QASAR M8

DESCRIPTION OF BLOCK DIAGRAM

(1) The Central Processing Unit

The central processing unit is either a mini-computer for large systems or a microprocessor for small low cost systems. The central processing unit has its own memory but the synthesiser visual display and disk storage unit can make direct memory accesses to the processor memory. The disk storage unit cannot write into the central processor memory unless it is in a special mode. One way of entering this mode is by a command sequence issued from the visual display keyboard.

(2) The Central Processor Memory

The central processor memory can be up to 1 Meg bytes for large systems or 32,000 bytes for micro-processor systems.

(3) The Memory Buss Buffer

The memory buss buffer interfaces the synthesiser to the C.P.U. memory buss and interprets various C.P.U. timing signals for selection of data lines, address lines, etc

(4) The Visual Display Terminal

The visual display terminal is associated normally with a 2048 byte buffer which is addressable by the computer as main memory. The display is operable in several modes -

(a) hexidecimal memory display
(b) alphanumeric display
(c) decoded display
(d) graphic display.

(a) In hexidecimal mode the display will display any group of locations in the computer memory or the synthesiser in hexidecimal form. Hex data may be entered above the cursor.

(b) In alphanumeric mode the display will display a 64 character ASCII character set. It has character insert and delete functions for editing purposes controlled by a cursor.

(c) In decoded display mode a byte is broken up into fields. The fields are evaluated by table look up and symbols are displayed. This mode of operation is used for dealing with command strings interpreted by the microprocessor meta language system.

(d) In graphic display mode the display will plot up to 8 amplitude vector strings up the screen. The amplitude vector table start and end addresses are placed in certain positions in the display buffer. By using the brightup feature the current amplitude profile value is made brighter dynamically so that a profile can be followed in real time. A waveform display mode is also available. In this case the display buffer is given the start and end address of the waveform which is plotted on a 512 x 256 matrix. Two waveforms may be simultaneously displayed in the vertical direction and 256 waveform points in the horizontal direction.

(5) The Floppy Disk

A floppy disk storage unit holds 256,000 bytes on a removable platter about as big as a 7" LP record in its jacket. The floppy disk has 2 x 256 byte buffers which look to the processor like normal memory. Each buffer holds 1 sector of disk information. For the purposes of loading the system programme the bootstrap loader is executed in the top disk buffer. The bootstrap is keyed into the disk buffer using the display in hexidecimal mode.

(6) Master Oscillator

The master oscillator is the synthesiser pitch standard and generates timing signals for various functions within the synthesiser.

(7) The Master Pitch & Octave Register

The master pitch and octave register enables all 8 synthesiser pitch generator channels to be controlled from a single point for additive synthesis or other purposes.The low 9 bits of the register control the within octave pitch; the high 3 bits control the octave over a range of eight octaves.

(8) The Pitch Registers

The pitch registers control the within octave pitch of each synthesiser channel. Each octave divides into ~~256~~ 2048 parts.

(9) The Octave Registers

The octave registers control the pitch octave for each synthesiser channel.

(10) Channel Assignment Registers

These three bit registers select a pitch and octave generator channel for each waveform generator channel thus allowing several waveform generator channels to be controlled by one pitch and octave channel for phase additive synthesis or each individual waveform generator to be controlled by a separate pitch and octave generator channel for normal polyphonic purposes.

The synch mask register resets and stops a waveform generator channel running if its bit is set, and therefore enables several waveform generators to be synchronised in a precise phase relationship if they are all driven from the one pitch and octave generator channel. The mask register also is necessary when synthesising percussive sounds as it enables the sound to be started with all overtones in the correct phase.

(11) Modulus Registers

The modulus registers are used to set the number of time slots used to synthesise a particular waveform. Variable modulus counters controlled by the modulus registers provide addresses for each time slot of a waveform to the waveform memory address computing circuits. A waveform may be allowed from 2 to 256 time slots, the highest harmonic content possible in a waveform is approximately one half of the number of time slots. Therefore to resolve up to the 32nd harmonic at least 64 time slots are necessary and therefore the modulus register is set to a value of 63 and the waveform memory is given 64 values for synthesis of the waveform.

(12) Terminal Count Interrupts and Mask Register

The terminal count interrupts enable the processor to detect each cycle of a channel output waveform for any purpose. The mask register suppresses the terminal count interrupts to the processor. The lower byte of the mask register contains the address of the requesting channel. The request is dismissed if the lower byte is rewritten.

(13) The Memory Offset Registers

The memory offset registers contain a value which is added to the variable modulus counter value for that channel to form the absolute address of a particular point in a waveform. For example supposing that all synthesiser channels are set to modulus 64 or 64 points per waveform cycle but each channel is required to have a separate waveform we then for channel 1 set the offset register to 0 so that the data for channel 1 occupies locations 0 to 63 in the waveform generator memory. Channel 2 however is next and as its variable modulus counter is still counting from 0 to 63 it must be made to count from 64 to 127. We do this by adding 64 to the channel 2 counter value by placing 64 in the offset register. Channel 2 waveform is then loaded into locations 64 to 127 in the waveform generator memory and so we work up until all 8 channels have been allocated 64 individual values in the waveform memory.

