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THE STEALTH SPECTRUM ANALYSIS (SSA) OF THE ELECTRONIC SYSTEMS

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Abstract

In this paper author deemend that besides existence of the visible responde (VR: so called classical response) of theory up to now, simultaneously there are existence of the stealth response (SR) and the stealth interference which need to do the deep researches in this region. As before on the basis, the author put up a new theory of SSA and noise, at the some time, give it's equation of stealth spectrum and application has been discussed.

Ⅰ. Instroduction

The modern advanced vehicleborne electronic systems is developing in the direction of the high digitize, the synthesisize of system and miniaturization. It' s have the high quality、multifunction、high rate of performance to price good maintenance and reliability, and can dealt with a large number of information and whose processing to speed come more and more heigh . However since there are lots of specific electronic equipment mounted in the limited space such as the communications、the navigator , the radar and real time computers etc. in the given small range within, the interference among them is unavoidable . And what is more, intentional or unintentional jamming sources are increasing with each passing day at interior and actside of system, resulting in uninterrupted deterioration of the electromagnetic operation environment.

As far as our information goes , to add to the well known varied fault (the visible interference or visible fault) caused by the electric device , circuit and some factors that are determinate , there is another unclear reason which resultes is error and fault of systems contrary to one's expecations. Latter is related to the stealth input and the stealth circuit. ITs has fuzzy characteristic.

This paper open discussion into the stealth spectrum analysis.

Ⅱ. Single stage response of the system

Usually, we did not need the stealth input signal(a kind of fuzzy input which is difficult to forecast). For example , the man_made jam and natural interference, the heat perturbation and disturbance of magnetic field, which produced influence of the pleasma discharge and the ray of charged particle , many of there are unintentional signal (a variety of inputs without intention). In addition, the hardware (i.e. the chips, magnetic tapes, magnetic disks etc), and the software have been installed or sticked and put together with the viruses of the computer and the jamming pulses have been coupled into the system from slits of the computer keyboard , transmission line between the two processors and the circuits of transmission line etc. These belong to the stealth input. Some types and parameters of circuit is difficult to determining, this is called the stealth circuit. It's transfer function is called the stealth transfer function.

The stealth circuit is formed by the internal and external distributed parameter of systems, the changing parameter and unstable state caused by the conducted emissions or the radiated emissions and the field coupling, and some diffcult to predicted factors, the multisignal are unbalance , the sudden changing and gradual changing of circuit caused by the operative environment effect etc.

In order to simplification we are analysing the stealth response of a linear single_stage system preliminarily. The visible and stealth signal (VS and SS) at the output of system can then be represented either in the frequency domin as the product of H(f) + SH(f') and V(f) + SV(f) or the convolution (denote as ∗) of H(n) + SH(n') and V(n) + SV(n'), then

$$R(f,f')=[H(f)+SH(f')][V(f)+SV(f')]$$
$$=H(f)V(f)+H(f)SV(f')+SH(f')V(f)+SH(f')SV(f') \quad (1)$$
$$R(n,n')=[H(n)+SH(n')]*[V(n)+SV(n')]$$
$$=H(n)*V(n)+H(n)*SV(n')+SH(n')*V(n)+SH(n')*SV(n') \quad (2)$$

where H(f) and H(n) is the visible transfer function (VTF) , SV(f) and SV(n') is the stealth input function, respectively. The f and n inconformity with f' and n' (i.e. $f \neq f'$, $n \neq n'$) , the equations of (1) and (2) have frame of reference are conformed the Galileo transformation. But then f=f', n=n' it has changed into the cartesian coordinates system.

At the equation right hand the first term we can obtain the classical spectrum and the waveform , the second term is visible stealth response (VSR) of the frequency domain or the time domain, respectively. Among other things the VS is dominance, it have been become the coherent mixed responce (CMR) and the noncoherent mixed response (NCMR) from system.

