SPECTRUM ANALYZER의 응용분야 및 실제

◈ Spectrum Analyzer ◈

1.

2

Spectrum Analyzer   .

.

◈ Digital Storage   . Storage   Marker   .
◈   RBW   .   RBW

,

.

RBW   ,   **RBW**
.

RBW
.

◈   10dB   .
,   (Log Amp)   .
◈ Marker   .

Marker   .
◈   (Center Measure)   Spectrum Analyzer
.   .

◈   Spectrum Analyzer   ,   (+20dBm
+30dBm)   ,   (MAX Span)   . Analyzer
,   (   )
.

Spectrum Analyzer
.   ,   .

2. RF

Spectrum Analyzer   .
.

<   3-1>   ,   .

그림 3-1

1)   (+20dBm   +30dBm)   ,   (MAX span)   .
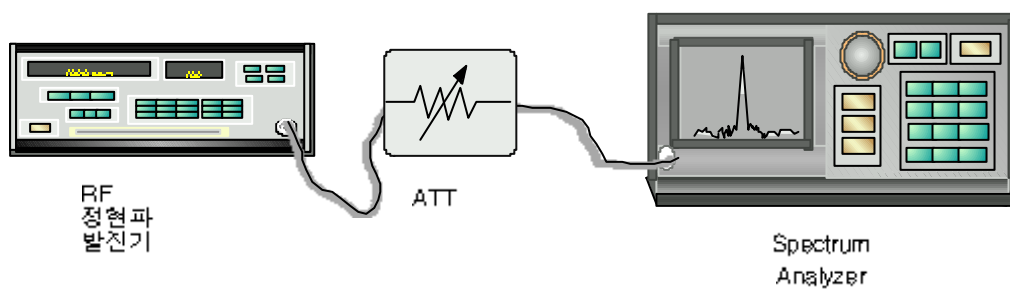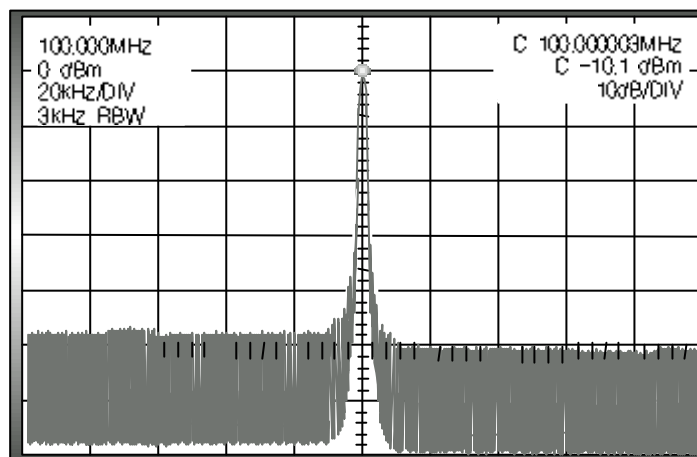(on   )

2) RF   ,   .

RF   Spectrum Analyzer   .

3)   0dBm   ,

.

4) Analyzer   Span   ,   .

5)   RBW   Analyzer   Span   RBW (Auto Mode   RBW   )

.

.

6)   (Center Measure)   .

,   .

.   .

Analyzer   ,   1Hz   .

<   3- 2>   "C"   .

RF 정현파의 스펙트럼

그림 3-2

3.   (Broadcast Signal Spectrum)

