sames

SAN3010
APPLICATION NOTE

SINGLE CHIP TELEPHONE INTERFACE FOR KEYBOARD ENTRY VIA uC

1 Scope

This application note describes a simple interface for keyboard entry to the SA253x family via a Microcontroller. It also includes hardware description , flowchart and a software example based on the 80Cxx - family of Microcontrollers.

2 Key Features

- only 5 outputs and 1 input required from µC for handshake to access all keys in the SA253x keyboard matrix
- universal interface, not restricted to specific Microcontrollers
- supports both 3V- and 5V- µCs
- same hardware for all single chip telephones : SA2531/2
- same software for all single chip telephones, only key labels must be replaced

Table of Contents

3 Other applicable documents and papers

1. Data Sheet SA2531, SA2532
2. Pin-out Comparison SA2531/2
3. Product Presentation
4. Single Chip Telephone Evolution (Apr. 16, 1996)

4 Revision status

SAN3010 Application Note (this document):
AN3010 Schematic: Rev.: A02
AN3010 Sample Software Rev.: A01

5 General Description

The interface must be capable of forcing the keyboard rows (hereafter indicated as R1...R4) both low (Vss) and high (V_{DD}) and forcing the keyboard columns (hereafter indicated as C1...C4) to high (V_{DD}). Only one row or column is forced at the same time while the remaining rows/columns must be high ohmic (hereafter indicated as Hi Z). Since only one row/column must be driven at the same time, a decoder (IC5 = 74138) was implemented to save pin count of the µC. 3 output ports were used for row/column selection, 1 output port to disable all rows/columns and 1 output port for the 3-state buffer inputs to select forcing high or low .
One µC pin must be configured as input for handshake.
If 9 output + 1 input pins are available from the µC (8 row/column selectors, 1 force hi/lo selector , 1 handshake input) , IC5 = 74138 can be omitted.
IC3 & 4 (=74HC125) are separately addressable 3-state buffers.
A simple discrete NOR gate (Q1,D2,D3,R9..11) is used for synchronization.

6 Hardware configuration

The SA253x Single Chip Telephone can be connected to a µC for key entry when the following conditions are met:

Supply voltage: The SA253x works at 4V V_{DD}, its high/low input levels are 30/70% V_{DD}.
If the µC is supplied with >4V a current limiter (serial resistor) must be added to the row/column pins of the SA253x.
If the µC supply is <4V it must provide adequate high level (> 70%V_{DD} of SA253x = >2.8V)

Row driver : 4 Tristate output pins, each separately adjustable as either output (Hi/Lo) or tristate . Only one row is driven at the same time, all other rows/columns are high ohmic.

Column driver: Tristate output pins, each separately adjustable as either output (Hi) or tristate. Only one column is driven at the same time, all other rows/columns are high ohmic.

Synchronization: The SA253x is intentionally designed for low standby power, so no oscillator is running as long as no key is pressed. All the external row/column driving is done asynchronously. The scanning sequence is synchronized by triggering a rising edge on specific columns (see table 1).
Therefore a 1-bit input must be provided for the synchronization.

7 Application schematic:

See also: Appendix A:
One solution which only requires 5 output pins and 1 input pin is shown in the attached schematic. A common µC (80C51-family) is used. This controller is widely known, so both hardware and software description in this application note should be easily understood which simplifies adaption to any other controller.

The rows/columns are driven by 8 separately selectable tristate buffers (e.g. 74HC125). Power supply is 5V, therefore resistors R2...R8 are necessary to provide adaption to the 4V-logic of the SA253x.
R1 is always connected by a 5kOhms resistor to prevent collision of two outputs when it initiates the key entry in an unsynchronous state.