The former is superposition of the VSR spectrum or waveform each other, and it is increasing (or decreased) in the energy density spectrum. Third term is the stealth visible response (SVR) in the frequency domain and the frequency domain, respectively. It is similitude to second term of the equation but the response has a difference character, the stealth circuit which make a greater contribution to the stealth spectume. If input of second term is the noise , the second term can see for the reseach fourth term is stealth responce (SSR) in the *frequency domain* and the *time domain. Third term* and fourth term not only is capable visiblize but revealed subtle diversity and complexity from responce of *the system*

Equation (1) (2) is a great surprise to us, there are not the visible input ($V(f)=0$, $V(n)=0$) of the system , when existence the stealth input and staelth circuit , the system also have output signal (In *equation (1) (2)/, the second term and fourth term*), that is

$$R(f,f')=H(f)SV(f')+SH(f')SV(f') \qquad (3)$$
$$R(n,n')=H(n)*SV(n')+SH(n')*SV(n') \qquad (4)$$

If the visible transfer function is equal to zero ($H(f)=0$ or $H(n)=0$) , and yet system existe the output of the stealth visible and stealth stealth response , *that is*

$$R(f,f')=SH(f')V(f)+SH(f')SV(f') \qquad (5)$$
$$R(n,n')=SH(n')*V(n)+SH(n')*SV(n') \qquad (6)$$

If the stealth circuit is not excitation , the response from then is defined by

$$R(f,f')=H(f)V(f)+H(f)SV(f') \qquad (7)$$
$$R(n,n')=H(n)*V(n)+H(n)*SV(n') \qquad (8)$$

On the supposition that system have not the stealth input and stealth transfer function ($SV(f')=0$, $SV(n')=0$, $SH(f)=0$, and $SH(n')=0$) i.e.

$$R(f)=H(f)V(f) \qquad (9)$$
$$R(n)=H(n)*V(n) \qquad (10)$$

The output of the *system* have becomed a classical frequency spectrum or classical convalution .

We come to the conclustion that , classical frequency response is called to special frequency response spectrum , the classical convolution is *called to specal convolution. The system* response spectrum consists of the visible input and stealth input, visible transfer function and stealth *transfer function , respectively.*

Equation (1) and (2), respectively, are called to the general frequency response and general convolution.

In practice the SV,SS,VS is very important. For the *nuclear reactor , the air* and sea transport, the railway dispatch , and the satellite and spacevehivle are launched etc., the output visiblize of the SV ,SS and the VS to draw *mistakes* which control beyond expectation the limitation may lead it to grave consequences uaually.

For the system perturbance was restrained, we should have dispelled influence of the SV,SS and the VS.

Ⅲ. The spectrum of the multistage systems

The *spectrum analysis problems* of the multistage systems are involved the visible input, stealth signal, the visible and the stealth transfer function of every stage as shown Fig. 1.

As indicated previously, the resulting spectrum at *the output to the final a* stage system can only repesented it by either in the frequency domain as the product of $H(f)+SH(f)$ and $V(f)+SV(f)$, then

$$\begin{aligned} R(f,f') &= \sum_{i=0}^{M}\sum_{j=0}^{N}[H_i(f)+SH_j(f')] \sum_{i'=0}^{M'}\sum_{j'=0}^{N'}[V_{i'}(f)+SV_{j'}(f')] \\ &= \sum_{i=0}^{M}\sum_{j=0}^{N}\sum_{i'=0}^{M'}\sum_{j'=0}^{N'} H_i(f)V_{i'}(f) + \sum_{i=0}^{M}\sum_{j=0}^{N}\sum_{i'=0}^{M'}\sum_{j'=0}^{N'} SH_j(f')V_{i'}(f) + \\ &\quad \sum_{i=0}^{M}\sum_{j=0}^{N}\sum_{i'=0}^{M'}\sum_{j'=0}^{N'} H_i(f)SV_{j'}(f') + \sum_{i=0}^{M}\sum_{j=0}^{N}\sum_{i'=0}^{M'}\sum_{j'=0}^{N'} SH_j(f')SV_{j'}(f') \\ &= \sum_{i=0}^{M}\sum_{i'=0}^{M'} H_i(f)V_{i'}(f) + \sum_{i'=0}^{M'}\sum_{j=0}^{N} SH_j(f')V_{i'}(f) + \\ &\quad \sum_{i=0}^{M}\sum_{j'=0}^{N'} H_i(f)SV_{j'}(f') + \sum_{j=0}^{N}\sum_{j'=0}^{N'} SH_j(f')SV_{j'}(f') \end{aligned} \qquad (11)$$

Where M,N and M',N' are numbers of the visible transfer, *stealth transfer function* and *the* visible input, stealth input signal, respectively.

