

# THD Character of Grid-tie System with APsystems Microinverters

## 1. APsystems Microinverter output character

The circuit diagram of APsystems Microinverter is shown in Fig.1:

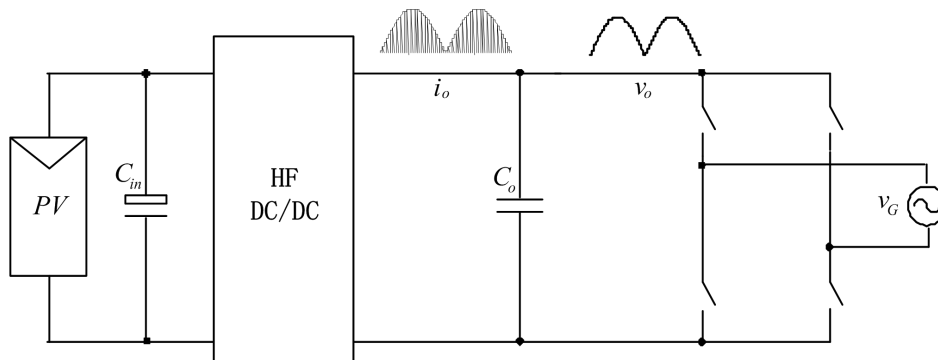


Fig. 1

The output character of APsystems Microinverter is current source, which is independent of the variation of loads. There is no inductance and capacitance in APsystems Microinverter output side, so this will not cause system resonance when APsystems Microinverter feeds electricity to grid. Similarly, they will not lead to system resonance when several APsystems Microinverters are connected to the grid.

## 2. The harmonics analysis of PV grid connection system with APsystems Microinverter

The Harmonics currents of each APsystems Microinverter output and THD meet the standard requirement. It will be discussed whether total harmonics currents and THD will meet the requirement if several microinverters are connected to the grid.

### 2.1 The definition of harmonics and THD

$n^{\text{th}}$  harmonic current ratio  $HRI_n$ :

$$HRI_n = \frac{I_n}{I_1} \times 100(\%)$$

Which,  $I_n$ — the RMS current of  $n^{\text{th}}$  harmonic

$I_1$ — the RMS current of the fundamental frequency

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The square of harmonics currents  $I_H$ :

$$I_H = \sqrt{\sum_{n=2}^{\infty} I_n^2}$$

The current THD<sub>i</sub>

$$THD_i = \frac{I_H}{I_1} \times 100(\%)$$

## 2.1 The THD analysis of PV grid connection system with APsystems

### Microinverter

Assume the system consists of APsystems Microinverter and the layout is shown below in Fig.2:

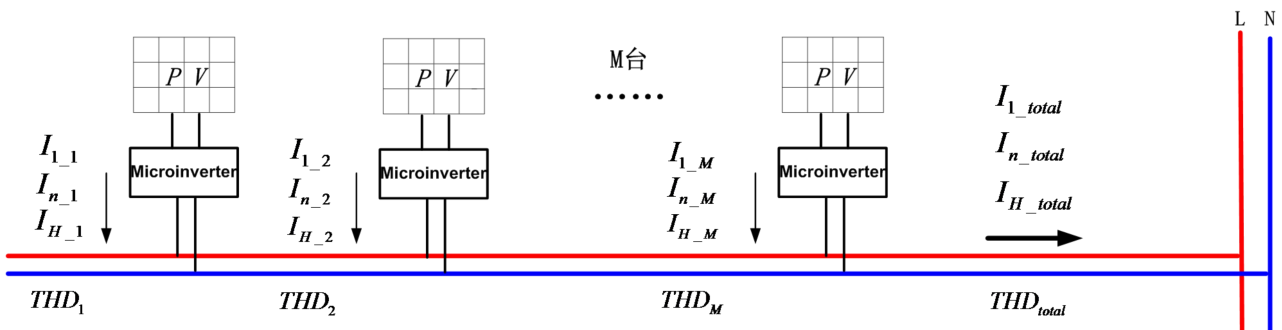


Fig. 2

The output power factor of APsystems Microinverter is almost 1, so the fundamental frequency of the total output and harmonics are in phase and thus the RMS of total output current is the sum of current of individual inverter.