Since only one row/column is forced high or low at the same time the number of µC output port pins can be limited by using a 1-of-8 decoder (74HC138). The 3 bits (A,B,C, respectively Port1 pins 0..2) select the appropriate row/column, Port 1.4 disables all outputs.
The selected row/column is forced high or low depending on the state of Port1.5 .
Port 1.7 is used as input to detect the acknowledge of the SA253x during the scanning phase. Acknowledge is done by the rising edge of either C1,C2,C3 or C4.
The detection logic can be simplified by just monitoring C1 and C2, because one of both can always be used for detection (see table 1, ColY).
Diode D1 is necessary to prevent collision of two outputs when Port1 is in output mode. Since Port1 of the 80C31 is an open-drain output a diode can be used. For other controllers, using standard I/O, a resistor must be used in place of the diode.

8 Scanning table/flowchart

See also: Appendix B:

The interfacing procedure is shown in the attached flowchart, additional information is given below:

1) Key entry can only occur, when the SA253x has been off-hook for >20ms.

2) Internal key scanning of the SA253x is started when any Row (in our case: R1) has been forced low, then the acknowledge by the SA253x is done by moving specific col-pins high.

3) When this Lo/Hi transition is detected by the µC the asynchronous timing must be started.

4) SCAN1 and SCAN 2 are the time slots at which a certain row must be forced high (SCAN1) and forced low (SCAN 2) , at time slot SCAN3 a certain column must be forced high. The key entry corresponding Row and Column is shown in table 1. Between the SCAN1..3 time slots all rows and columns must be high ohmic (see flowchart).

5) a valid key entry is accepted, when the SCAN1..3 procedure has been repeated 9 times.

6) a certain constant delay must be added between key entries. The only exception is, when memory keys are cascaded. In this special case, entering a subsequent memory key is only accepted, when the previous memory has been fully dialed out.

9 Sample software

See also: Appendix C:

Attached is a sample software program, written in 8051 Assembler language which incorporates all the necessary timing and correct row/column selection. The only entry is to load the accumulator with a key code and then make a subroutine call.
See Table 1 for appropriate key codes when using either SA2531-2
The assembler command lines are well described, so it should be easily understood.

