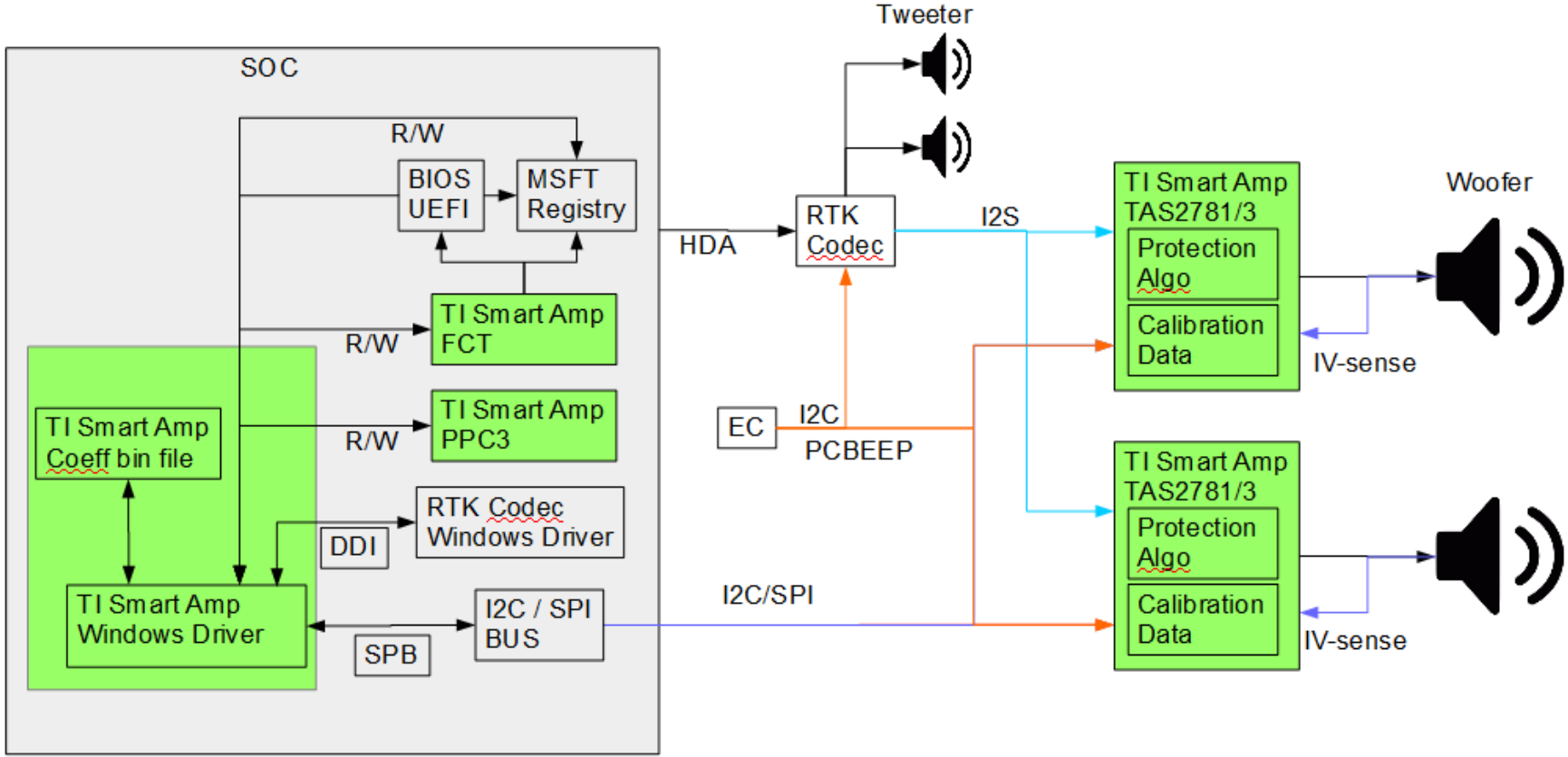
TAS2781/3 – FCT (using windows driver)