Spectrum Analyzer   TV

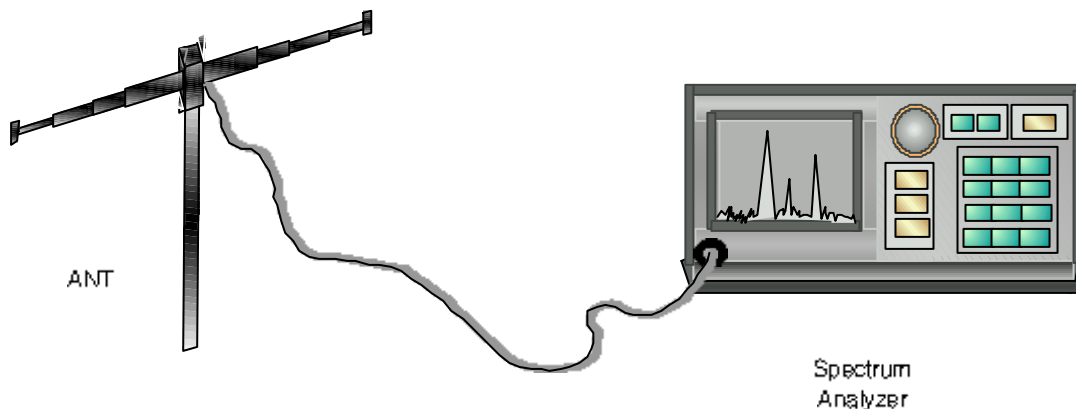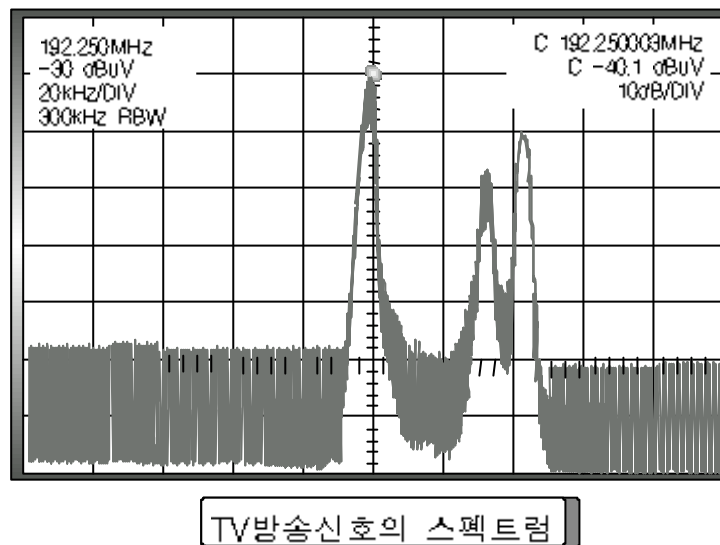. <   3- 3>   TV   .

ANT

Spectrum
Analyzer

그림 3-3

1) Analyzer   ,   2MHz/Div,   TV
   .

2) Analyzer   dB   ,   10dB/Div   .

3)   Analyzer   .
                                                            .

4) TV   .

5)   ,   (Center Measure)   .
                                          ,   .

6)   (dB   /m)   (dB   )   Factor   .
   Factor   **/m**   .

    <   3-4>   .

TV방송신호의 스펙트럼

4.   (Distortion)

                                                        .   2
            (Harmonic distortion)   (Inter-modulation Distortion)   .
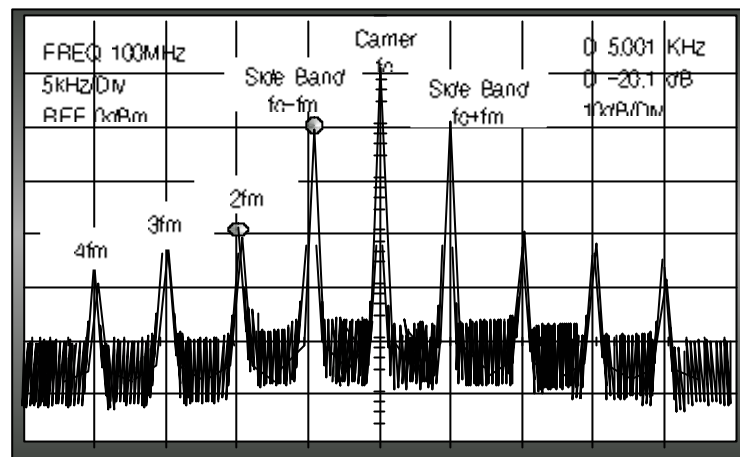   ,
                                                                                              .

                                          .

4-1.

                                                                                              ,
                  .

1) Audio   (5kHz)
              .

2)   .

3)   Spectrum Analyzer   .

4) Spectrum Analyzer
                                    .

5)
                    .

.

고조파 찌그러짐 스펙트럼

그림 3-5

(Side Band)   dB

.

,   RMS   ,

,   RMS   100   THD(%)   .

$$THD(\%) = \frac{\sqrt{Vf_2{}^2 + Vf_3{}^2 + Vf_4{}^2 \cdots}}{Vf} \times 100$$

, Vf :   (rms), $Vf_{2,3\cdots}$:   (rms)

4-2.   (IMD)