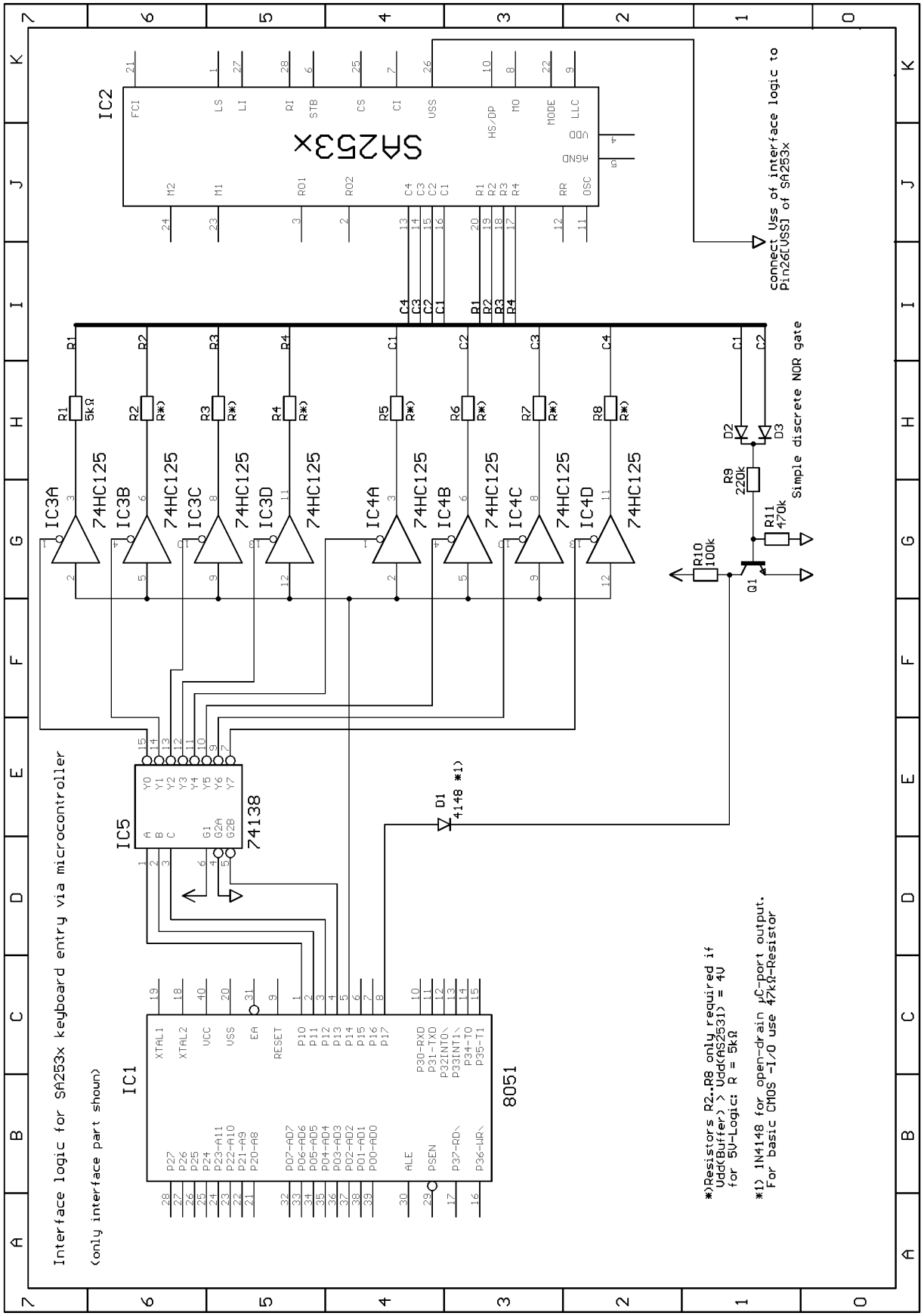
Again, adaption to other controllers based upon this software should be no problem.
Care must be taken when using a different system clock speed. In this case the delay blocks must be recalculated based on the number of machine cycles used.

10 Key entry signal table:

Keycode in S/W example	Key - ID. **SA2531**	Key - ID. **SA2532**	SCAN 1 Row X force Hi	SCAN 2 Row X force Lo	SCAN 3 Col X force Hi	Synchronization on Col Y:
0	Mute	Mute	R1	R1	C1	C2,3,4
1	1	1	R1	R1	C2	C1,3,4
2	2	2	R1	R1	C3	C1,2,4
3	3	3	R1	R1	C4	C1,2,3
4	4	4	R2	R2	C1	C2,3,4
5	5	5	R2	R2	C2	C1,3,4
6	6	6	R2	R2	C3	C1,2,4
7	7	7	R2	R2	C4	C1,2,3
8	8	8	R3	R3	C1	C2,3,4
9	9	9	R3	R3	C2	C1,3,4
10	0	0	R3	R3	C3	C1,2,4
11	*	*	R3	R3	C4	C1,2,3
12	#	#	R4	R4	C1	C2,3,4
13	Pause	Pause	R4	R4	C2	C1,3,4
14	R	R	R4	R4	C3	C1,2,4
15	R2	R2	R4	R4	C4	C1,2,3
16	LNR	LNR	none	R1	C1	C2,3,4
17	VOL		none	R1	C2	C1,3,4
18	VOL +		none	R1	C3	C1,2,4
19	VOL -		none	R1	C4	C1,2,3
20	Enter		none	R2	C1	C2,3,4
21	M5		none	R2	C2	C1,3,4
22	M6		none	R2	C3	C1,2,4
23	M7		none	R2	C4	C1,2,3
24	M8		none	R3	C1	C2,3,4
25	M9		none	R3	C2	C1,3,4
26	M10		none	R3	C3	C1,2,4
27	M1		none	R3	C4	C1,2,3
28	M2		none	R4	C1	C2,3,4
29	M3		none	R4	C2	C1,3,4
30	M4		none	R4	C3	C1,2,4
31	Mem		none	R4	C4	C1,2,3

