Digital Delay Unit For Surround Sound

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The Mitsubishi M65830 Digital Delay IC has been discontinued (for reasons beyond my comprehension), and so far a suitable replacement device has not been found. This means (of course) that you will be unable to build this delay circuit. I have left the project in place as reference, and the overall connection schematic is still valid if (when?) a replacement for the M65830 is located. The project will be updated at that time. In the meantime, just ignore the delay circuit :-(

Introduction

The Surround Sound Processor (Project 18) is a standard Hafler matrix, and will provide a passable rear channel signal. In order to confuse the brain, we really need to delay the signal, which makes it sound as if it were further away. This principle is used in virtually all commercial units, but they have a tendency to be somewhat more complex than a simple passive unit.

The digital delay presented here is expected to be sufficient for most applications, and although the delay is fixed at 20ms, this is the most usable delay period. This is the equivalent of being about 7 metres away from the rear speakers, and they will have a suitably 'distant' sound, even when relatively close to the listening position.

Most commercial units will add extra features (different delay periods, reverberation, etc), which are all missing from this circuit quite deliberately. These effects are possibly fine to impress your friends, but will become very tedious after a relatively short time, and end up detracting from the program material - you are listening to the effects instead of the sound.

Also included is a complete diagram showing how the Digital Delay Unit, Surround Sound Processor (Project 18), either of the Stereo Width Controllers (Project 21) and even electronic crossover (Project 08 or Project 09) can be assembled into a complete unit. All that is needed is a whole bunch of amplifiers (8 of them for the most complete arrangement, but you could survive with *only* 7).

The Delay Circuit

The delay circuit is shown in Figure 1, and uses the Mitsubishi M65830 Digital Delay chip. This has been around for a while now, and is simple and effective (provided that a fixed delay is acceptable). The serial data required to obtain different delay settings is not easily obtained, and would add considerably to the complexity of the circuit. As such, it would no longer be a simple matter to construct using Veroboard or similar, and would require a printed circuit board.

The circuit is (almost) a direct adaptation from the Mitsubishi data sheet, and as shown will give good performance over a wide frequency range. The filters are tuned to around 9.5 kHz, and although this could be reduced there does not seem to be any good reason to do so. This seems to be the optimum response for rear channel speakers, so should be left alone. The filter circuits use internal opamps, and only require the external components shown below.

