Initial Project Report - FYP

September 30th 2005

Student	Ronan O'Malley (02007894)
Department	Electronic Engineering
Supervisor	Dr Martin Glavin
Project Title	Wireless MIDI Guitar Effects System

Table of Contents

1. Project Overview

The aim of the project is to research and develop a digital effects system with wireless MIDI control for the electric guitar.

Analogue effects have been hugely popular with guitarists for decades, and have helped shape music over the last half century. However, in recent times, due to significant advances in digital electronics, guitar effects are making the switch to digital processing. Digital signal processing offers practicality and flexibility over existing analogue guitar effects, and the power to do things that could never be realised until the switch to the digital domain.

The first stage of the project is to confirm existing effects theory with Matlab, and develop unique algorithms that can be ported to a DSP board without extended alteration. A set of variable parameters with boundaries for each effect must be established to ensure easy manipulation for users who have no underlying knowledge of the algorithm. The array of different effects that are developed will be embedded in a Digital Signal Processor.

The second phase of this project will consist of a pedal board for live control. Guitar effects are traditionally foot controlled as both hands are occupied when playing. To reduce on stage clutter and positioning constraints, it will transmit the control data over a wireless link to the digital signal processor located at the amplifier. This control system will take advantage of existing MIDI (Music Instrument Data Interface) protocol; however for this project, a wireless implementation will be designed. It is envisaged that the DSP system will be controlled in two ways using this technology:

- Static on/off data sent from foot-switches, indicating when an effect should be enabled or disabled in real-time.
- Dynamic positional data sent from a variable pedal, this can alter an effect parameter in real-time and makes for a versatile performing environment.

The final element of the project is to provide user-friendly configuration of the effects. Existing systems are configured using a series of knobs, buttons and low resolution displays. This method is cumbersome and time consuming. It is proposed to construct a link for the DSP to a PC, where a GUI will be constructed to enable fast and flexible reconfiguration of effects, and storage of set "scenes" which can be recalled at the push of a footswitch.

It is intended to document the project in the form of a formal technical paper, suitable for submission to a conference.

2. Design Plans

In the initial stages of the project, the electric guitar will be used to record samples in wav file format. Using a combination of Matlab and Simulink a database of well known guitar effects will be constructed and performed on the afore-mentioned wav files. The will serve to confirm existing effects theory, conduct experiments with new effects and provide the base code for embedding the effects on the DSP. When a suitable amount of effects are created, the developed effects will be embedded in the boards memory using the interface Matlab and Simulink have with digital signal processors. The guitar will be used to provide the analogue input stream to this system. The aim is to make the task of embedding the effects on a DSP as short as possible so other areas of the project can be

concentrated on. A set of controls and mechanisms for controlling effect parameters must also be embedded.

A micro-controller, such as Analog Devices 8051, will be utilised to create a small operating system for the pedal board control unit. This will entail polling of pedal switches and positional pedals, conversion to midi messages and transmission over the wireless link.

The wireless link from the pedal board to the effects processor will be a low bandwidth link using RF technology. A suitable transmitter/receiver pair will be chosen to ensure the wireless connection comfortably meets the needs of the system. It must have a sufficient range to allow for use on a large stage; it must be suitable for home use and not be affected by common household electromagnetic radiation and it must have sufficient bandwidth to ensure no noticeable delay when using a foot pedal.

Once this system is running and stable, a PC link with the DSP board will be formed. A GUI will be programmed in Java allowed easy advanced configuration of effects. It is envisaged that there will be different configuration options depending on the level of user knowledge, ranging from novice to expert. The link with PC will initially be a link with the PC's serial port, but if time permits, to ensure total wireless freedom a Bluetooth wireless link would be preferred.

3. Technologies

3.1 Matlab

Mathworks.com – ADD SOME SIMULINK STUFF HERE, AND DSP INTERFACE

"MATLAB is a high-level language and interactive environment that enables the performance of computationally intensive tasks faster than with traditional

programming languages such as C, C++, and Fortran. The Signal Processing Toolbox is a collection of industry-standard algorithms for analogue and digital signal processing. It provides graphical user interfaces for interactive design and analysis and command-line functions for advanced algorithm development."

3.2 MIDI

Advanced MIDI user's guide 2nd Ed, R.A. Penfold, PC Publishing

Wikipedia.org

Musical Instrument Digital Interface is an industry-standard protocol that allows electronic musical instruments and computers to exchange data. MIDI allows computers, synthesizers, sound cards and drum machines to control one another, and to exchange system information.

MIDI messages can be divided into two main categories: channel and system types. System messages are sent to every piece of equipment in the system and where appropriate, each item of equipment will respond to a system message. Channel messages carry a channel number from 0 to 15 in terms of the actual binary number contained in a message. However, the convention has MIDI channels numbered from 1 to 16, and therefore MIDI channel number is actually one higher than in the message. MIDI is a framework in which all MIDI equipment must operate. It has to accommodate instruments ranging from the very simple through to the most sophisticated units that modern technology can provide.

3.3 Electric Guitar

Howstuffworks.com

The guitar that will be used in the project will be a Peavey Raptor®, which has 3 single coil pickups. "A single coil pickup consists of a bar magnet wrapped with as many as 7,000 turns of fine wire. The vibrating steel strings produce a corresponding vibration in the magnet's magnetic field and therefore a vibrating current in the coil." The max amplitude of the output of these pickups is approximately 160mV.