Windows Hardware Architecture

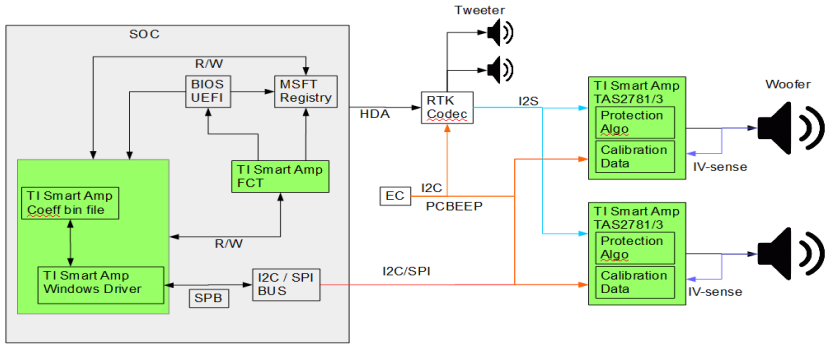


Independent FCT Tool

- TAS2781/3 is integrated device and protection algorithm runs on TAS2781/3 internal DSP.
- FCT process contains below tasks
  - Calculating the calibration data of speaker connected with the device at factory setup.(FCT App)
  - Saving the calibrated data in a persistent non volatile memory during factory. (FCT App)
  - Fetching calibrated data from persistent memory during boot up and programming TAS2781/3 DSP with calibrated data. (Windows Driver)
  - Calibrated data generated for TAS2781/3 is Re, rms_pow, t_limit.
    - Re : Speaker Re
    - rms_pow : Total RMS power coefficient
    - t_limit : Delta temperature limit coefficient
    - Data Stored in the persistent memory will be Re, rms_pow, t_limit, R0_low, Inverse R0.
    - R0 low & inverse R0 will be calculated using calibrated Re
  - Each calibration parameter would need 4 byte data and hence we would need 20 bytes of calibration data per channel.

TAS2781/3 FCT Process using UFEI/windows registry Memory

- FCT app will run on Intel/AMD processor during factory setup. (this is done only once at Factory)
- Calibrated data will be stored in dual storage of BIOS & windows registry edit.
- Window's driver will read the calibration data from windows registry during device bootup and configure the TAS2781/3 AMP with calibration data. Calibration data should also be downloaded every time firmware binary is loaded (e.g new configuration profile like music/voice etc to be loaded). So this means that firmware configuration is changed, download calibration data must be downloaded.
- If calibrated data is not available at win registry, windows driver will read calibrated data from BIOS and copy it to win registry and also program TAS2781/3 DSP.
- Location of TAS2781/3 where calibration data to be stored :



Calibration Data	Book	Page	Reg
Re	0x00	0x17	0x74
Re_Low	0x00	0x18	0x0c
INV_RE	0x00	0x18	0x14
RMS_Pow	0x00	0x13	0x70
T_Limit	0x00	0x18	0x7c

Windows Driver GUID to access UEFI memory

- FCT app will save the calibration data at UEFI Memory as Key/Value Pair.
- GUID will be required to access UEFI Memory for read/write as per below UEFI API requirements. Windows driver GUID can be used to access UEFI Memory by FCT App.
- . Sample code as below

```
int write_to_ufei(int re_value, bool right)
{

    DWORD dwErr = ERROR_SUCCESS;
    INT32 data = re_value;
    BOOL success = false;

    if (right) {
        success = SetFirmwareEnvironmentVariable(
            L"Re_R"
            , L"{9A44A769-1A51-464A-A54B-1A4084BF370B}"
            , &data
            , sizeof(data)
        );
    }
```

```
int write_kvpair_ufei(wchar_t* key, int32_t value)
{
    DWORD dwErr = ERROR_SUCCESS;
    INT32 data = value;
    BOOL success = false;

    if (!key)
        dwErr = ERROR_INVALID_DATA;

    if (key)
    {
        success = SetFirmwareEnvironmentVariable(
            key
            , L"{9A44A769-1A51-464A-A54B-1A4084BF370B}"
            , &data
            , sizeof(data)
        );
    }
```

- Accessing to UEFI would need special privilege permissions to read/write to this memory.
- In TI SmartAMP driver, below is default GUID for save FCT data in BIOS:

  { {0x1f52d2a1, 0xbb3a, 0x457d, {0xbc, 0x09, 0x43, 0xa3, 0xf4, 0x31, 0x0a, 0x92}}, Name = L"CALI_DATA", 128 Bytes.