Table 1: key entry lookup table

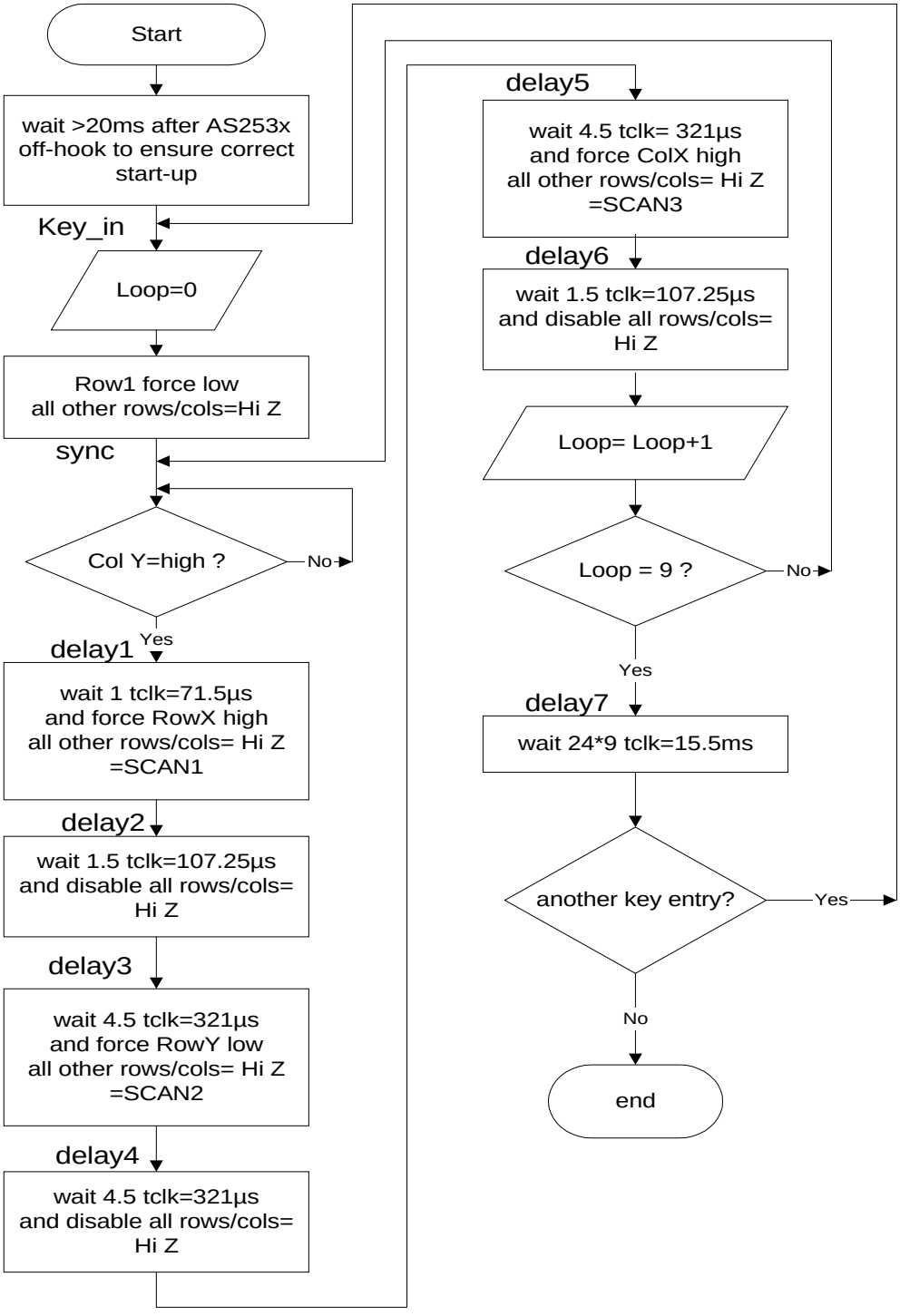
11 Appendix A: Application Schematic



12 Appendix B: Flowchart:

Flowchart for Microcontroller interface to AS253x single-chip-telephone

Notes: RowX,ColX,ColY: see table1
1 tclk= 256/3.58MHz = 71.5µs
all timings: Tol.:+-30µs



13 Appendix C: Sample Software listing

```
MCS-51 MACRO ASSEMBLER    KEY
09/09/96   PAGE    1
LOC  OBJ            LINE     SOURCE
                       1     ; (c) Austria Mikro Systeme International AG AMS
                       2     ; J.Janisch  / telecom applications
                       3     ; Program name:         KEY.ASM
                       4     ; Version:              A01
                       5     ; Date:                 1996-09-09
                       6     ; Author:               J.Janisch / Telecom Applications
                       7     ;
                       8     ; User program for 8051 interface to SA253x for key entry via
                       9     ;  microcontroller
                      10     ; Application Note AN3010
                      11     ; Program code is at Address 4000 HEX
                      12     ;
                      13     ; Reference for calculations:
                      14     ; Clock Frequency of Microcontroller (80C31) = 11.0592 MHz
                      15     ;       --> 1 machine cycle = 12 clock cycles = 1.085 us
                      16     ;
                      17     ; Decoder Logic:
                      18     ; Port1:
                      19     ; P1.7 : active low input; detects rising edge of C1 OR C2
                      20     ;        should be set high by any output command to port 1
                      21     ; P1.6 : not used
                      22     ; P1.5 : not used
                      23     ; P1.4 : forces selected row/column high or low
                      24     ; P1.3 : when high, disables all rows/columns (high Z)
                      25     ; P1.2 : row / column selector  MSB
                      26     ; P1.1 : row / column selector
                      27     ; P1.0 : row / column selector  LSB
                      28     ;
                      29     ;       P1.2 P1.1 P1.0    select:
                      30     ;        0    0    0     row 1
                      31     ;        0    0    1     row 2
                      32     ;        0    1    0     row 3
                      33     ;        0    1    1     row 4
                      34     ;        1    0    0     column 1
                      35     ;        1    0    1     column 2
                      36     ;        1    1    0     column 3
                      37     ;        1    1    1     column 4
                      38     ;
                      39
                      40
  0000                41     Row1    equ     0
  0001                42     Row2    equ     1
  0002                43     Row3    equ     2
  0003                44     Row4    equ     3
  0004                45     Col1    equ     4
  0005                46     Col2    equ     5
  0006                47     Col3    equ     6
  0007                48     Col4    equ     7
  0090                49     ForceHi equ     90H
  0080                50     ForceLo equ     80H
```

```
PAGE    2
LOC  OBJ            LINE     SOURCE
  0088                51     Disable equ     88H
                      52
                      53     ; ###########################################################
                      54     ; Main program: load Accumulator with key code (see below) and
                      55     ;               call subroutine "Key_In"