3.4 Digital Signal Processor

Wikipedia.org

A digital signal processor (DSP) is a specialized microprocessor designed specifically for digital signal processing, generally in real-time. DSPs can also be used to perform general-purpose computation, but they are not optimised for this function. DSPs usually have an instruction set (ISA) optimised for the task of rapid signal processing.
Generally, DSPs are dedicated integrated circuits; however DSP functionality can also be realised using Field Programmable Gate Array chips.

3.5 RF Transmitter and RF Receiver

3.6 ADuC 8051

The 8051 is one of the most popular microcontrollers in use today. It is simple to program yet still very powerful despite its age.

3.7 Java

Java is an object oriented programming language developed by Sun Microsystems. It's ease of use, portability and vast API libraries make it powerful language. It is ideally suited for designing an advanced Graphical User Interface (GUI), has libraries to interface with major network protocols and has a MIDI library to aid in the generation and decoding of MIDI messages.

4. Risk Analysis

Risks and measures being taken to prevent them

Effect not synthesisable, unable to embed in DSP.

During the effect design care, extra attention will be given to ensure effects can be embedded with minimal disruption.

Not enough time.

A detailed timeline is outlined in section 5. This timetable will be adhered to strictly, and a sizable buffer has been included for unforeseeable events.

MIDI protocol unable to meet control needs.

Need DSP to understand and interpret MIDI messages.

Expansion beyond midi??

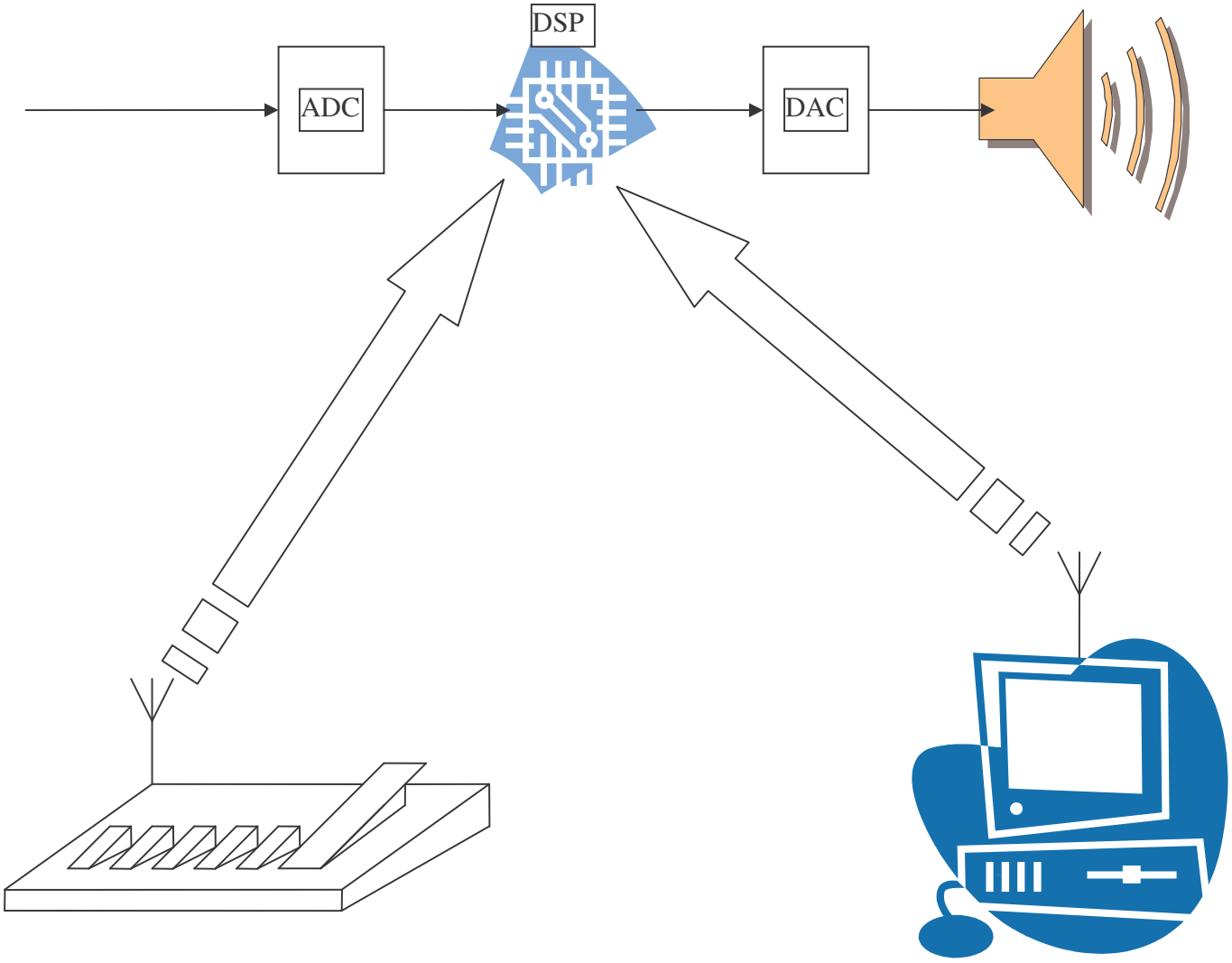
RF is especially tricky.

Not enough time

Not enough midi channels

5. Timetable

Create Array of effects in Matlab	1.5 weeks	9th October 2005
Embed in DSP	2.5 weeks	28th October 2005
MIDI control of DSP	2 weeks	13th November 2005
Wireless communication	3 weeks	4th December 2005
uC Control and generation of MIDI messages	5 weeks	8th January 2006
PC link to DSP	2 weeks	20th January 2006
Construct GUI	3 weeks	5th February 2006
Write report	5 weeks	22nd March


DSP
ADC
DAC