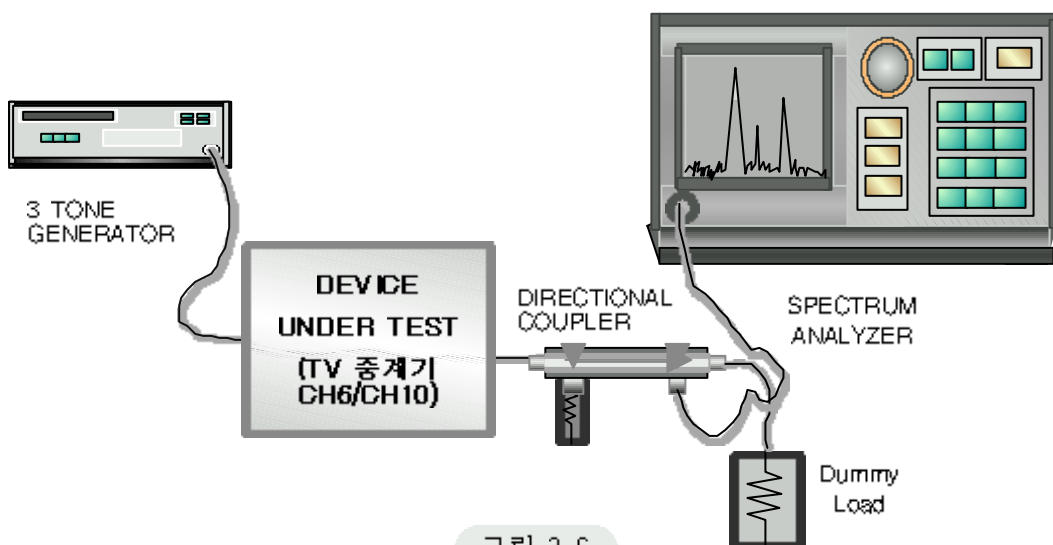(Inter-modulation Distortion)

.   2

,   .

(padded)   ,

.

그림 3-6

<   3-6>   3 Tone Generator   Spectrum Analyzer

,   6/   10   TV   IMD   .

1) 3 Tone Generator   6   ,   ,
   .

2) 3 Tone   .
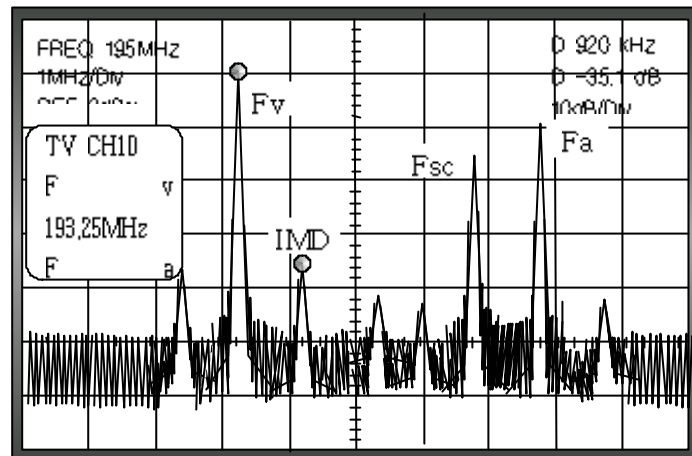   (Fv : - 4dB,   Fa : - 10dB,   Fsc : - 16dB)

3) <   3-7>   .
   920kHz   ± 920kHz   .

4)   .

5)   Maker Mode   ± 920kHz   .

상호변조 쩌그러짐의 주파수 엽역

그림 3-7

5.   (Modulation)

.

(modulating)   .   ?

,   .
.

(Amplitude Modulation)   ,

(Frequency Modulation)   .

5-1.   (Amplitude Modulation)

(carrier)   ,   (Modulating signal)
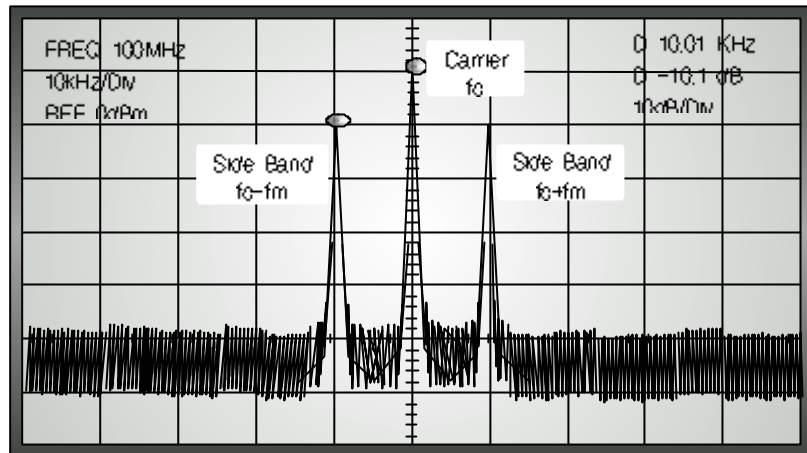.   (Modulation Envelope)

.

(Modulation Factor)   ,
peak- peak   peak- peak   1/2   . 100%
peak- peak   2   ,   peak- peak
"0"   .

,   Spectrum Analyzer
.

5-1-1.

<   3-8>   .   3

진폭변조의 주파수 영역 표시

그림 3-8

(   )   .

(modulation sideband)   Fc+Fm, Fc-Fm   .

<   3-8>   100MHz   ,   1

10kHz   .