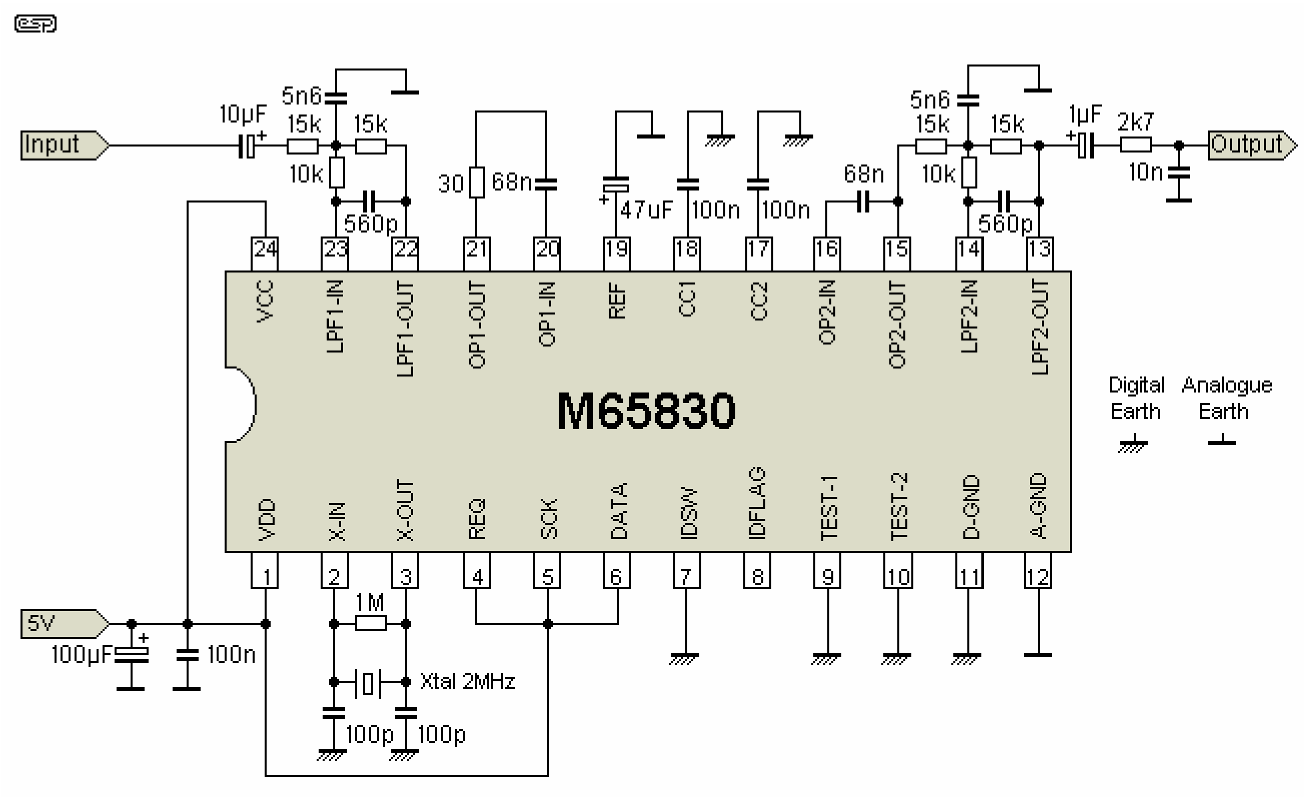

Figure 1 - The Digital Delay Unit

As shown, the unit can be constructed as a module quite easily, requiring a 5 Volt supply, analogue and digital earth connections, and an input and output. This is easy to wire up, and will keep (expensive) mistakes to a minimum. The two 68nF capacitors should be matched to within 5% for best results, according to the Mitsubishi data sheet, as these control the modulation (analogue to digital conversion) and demodulation (digital to analogue conversion). Standard tolerance capacitors are fine for the others, and as usual I recommend 1% metal film resistors. The 2MHz crystal (or you can use a ceramic resonator if you prefer) is probably the only item (apart from the M65830) that may be a little awkward to obtain.

The 5 Volt supply **must** be regulated, as anything over 6 Volts will destroy the delay chip. See Figure 4 for a suitable power supply circuit.

Input Buffer And Output Driver

The input driver circuit is designed to reduce the signal level applied to the delay chip, to prevent any risk of overload. Since the maximum specified level is 1 Volt RMS, it is important to ensure that the signal is below this at all times. The output from a CD player is generally about 2.5V (maximum), so the input circuit reduces the level by a factor of about 3.5 (10.8dB). Since this must be amplified again after the delay, there is a pre-emphasis circuit included to increase the level of high frequencies. The frequency response is restored to normal with treble cut after the delay, reducing noise as well. This technique is used with FM radio broadcasts, vinyl disks and in many other areas and is effective in minimising noise levels.

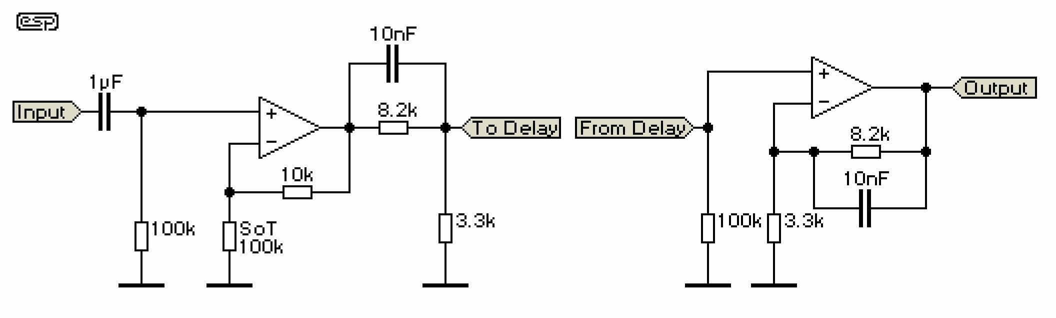

Figure 2 - The Preamp And Output Amp

As can be seen, the circuit is very simple. The resistor marked "SoT" (Select on Test) is designed to allow for the fact that the gain or loss through the delay circuit is not necessarily unity, but can vary. This is designed only to compensate for units with a lower than normal gain, and might be as low as 15k for the worst case. This is unlikely, so if desired, the resistor may be omitted altogether, or a 100k pot can be used to allow the gain to be changed easily.

