Tutorial No 5, Semester 2, 2023/2024

1. The first 8 notes of a well-known Singapore National Day song are: F4, E4, D4, D4, C4, C4, D4 and E4. What are the MIDI key numbers for these 8 notes? If the song is to be played by a player piano using a standard player piano paper roll, what are the paper roll track numbers for the first 8 notes of this song? Show how, in general, the MIDI key numbers can be converted to paper roll track numbers. If we start on C5 instead of F4, give the MIDI key numbers and the paper roll track numbers for these 8 notes, assuming that the notes of the song will still have the same interval relationships with the first note.

2. A MIDI interface box is connected to a desktop computer to enable the computer to send and receive MIDI messages through MIDI in and MIDI out sockets on the interface box. These sockets are labelled IB and OB respectively. An electronic piano which has only MIDI in and MIDI out sockets labelled IP and OP respectively is used to send MIDI messages to the computer to compose a song on the computer. An electronic tone generator has MIDI in, MIDI out and MIDI thru sockets labelled IG, OG and TG respectively, an electronic organ has MIDI in, MIDI out and MIDI thru sockets labelled IR, OR and TR respectively, and an electronic synthe-

sizer has MIDI in, MIDI out and MIDI thru sockets labelled IS, OS and TS respectively. The completed song is to be performed on the four electronic musical instruments (including the electronic piano). What are the connections which need to be made between the computer and the four electronic musical instruments (including the electronic piano), to enable the song to be composed and then performed as desired? If the electronic piano does have a MIDI thru socket, show how this affects the required connections.

3. The Singapore National Day song in question 1 is to be performed by an electronic synthesizer, starting on the note F4, by sending MIDI messages from a computer through a MIDI interface box to the MIDI input of the electronic synthesizer. The song is to be played by the clarinet MIDI instrument in the General MIDI or GM set of the electronic synthesizer, and the MIDI messages are to turn each note on and off in the lowest numbered MIDI channel as quickly as possible. What is the correct sequence of the MIDI messages to be sent to the electronic synthesizer, to enable the first 8 notes of the song to be played in the correct order?

4. 12 electronic organs are controlled through MIDI cables by a notebook computer, to enable all the organs to play a piece of music together. A particular chord is to be played simultaneously during the piece by all the 12 electronic organs. All the 12 organs should

play the same number of notes of this chord. If we assume that all the notes of the chord have to be played within 0.09 seconds, what is the maximum number of notes which this chord can have? If the time duration is 0.11 seconds instead of 0.09 seconds, what is the maximum number of notes possible in the chord? (Assume that it takes exactly one millisecond for a MIDI message to go through the MIDI sockets of all the 12 electronic organs.)

5. According to the Nyquist theorem, the sampling rate of a digital recording or transmission is double the highest frequency to be preserved in the recording or transmission. If, for example, the highest frequency to be preserved is f Hz, the sampling rate should be $2f$ samples per second. The highest frequency to be preserved is 18,500 Hz in a digital recording of a pop concert. If the bit length of the digital samples in the digital recording is 14 bits, calculate the bit rate of the recording. If we change the highest frequency to be preserved to 16,400 Hz, calculate the maximum possible bit length of the digital samples for the same bit rate. (Assume that the digital recording is in stereo, with two audio channels of equal bit rates to be digitally recorded.)

Scientific Inquiry discussion points

(a) The invention of sound recording by Edison and others, and of radio transmission later, made it possible for music to be recorded and heard by many more

listeners than hitherto. This was multiplied greatly and the fidelity of the recordings vastly improved when digital transmission and recording, coupled with smartphones and the Internet, made both live and recorded music easily accessible to a large proportion of the world's population. Hence the societal impact of science and technology can indeed be immense. Can you cite other scientific and technological innovations which had a similar or greater impact on society?