Using the HT66FV130/140/150/160 for the Development of Voice Products

D/N: AN0375E

Introduction

The HT66FV130/140/150/160 devices, from the lower end HT66FV130 to the higher end HT66FV160, form a complete voice MCU series to meet the needs of a wide variety of voice products. As more and more appliances and consumer products are now incorporating voice functions, these enhanced voice Flash MCUs are well placed to offer excellent solutions in being able to easily change their voice content by using their SPI interface together with external SPI Flash Memory for voice data storage. Depending upon their specific applications, users can select different external standard SPI Flash Memory capacities, which will vary with regard to sound quality, voice length, voice type etc.

These devices are highly integrated SOC MCUs. With their internal 16-bit DAC and 1.5W Audio Power Amplifier, the devices can meet the demands of high-quality sound applications. Their voice application flexibility can be seen in internal features such as a digital volume control speaker output. The I/O ports can directly drive LEDs without requiring current-limiting resistors and transistors. The internal 12-bit SAR ADC can be used to interface to external sensors or to other analog signals.

With the exception of the HT66FV130, all the other devices include an I2C or SPI interface, which provides a means of communication with other peripheral devices. Also included is an external 32768Hz crystal oscillator which can be used in applications that require a real time clock.

In addition, the HT66FV150/160 includes four software SCOM outputs for LCD display driving and a UART communication interface for wired networking communication products.

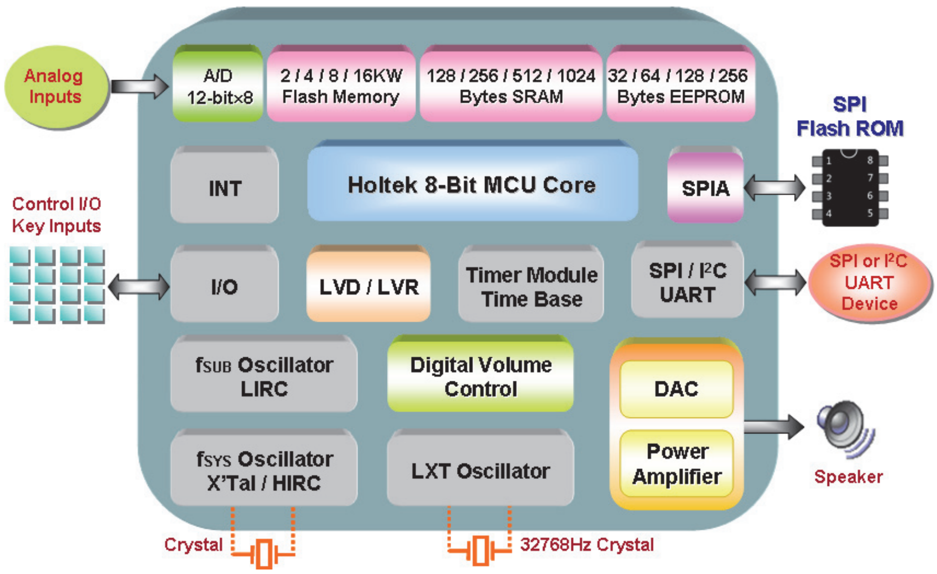
By using Holtek's Voice Development Software Platform, users can easily edit their product voice content and then automatically generate the resulting program code using a simple user-interface. This code can then be immediately programmed into the device and verified.