.

$$m(\%) = \frac{2Esb}{Ec} \times 100$$

$$m(\%) = \frac{2}{10^{-(\Delta dB/20)}} \times 100$$

, Esb :   ,   Ec :   , m :

1)   Maker   ,   (Center Measure)   .

.

2)   Maker Mode   .

3)   .

.

4)   "D"

.

5)   <   3-1>   .

Modulation index(%)	Sidebnd amplitude relative to carrier		Modulation index(%)	Sidebnd amplitude relative to carrier	
	(%)			(%)	
100	50.0	- 6.02	30	15.0	- 16.48
95	47.5	- 6.47	25	12.5	- 18.06
90	45.0	- 6.94	20	10.0	- 20.00
85	42.5	- 7.43	15	7.5	- 22.50
80	40.0	- 7.96	10	5.0	- 26.02
75	37.5	- 8.52	9	4.5	- 26.94
70	35.0	- 9.12	8	4.0	- 27.96
65	32.5	- 9.76	7	3.5	- 29.12
60	30.0	- 10.46	6	3.0	- 30.46
55	27.5	- 11.21	5	2.5	- 32.04
50	25.0	- 12.04	4	2.0	- 33.98
45	22.5	- 12.96	3	1.5	- 36.48
40	20.0	- 13.98	2	1.0	- 40.00
35	17.5	- 15.14	1	0.5	- 46.02

표 3-1

5- 1- 2. Zero Span

(Zero Span)   .

1) Maker

   .

2) Zero Span Mode   .   <   3- 9>   .

3) Analyzer   ("Linear")   (Reference Level)

   .

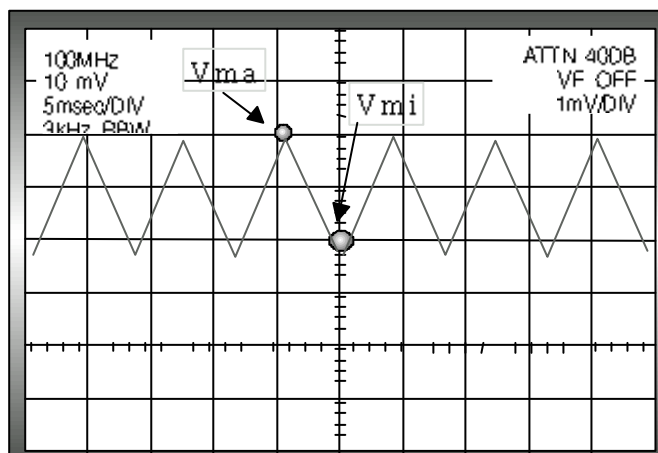4) "Single Line"   Maker   (pk- pk)   Vmax(   )

   .

5) Maker   Vmin(   )   .

6)   .

$$m(\%) = \frac{Emax - Emin}{Emax + Emin} \times 100 = \frac{1 - Emin/Emax}{1 + Emin/Emax} \times 100$$

Zero Span Mode AM

그림 3-9

<   3- 9>   Zero Span   .

5-2.   (Frequency Modulation)

                                                        .

    ,   .

                .   (Frequency Deviation,   F)

          .

            FM

                                          .

(Bessel functions)   .   M

    .   .

            $M = \Delta f / fm$
            , M Δf , fm

5-2-1

                                                                                            MAX

HOLD   Digital Storage   .
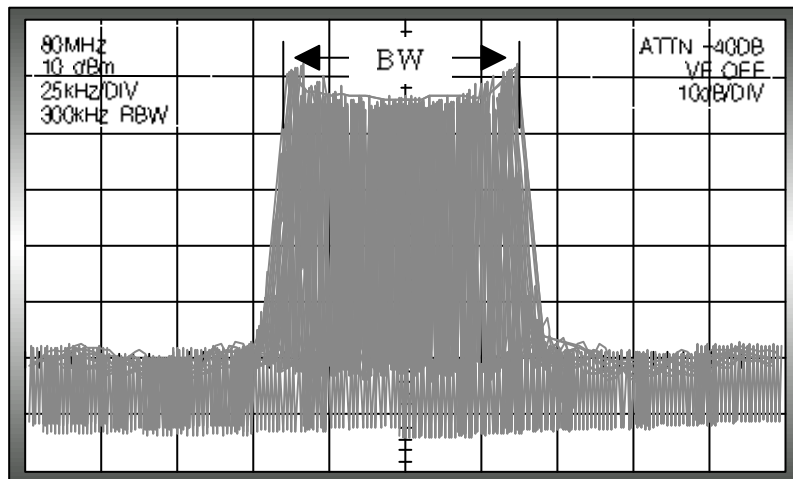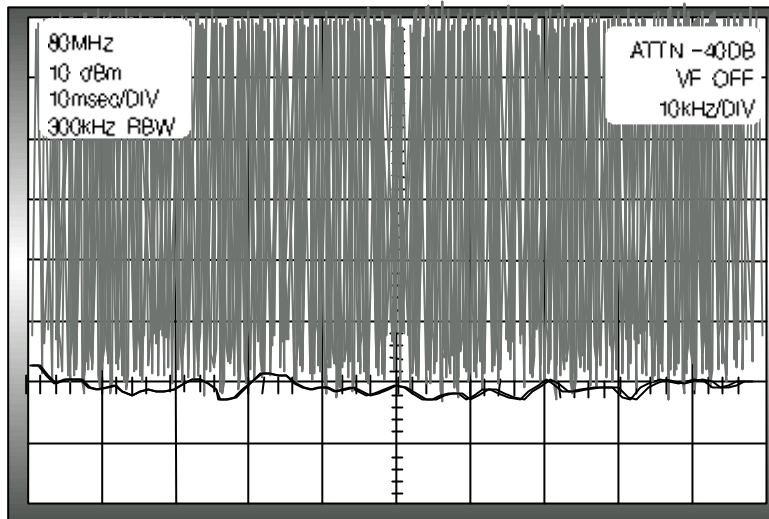
            <   3-10>   .

