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FILTER CHARACTERISTICS FOR PROCESSING BIOMECHANICAL SIGNALS FROM IMPACT TESTS

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This work, initially started in 1983 as part of the Advanced Anthropomorphic Test Device Project, was finalized in April-June 1986.

16. Abstract

Digital signals generated in head and chest impact tests were used as the basis for characterizing the frequency responses of the human head and chest, and for specifying filters for the data acquisition and analysis of such signals. Spectral analysis of about 450 signals resulted in some 23 approximate characterizations that were further combined into three final recommendations. Each recommended filter is a low-pass Butterworth filter specified by its -3 dB corner (Hertz) and the slope of its rolloff asymptote (dB/decade). The three recommended filters are:

HEAD signals:	Corner = 550 Hz,	Slope = -26 dB/dec.
CHEST (anti-alias):	Corner = 500 Hz,	Slope = -27 dB/dec.
CHEST (analysis):	Corner = 177 Hz,	Slope = -15 dB/dec.

The use of a single analog Butterworth filter with corner at 800 Hz and a slope of -30 dB/decade for anti-aliasing with sampling at 8000 Hz would preserve significant frequencies in both head and chest signals, and would allow further digital filtering using one of the recommended filters.

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SUMMARY

Digital signals generated during head and chest impact tests were used as the basis for characterizing the frequency response of the human head and chest and to specify filters to be used during the data acquisition and analyses phases in biomechanical impact tests. About 450 signals were used in this *filter study*. These were combined into 35 different groups to produce different frequency response characterizations.

The grouping was based on several considerations. Those included whether the signal resulted from a head or a chest impact, the type of impacting surface, the direction of impact, the proximity of the sensor to the impact site, and whether a fracture occurred at or near the transducer mount. The sensitive axis of the sensor and the severity of impact were not considered as key factors in the grouping. No fractures occurred in only 23 groups, and these groups were eventually combined to produce the specifications for head and chest filters.

A low-pass Butterworth filter, specified by its -3 dB corner frequency (Hertz) and its rolloff slope (dB/decade), was used as a model to describe the frequency responses of the analyzed signals. An approximation procedure was developed and applied to estimate these two system parameters, given the limited information about the signals available for analysis.

Analysis of frequency responses of head signals indicated that a single filter may be used for data acquisition and/or analysis. For chest signals, it was not possible to specify a single filter. Instead, the analysis indicated that anti-alias filtering for data acquisition should use one filter, and filtering for biomechanical data analyses may use a lower-frequency filter. The three recommended Butterworth filters are:

	Corner (Hertz)	Rolloff (dB/dec)
HEAD	550	-26
CHEST (anti-alias)	500	-27
CHEST (analysis)	177	-15

It was also concluded that a single analog Butterworth filter with a corner at 800 Hz and a rolloff slope of -30 dB/decade may be used as an anti-alias filter for both head and chest signals with a sampling rate not below 8000 Hz, provided that signals are filtered further using the recommended filters.

INTRODUCTION

As part of the biomechanical data analysis task of the AATD program, a comprehensive filter study was undertaken to provide a rational basis for filtering biomechanical signals prior to their analysis and their use for specifying response characteristics of an advanced anthropomorphic test device.

The filter study used the biomechanical data base that was consolidated from various sources and experiments conducted over the past ten years. The objectives of this study were:

A. To conduct a spectral analysis on all appropriate biomechanical signals in order to document their frequency contents.

B. To use the spectral analysis to characterize the mechanical systems that produced them.

C. Based on this characterization, to recommend specifications of the filters to be applied prior to analyzing biomechanical signals, and to extend these recommendations to the data acquisition instruments used during biomechanical testing.

The purpose of this document is to describe the methodology followed in the *filter study*, the rationales and justifications for their adoption, and the results and recommendations of the study.

DATA BASE

The complete data base that was available for the filter study consisted of over 5000 signals, not all of which were of practical use. After careful examination of these signals, only about 450 of them were finally selected as a basis for the study. There were several reasons for eliminating many signals from consideration, and for setting criteria for inclusion of others in the subset of the data base.

First of all, many signals contained in the complete data base do not pertain to biomechanical response *per se*, but are time-base, velocity, and other event-timing signals. Along with these signals were those that are "external" to the surrogate being tested, such as sled pulses, vehicle acceleration, and externally measured impactor accelerations and forces. This class of signals would (and should) not be used for characterization of the frequency response of human surrogates in biomechanical tests.