HT66FV130/140/150/160 Main Specification Comparison Table

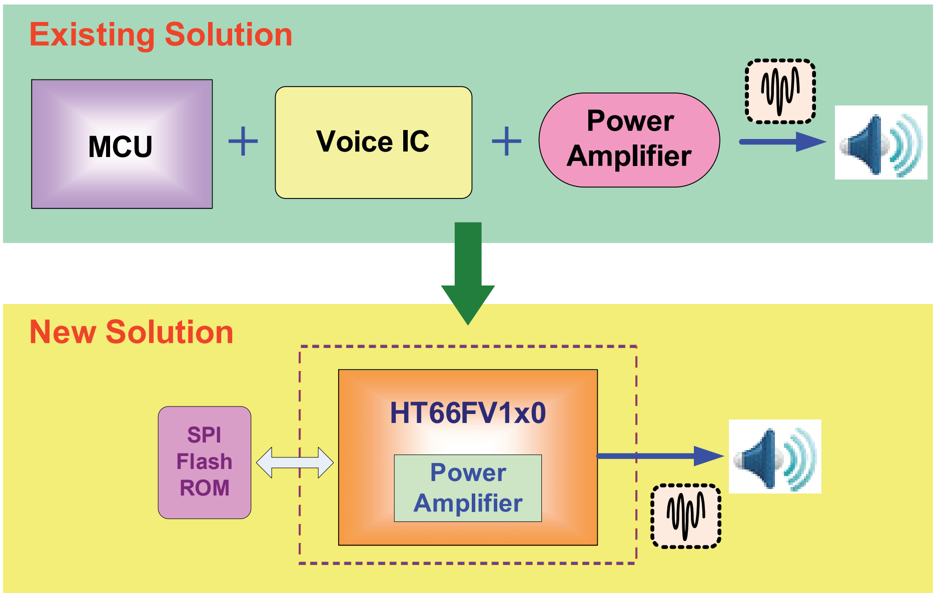
Part No.	VDD	Program Memory	Data Memory	Data EEPROM	I/O	Timer Module	RTC	LVR/ LVD	A/D	IAP	16-bit DAC	Power Amp. (5V)	SCOM	Interface	Stack	Package
HT66FV130	2.2V~ 5.5V	2K×16	128×8	32×8	15	CTM 10-bit ×1 PTM 10-bit ×1	—	√	12-bit ×4	√	√	1.5W	—	SPIA ×1	4	20/24 SOP
HT66FV140		4K×16	256×8	64×8	19	CTM 10-bit ×1 PTM 10-bit ×2	√		12-bit ×8					SPIA ×1 SPI / I²C ×1	8	20/24/28 SOP
HT66FV150		8K×16	512×8	128×8	27	CTM 10-bit ×2 PTM 10-bit ×2							√	SPIA ×1 SPI / I²C ×1 UART ×1		28SOP 44LQFP
HT66FV160		16K×16	1024×8	256×8	35	CTM 10-bit ×2 PTM 10-bit ×2 STM 16-bit ×1										44LQFP

Note: The SPIA is a hardware SPI serial interface, which is specifically used for external SPI Flash Memory play voice data accessing and can implement a level shifting function via its VDDIO pin.

Block Diagram



Application Circuits



16-bit DAC and Power Amplifier

The HT66FV1x0 devices include a fully integrated Class AB audio power amplifier with a high output power of 1.5W @ 5V and 10% THD. The pins are described in the following table.

SP+	Power amplifier positive output
SP-	Power amplifier negative output
AUD_IN	Power amplifier input
BIAS	Power amplifier internal reference voltage
AUD	16-bit DAC output
AVDD_PA	Power amplifier positive power supply
AVSS_PA	Power amplifier negative power supply

The 16-bit DAC and power amplifier can be easily controlled using MCU registers as follows.

DAEN (PLAC.0): 16-bit DAC on/off control. When this bit is set high the 16-bit DAC will be powered on.

PAEN (PLAC.1): Power Amplifier on/off control. When this bit is set high the Power Amplifier will be powered on.

Pin AUD is the 16-bit DAC output pin while the data buffer registers are PLADL (Low Byte) and PLADH (High Byte). The software uses the Timer Module to generate a regular interrupt by setting it to be in the Timer Mode. For example an interrupt will be generated every 125μs for a voice sampling frequency of 8kHz. When the interrupt time has elapsed the voice data read from the SPI Flash Memory will be written into the 16-bit DAC by software then amplified via the integrated Power Amplifier and output to drive the speakers.