- For HP & DELL machine.
  DEFINE_GUID(GUID_HP_FCT_READ, 0x02f9af02, 0x7734, 0x4233, 0xb4, 0x3d, 0x93, 0xfe, 0x5a, 0xa3, 0x5d, 0xb3);
  DEFINE_GUID(GUID_DELL_FCT_READ, 0xcc92382d, 0x6337, 0x41cb, 0xa8, 0x8b, 0x8e, 0xce, 0x74, 0x91, 0xea, 0x9f);

Details about the Calibration data for TAS2781/3

TAS2781/3 calibration data : total 20 byte of calibration data will be generated by each channel

Below data is generated during FCT process by each AMP

- Re : Speaker Re (4 Byte)
- rms_pow : Total RMS power coefficient (4 Byte)
- t_limit : Delta temperature limit coefficient (4 Byte)

Below data is calculated by FCT App using calibrated data (Calibrated Re) of each AMP

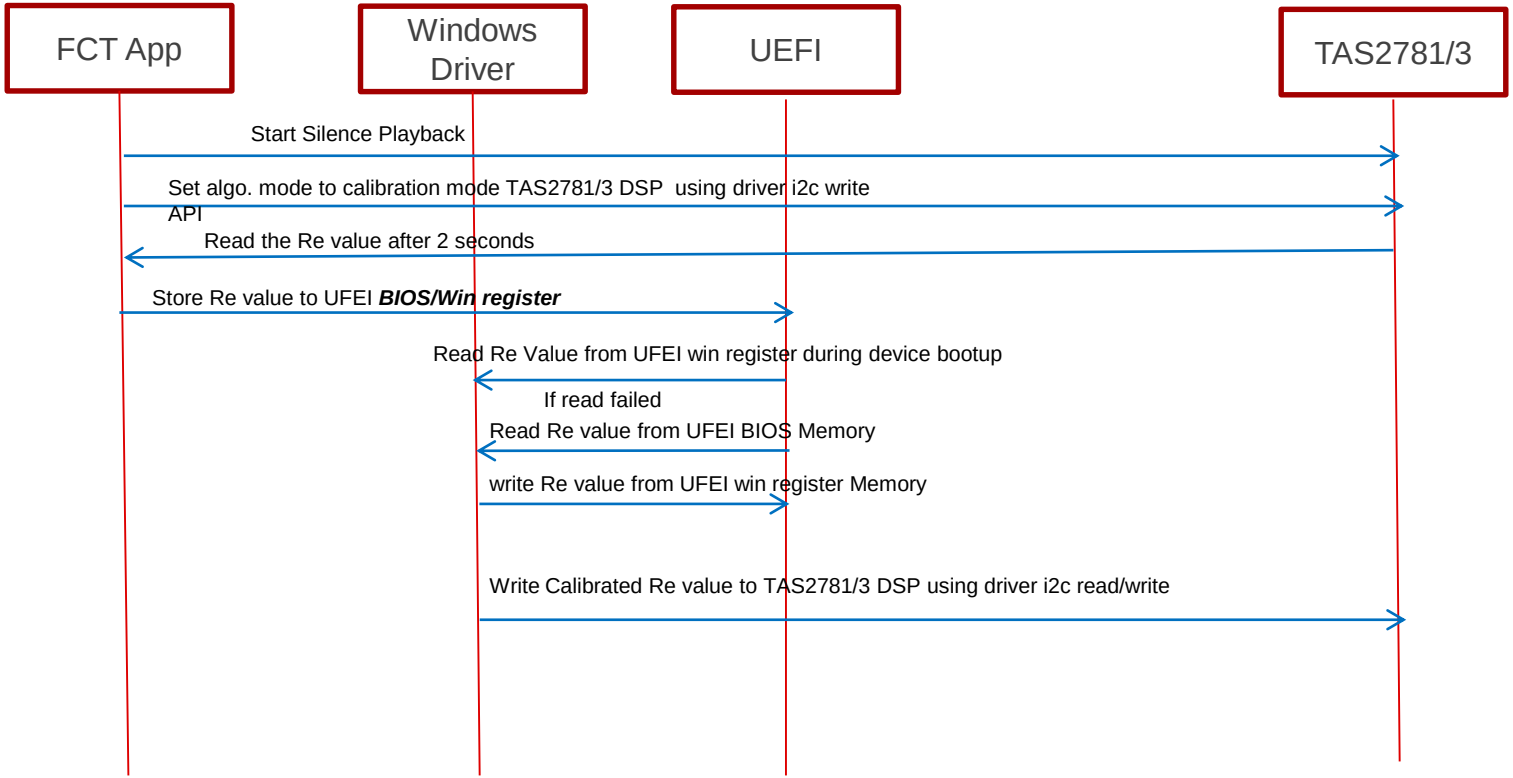
- Re_low (4 Byte)
- Inverse_Re (4 Byte)