                      56
4000                  57             Org     04000H          ; set start address of program
4000 758160           58             mov     SP,#060H        ; set stack pointer
4003 00               59     HS_OK:  NOP                     ; make sure that at this point
                      60                                     ; the SA253x has been off-hook
                      61                                     ; for >20ms
4004 740A             62     Ld_Key: mov     a,#10           ; load keycode, here key "0"
4006 12400B           63             Call    Key_in          ; execute keystroke
4009 80FE             64             jmp     $               ; end of main program, exit at
                      65                                     ; this point or continue with
                      66                                     ; next key entry
                      67                                   ; rem.: add additional delay when
                      68                                   ; cascading memories (s. Delay7:)
                      69     ; ###########################################################
                      70     ; ***********************************************************
                      71     ; Subroutine Key_in
                      72     ; ***********************************************************
                      73     ; this subroutine executes a key entry to the SA253x
                      74     ; the corresponding key code(0...31) must be loaded in the accu
                      75     ; see table at label:"scantbl"  for key codes
                      76     ; affected Registers:
                      77     ;       A,B,R1,R2,R3,R5,R6,R7,DPTR
                      78
                      79
                      80
400B 12405C           81     Key_in: call    getScTb       ; preload Reg5..7 with scan table
                      82                                     ; Row X: variable in Reg5
                      83                                     ; Row Y: variable in Reg6
                      84                                     ; Col X: variable in Reg7
                      85
400E 7B00             86     Exe_Key:mov     R3,#0           ; clear loop counter
4010 7480             87             mov     a,#ForceLO      ; force R1 low
4012 F590             88             mov     P1,A
4014 3097FD           89     sync:   jnb     P1.7, $         ; make sure, C1= C2 = low
4017 2097FD           90             jb      P1.7, $         ; wait for rising edge C1 or C2
                      91                                     ; = trigger for asynch. timing
                      92
                      93     ;- Delay 1:wait 71.5 us = 66 machine cycles and force RowX high
401A 791F             94     delay1: mov     R1,#31          ; 1 cycle
401C D9FE             95             djnz    R1,$            ; 2 cycles; #Loops=(66-4)/2 =31
                      96
401E 7490             97     SCAN1:  mov     A,#ForceHi      ; 1 cycle
4020 4D               98             orl     A,R5            ; 1 cycle
4021 F590             99             mov     P1,A            ; 1 cycle
                     100
                     101     ;-------------------------------------------------------------
                     102     ;Delay2:wait 107.25us= 99 machine cycles +disable all rows/cols
4023 7930            103     delay2: mov     R1,#48          ; 1 cycle
4025 D9FE            104             djnz    R1,$            ; 2 cycles; #Loops =(99-3)/2 = 48
4027 7488            105             mov     A,#Disable      ; 1 cycle
```