The total  $n^{\text{th}}$  harmonics current:

$$I_{n\_total} = I_{n\_1} + I_{n\_2} + \dots + I_{n\_M}$$

The total current of fundamental frequency:

$$I_{1\_total} = I_{1\_1} + I_{1\_2} + \dots + I_{1\_M}$$

$K_n$ , which is constant, is defined as the THD requirement.  $K_n$  is the THD requirement of  $n^{\text{th}}$  harmonic.  $K_n$  is constant but they are different for each harmonic.

For  $n^{\text{th}}$  harmonic ( $n \geq 2$ ):

$$HRI_{n\_1} = \frac{I_{n\_1}}{I_{1\_1}} < K_n$$

$$HRI_{n-2} = \frac{I_{n-2}}{I_{1-2}} < K_n$$

$$HRI_{n-M} = \frac{I_{n-M}}{I_{1-M}} < K_n$$

Therefore,

$$HRI_{n\_total} = \frac{I_{n-1} + I_{n-2} + \dots + I_{n-M}}{I_{1-1} + I_{1-2} + \dots + I_{1-M}} < K_n$$

So the total harmonic currents will meet the requirement if several microinverters feed their output into grid.

For THD:

$$THD_1 = \frac{I_{H-1}}{I_{1-1}} = \frac{\sqrt{\sum_{n=2}^{\infty} I_{n-1}^2}}{I_{1-1}} < K$$

$$THD_2 = \frac{I_{H-2}}{I_{1-2}} = \frac{\sqrt{\sum_{n=2}^{\infty} I_{n-2}^2}}{I_{1-2}} < K$$

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$$THD_M = \frac{I_{H-M}}{I_{1-M}} = \frac{\sqrt{\sum_{n=2}^{\infty} I_{n-M}^2}}{I_{1-M}} < K$$

Derived by the following formulas

$$a_1^2 + b_1^2 < K^2 c_1^2$$

$$a_2^2 + b_2^2 < K^2 c_2^2$$



$$(a_1 + a_2)^2 + (b_1 + b_2)^2 < K^2 (c_1 + c_2)^2$$

Therefore,

$$THD_{total} = \frac{I_{H\_total}}{I_{1\_total}} = \frac{\sqrt{\sum_{n=2}^{\infty} (I_{n-1} + I_{n-2} + \dots + I_{n-M})^2}}{I_{1-1} + I_{1-2} + \dots + I_{1-M}} < K$$

So the total THD will meet the requirement if several microinverters feed their output into grid.

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### 3. The test of harmonics for microinverter

In the test, the number of inverters in parallel increases from 1 to 20 gradually. Fig.3 shows the variation of THD with the number of microinverters. As we can see, THD become smaller as the number of inverters in parallel increases, which is the same as the analysis discussed above.

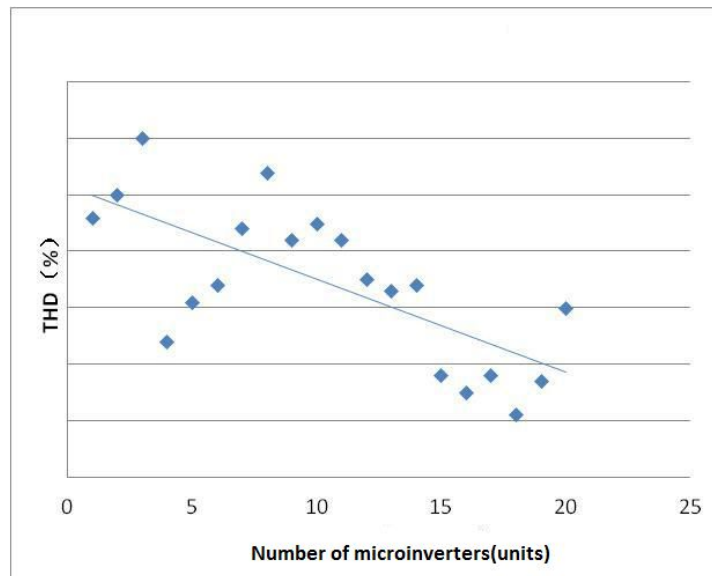


Fig.3