The following example shows how the CTM0 generates an 8 kHz interrupt in the Timer Mode for f_{SYS}=16MHz:

```
;CTM0 Setting (Timer Mode), Timer Counter Clock=fSYS/4=4MHz
SET      T0M1
SET      T0M0           ;Timer Mode
SET      T0CCLR         ;Compare A match
SET      CTMA0E         ;CTM0 Comparator A match interrupt control
CLR      TM0DL
CLR      TM0DH
;------8kHz---------------------
MOV      A,LOW(4000/8)
MOV      TM0AL,A
MOV      A,HIGH(4000/8)
MOV      TM0AH,A
SET      T0ON           ;CTM0 Enable
SET      MF0E           ;MF0(CTM0) Enable
```

To avoid the annoying popping sound caused when the DAC and Audio Power Amplifier are powered on or off, a ramp up and ramp down procedure is used.

First initialise the DAC 16-bit data registers, known as PLADL/PLADH, to 0000H and MUTEB=0.

Use a ramp up to start playing the voice:

Set PAEN=1 and DAEN=1, increase PLADL/PLADH from 0000H to 8000H gradually, MUTEB=1, and then begin to play the voice.

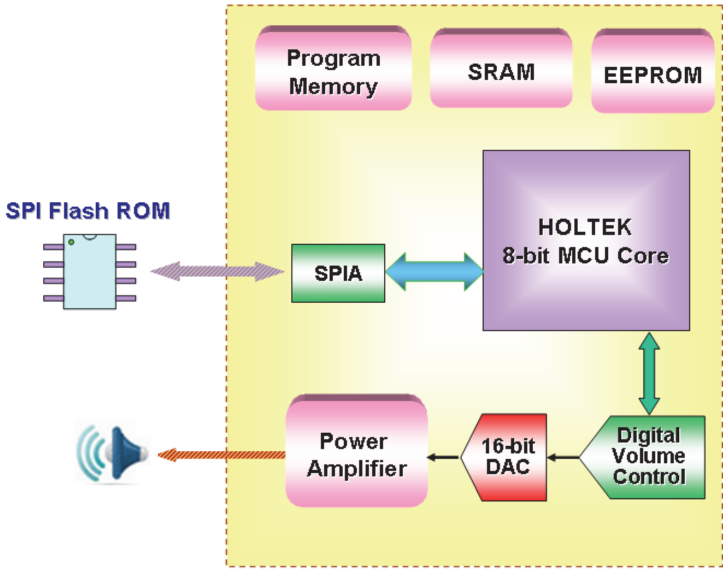
Use a ramp down to stop playing the voice:

Adjust the current 16-bit DAC contents PLADL/PLADH to 8000H, MUTEB=0, reduce the DAC content PLADL/PLADH from 8000H to 0000H gradually, then close the Power Amplifier and DAC by setting PAEN=0 and DAEN=0.

As a general rule, if the ramp up/down process takes more than 200ms, then this will reduce any popping sounds.

Voice Data

The voice data is stored in an external SPI Flash Memory. The stored data can be read by the MCU via an integrated SPI interface as shown below.



The maximum operating voltage of the SPI Flash Memory is 3.6V. Therefore for applications using a 5V system power supply, an external LDO is normally required to drop the voltage to 3V which is then connected to the VDDIO pin. Here the PBS01 and PBS00 bits in the PBS0 register should be set to 11 to select the VDDIO function. The SPIA interface power supply is provided on the external VDDIO pin, thus enabling the SPI interface voltage to be 3V.

Note: During the HT66FV1x0 voice product EFT test, the SPI clock SCK connected to the SPI Flash Memory is easily disturbed by EFT. Therefore during PCB Layout care must be taken to ensure that the SCK line should be as close to the MCU as possible and that the routing length remains as short as possible.

SPI Flash Memory Capacity Example:

Assume that the sampling frequency is 16kHz and that the audio format is 16-bit PCM with no compression. If a 2-minute voice needs to be stored then it requires 16k × 16-bit × 2 × 60 seconds = 30720kbits = 30Mbits. Therefore the SPI Flash Memory capacity needs to be 32Mbits (Ex: MX25R3235F).

