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MART-03:
GENERAL PURPOSE MODULE TO RECORD AND TO PLAY-BACK AUDIO MESSAGES

Assemble-it-yourself kit

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The MART-03 Module is applicable for multiple recording and playing back audio signals using non-volatile analog memories, types ISD2560, ISD2575, ISD2590 or ISD25120 made by ***Winbond Electronics Corporation America (WECA)***. They feature high quality of sound recording, simple design and long storage time without power supply (as much as 100 years). Integrated circuits applied, like most of ISD devices, enable easy way to create various functions without any additional control circuits. These functions including, but not limited to the following:

- **ADDRESSABLE RECORDING OF MESSAGES,**
- **ADDRESSABLE LEVEL-ACTIVATED PLAYBACK OF MESSAGES,**
- **ADDRESSABLE EDGE-ACTIVATED PLAYBACK OF MESSAGES,**
- **OPERATIONAL MODES (ADDRESSLESS) enable to:**
    - **message looping (continuous playback),**
    - **consecutive record with message separation method,**
    - **consecutive record with message linking method,**
    - **edge-activated playback,**
    - **edge-activated consecutive record and playback,**
    - **message cueing .**

Figure 1 illustrates a circuit diagram of MART-03 with external components to be connected to the Module to create the unit with all functionalities.

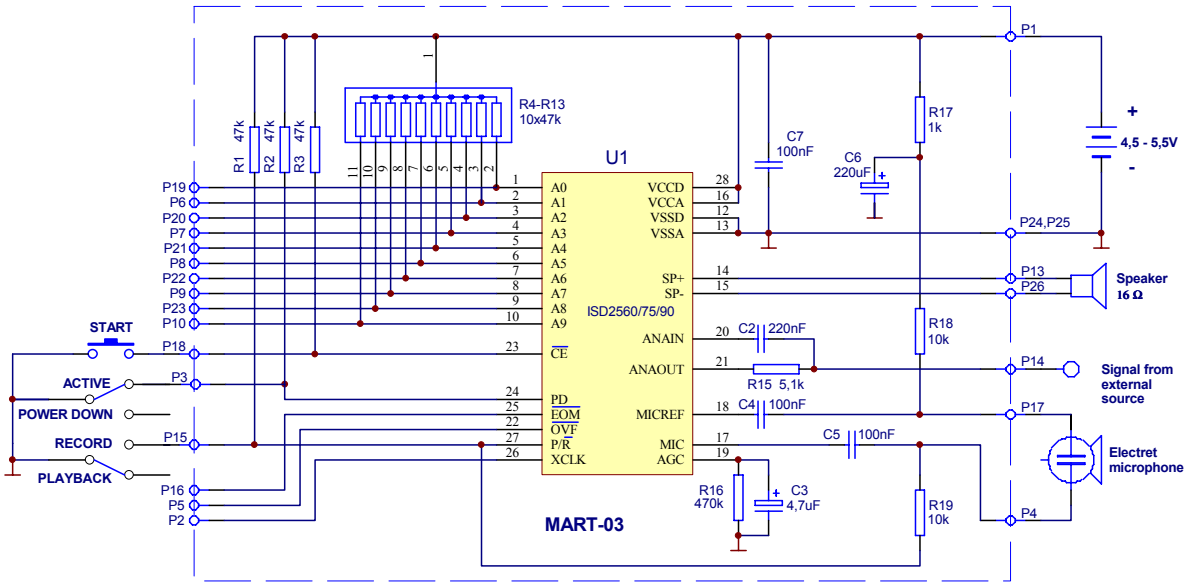

Fig.1. Circuit diagram of MART-03 Module.

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The kit includes integrated circuit ISD25xx and PC board (without other electronic devices). PC board component layout is shown in Fig.2.