- TAS2781/3 is Integrated device with protection algorithm being run on TAS2781/3 DSP.
- TAS2781/3 DSP algorithm expect FCT App to provide and program each AMP with Re, rms_pow, t_limit , Re_low and Inverse_R0.
- TAS2781/3 can retain these values in TAS2781/3 DSP even during device shutdown and hence these values need to be updated only during device boot-up time.
- UFEI would need to store all these values for each speaker present in system so values need to be stored in case of stereo use case as below:

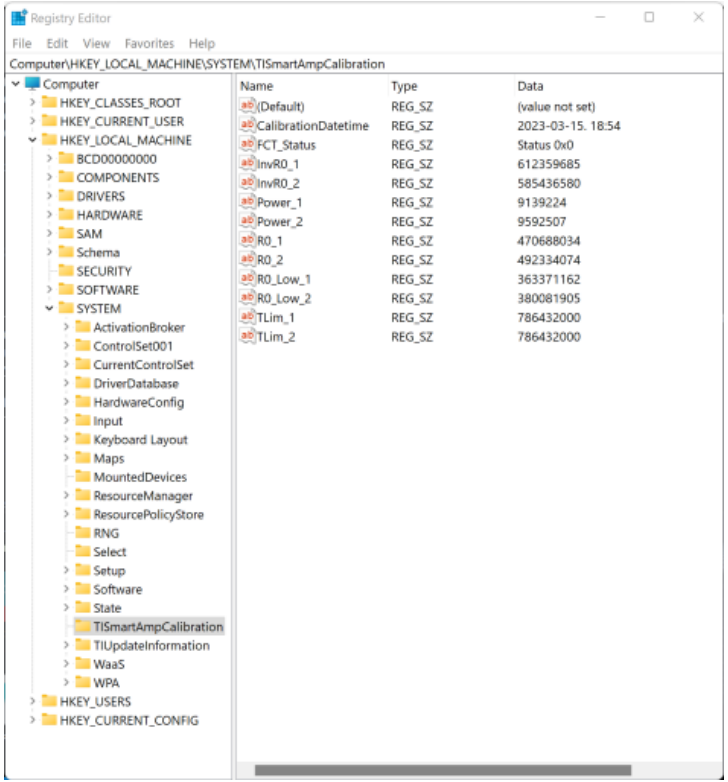
Left Speaker:
1. Re_L (4 bytes)
2. Rms_power_L (4 bytes)
3. T_limit_L (4 bytes)
4. Re_Low_L (4 bytes)
5. Inverse_Re_L (4 bytes)