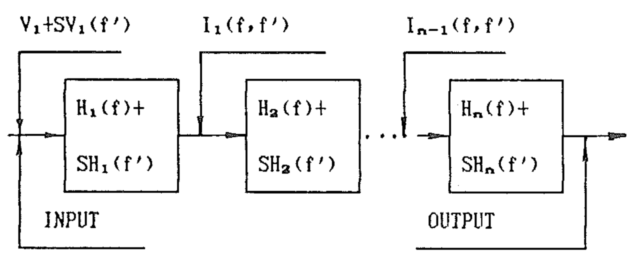

Fig. 1 The multistage system

The three stage systems then is defined by

$$\begin{aligned} R_3(f,f') &= [H_1(f)+SH_1(f')][V_1(f)+SV_1(f')] \\ &\quad [H_2(f)+SH_2(f')][H_3(f)+SH_3(f')] \\ &= I_2(f,f')[H_3(f)+SH_3(f')] \end{aligned} \qquad (12)$$

Where

$$I_2(f,f')=I_1(f,f')[H_2(f)+SH_2(f')] \qquad (13)$$
$$\begin{aligned} I_1(f,f') &= H_1(f)V_1(f)+H_1(f)SV_1(f') \\ &\quad +SH_1(f')V_1(f)+SH_1(f')SV_1(f') \end{aligned} \qquad (14)$$

If the stealth signal inserting transmission line between the two systems, then

$$R_3(f,f')=[I_2(f,f')+SV_3(f')][H_3(f)+SH_3(f')] \qquad (15)$$

$$I_2(f,f')=[I_1(f,f')+SV_2(f')][H_2(f)+SH_2(f')] \quad (16)$$

The solutions of (12) have sixteen terms , the visible response with the three stages only has a term.
The equation (15) have the twenty one terms except the a visible response term.
Therefore we should careful consider influence of the stealth signal and the stealth circuit when evaluated the performance of systems.
At the equation (11) right hand, the fist term and the fourth term respectively ,are all visible response and all stealth response. The second term and the third term , respectively, are general cross modulation.
In the place between two systems coupling , the stealth signal will result in much multiple the stealth aross modulation.
On the other hand , M>N and M'>N' shows the visible response is dominance, M<N M'<N' the staelth response is dominance in the systems. The former stability is relative better, the latter is difference.
The M and N can not at once equal zero , otherwise equation will be nonmeaning.
In practical the multistage systems, there are four kinds special states:
(a) If $SV_{j'}(f')=0$, then

$$R(f,f')=\sum_{i=1}^{M}\sum_{j=1}^{N}[H_i(f)+SH_j(f')]\sum_{i'=1}^{M'}\sum_{j'=1}^{N'}[V_{i'}(f)+0]$$
$$=\sum_{i=1}^{M}\sum_{i'=1}^{M'}H_i(f)V_{i'}(f)+\sum_{j=1}^{N}\sum_{i'=1}^{M'}SH_i(f')V_{i'}(f) \quad (17)$$

(b) If $SH_j(f')=0$, then

$$R(f,f')=\sum_{i=1}^{M}\sum_{j=1}^{N}[H_i(f)+0]\sum_{i'=1}^{M'}\sum_{j'=1}^{N'}[V_{i'}(f)+SV_{j'}(f)]$$
$$=\sum_{i=1}^{M}\sum_{j=1}^{N}[H_i(f)V_{i'}(f)+\sum_{i=1}^{M}\sum_{j'=1}^{N'}[H_i(f)SV_{j'}(f) \quad (18)$$

(c) If $V_{i'}(f)=0$, then

$$R(f,f')=\sum_{i=1}^{M}\sum_{j=1}^{N}[H_i(f)+SH_j(f')]\sum_{i'=1}^{M'}\sum_{j'=1}^{N'}[0+SV_{j'}(f')]$$
$$=\sum_{i=1}^{M}\sum_{j'=1}^{N'}H_i(f)SV_j(f')+\sum_{j=1}^{N}\sum_{j'=1}^{N'}SH_j(f')SV_{j'}(f') \quad (19)$$