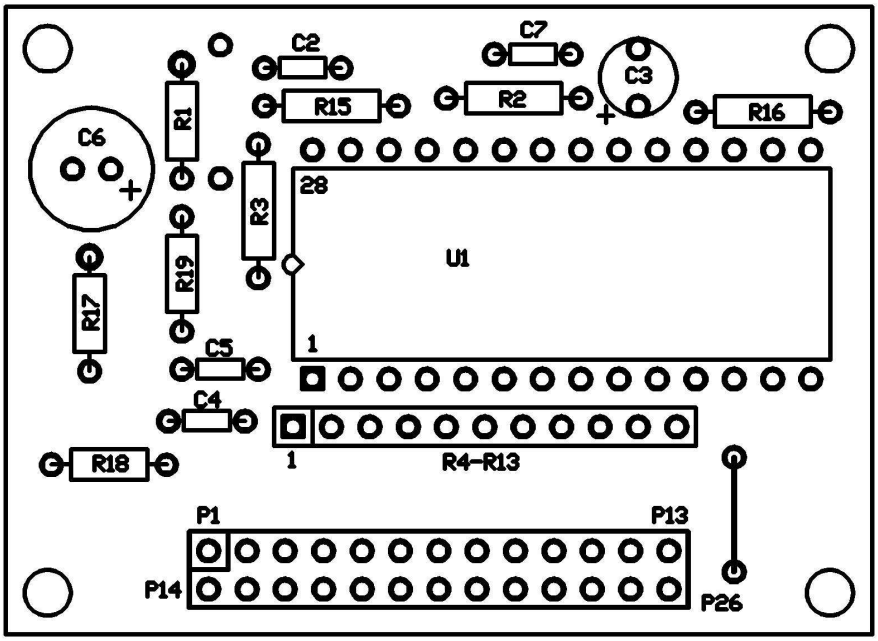

Fig.2. Component layout on PC board of MART-03 (Scale 2:1).

All applicable control and audio signals are connected to soldering points P1÷P26 located in two rows and spaced each other by 0.1" (2.54 mm) which enable to solder a 20-pin double-row connector or a wire harness. Leads of microphone shall be shielded and as short as possible.

PORTS OF MART-03 MODULE

All address signals, A0 through A9, and control signals, and $\overline{CE}$, PD, P/$\overline{R}$, $\overline{EOM}$, $\overline{OVF}$ and XCLK of ISD devices are of digital nature and may take one of two possible levels: L* or H*.

* Voltage of L-level (shortly: L level) means, in case of ISD devices, the voltage of 0÷0.8 V with respect to ground.
Voltage of H-level (shortly: H level) means, in case of ISD devices, the voltage of 2.4V÷Vcc with respect to ground, where Vcc – the supply voltage.
Hereinafter, an alternative notation will be used for specific address or control signal (input/output): *signal name* = L, *signal name* = H.

P1 - power supply +4.5 ÷ +5.5 V.

P2 - input of external clock signal XCLK. Refer to ISD Data Sheets as to how use this signal. If not used, connect this input to electrical ground.

P3 - input of PD signal used to switch over the system to operation (L-level voltage) or to standby (non-activity, Power Down mode), when consumed power is greatly reduced (H-level voltage). When module is switched over to Power Down, all ongoing operations are immediately interrupted and internal registers are cleared. **If a short H-level pulse is applied to this port, it causes total clearing of the system while audio memory remains unaffected.**

P4 - microphone input (-).

P5 - output to indicate a so called *overflow status* $\overline{\text{OVF}}$. The output goes to permanent L-level when memory end is reached during playback or record operations to indicate memory overflow. This may be used in cascade arrangements of ISD25xx devices.

P6 - address input A1.

P7 - address input A3.

P8 - address input A5.

P9 - address input A7.

P10 - address input A9.

P11 - not used.

P12 - not used.

P13 - ~~loud~~speaker output (+).

P14 - input for signal to record from external source.

P15 - input of $\overline{\text{P/R}}$ signal used to switch-over the operating mode : playback (H-level voltage) or record (L-level voltage).

P16 - output of end-of-message signal $\overline{\text{EOM}}$. When an internal end-of-message marker is detected, this output goes low for time period of 12.5, 15.6, 18.7 or 25 ms (depending on type of ISD device).

P17 microphone input (+).