            RBW   .

            $BW = 2(\Delta f + fm)$
            , BW :   , Δf :   , fm :

    Tektronix 2712 Spectrum Analyzer

            . <   3-11>   .

FM변조파의 스펙트럼

그림 3-10

```
80MHz          ATTN -40DB
10 dBm         VF OFF
10msec/DIV     10kHz/DIV
300kHz  RBW
```

2712의 주파수편이 표시

그림 3-11

1) FM   .
2) RBW   300kHz   500kHz   .
3) FM   .
4) Display Menu   "Display Source"   "FM   " Mode   .

   <   3-11>   .   0   ,
      10kHz(5kHz/div   1kHz/div   )   .   7
              ,   70kHz   . MIN HOLD
                                                                              .

5-2-2 Bessel Null

                              BESSEL NULL   .
                                                                    . BESSEL NULL
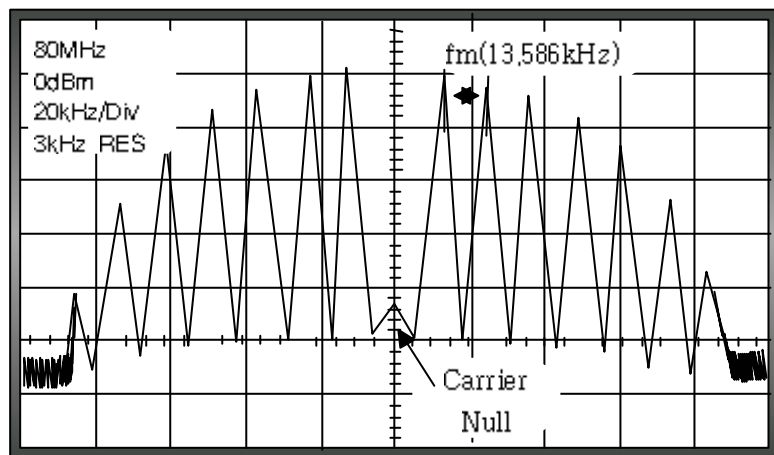   FM   "0"
       .

(NULL NO)	J₀(M)	1 J₁(M)	2 J₂(M)	3 J₃(M)
1	2.4048	3.8317	5.1356	6.3802
2	5.5201	7.0156	8.4172	9.7610
3	8.6531	10.1735	11.6198	13.0152
4	11.7915	13.3237	14.7960	16.2235
$M = f / fm$ M , f , fm				

표 3-2

FM   Jo(M)   Jn(M)   .   n

M   .   FM   , <   3-2>

.   ± 75kHz   100%

.

1) NULL   <   3-2>

75kHz   .   2   NULL

31.188kHz   NULL   .

2)   31kHz   13.586kHz

NULL   .

75kHz ÷ 5.5201 = 13.586kHz.

3)   13.586kHz   .

. Bessel null

.

4)   "0"(0)   Spectrum Analyzer   RF

.

5)   (Deviation meter)   ,   100%

.   Analyzer   NULL

.

6)   NULL   .

<   3-12>   .

80MHz
0dBm
20kHz/Div
3kHz RES

fm(13,586kHz)

Carrier
Null

Bessel Carrier Null

그림 3-12

NULL-CARRIER   100%   ,   100%

. Bessel null   100%

.   2   NULL

6.793kHz(13.586kHz   )   50%   .

6.   (Squre Wave Spectrum)

6-1.