(d) If $H_i(f)=0$, then

$$R(f,f')=\sum_{i=1}^{M}\sum_{j=1}^{N}[0+SH_j(f')]\sum_{i'=1}^{M'}\sum_{j'=1}^{N'}[V_{i'}(f)+SV_{j'}(f')]$$
$$=\sum_{j=1}^{N}\sum_{i'=1}^{M'}[SH_j(f')V_{i'}(f)+\sum_{j=1}^{N}\sum_{j'=1}^{N'}[SH_j(f')SV_{j'}(f') \quad (20)$$

The equation (a) results have shown that if only existing the visible and stealth circuit in the systems operation band, we are obtainable for sum of differential response of the classical and the stealth_visible . IF the stealth input is a noise , the (b) will has changed to the classical response. The (c) been shown to be characteristic of the visible and stealth circuit response with the stealth signal, this great interest as for the real time and launching control systems. The (d) find an expression for the stealth circuit (no visible transfer function) , it ease give occasion to some can not suffer the malfunction when the complicated systems are operation.
The convolution of the multistage linear and time invariant syatems, that is

$$R(n,n')=\sum_{i=0}^{M}\sum_{j=0}^{N}[H_i(n)+SH_j(n')]*\sum_{i'=0}^{M'}\sum_{j'=0}^{N'}[X_{i'}(n)+SX_{j'}(n')]$$
$$=\sum_{i=0}^{M}\sum_{j=0}^{N}\sum_{i'=0}^{M'}\sum_{j'=0}^{N'}H_i(n)*X_{i'}(n)+\sum_{i=0}^{M}\sum_{j=0}^{N}\sum_{i'=0}^{M'}\sum_{j'=0}^{N'}H_i(n)*SX_{j'}(n')+$$
$$\sum_{i=0}^{M}\sum_{j=0}^{N}\sum_{i'=0}^{M'}\sum_{j'=0}^{N'}SH_j(n')*X_{i'}(n)+\sum_{i=0}^{M}\sum_{j=0}^{N}\sum_{i'=0}^{M'}\sum_{j'=0}^{N'}SH_j(n')*SX_{j'}(n')$$
$$=\sum_{i=0}^{M}\sum_{i'=0}^{M'}H_i(n)*X_{i'}(n)+\sum_{i=0}^{M}\sum_{j'=0}^{N'}H_i(n)*SX_{j'}(n')+$$

$$\sum_{i=0}^{M}\sum_{j'=0}^{N'} SH_j(n') * X_{i'}(n) +$$
$$\sum_{j=0}^{N}\sum_{j'=0}^{N'} SH_j(n') * SX_{j'}(n') \qquad (21)$$

Where $X_{i'}(n)$, $SX_{j'}(n')$ are the visible and the stealth input signal , $H_i(n)$, $SH_j(n)$ are the visible and the stealth transfer function, *respectively.*

The footnote of i, i', j, and j' are not equals to zero at the same time , with general convolution otherwise has not significance.

The equation (21) is called the general *convolution* . At equation (21) right hand, first term is the visible (i.e. classical) convolution, the fourth term is the stealth convolution.

The general convolution and the general frequency response have *similar special states*, i.e.

(A) If $SX_{j'}(n')=0$, then

$$R(n,n') = \sum_{i=1}^{M}\sum_{j=1}^{N} [H_i(n) + SH_j(n')] * \sum_{i'=1}^{M'}\sum_{j'=1}^{N'} [X_{i'}(n) + 0]$$
$$= \sum_{i'=1}^{M}\sum_{j'=1}^{M'} H_i(n) * X_{i'}(n)$$
$$\sum_{j=1}^{N}\sum_{i'=1}^{M'} SH_j(n') * X_{i'}(n) \qquad (22)$$

(B) If $SH_j(n')=0$, then

$$R(n,n') = \sum_{i=1}^{M}\sum_{j=1}^{N} [H_i(n) + 0] * \sum_{i'=1}^{M'}\sum_{j'=1}^{N'} [X_{i'}(n) + SX_{j'}(n')]$$
$$= \sum_{j'=1}^{M}\sum_{i'=1}^{M'} H_i(n) * X_{i'}(n) +$$
$$\sum_{j=1}^{N}\sum_{j'=1}^{N'} H_i(n) * SX_{j'}(n') \qquad (23)$$