P18 - input of $\overline{\text{CE}}$ triggering signal. Depending on $\overline{\text{P/R}}$ input status, this signal initiates either edge-activated (by a short L-level pulse) playback of entire message, or level-activated (by L-level signal) record operation. Playback is initiated by HL edge of this signal. Record is also initiated by HL edge and it continued as long as the port is kept low.

P19 - address input A0.
P20 - address input A2.
P21 - address input A4.
P22 - address input A6.
P23 - address input A8.
P24, P25 - power supply (-) (electric ground).
P26 - speaker output (-).

Note that audio signals at both speaker outputs are at DC voltage of about 1.5 V and are phase shifted each other by 180^{o}.
WARNING: Connection of speaker outputs (P13 and P26) both with each other and with electric ground may cause damage to the integrated circuit.

In Power Down mode (when PD=H) the current drawn from power source is dependent from voltage levels at address and control inputs. The ISD2560/75/90/120 devices draw for themselves about 1 μA typically.

DESCRIPTION OF OPERATION

A basic operating mode of the Module is the address mode which enables to record and to playback many independent audio signals of maximum total duration and frequency band of: (i) 60 s and 0.15÷3.4 kHz for ISD2560, (ii) 90 s and 0.15÷2.3 kHz for ISD2590, or (iii) 120 s and 0.15÷1.7 kHz for ISD25120 in successive cells of multilevel storage memory, divided into 600 addressable rows (identical number of rows in all ICs). This means that **maximum 600 independent messages may be recorded, each of duration time 0.1 / 0.125 / 0.15 / 0.2 s, respectively.** Actual number of messages and their duration depend on address selection within the memory address space. Addressing is made with a binary coding at ten (10) address inputs A0 ÷ A9 to the rule specified in Table 1 below. Binary digit 0 is equivalent to the L-level voltage while binary digit 1 – to H-level voltage.

Note that an address being specified always points out a memory row wherefrom specific operation is started. Further internal addressing of successive memory cells is made without any involvement of the user, via a so called Message Start Pointer (MSP), which is inaccessible from outside. At the start of record/playback cycle and after the reseting cycle (PD=H), the MSP pointer is set to the initial value corresponding to the specified address.

Longer messages will be automatically loaded into successive memory rows, as necessary, until the process is completed or memory end is reached. In the latter case, the system enters to the *overflow* status and fails to react to successive activations (this is indicated by L-level at $\overline{OVF}$ output). This status may be cancelled via reseting cycle (PD=H).

Table 1

Digital number of memory row	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	Start time of operation for ISD2560/75/90/120 [s]
0	0	0	0	0	0	0	0	0	0	0	0.0/0.000/0.00/0.0
1	0	0	0	0	0	0	0	0	0	1	0.1/0.125/0.15/0.2
2	0	0	0	0	0	0	0	0	1	0	0.2/0.25/0.30/0.4
...											
8	0	0	0	0	0	0	1	0	0	0	0.8/1.0/1.20/1.6
...											
16	0	0	0	0	0	1	0	0	0	0	1.6/2.0/2.40/3.2
...											
32	0	0	0	0	1	0	0	0	0	0	3.2/4.0/4.80/6.4
...											
64	0	0	0	1	0	0	0	0	0	0	6.4/8.0/9.60/12.8
...											
128	0	0	1	0	0	0	0	0	0	0	12.8/16.0/19.20/25.6
...											
256	0	1	0	0	0	0	0	0	0	0	25.6/32.0/38.40/51.2
...											
512	1	0	0	0	0	0	0	0	0	0	51.2/64.0/76.80/102.4
...											
598	1	0	0	1	0	1	0	1	1	0	59.8/74.75/89.7/119.6
599	1	0	0	1	0	1	0	1	1	1	59.9/74.875/89.85/ 119.8

Operation may also run without addressing (so called **Operational Modes)** where the initial address is always equivalent to the beginning of the system memory (00000000). In these modes the states at address inputs are not treated as address, but specify the type of the function being realized. These functions affect then internal addressing within the memory. The system is switched over into operational modes by providing H-level voltage to A8 and A9 address inputs (P18 and P9 ports). Individual modes, denoted by **Mx** symbols, are activated by applying H-level signals to specific address inputs as specified below:

M0 : (A0=H0) - message cueing (for playback only),

M1 : (A1=H) - deleting of internal end-of-message (EOM) marker (for record only),

M3 : (A3=H) - message looping during playback,

M4 : (A4=H) - consecutive addressing; retaining current value of MSP when starting specific operation,

$\overline{}$

M5 : (A5=H) - playback being level-activated at CE input,

M6 : (A6=H) - a so called push-button mode enabling various functionalities including, to name a few, pulse control of record and playback operations (this mode is detailed further on).

Combinations of operational modes may also be used to effect various functions of the module.

All address and control inputs on PC board are biased at the H-level. These inputs may be driven to L-level by applying external signal at L-level, e.g. by connecting to electric ground (current consumption at these inputs may be neglected).

Before starting with recording and playing back, external components shall be connected to the ports P1÷P26 as shown in Fig.1. These are as follows:

- power supply unit (battery, power pack);
- electret microphone providing signal voltage c. 20 mVpp;
- speaker, 16 Ω;
- push-button and selectors referred to in the diagram as START, ACTIVE/POWER DOWN and PLAYBACK/RECORD.

The diagram does not provide all possible means for controlling ISD25xx devices. In particular, record or playback may be initiated by means of external control signals of specified levels (instead of push-buttons). Furthermore, signals from speaker outputs may be applied to audio amplifier input so as to get higher output power.

It was assumed, in descriptions of individual functions hereinafter, that **the initial status of the system is the Power Down** , when PD = H.

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ADDRESSABLE RECORD OF MESSAGES**

This function enables to record independent messages under various addresses. The total recording time must not exceed 60 s / 75 s / 90 s / 120 s respectively to the device used.

1. Record triggered with $\overline{CE}$ signal.

- Apply address as per Table 1 to the address inputs A0 ÷ A7 (record shall start from the memory row of this address).
- Apply L-level voltage to the P/$\overline{R}$ input, e.g. connect P15 with electric ground via PLAYBACK/RECORD selector switch. This causes the system to switch over to record mode.
- Activate the system by applying L-level voltage to PD input, e.g. by connecting P3 to electric ground via ACTIVE/POWER DOWN selector switch.
- Apply L-level voltage to CE input (port P18), e.g. connect P18 with electric ground via START push-button, to start with recording.
- Record message using microphone connected to ports P17 and P4. Record is initiated with HL edge of $\overline{CE}$ signal and lasts until the end of L-level of this signal (LH edge). At the same time, the end of record is marked out with an internal marker EOM. Record terminates also when: (i) during record operation, the system is driven to the Power Down (PD = H), or (ii) memory end is reached (*overflow*), the latter case being indicated by L-level voltage at $\overline{OVF}$ output.
- Apply successive address to the address inputs to record the next message and repeat the operation. Pay attention for the messages do not overlap one another within the address space of the system as it will cause disturbances during playback (overlapped messages will be seen as the single message and the message recorded later on will cancel the previous one within their common portion).

** Observe the order of specified actions. Especially, the address line and P / $\overline{R}$ voltages shall be stabilised before the signals are applied to the control inputs PD and $\overline{CE}$.

2. Record triggered by system activation at PD input.

- Bias the address inputs and P/ $\overline{R}$ input as above.
- Apply L-level voltage to $\overline{CE}$ input.
- Apply L-level voltage to PD input to start with recording.
- Record the message as outlined above. Record is initiated by HL edge of PD signal and continues as long as this signal is kept low. Record is terminated by LH edge which switch over the system to the Power Down. Record is also interrupted when H-level is applied to $\overline{CE}$ input or when the end of memory is reached (*overflow*).
- It is also possible to record audio signal applied to ANA IN input from external source, e.g. tape recorder, tuner, generator, computer sound card, etc., via P14 port. Under such conditions, the microphone circuit may be omitted.