Spectrum Analyzer   50kHz   .
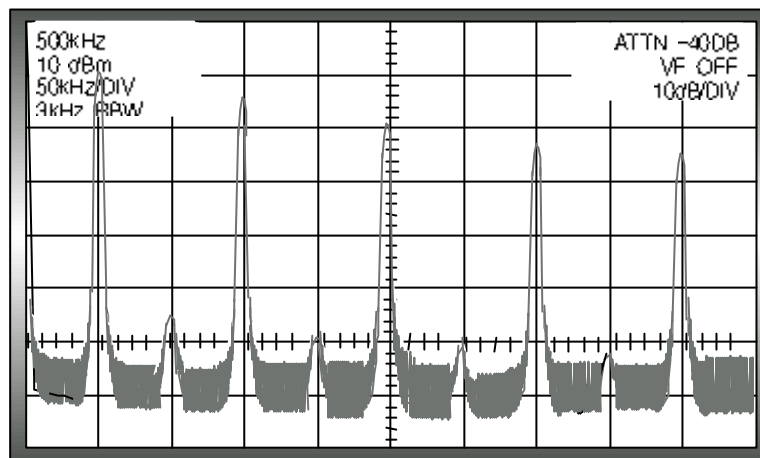
1) Analyzer   , 500kHz   , Span   50kHz/Div   .
2)   50kHz   (   )
   Analyzer   .
3)   10dBm(+57dBmV)   Analyzer
                   .   , 50kHz   .
     <   3- 13>   Analyzer   (50kHz)
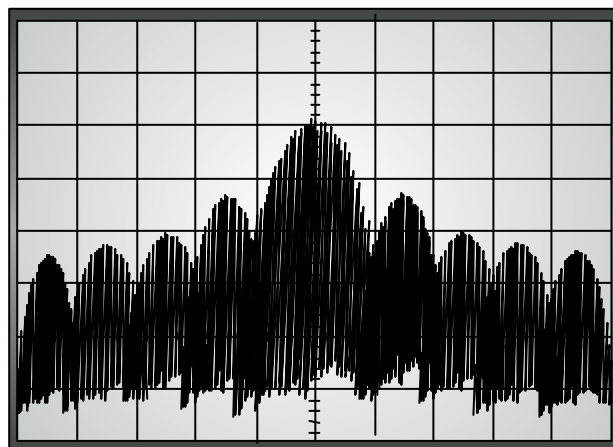(Fundamental)   .
              3   , 5   , 7   .
                                                                (Duty Cycle)   50%
        .   "   "   .
                              .

   (Distortion   )   .

100kHz 구형파의 스펙트럼

그림 3-13

6- 2.   (Pulsed Carrier Waveform)
                  ,   .   (tpw)
     (fc)   .   ,   ,
                              (fr)   .   <
3- 14>   .

펄스반송파의 주파수 염역

그림 3-14

7.   (Noise Measurements)

  Spectrum Analyzer   .
(GRASS)   .   dBm/Hz   Watt/Hz
        ,   1Hz   .

$$Noise(dBm, 1Hz) = 10\log\left[\frac{No}{(Zo \times 1mW)}\right]$$

       No =   (volts^2/Hz),   Zo =   .
                                                                                                          1
                        .

$$Noise(dBm) = 10\log\left[BW_N \frac{No}{(Zo \times 0.001)}\right]$$

dBm(1   )   10log(BW$_N$)   .
                                                              .

$$K = 10\log\left(\frac{BW2}{BW1}\right)$$

  BW$_1$ BW$_2$ BW$_1$ K   .
                                                                                                          .

                                          (AVG)   .

  Spectrum Analyzer
                                    .

❖
                    .
                    .

❖   RBW   .
                                        3   15%   20%   .

❖
                            .

❖ Spectrum Analyzer   2.5dB(LIN
        1.06dB)   .

❖   Analyzer   3dB   .
                                              Analyzer   ,
                            .

      <   3-3>   .

(dB)	( )	(dB)	( )
20 dB	0.04 dB	6 dB	1.26 dB
15 dB	0.14 dB	5 dB	1.65 dB
10 dB	0.46 dB	4 dB	2.20 dB
9 dB	0.58 dB	3 dB	3.02 dB
8 dB	0.75 dB	2 dB	4.33 dB
7 dB	0.97 dB	1 dB	6.87 dB

표 3-3

Spectrum Analyzer

.

7-1. C/N

271X Spectrum Analyzer   TV CH3   C/N   .

.

1) Analyzer   TV

,   Analyzer   .

(baseline)   .   Analyzer   RF   0

.

2)   (APPL Menu)   ,   (Setup Table)   4.0MHz

C/N   .