The following examples are the SPIA SPI_Init and RW_SPI subroutines. The MCU is in Master Mode and the SPI Flash Memory is in Slave Mode:

```
;***************************************************************
;Function Name: SPI_Init
;Objective: Hardware SPIA Initialisation
;***************************************************************
SPI_Init:
                           ;SPIA Setting
  CLR  SPIC00
  CLR  SPIC01
  CLR  SPIC02
                           ;SPIC2~SPIC0=(000): SPI master mode; SPI clock is fSYS/4
  SET  SPIMLS ;MSB First

  SET  SPICKEG
  SET  SPICKPOLB
  SET  SPIEN               ;Enable SPI Interface
  SET  SPICSEN             ;Enable SPI CS
  ;------------------------------------------------------
  RET

RW_SPI:
  MOV  A,WriteSPIBuf
  MOV  SPID,A
  SZ   SPIWCOL
  JMP  RW_SPI
CHECKTRF:
  CLR  WDT
  SNZ  SPITRF
  JMP  CHECKTRF
  CLR  SPITRF
  MOV  A,SPID
  MOV  READSPIBUF,A
  RET

Main_Start:
:
:
;----------------------------------------------------------
;SPIA I/O Setting
SET    PCS10
CLR    PCS11               ;PC4/SDOA
SET    PCS12
CLR    PCS13               ;PC5/SCKA
SET    PCS14
CLR    PCS15               ;PC6/SDIA
SET    PCS16
CLR    PCS17               ;PC7/SCSAB
SET    PCPU7               ;PC7/SCSB PULL-HIGH ENABLE
MOV    A, 00110000B
ORM    A,SLEDC0            ;SPIA Source Current MAX
;----------------------------------------------------------
:
:
CALL   SPI_Init
MOV    WRITESPIBUF, A
SET    SPICSEN
CALL   RW_SPI
CLR    SPICSEN
:
:
```

Volume Control

The HT66FV1x0 devices have two volume control methods.

1. Variable Resistor VR Volume Control - Analog method
2. Digital Volume Control

Variable Resistor VR Volume Control - Analog method:

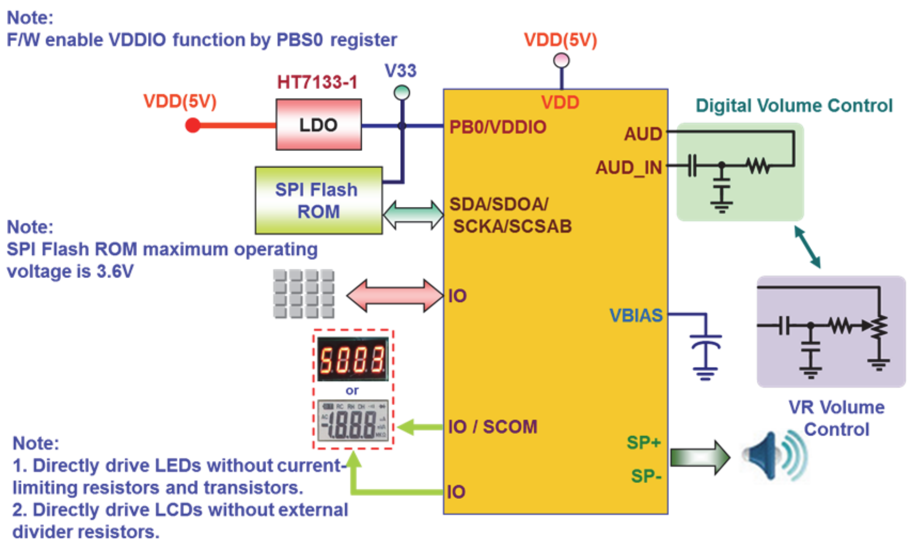
Connect an external variable resistor between the DAC output AUD and the Power Amplifier input AUD_IN to control the volume.