EDGE-ACTIVATED ADDRESSABLE PLAYBACK OF MESSAGES

Independent messages having been recorded in various but known addresses may be played back in two ways. To effect them proceed as follows:

- Apply the message address to address inputs A0 ÷ A9 (playback will start from the memory row of this address).
- Apply H-level voltage to P / $\overline{R}$ input to cause switching over to playback mode.
- Activate the system by applying L-level voltage to PD input.
- Apply, to $\overline{CE}$ input, a short L-level triggering pulse, its duration being less than that of the message to be played back, however not less than 100 ns (e.g. by momentary connection of P18 port to electric ground using START push-button). Playback is initiated by HL edge. The message will be played back entirely, i.e. until the end-of-message (EOM) marker is detected. Obviously, playing back may be at any moment interrupted by driving the system to Power Down mode. Please however note that if the triggering pulse is of prolonged time period, the EOMs detected during its duration, i.e. when $\overline{CE}$=L, are ignored. Under such situation, the system shall continue playing back until the first EOM marker detected after terminating the triggering pulse.

ADDRESSABLE PLAYBACK OF MESSAGES TRIGGERED BY ACTIVATING THE SYSTEM (LEVEL-ACTIVATION AT PD INPUT)

- Apply message address to address inputs.
- Apply H-level voltage to P / $\overline{R}$ input and L-level voltage to $\overline{CE}$ input.
- Applying L-level to PD input caused playback to start (initiation is made by HL edge) which is continued until the input is kept low and is terminated when H-level is restored (LH edge) or when memory is exhausted. As long as PD=L (while $\overline{CE}$ = L), the end-of-message markers are ignored and the system is playing back the memory contents continuously starting from the row of specified address.

Note that in each playback method, if message end is reached, i.e. when EOM marker is detected, the L-level pulse with the duration of 12.5, 15.6, 18.7 or 25 ms (depending on type of ISD device) is generated at $\overline{EOM}$ output (P16 port). Should memory end is reached and overflow status entered, a continuous L-level appears at $\overline{OVF}$ output (P5 port, that is normally high), which remains until system reset. When the system is in overflow status, it does not react to renewed triggering.

OPERATIONAL MODES (ADDRESSLESS)

1. Message looping

This mode enables continuous playing back a single message recorded from the beginning of memory. This operation is level-activated at $\overline{CE}$ input.

- Apply L-level voltage to all address inputs.
- Record one message which may fill in full memory.
- Apply H-level voltage to address inputs A8 and A9, which causes the system to be switched over to operational modes.
- Apply H-level voltage to address input A3.
- Apply L-level voltage to PD input.
- Start playback operation by applying L-level voltage to $\overline{CE}$ input. The message having been recorded will be played back continuously as long as the CE input is kept low when the end-of-message is encountered. Playback is immediately interrupted when the system is driven to Power Down mode (PD=H).

2. Consecutive recording

This mode enables to record many messages one after another with no need to address each of them. There are two methods of such record as outlined below.

Consecutive record by message linking method

Messages are recorded consecutively from the beginning of memory; they compose an entirety which, when played back, is treated as a single record.

- Apply H-level voltage to address inputs A1, A4, A8 and A9; the remaining address inputs, P /R and PD to be kept low.
- Record the first message by applying L-level voltage to the input $\overline{CE}$. Terminate the record by returning H-level voltage at this input.
- While keeping the state of address inputs, use the same method to record the second message and possibly the successive ones.

Consecutive record by message separating method

Messages are recorded one after the other from the beginning of memory, each successive message having been recorded immediately after the previous one. Messages are independent each other which, in effect, is similar to the addressable record, but in this case the addresses of individual messages are unknown.

- Apply H-level voltage to the address inputs A4, A8 and A9 and L-level voltage to the remaining address inputs, P / $\overline{R}$ and PD
- Record consecutive messages as outlined above.

3. Playing back messages which were recorded consecutively

Method I –normal playback

With this method, the pointer MSP is cleared which causes that each new playback operation commences from the memory beginning.

a) activation via PD input

- Apply H-level voltage to address inputs A8 and A9 and L-level voltage to the remaining address inputs.
- Apply H-level to P / $\overline{R}$ input and then the L-level to $\overline{CE}$ input.

