wired a few of these to the same chip already this should be fairly straightforward. For net/boundary we wire pin 13 to pin 1, for paddle 2 we'll wire pin 9 to pin 5. For paddles 3 and 4 we can cheat a bit and grab the combined paddle signal from F3 pin 1, this one signal contains both PADDLE 3/4 signals... so, we need to tie the remaining input LOW to disable it on the 7425, so we wire pin 4 to 7... and thats BLUE done!

Now we have built the 7425 arrangement, its output is the inverse of what we need. Fortunately there are some unused gates on this pcb, by looking at all the 7404's on the pcb I can see that C1 pins 8/9/10/11 are not connected to anything, and so is E4 pins 8+9. To keep it tidy, we can use the chip at C1 for our final output inversions. We connect a 33ohm resistor to pin 8 and run the other end of the resistor to the edge connector, which is in turn connected to our GREEN video signal. We wire pin 10 of C1 through another 33ohm resistor to the edge connector, this gives us our BLUE video signal.

Now its time to power it back up... and we get.....

Success!!

Which I think you'll admit, looks pretty close to what I had intended!!! My monitor quite often misses the top few

scanlines of a video signal, so the top line is not shown in the photo, but trust me, its actually there :)

And of course, in the classic 2-player regular PONG mode opposite :

here is a large photo of the pcb as it is modded now, you can see there's quite a number of patch wires. I used 32swg enameled winding wire.

Misc Work..

Not sure why, but this pcb had a couple of huge patch wires using an empty NAND gate at B1. I removed the huge wires from the underside and replaced with my small patch wire. I'm just documenting it here in case i work out what it was for in the future, or just for general reference.

Now to do Step D and E... but I'll leave those for another day

B/W games can be fun, if you mercilessly hack them kicking and screaming in to the 80's by making them output in Colour :)

LINKS

WIKIPEDIA ENTRY FOR PONG

UKVAC FORUM
I originally posted my progress on the forum at UKVAC but have since moved it here so i can add/modify/update and expand on the process...

DanB's PONG Tech Page
Created the DiscreteSIM software, running a chip-level simulation of a PONG pcb, plus he re-made all of the schematics in an easily readble format!

PONG-STORY.COM
For everything PONG related, with a special slant on home systems.

YOUTUBE LINK
Wolfgang made his own PONG PCB!

Can you think of a link to go here? there's not much out there?!?
Contact me if you have an idea!