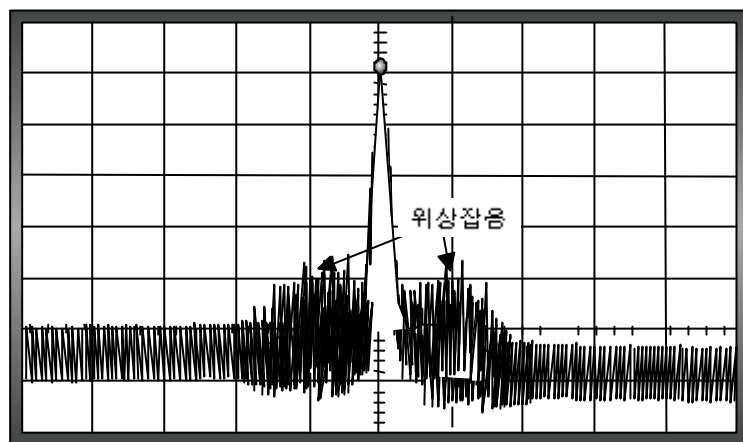3)   .

.

<   3-15>   2712   MIN/MAX (Acquire mode)   .

C/N   , Analyzer

.
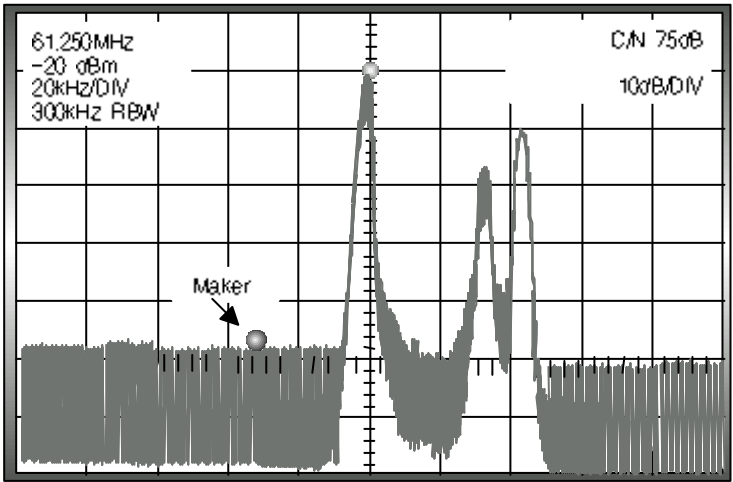
그림 3-15

7-2.   (Phase Noise)

          RF   ,   (Oscillators)
      .   ,
                        .

                                                    .

      Vo   zero-to-peak   fo   .

$$v(t) = [\,Vo + a(t)\,]\sin[2\pi fot + \phi(t)\,]$$

          a(t)=   ,   (t)=

                                                              .

<   3-16>   Spectrum Analyzer
      .

RF 정현파의 위상잡음 스펙트럼

그림 3-16

8. Tracking Generator
8-1.
      Tracking Generator   Spectrum Analyzer
                  . Tracking Generator   Spectrum Analyzer   ,   ,
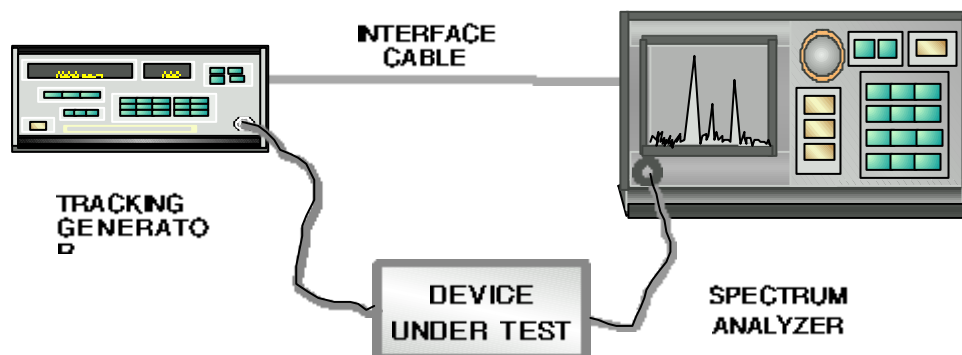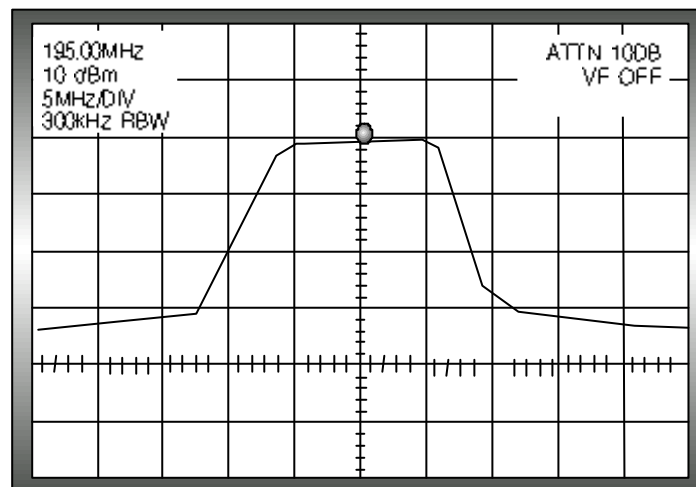(Couplers)   X-tal   Q   .
                  <   3-17>   Tracking Generator
            Spectrum Analyzer   .