Complete Surround System

A complete surround system would consist of a power supply, the decoder matrix, optionally the stereo width controller, and the delay unit. Figure 3 shows my suggested method of interconnecting the units, which can all be housed in a single case. For the more adventurous, you can add a pair of Linkwitz-Riley crossovers for bi-amping (shown in the dotted box) for the front left and right speakers.

This keeps everything together, and only the switches needs to be accessible in normal use. All level controls should be set to the desired volume, and not fiddled with once you have it the way you want. If these are accessible, everyone will want to fiddle, and you will then have to try to set it back to where you want - until someone else comes and fiddles again.

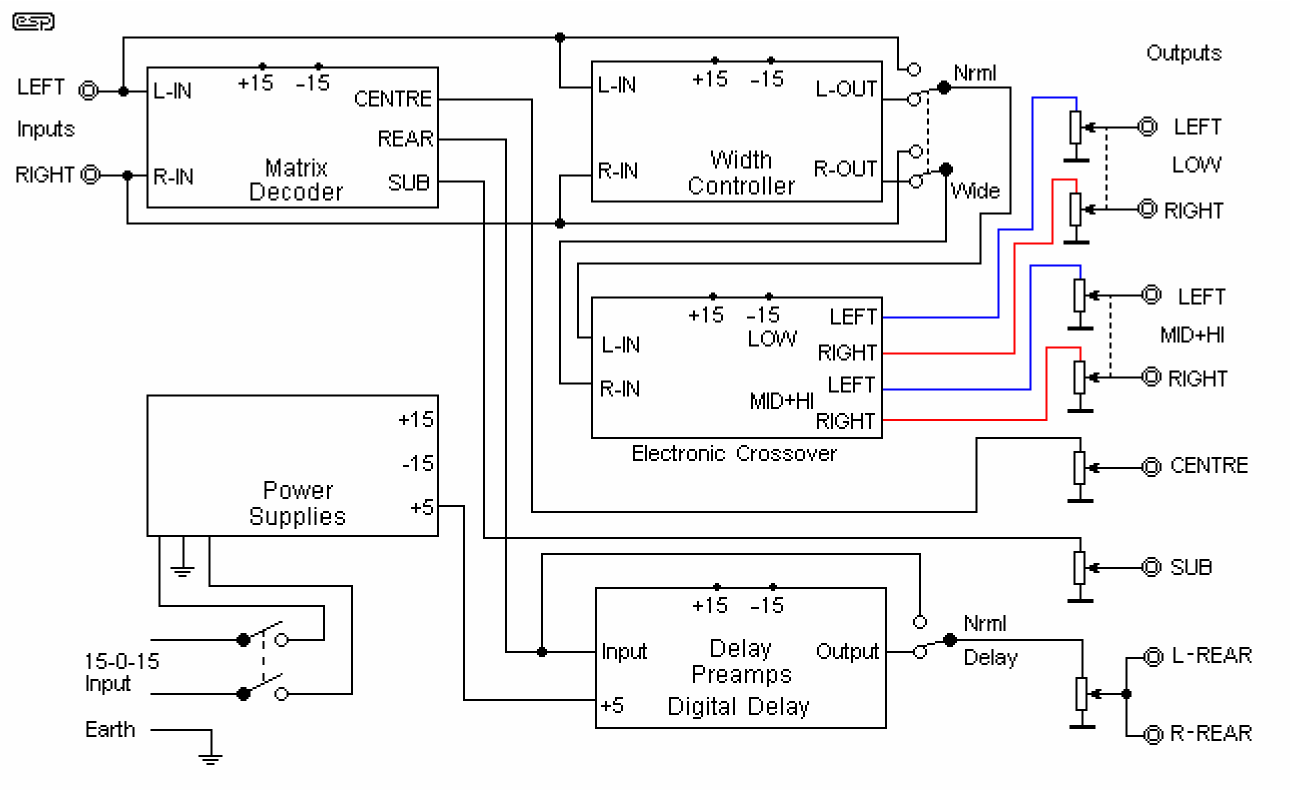

Figure 3 - Suggested Connection Of All Units For Surround Sound Decoder

The various "blocks" of the circuit above all require +/-15 Volt supplies, and naturally an earth connection - these are not shown for clarity. The 5 Volt supply is used only for the digital delay chip.