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PAGE    3
LOC  OBJ            LINE     SOURCE
4029 F590            106             mov     P1,A            ; 1 cycle
                     107
                     108     ;-------------------------------------------------------------
                     109     ;-- Delay 3:wait 321 us = 295 machine cycles and force RowY low
402B 7991            110     delay3: mov     R1,#145         ; 1 cycle
402D D9FE            111             djnz    R1,$            ; 2 cycles;#Loops=(295-5)/2=145
                     112
402F 00              113     SCAN2:  NOP                     ; 1 cycle
4030 7480            114             mov     A,#ForceLO      ; 1 cycle
4032 4E              115             orl     A,R6            ; 1 cycle
4033 F590            116             mov     P1,A            ; 1 cycle
                     117
                     118     ;-------------------------------------------------------------
                     119     ;Delay 4: wait 321us= 295 machine cycles +disable all rows/cols
4035 7992            120     delay4: mov     R1,#146         ; 1 cycle
4037 D9FE            121             djnz    R1,$            ; 2 cycles;#Loops=(295-3)/2=146
4039 7488            122             mov     A,#Disable      ; 1 cycle
403B F590            123             mov     P1,A            ; 1 cycle
                     124
                     125     ;-------------------------------------------------------------
                     126     ;--- Delay 5:wait 321 us = 295 machine cycles + force ColX high
403D 7991            127     delay5: mov     R1,#145         ; 1 cycle
403F D9FE            128             djnz    R1,$            ; 2 cycles;#Loops=(295-5)/2=145
                     129
4041 00              130     SCAN3:  NOP                     ; 1 cycle
4042 7490            131             mov     A,#ForceHi      ; 1 cycle
4044 4F              132             orl     A,R7            ; 1 cycle
4045 F590            133             mov     P1,A            ; 1 cycle
                     134     ;-------------------------------------------------------------
                     135     ;Delay 6:wait 107.25us=99 machine cycles +disable all rows/cols
4047 7930            136     delay6: mov     R1,#48          ; 1 cycle
4049 D9FE            137             djnz    R1,$            ; 2 cycles;#Loops=(99-3)/2 = 48
404B 7488            138             mov     A,#Disable      ; 1 cycle
404D F590            139             mov     P1,A            ; 1 cycle
                     140
                     141     ;-------------------------------------------------------------
404F 0B              142             inc     R3              ; increment loop counter
4050 BB09C1          143             cjne    R3,#9,Sync      ; repeat loop 9 times
                     144
                     145
                     146     ;----- Delay 7:  wait >15444 us = 14233 machine cycles before
                     147     ;-----           next key entry
                     148     ;----- Remark:  when cascading memory keys (M1...M10, Mem)
                     149     ;----- dialling of a subsequent stored number is only accepted
                     150     ;----- when the previous number has been fully dialled out.
                     151     ;----- Example1: key entry is  "M1","M2"
                     152     ;-----       M2 is only detected when M1 has completed dialing
                     153     ;-----       its stored number, a delay has to be added between
                     154     ;-----           key entries
                     155     ;----- Example2: key entry is  "M1","0"
                     156     ;----        numbers are stored in FIFO ,so they can be entered
                     157     ;-----       immediately after a Memory entry, no additional
                     158     ;-----       delay necessary
4053 7900            159     delay7: mov     R1,#0           ;
4055 7A1C            160             mov     R2,#28
```