(C) *If* $X_{i'}(n)=0$, then

$$R(n,n') = \sum_{i=1}^{M}\sum_{j=1}^{N} [H_i(n) + SH_j(n')] * \sum_{i'=1}^{M'}\sum_{j'=1}^{N'} [0 + SX_{j'}(n')]$$
$$= \sum_{i'=1}^{M}\sum_{j'=1}^{N'} H_i(n) * SX_{j'}(n') +$$
$$\sum_{j=1}^{N}\sum_{j'=1}^{N'} SH_j(n') * SX_{j'}(n') \qquad (24)$$

(D) If $H_i(n)=0$, then

$$R(n,n') = \sum_{i=1}^{M}\sum_{j=1}^{N} [0 + SH_j(n')] * \sum_{i'=1}^{M'}\sum_{j'=1}^{N'} [X_{i'}(n) + SX_{j'}(n')]$$
$$= \sum_{i'=1}^{M'}\sum_{j=1}^{N} SH_j(n') * X_{i'}(n) +$$
$$\sum_{j=1}^{N}\sum_{j'=1}^{N'} SH_j(n') * SX_{j'}(n') \qquad (25)$$

The convolution as was stated above characteristic and method. It can be *using analysis* and *solve* many problem of complicated systems.

As seen the stealth input and the stealth transfer function are equal to zero, the general frequency response and the general convolution change into the special frequency response and the special convolution , respectively.

New theory was virtual involved the classical *analysis* method.

In consideration of the visible and stealth frame of reference can be transposing each other. Usually, we are given based upon the visible reference.

Thereby, the general convolution in close relationship with the origin of two reference and n'/n.

We now are defined the parallel move distance or the deflection angal as the location (or insert) function I(x) of the general convolution .

If I(x) is negative number, the stealth reference belong in late insert . When I(x) is postive number , the stealth reference belong in lead insert.

Characterizing relation of n' and n, deterministic the relational function of general convolution as

$$K(x) = \frac{n'}{n} \text{ in the time domain.}$$

Therefore , the function of I(x) and K(x) are linear or nonlinear quite have an effert on the general convolution.

A time_domain results of the general convolution depend on four key to the factors : the stealth input , *the stealh circuit*, the location *function* (or insert function) and the relational function.

In general , the general convolution under the control of I(x) and K(x) , we are obtainable for infinite kinds results. When assuming that I(x), K(x) random change.

Ⅳ. The general energe density spectrum

In the linear and time invariant systems, the total input are equal to the visible input and the stealth input add together, that is

$$X(t) + SX(t') = e^{j2\pi f t} + Se^{j2\pi f' t'} \qquad -\infty < t < \infty, \quad -\infty < t' < \infty \qquad (26)$$

Where SX(t') and $e^{i2\pi f't'}$ are the stealth input, X(t') and $e^{i2\pi ft}$ are the visible input, respectively.

Now consider two linear transfer paths with impulse response H(t)+SH(t), with system output, as

$$R(t,t')=[H(t)+SH(t')]\cdot[X(t)+SX(t')] =H(t)e^{i2\pi ft}+H(t)Se^{i2\pi f't'}+SH(t)e^{i2\pi ft}+SH(t)Se^{i2\pi f't'} \quad (27)$$

The impulse response with general Fourier transform integration is

$$R(f,f')=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} h(t)e^{-i2\pi ft}dtdt' +\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} h(t)Se^{-i2\pi f't'}dtdt' +\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} Sh(t')e^{-i2\pi ft}dtdt' +\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} Sh(t)Se^{-i2\pi ft}dtdt'$$

$$=\int_{-\infty}^{\infty} h(t)e^{-i2\pi ft}dt+\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} h(t)Se^{-i2\pi f't'}dtdt' +\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} Sh(t')e^{-i2\pi ft}dtdt' +\int_{-\infty}^{\infty} Sh(t')Se^{-i2\pi f't'}dt' \quad (28)$$

At equation right hand, first and fourth terms, respectively, are the special frequency response and *all stealth* response.

Thus the general Fourier transform reflects more and true than the special Fourier transform at the *non_absolute stabilizing syatem.* Because of non_balance bias voltage , the hot confusion and microinterference input to the absolute systems, these result in output value non_control with the ideal network, the ideal differential and integrator , *for special* Fourier transform analysis is much more difficult in an actual complex system.