그림 3-17

Tracking Generator   Spectrum Analyzer   ,
.

.   Analyzer
"B- SAVE A"   "B, C MINUS A"   .

1) Tracking Generator   Spectrum Analyzer   "
     A"   .

2) Tracking Generator   Analyzer   ,
     Analyzer   .
                    "Tracking Generator   Spectrum Analyzer"   .
                    "B"   "C"   .

3) "B,C- SAVE A"
                              ,
                    .   "D"   off
         .

     <   3- 18>   TV   10
     .

그림 3-18

8- 2.   (VSWR)
                                                                                .

              (Standing Wave Ratio)   ,
                              .   (return loss)
         .

              Spectrum Analyzer,   (bridge), Tracking Generator
         .

     Bridge   .
                         Tracking Generator   Bridge   .   Bridge

Bridge

Spectrum Analyzer

Tracking Generator Analyzer Analyzer

< 3-19> SWR

INTERFACE
CABLE

TRACKING
GENERATOR

A N

50

Return
Loss

50   50

SPECTRUM
ANALYZER

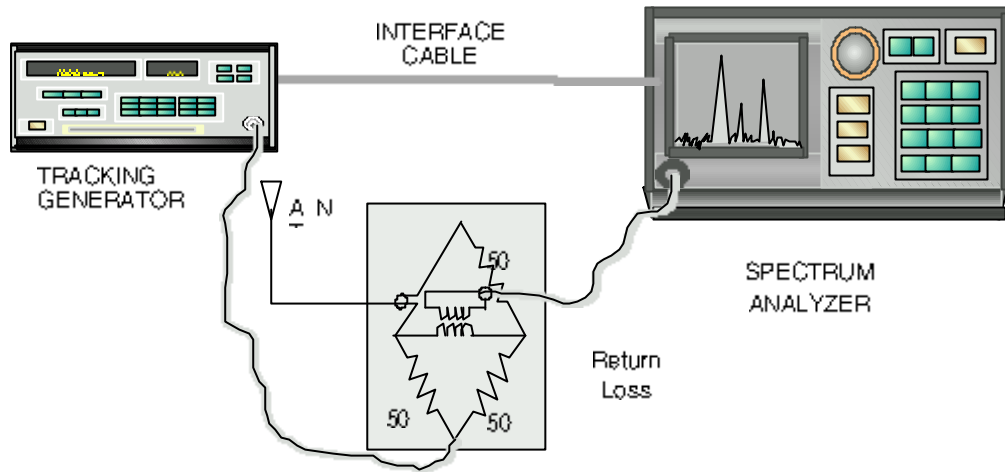그림 3-19

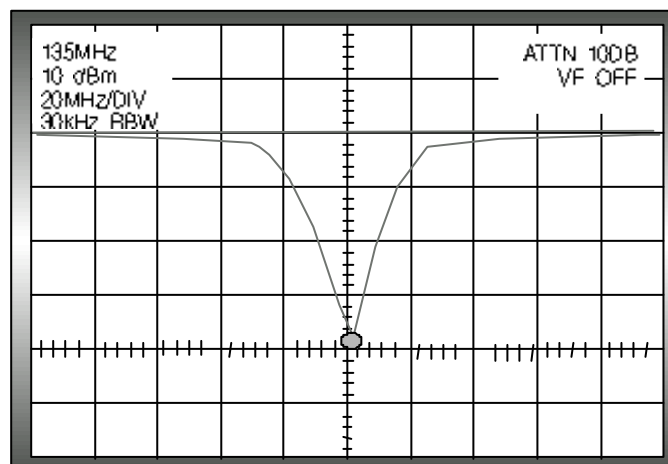1)   ,   (   )   (   )
                      ,
              .

2)   (   )   (Reference) Dummy-load(50)   ,
                - 30 ˚ - 60 dBm   .

3) Reference Dummy-load   .

< 3-20> 35MHz   235MHz   .
  135MHz   38dB   .

135MHz
10 dBm
20MHz/DIV
30kHz RBW

ATTN 10DB
VF OFF

2712의 ANT Sweep

그림 3-20