```
PAGE    4
LOC  OBJ            LINE     SOURCE
4057 D9FE            161     Del7a:  djnz    R1,$            ; =256*2 machine cycles
4059 DAFC            162             djnz    R2,Del7a        ; =2 machine cycles
                     163                                     ; 28*(256*2+2)=14392mc's=15.6ms
                     164
405B 22              165             ret                     ; return from subroutine
                     166
                     167
                     168     ;***************************************************************
                     169     ; Subroutine GetScTb
                     170     ;***************************************************************
                     171     ; this subroutine loads the Reg5..Reg7 registers according to
                     172     ; the keycode passed by the accumulator contents.
                     173     ; valid keycodes are  0.....31 (dec) = 0....1F (Hex)
                     174
                     175
405C 904074          176     GetScTb:mov    dptr,#Scantbl    ; calculate offset Address:
405F 75F003          177             mov     B,#3            ; scantable startaddress
4062 A4              178             mul     AB              ;      + (keycode *3)
4063 F5F0            179             mov     B,A             ; save offset address
                     180
4065 93              181             movc    A,@A+DPTR       ; get scan table: Row X
4066 FD              182             mov     R5,A            ; RowX
                     183
4067 E5F0            184             mov     A,B
4069 04              185             inc     A               ; get next code
406A F5F0            186             mov     B,A             ; save
406C 93              187             movc    A,@A+DPTR       ; get scan table: Row X
406D FE              188             mov     R6,A            ; RowY
                     189
406E E5F0            190             mov     A,B
4070 04              191             inc     A               ; get next code
4071 93              192             movc    A,@A+DPTR       ; get scan table: Row X
4072 FF              193             mov     R7,A            ; ColX
                     194
4073 22              195             ret
                     196
                     197     ; Scan table: the three constants indicate the rows/columns
                     198     ;             to be driven in the SCAN1....SCAN3 phase
                     199     ;
4074 00              200     Scantbl:db      Row1,Row1,Col1    ;   key "Pgm/Mt, keycode= 0
4075 00
4076 04
4077 00              201             db      Row1,Row1,Col2    ;   key "1"    , keycode= 1
4078 00
4079 05
407A 00              202             db      Row1,Row1,Col3    ;   key "2"    , keycode= 2
407B 00
407C 06
407D 00              203             db      Row1,Row1,Col4    ;   key "3"    , keycode= 3
407E 00
407F 07
4080 01              204             db      Row2,Row2,Col1    ;   key "4"    , keycode= 4
4081 01
4082 04
4083 01              205             db      Row2,Row2,Col2    ;   key "5"    , keycode= 5
```