- Playback will start upon applying L-level to PD input. Independently of the consecutive record method used, playback will start as in the addressed method activated by PD signal for the message with the initial address of 0000000000.

b) signal edge activation

- Bias the address inputs and P / $\overline{R}$ input as in previous case.
- Apply L-level to PD input.
- Apply activating L-level pulse to $\overline{CE}$ input. In case of messages which have been recorded by means of link method, they all will be played back one after the other as a single entirety. In case of messages which have been recorded by separation method, just the first on will be played back as in the addressable edge-activated method for the message with address of 0000000000.

c) signal level activation

- Apply H-level voltage to address inputs A5, A8 and A9 and L-level voltage to the remaining address inputs.
- Apply H-level to P / $\overline{R}$ input and then L-level to PD input.
- Start playing back by applying L-level to $\overline{CE}$ input. Playback will start from the beginning of memory and will be continued, independently of the consecutive record method used, as long as $\overline{CE}$ = L (all EOM markers will be ignored) or until the end of memory.

Method II – consecutive playback

With this playing back mode, there is no clearing of the message pointer MSP, so it is possible to memorise current location in memory and to playback its full content.

a) activation via PD input

- Apply H-level voltage to the address inputs A4, A8 and A9 and L-level voltage to the remaining address inputs.
- Apply H-level to P / $\overline{R}$ input and then L-level to $\overline{CE}$ input.
- System is activated by driving PD input low. Independently of the consecutive record method used, playback will proceed like in addressable mode activated via PD signal for the message with starting address of 0000000000.

As it results from the description, playback in this case is identical to that of Method I.

b) edge-activation

- Bias the address inputs and P / $\overline{R}$ input as in previous case.
- Apply L-level to PD input.
- Apply activating L-level pulse to CE input. All messages having been recorded with link method will be played back continuously as an entirety. However in case of messages having been recorded with separation method, each successive activation pulse will cause the consecutive message to be played back to its end (until detecting EOM marker). Repeating this procedure, you may playback consecutive independent messages without knowing their addresses – until the end of memory.

c) level-activation

- Apply H-level voltage to the address inputs A4, A8 and A9 and L-level voltage to the remaining address inputs.
- Apply H-level to P / $\overline{R}$ input and then L-level to PD input.
- Start playback by driving $\overline{CE}$ input low. Playback will start from the beginning of memory independently of the consecutive record method and it will proceed as long as $\overline{CE}$ = L (EOM markers detected will be ignored). Playback will be stopped by LH edge of $\overline{CE}$ signal. When the operation is restarted, it will be continued from the point it was interrupted. Repeating this procedure, you may playback consecutive independent messages until the end of memory.

4. Message cueing

This function enables to find out any message (among others being recorded with addressing method or with consecutive recording with message separating) without specifying its address. To use this function we need to know the successive number of the message being searched for.

- Apply H-level voltage to the address inputs A0, A4, A8 and A9, and L-level voltage to the remaining address inputs.
- Apply H-level to P / $\overline{R}$ input and then L-level to PD input.
- Apply shifting pulses of L-level and duration 100 ns ÷ 10 μs to $\overline{CE}$ input. Each such pulse induces “a jump” to the next message forward (without playing back) and indication of the next message.
- Apply L-level voltage to A0 input (cueing procedure completion).
- Playback the indicated message by applying L-level activating pulse to $\overline{CE}$ input.
- Consecutive activating pulses will cause playing back successive messages.

- When cueing is restarting (application of H-level to A0 input) will resume the above process from the point of the last played back message on.

5. Push-button mode

For this mode, control signals at $\overline{CE}$, PD inputs and at $\overline{EOM}$ output provide different actions enabling simple implementing additional functions.