The general energe density spectrum of R(t, t') is *defined as*

$$|R(f,f')|^2=|H(f)+SH(f')|^2\cdot|V(f)+SV(f')|^2 =|H(f)^2+2H(f)SH(f')+SH(f')^2|\cdot|V(f)^2+2V(f)SV(f')+SV(f')^2| =|[H(f)V(f)]^2+[H(f)SV(f')]^2+[SH(f')V(f)]^2+[SH(f')SV(f')]^2+2H(f)SH(f')V(f)^2+2H(f)SH(f')SV(f')^2+2H(f)^2V(f)SV(f')+2SH(f')^2V(f)SV(f')+4H(f)SH(f')V(f)SV(f')| \quad (29)$$

There are four kinds special states of the general energe density spectrum as

(1) If SV(f')=0, then

$$|R(f,f')|^2=|H(f)+SH(f')|^2\cdot|V(f)+0|^2 =|[H(f)V(f)]^2+[SH(f')V(f)]^2+2H(f)SH(f')V(f)^2| \quad (30)$$

(2) If SH(f')=0, then

$$|R(f,f')|^2=|H(f)+0|^2\cdot|V(f)+SV(f')|^2 =|[H(f)V(f)]^2+[H(f)SV(f')]^2+2H(f)^2V(f)SV(f')| \quad (31)$$

(3) If H(f)=0, then

$$|R(f,f')|^2=|[0+SH(f')|^2\cdot|V(f)+SV(f')|^2 =|[SH(f')V(f)]^2+[SH(f')SV(f')]^2+2SH(f')^2V(f)SV(f')| \quad (32)$$

(4) If V(f)=0, then

$$|R(f,f')|^2=|H(f)+SH(f')|^2\cdot|0+SV(f')|^2 =|[H(f)SV(f')]^2+[SH(f')SV(f')]^2+2H(f)SH(f')SV(f')^2| \quad (33)$$

As above the general energe density spectrum (Eq. (29)) all things considered with stealth signal and the stealth circuit result in it have increaseed eight terms over and above the *special* energe spectrum. As seen it's similar to amplification come to be known as amplification effert (i.e. Like atate *fild additive mixing*).

Equation (30) have increased two terms from the stealth circuit response , except that the special energe density spectrum. At equation (31) right hand, second and third terms are caused by the stealth *input signal. The energe density spetrum of equation* (32) quite are caused by the stealth circuit. When system has not the visible input, the output of energy density spectrum have three terms are caused by *the stealth input signal and stealth circuit* with equation (33).

As stated above the general energe density *spectrum* have much complex component of the *special* (classical) , all stealth and the mixing energe density spectrum. Therefore it's influence with system performance should not neglect.

The general equivalent noise bandwidth of systems defined by

$$B(f,f')=\frac{1}{|H_o+SH_o|^2}\int_0^{\infty}\int_0^{\infty}|H(f)+SH(f')|^2dfdf' =\frac{1}{|H_o+SH_o|^2}[\int_0^{\infty}|H(f)|^2df+\int_0^{\infty}\int_0^{\infty}H(f)SH(f')dfdf'+$$

$$+\int_0^\infty SH(f')^2 df']$$

(34)

Where H_o and SH_o, respectively, are the visible and stealth transfer constant . When equation (33) $SH_o=0$, it is the classical equivalent noise bandwidth (first term). The second term is the half_fuzzy equivalent noise bandwidth. The third term is the all fuzzy equivalent noise bandwidth. $2H_oSH_o$ is the half_fuzzy transfer constant.

V. Conclusion

Systems stablity not only is dependent on the visible input and the visible circuit but to a great extent under the influence of the stealth input and the stealth circuit. In frequency domain and time domain, the general frequency response and the general convolution is calculated that the all frequency spectrum of systems.

Make use of equation of the general energy density spectrum, we have obtained distribution of the all energy density spectrum with two kinds (i. e. the visible and stealth) input and circuit .

The general equivalent noise bandwidth may be compute the increment caused by the stealth transfer function .

The stealth spectrum theory is supplied effective new method for the analyse the causes of visiblize trouble and stealth trouble.