```
PAGE    5
LOC  OBJ            LINE     SOURCE
4084 01
4085 05
4086 01              206            db      Row2,Row2,Col3    ;   key "6"    , keycode= 6
4087 01
4088 06
4089 01              207            db      Row2,Row2,Col4    ;   key "7"    , keycode= 7
408A 01
408B 07
408C 02              208            db      Row3,Row3,Col1    ;   key "8"    , keycode= 8
408D 02
408E 04
408F 02              209            db      Row3,Row3,Col2    ;   key "9"    , keycode= 9
4090 02
4091 05
4092 02              210            db      Row3,Row3,Col3    ;   key "0"    , keycode= 10
4093 02
4094 06
4095 02              211            db      Row3,Row3,Col4    ;   key "*"    , keycode= 11
4096 02
4097 07
4098 03              212            db      Row4,Row4,Col1    ;   key "#"    , keycode= 12
4099 03
409A 04
409B 03              213            db      Row4,Row4,Col2    ;   key "PS,R1", keycode= 13
409C 03
409D 05
409E 03              214            db      Row4,Row4,Col3    ;   key "R,R2" , keycode= 14
409F 03
40A0 06
40A1 03              215            db      Row4,Row4,Col4    ;   key "R2,R3 , keycode= 15
40A2 03
40A3 07
40A4 88              216            db      disable,Row1,Col1 ;   key "LNR"  , keycode= 16
40A5 00
40A6 04
40A7 88              217            db      disable,Row1,Col2 ;   key "Vol"  , keycode= 17
40A8 00
40A9 05
40AA 88              218            db      disable,Row1,Col3 ;   key "Vol+" , keycode= 18
40AB 00
40AC 06
40AD 88              219            db      disable,Row1,Col4 ;   key "Vol-" , keycode= 19
40AE 00
40AF 07
40B0 88              220            db      disable,Row2,Col1 ;               keycode= 20
40B1 01
40B2 04
40B3 88              221            db      disable,Row2,Col2 ;               keycode= 21
40B4 01
40B5 05
40B6 88              222            db      disable,Row2,Col3 ;               keycode= 22
40B7 01
40B8 06
40B9 88              223            db      disable,Row2,Col4 ;               keycode= 23
40BA 01
```

```
PAGE    6
LOC  OBJ            LINE     SOURCE
40BB 07
40BC 88              224             db      disable,Row3,Col1 ;               keycode= 24
40BD 02
40BE 04
40BF 88              225             db      disable,Row3,Col2 ;               keycode= 25
40C0 02
40C1 05
40C2 88              226             db      disable,Row3,Col3 ;               keycode= 26
40C3 02
40C4 06
40C5 88              227             db      disable,Row3,Col4 ;               keycode= 27
40C6 02
40C7 07
40C8 88              228             db      disable,Row4,Col1 ;               keycode= 28
40C9 03
40CA 04
40CB 88              229             db      disable,Row4,Col2 ;               keycode= 29
40CC 03
40CD 05
40CE 88              230             db      disable,Row4,Col3 ;               keycode= 30
40CF 03
40D0 06
40D1 88              231             db      disable,Row4,Col4 ;               keycode= 31
40D2 03
40D3 07
                     232
                     233
                     234     end

REGISTER BANK(S) USED: 0

ASSEMBLY COMPLETE, NO ERRORS FOUND
```

14 Liability and Copyright Statement

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