Another use for the offset register is for the mellotron or progressive structure mode. We can rapidly switch a particular channel from one waveform to another using the offset register.

Still another use of the offset register is for the phase summation mode where, if we store say 1½ or 2 cycles of a waveform in the waveform memory, adding an offset increment of 1 will shift the phase of the waveform output by $\frac{360}{N}$ degrees where N is the number of time slots per cycle.

One feature of the offset register which makes it easy to use is that it only executes a change during a channel terminal count. This has been done to ensure glitch free waveform switching and is done by hardware buffering the user written offset value so that the value placed in the user offset register is not accepted by the offset register proper until a terminal count occurs and hence if all waveforms are made to have their zero crossing points at the lowest memory address occupeed by that waveform, glitch free waveform switching results without recourse to processor interrupts.

(14) Memory Request Detector

The memory request detector is responsible for allocating memory cycles in the waveform memory to each active waveform generator channel. It allocates on a priority basis with channel 0 having the highest priority. The memory request detector also enables the processor to write into the waveform memory and to read from the waveform memory. The memory request detector will allocate a memory cycle each 120 nanoseconds before the lowest priority channel (#7) looses out.

(15) Memory Address Computing

The memory address computing logic adds the offset value to the variable modulus counter value for each channel. However, if the offset register has bit 11 set (12th bit) a normal computation of address follows but instead of the variable modulus counter being one operand a 7 bit random number is used from the random number generator. The resulting address is used normally but the stored waveform can now be regarded as the probability density function of a random process. Hence by setting up a 128 value PDF in the waveform memory one can cause a channel of the synthesiser to generate a random function with almost any probability density function. The rate of sampling of this PDF is governed by the pitch and octave setting for the particular channel. The sampling rate will govern the high frequency limit of the random function.

(16) The Random Number Generator

The random number generator generates equiprobable random numbers in the range 0 to 127 for use in the probabili density function synthesis mode.

(17) The Waveform Random Access Memory

This memory is available in modules of 1024 bytes. Up to 3072 bytes of this memory can be accessed. The memory cycle time is 120 nanoseconds.

(18) The Waveform Processor

The waveform processor takes the waveform memory data stream and converts it into a digital form suitable for amplitude processing.

(19) The Amplitude Processors

The amplitude processor converts the data streams from the waveform processor into signed amplitude controlled information suitable for conversion into audio. The amplitud value processor behaves like a balanced modulator and should the waveforms stored in the waveform memory contain large D.C components modulation "thump" will be generated by the amplitude control signal transients.

(20) The Clock

The clock circuit is a timing circuit which delivers 50 ns pulses to the amplitude rate generators.

(21) The Amplitude Rate Generators

The amplitude rate generators provide clock pulse streams adjustable over a 32,000:1 range to the amplitude profile vector generators. These pulse streams govern the slope of the amplitude vectors.

(22) Amplitude Vector Generator

The amplitude vector generators are presetable up down counters whose value determines the audio output levels of the channels to which they are assigned. They may be set directly by the processor to a particular value or may be counted up or down under control of the amplitude profile mode and target registers.

(23) Amplitude Profile Mode & Target Registers

These registers control the flow of clock pulses to the up down counters in the amplitude vector generators. When these registers are zero no clock pulses are fed to the corresponding amplitude vector channel. The low 8 bits of these registers select the number of clock pulses allowed out before a vector complete interrupt is generated. If the most significant bit is set the corresponding amplitude vector generator counts downward; if it is reset the amplitude vector generator counts upward. If the second most significant bit is set the amplitude vector generator is not incremented but a timeout is caused by a countdown of the target register and an interrupt is generated at a count of zero. The rate of countdown of the target register is set by the amplitude profile rate generator.

Hence the profile target register may be made to function as an amplitude vector length counter or as a timer.

(24) The Vector Complete Interrupt Mask Register

The vector complete interrupt mask register disables the vector complete interrupts from the amplitude profile target registers. The upper 8 bits of this register form the mask. The lowest 3 bits of the byte forms the address of the channel requesting service. The request for service is reset when the address byte is rewritten.

(25) Profile Assignment Registers

The profile assignment registers assign amplitude vector generators to amplitude generators. They can be set to allow one amplitude vector generator to control all eight synthesiser channels or may be assigned on a 1 for 1 basis or on other combinations.

(26) Digital to Analogue Conversion

The digital to analogue conversion stage converts the digital information used all the way through the synthesiser to an audio waveform.

(27) The Output Assignment Registers and Switching Matrix

This bank of registers assigns each synthesiser channel to any combination of audio output channels via the switching matrix and allows 8 channels to be mixed together, each channel to be output separately and any combinations between.