The pots should be linear, and I suggest 10k to keep impedances reasonably low to prevent high frequency losses. Linear pots are not ideal for audio, but are fine for 'set and forget' controls such as these. They also have better tracking than log pots, so will cause less disturbance to the stereo balance.

If desired, another switch can be added to bypass everything - basically a Stereo/Surround switch. The only part of the circuit that you might want to retain is the sub-woofer output when in Stereo mode. Remember that the sub-woofer output does not have a filter - this is expected to be in the sub itself.

Power Supply Unit

I suggest that a the power supply shown here be used instead of a modified version of the unit described in Project 05, as this will operate all the devices shown in Figure 3. The simple trick used in the previous project was quite suitable for audio only circuits, but with the addition of the digital circuitry we need more power and better regulation than can be obtained from the full-wave voltage doubler circuit used.

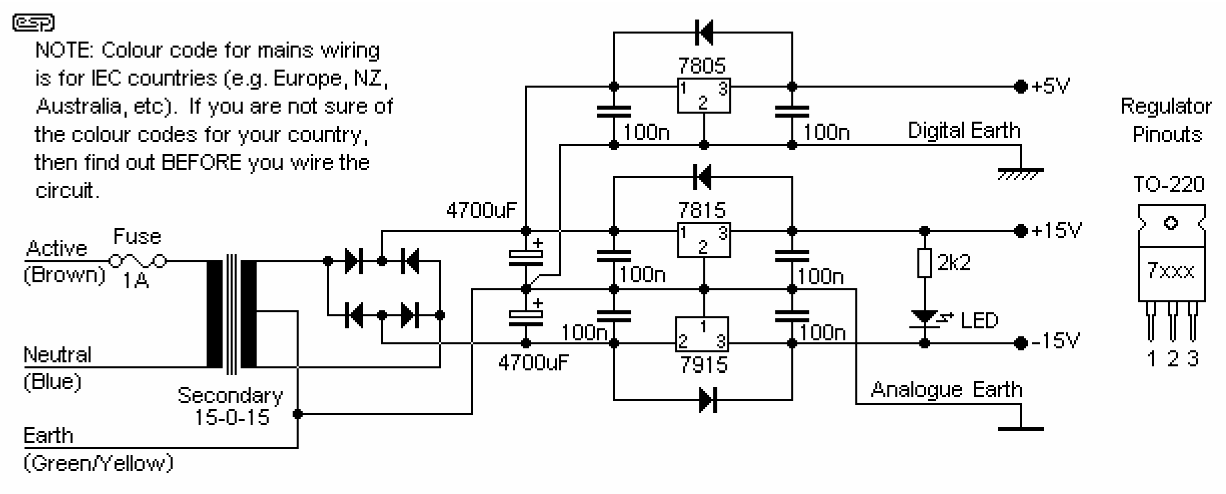

Figure 4 - Complete Power Supply

The transformer can be in the same case as everything else, but installing it in a separate box means that you will not have to worry about stray magnetic fields causing hum in the rest of the circuit. Using a toroidal transformer helps, but is still not as good as a separate enclosure. On the 'less than ideal' side, the transformer will be powered all the time, as it is unwise to run the mains back into the main unit to a power switch.

Use a 15 - 0 - 15 Volt transformer, which should be rated at 20VA, and remember *all regulators will need a heatsink*. Do not skimp on the heatsink for these, as it is far better for them to run too cool (no such thing) than too hot. Make sure that all regulators are isolated from the heatsink with mica washers and insulating bushes. Also remember to use thermal compound on the mica to obtain good heat transfer.

A SPDT switch may be used to switch the incoming AC (not the earth - leave that connected). The LED is a power-on indicator, and will operate at about 12mA.

Observe the pinouts of the regulators - the negative is completely different from the positive type, and they will be destroyed instantly if connected incorrectly. Also make sure that the analogue and digital earth connections are kept separate as shown. Digital switching noise will be introduced into the analogue circuit if the earthing is not kept as shown.

As always, be extremely careful with the mains wiring - dead readers are not one of my favourites. Also make sure that the external transformer is fused, and preferably has an integral thermal fuse to protect against fire, should the transformer develop a fault. All exposed mains connections must be insulated to prevent accidental contact when the cover is removed.