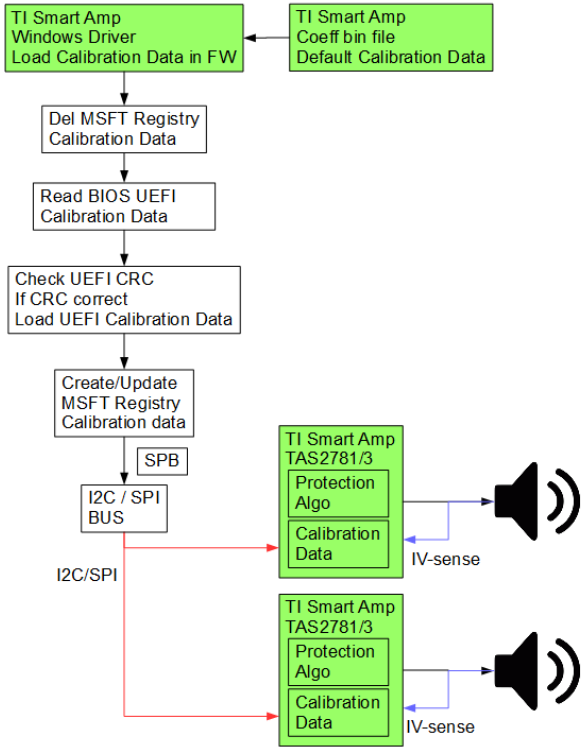
Right Speaker:
1. Re_R (4 bytes)
2. Rms_power_R (4 bytes)
3. T_limit_R (4 bytes)
4. Re_Low_R (4 bytes)
5. Inverse_Re_R (4 bytes)

Process Flow for UEFI Based Approach



How Calibration data will be stored




TI Smart Amp
Windows Driver
Load Calibration Data in FW
TI Smart Amp
Coeff bin file
Default Calibration Data
Del MSFT Registry
Calibration Data
Read BIOS UEFI
Calibration Data
Check UEFI CRC
If CRC correct
Load UEFI Calibration Data
Create/Update
MSFT Registry
Calibration data
SPB
I2C / SPI
BUS
I2C/SPI
TI Smart Amp
TAS2781/3
Protection
Algo
Calibration
Data
IV-sense
TI Smart Amp
TAS2781/3
Protection
Algo
Calibration
Data
IV-sense

Factory Line Calibration

Smart Amp | Factory Line Calibration

- Factory Line Calibration is required for baselining the speaker DC resistance
- At factory floor, the DC resistance of the speaker is measured at ambient temperature using a low level signal. This value is then used to detect the temperature rise of the speaker relative to the factory line ambient temperature
- The factory line calibration compensates for speaker-to-speaker variation of DC resistance.

System Impact (without FTC)

- Let us consider a speaker spread of Rdc variance of ± 5% for a 4 Ω load.
- Let us assume the Tmax to be 100 degC and Talpha (thermal coefficient of copper) as 0.00345.

	Rdc	Talpha	Tmax	Rdc' @ Tmax	Actual Tmax @ Rdc
Rdc	4	0.00345	100	5.104	80
Rdc + 5%	4.2	0.00345	100	5.3592	62.38
Rdc – 5%	3.8	0.00345	100	4.8488	99.46

α

- As can be seen for speaker with -5% variance although the actual Tmax is 100 degC it settles at around 99 degC which is dangerous. To mitigate this the Tmax will need to be set to (99 – 80 degC) however this can further reduce the settling temperature of speaker with +5% variance. This can result in each speaker sounding at different SPL levels.

- $R = R_{ref} * [1+\alpha*(T-T_{ref})] = Rref*[1+ \alpha*\Delta T]$
  - R = conductor resistance at temperature “T”
  - R_{ref} = conductor resistance at reference temperature “T_{ref}”, usually is 20ºC
  - α = Temperature coefficient of resistance for conductor material, cooper is $0.0033K^{-1}$.
  - T = Conductor temperature in degree Celsius.
  - T_{ref} = Reference temperature that α is specified at for the conductor material.

- Calibration data structure:
  ChipID (2781, 4 bytes)
  Device-Number (4 bytes)
  TimeStamp of Calibration (4 bytes)
  for (i = 0; i < Device-Number; i++) {
  Device index (4bytes)
  Calibrated Data of Device #i (20 bytes)
  }
  CRC (4 bytes)

  Total size = 16+24*dev_num;
  40, 64, 88, 112, ...