(28) The Keyboard Controller Option

The keyboard controller option interfaces to from 1 to 8 keyboards. Each keyboard is connected via a 2 pair cable along a multi drop line. Each keyboard uses 2 bytes in the interface; one of these bytes contains the number of the highest or lowest key depressed. Any change in data in this register will cause a processor interrupt. Interrupts from any keyboard are maskable by setting bit 8 in the second byte.

(29) The Player Terminals

Each player terminal contains a 4 octave keyboard, An octave switch AND may be linked to be monophonic or polyphonic In polyphonic mode a keyboard is allowed to generate data on from 2 to 8 key depressions by allowing it to respond to 2 or more keyboard addresses. If a keyboard is programmed for all addresses no other keyboards can be supported by the controll option.

Provision is also made on a player terminal for 6 slider controls and a self centering joystick control. These controls require connection via another multi drop data line to an analogue control converter option.

(30) The Analogue Control Converter Option

This option handles 8 analogue controls on each of 8 keyboards. Change in data on any control causes an interrupt to the processor. Data is passed to the processor from each keyboard through one register. The least significar 3 bits of the top byte of each channel give the control no; the lower byte gives the value. The most significant bit of the top byte disables the interrupts from a particular channel

(31) The Player Video Display Option

The player video display option allows each player a 256 character display (32 x 8) or a single graph line and connects to the synthesiser via a special interface which supports 8 terminals. The display connects to the interface using a single ¼" coaxial video cable.

(32) External Sound Digitiser Option

This device will synchronise to an external sound source and provide 64, 128 or 256 values per cycle of the sound. It takes 8 cycles of the sound to produce the values.

(33) Visual Effects Generator Option

The visual effects generator option allows the synthesiser to be interfaced to laser beams, holographic display devices, multiple slide projectors, etc.

(34) The Timer Bank Option

The timer bank allows the synthesiser to generate clock tracks on tape at audio or ultrasonic frequencies and allows the synthesiser to synchronise to a clock track or motion picture sprocket holes or any other synch source of priod 50 µs or below. The registers in the timer bank set the number of synch pulses that must occur before the next processor interrupt. Interrupts are disabled by loading a zero value into the register.

Other Options under Review

The following options have been proposed and found technically feasible -

(1) Music Reader

A music reader interface which optically scans preprinted 2 fold manuscript sheet and reads normal music symbols for the purpose of automatic part writing, automatic arranging, playing or just encoding for interactive modification.

This device is based on current mark sense and limited alphabet optical character recognition techniques. It does require however that musical symbols are written by the composer within a range of heights, widths and slopes.

(2) Music Writer

The music writer interface is a plotter which draws staves symbols etc. resulting from any computational process or part writing, etc. Supporting software for the music writer will allow all manner of transposition, rhythm change, cleff change and time frame change.

(3) Dancer Interface

This is a 3 dimensional ultrasonic "radar" unit which divides a stage area into a cube with all sides containing 1024 points. It ranges the dancer in 3 dimensions and passes the parameters to the computer synthesiser where they may be employed to control any function. The system pulses ultrasonic signals into the stage area. Reflections are picked up by 3 microphones fed to crude delay line cross correlators coupled to a processor which converts the data to rectangular co-ordinates.

(4) Conductor Interface

This device is a miniature version of the dancer interface with the exception that the player uses a wand which emits the ultrasonic signal. The wand is entirely self contained and runs from miniature hearing aid batteries. This interface could be made to sort out signals from several wands.

(5) Tactile Player Interface

Various tactile interfaces have been designed which allow a player to control several synthesiser parameters simultaneously by touching, stroking, hitting and otherwise abusing the tactile interface structure. This area still requires much research work.

Areas for Future Research

(1) Sequential machines using pseudo random sequence generators;

(2) Computer driven hologram generators for 3 dimensional image projection;

(3) Tactile transducers;

(4) Bionic transducers;

(5) Musical and artistic programming languages;

(6) Choreographic techniques using computers;

(7) High level language computer hardware (80% of current computer software is necessary only because of the architectural shortcoming of the machines themselves);

(8) Abstract subliminal control using vision and hearing;

(9) 3 dimensional polyphonic musical systems;

(10) Interactive music systems with listener directed variations;

(11) Music to equation conversion for data compression;

(12) Another look at human hearing

- (a) factors in pitch and timbre recognition;
- (b) directional recognition;
- (c) masking and harmonic phase in timbre recognition;
- (d) random noise in timbre and pitch perception.

(13) Another look at musical instruments

- (a) the first 100 milliseconds

(b) inharmonic partials
(c) nuances
(d) random noise in pitch
(e) random noise in timbre.

(14) A look at natural sounds

(a) bongs
(b) clicks
(c) pops
(d) grunts
(e) howls
(f) rustles
(g) scratches
(h) jingles
(i) bubbles/babbles
(j) tinkles
(k) rattles
etc. etc.