- The $\overline{CE}$ inputs provides a START/PAUSE type function initiated with activating pulse like for other operating modes. This functions is operable both in record and in playback mode (depending on how is the level of P / $\overline{R}$ input). An operation initiates with HL edge of this pulse (START) and continues until one of the following situation occur: (i) a successive pulse is applied to this input (operation is then suspended – PAUSE), (ii) end-of-message marker (EOM) is detected (for playback only); (iii) end of memory is reached, or (iv) the system is cleared. For the time period when the function is underway, the MSP pointer is not cleared (except situation when PD=H), so the next activating pulse causes the specific operation to be resumed from the point it was suspended. Thus, successive pulses at $\overline{CE}$ input will alternately resume and suspend the operation being executed.
- The PD input performs RESET function when the input is high. It operates both for record and playback operation. Unlike in the remaining modes, LH edge of this signal causes just immediate termination of the operation underway and clearing the MSP pointer. In M6 mode, ISD25xx devices goes to the Power Down mode automatically upon terminating a specific operation while current value of MSP pointer is not cleared. This would enable to start the next operation from the successive memory row.
- The EOM output operates as an indicator of record /playback operation currently active. If the process is underway, the output is high while in Power Down it is low. This enable to indicated, e.g. by means of LED, when a specific operation is started or suspended.

If, during playing back, the system enters into overflow status, then consecutive activating pulse at $\overline{CE}$ will cause the MSP pointer to be reset and the playback to be restarted from the beginning.

Consecutive record with message separating method in push-button mode

- Apply H-level voltage to the address inputs A6, A8 and A9, and L-level voltage to the remaining address inputs, P / $\overline{R}$ and PD.
- Apply activating pulse to $\overline{CE}$ input. This will start message recording and the EOM output goes high to indicate that the operation is underway.
- Apply consecutive activating pulse to $\overline{CE}$. Record is suspended, the message is marked out with EOM and $\overline{EOM}$ output returns low. The MSP pointer shall not be reset. At this state, the system may be switched over to playback mode (P / $\overline{R}$ = H) to run playback from the memory beginning.
- Apply consecutive activating pulse to CE. Record will be resumed from the point of previous stoppage. By repeating this procedure, you may make consecutive records until the system is reset or memory is exhausted.

If, before starting with recording, the A1 address input is set to high, consecutive records are possible with message linking method.

Playback in push-button mode

- Apply H-level voltage to the address inputs A6, A8 and A9, and L-level voltage to the remaining address inputs.
- Apply H-level to P / $\overline{R}$ input and L-level to PD input.
- Apply activating pulse to $\overline{CE}$ input. This causes the messages to be played back from the beginning of memory and $\overline{EOM}$ output goes high.
- Consecutive activating pulse at $\overline{CE}$, or detection of end-of-message EOM marker would cause the playback to be stopped without resetting MSP pointer, and $\overline{EOM}$ output to go low. In this state, it is possible to switch over the system to record mode (P / $\overline{R}$ = L) and to record from the point where the playback was stopped.
- Consecutive activating pulse at CE will cause the playback to be resumed from the point of previous stoppage. When repeating this procedure we may run successive partial playbacks until the system is reset (PD=H) or until memory end is reached. Should the systems enters to overflow status, activating pulse applied to CE (with PD=L) would cause the MSM pointer to be reset and the playback to start from the beginning.

Note: The M6 push-button mode may be used together with M0, M1 and M3 modes.

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BASIC TECHNICAL DATA OF MART-03 MODULE

- Power supply: +4.5 ÷ 5.5 V.
- Recording time/frequency band: 60 s / 3.4 kHz (for ISD2560), 75 s / 2.7 kHz (for ISD2575), 90 s / 2.3 kHz (for ISD2590) or 120 s / 1.7 kHz (for ISD25120).
- Message retention: 100 years – non-volatile message storage without power supply.
- Acoustic power: 12 mW at speaker resistance of 16 Ω.
- Recording signal voltage from external source: max. 50 mVpp.
- Microphone inputs adapted to connect any electret microphone providing output signal about 20 mVpp.

The MART-03 Module enables also many other functions which are derivatives of those outlined above. It is up to user's invention how they will be exercised.