Digital Volume Control:

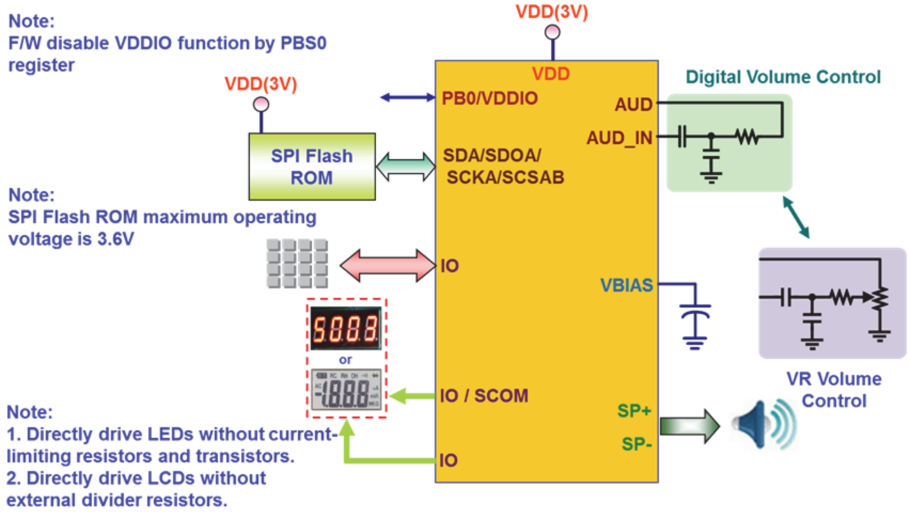
No external variable resistor VR is required. The digital volume can be adjusted by the USVC[6:0] bits, the range of which is +6dB ~ -32dB with each step having a 0.5dB (big), or 1dB (small) increment. MUTEB, that is the bit 7 of the USVC register, is the speaker mute control bit. When this bit is cleared to 0, the speaker will be muted.

Application circuits are shown below:

- 5V Application Block Diagram



- 3V Application Block Diagram



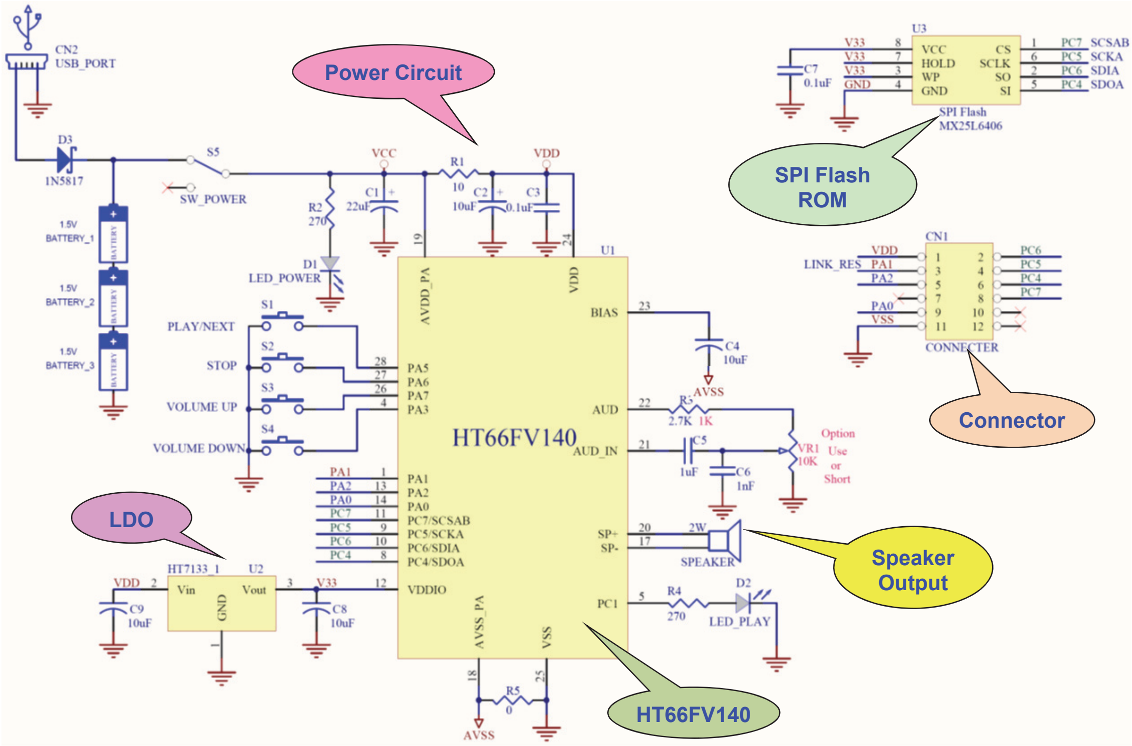
For the HT66FV140 Demo Board, the application circuit is described as follows:

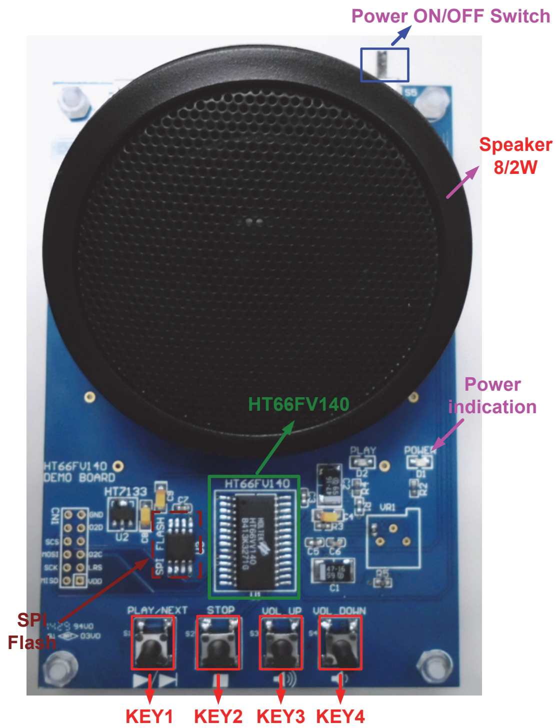
AVDD_PA should be connected to the positive power supply directly and AVSS_PA should be connected to the negative power supply directly. As AVDD_PA will output a large current when the Audio Power Amplifier is functioning it may cause the AVDD_PA voltage to experience rather large fluctuations. Therefore, it is necessary to connect an external R1/C2/C3 as a filter to prevent the MCU Power VDD from experiencing interference.

PCB Layout Considerations:

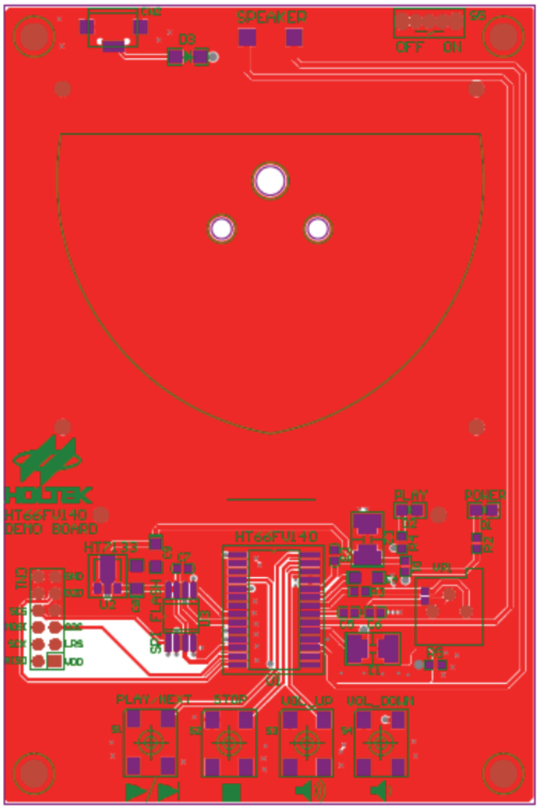
- Give priority to the power filter capacitor which should be placed as close to the MCU as possible. Other components should also be located as close to the MCU as possible, especially for the SPI clock. Line lengths should be as short as possible.
- To avoid interference caused due to instantaneous large currents generated when the Audio Power Amplifier is operating, the two power groups, VDD and AVDD_PA, should have their power sources routed separately.
- The Audio Power Amplifier power supply pin AVDD_PA should be connected to the positive power supply directly. The routing width must not be less than 12 mils.
- To avoid interference caused due to instantaneous large currents generated when the Audio Power Amplifier is functioning, the two ground lines, VSS and AVSS_PA, should be independently connected to ground using poured copper.
- The Audio Power Amplifier ground pin AVSS_PA should be connected to the negative power supply directly. The routing width must not be less than 12 mils.
- Reserve enough space for VDD and VSS line routing during component placement.
- The Power Amplifier output SP+/SP- routing widths must be thick and not use vias if at all possible.
- As rectangular outlines more easily accumulate charge there exists point discharge effects. Therefore PCB stability will be adversely affected. To solve this problem it is better to use 45 degree angles or arcs.
- In higher current applications such as driving many LEDs, the VDD large capacitor is suggested to be placed as close to the MCU.

Application Circuits – HT66FV140 Demo Board

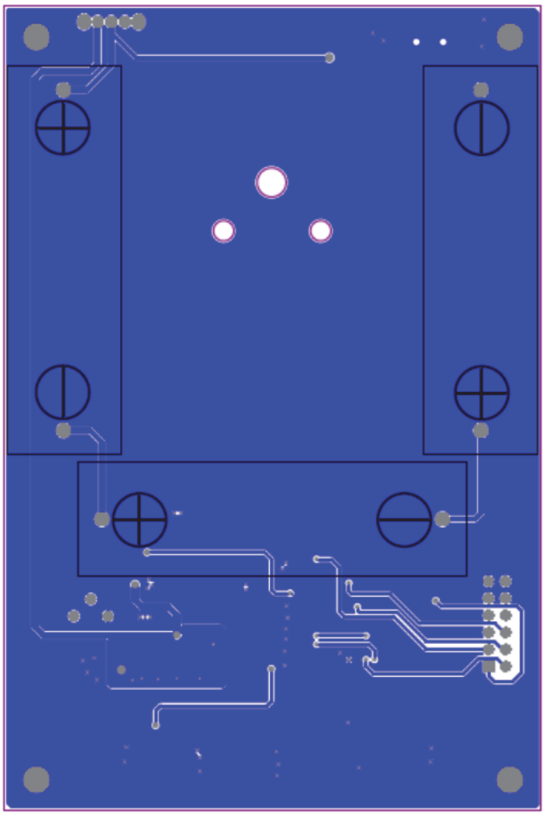




HT66FV140 Demo Board



HT66FV140 Demo Board PCB Layout Top View



HT66FV140 Demo Board PCB Layout Bottom View

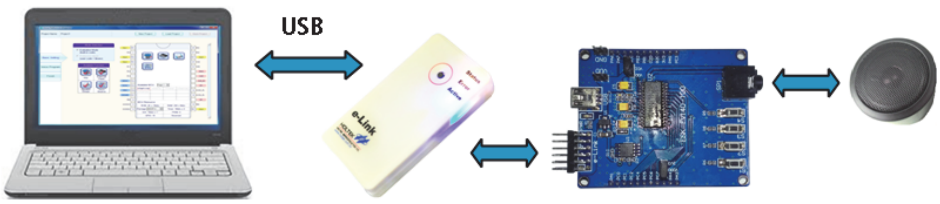
Development Environment

Voice MCU Workshop

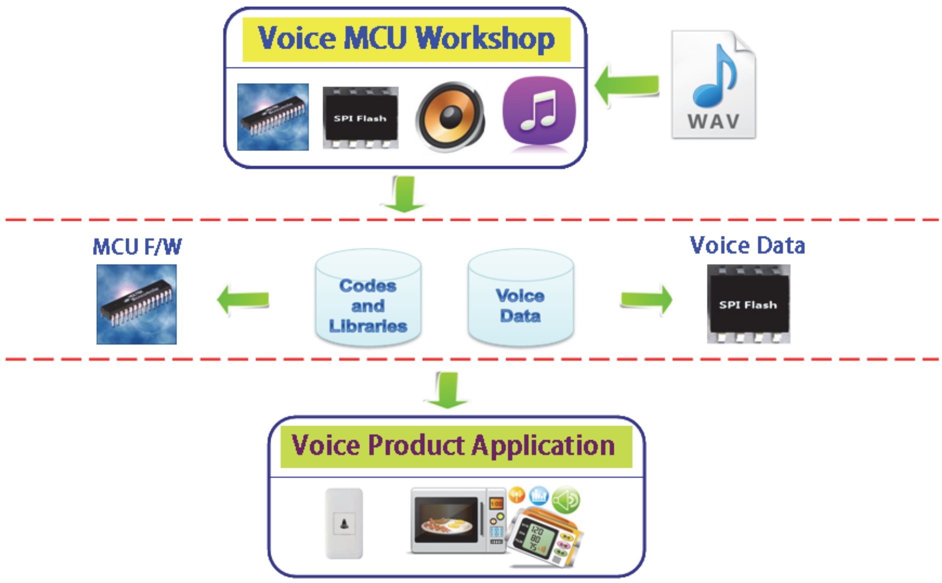
In order to help customers rapidly develop their voice products, Holtek supplies a Voice MCU Workshop to assist customers to quickly use the Voice functions of the HT66FV1x0 series. The main features are as follows:

- Customers do not need to develop the underlying voice program code themselves.
- By using the workshop voice projects can be easily implemented.
- Based on the program framework generated by the workshop, users can add their own MCU functional program for fast application development.

The system architecture is shown below:



The program development architecture is shown below:

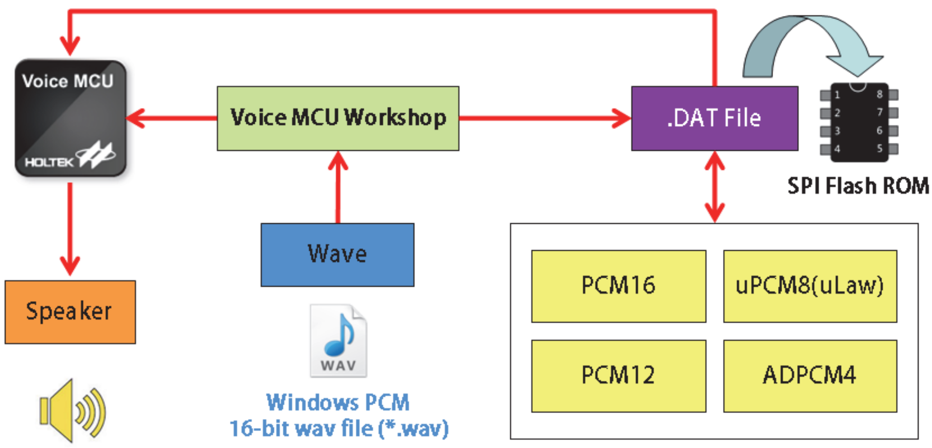


The Voice MCU Workshop can be downloaded from the Holtek website. A YouTube Introduction video is also provided for additional assistance. These allow users to quickly learn how to use the Voice MCU Workshop to complete their projects.

Development Platform		
Model	Function	Note
Holtek Voice MCU Workshop	Development Platform for Voice MCU	Can be used with ESK-66FV-100+ e-Link

PC Software			
Model	Function	Support Hardware	Note
Holtek Voice MCU Workshop	Voice development platform	ESK-66FV-100 + e-Link	Supports: Windows XP or above

Tools Introduction Video	
Model	Link
Holtek Voice MCU Workshop	https://www.youtube.com/watch?v=fFIP32HpEfM&feature=youtu.be



Note：Refer to the Holtek Voice Workshop User's Guide for more information.

Voice MCU Workshop

Reference Files

Reference File: Holtek Voice Workshop User's Guide

For more information, refer to the Holtek official website http://www.holtek.com/en/.

Versions and Modify Information

Date	Author	Issue Release and Modification
2015.04.02	李乾嘉、李凡	First Version
2016.06.06	李乾嘉、李凡	V1.10
2016.12.30	李乾嘉、李凡	V1.20

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