Second, a large number of signals were measured as responses of anthropomorphic dummies. Accelerometers and other transducers mounted on dummies provide response of the mechanical hardware of the dummy, and not of the skeletal or muscular structure of cadavers. Since the objective of this study was to characterize human frequency response, and not that of a mechanical dummy, all signals generated from transducers mounted on dummies were eliminated from consideration for the filter study. This left only those signals generated in cadaver tests, from transducers (primarily accelerometers) mounted on cadavers.

A third reason for eliminating further cadaver signals was the low sampling rate of a large number of them. An objective study of frequency response should not be limited to low-frequency ranges, since many "events" could be happening near the higher end of the frequency spectrum. The NHTSA Biomechanics Data tape format requires that all signals be filtered at SAE Channel Class 1000, that has a corner frequency at 1650 Hz. Since the theoretical sampling rate which would preserve this frequency must be greater than twice the highest frequency in the signal, all signals that were sampled at rates less than 3200 Hz were eliminated from consideration in the filter study.

The resulting "pool" of acceptable tests was reduced to the 60 tests listed in Table 1. Signals from these tests had been digitized at different sampling rates that were chosen by the organizations who conducted the tests and/or digitized the analog signals. The majority of these were sampled at 6400 Hz, others at 8000, 10000, and 13333 Hz, and some at 25000 Hz.

Finally, signals that met all of the above criteria were further examined to determine their "quality," and to eliminate those that clearly did not represent cadaver response. These "rejects" were primarily "dead channels" and "broken cables," as indicated in the data base coding or determined from visual examinations. The remaining signals were assumed to be accurate and reliable responses of the tested cadavers at the indicated attachment sites.

SPECTRAL ANALYSIS

The following discussion is not intended to be a rigorous presentation, but is included here in order to define the terminology used in the study. For a complete presentation, the reader is referred to the textbook by A. V. Oppenheim and R. W. Shafer, *Digital Signal Processing*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1975.

A time signal x(t) may be represented in the time domain as a finite sequence of N samples taken at a constant sampling rate, S, usually expressed in Hertz or samples per second. By assuming that this finite record represents one cycle in a periodic phenomenon, it is possible to express x(t) in terms of a Fourier series consisting of a sum of sine and cosine terms at frequencies that are integer multiples of the fundamental frequency S/N associated with the periodic phenomenon:

$$x(t) \doteq \sum_{k=0}^{N/2} A_k \cos [k(S/N)t] + B_k \sin [k(S/N)t]$$

This is known as the discrete Fourier series of the signal. The coefficients A_k and B_k may efficiently be computed using Fast Fourier Transform (FFT) algorithms.

Since both sine and cosine terms are at the same frequency, another form of the same equation is:

$$x(t) = \sum_{k=0}^{N/2} M_k \sin [k(S/N)t + \phi_k]$$

where $M_k^2 = A_k^2 + B_k^2$, and $\phi_k = \arctan (B_k/A_k)$.

The term M_k is the magnitude of the k-th frequency component, and ϕ_k is its phase angle. Both magnitude and phase may be plotted against frequency, and study of these responses is generally referred to as *spectral analysis.* Because the power of a signal is proportional to the square of its magnitude, sometimes the squared magnitude is plotted against the frequency. And depending on the units chosen for expressing this squared function, it is possible to consider its plot as the power function, usually referred to as the *power spectral density*, or PSD for short.

The discrete Fourier series states that any finite segment of a time signal is composed of pure sinusoidal components at frequencies ranging from zero (the D.C. term) up to the Nyquist frequency, which equals half the sampling rate. The number of components is limited to N/2, half of the number of time samples. This is a direct result of the *Sampling Theorem.* Another result is that frequencies above the Nyquist rate will be *folded* about this frequency and will *appear* in the digital signal as lower-frequency components that do not, in reality, exist in the analog signal. Since these *aliased* frequencies cannot be distinguished from *real* ones in the digital signal, it is necessary to filter out all components above the Nyquist frequency prior to digitizing, using low-pass filters. These filters are referred to as *anti-aliasing* filters.

While the phase response of a system is just as important as its magnitude response for its characterization, spectral analysis practices usually emphasize the study of the magnitude response. In this filter study, the focus will also be on the magnitude, since study of the phase requires more controlled data acquisition procedures than were documented in the available data base.

Most mechanical systems respond to external excitations by vibrations that can be monitored. When the excitation is a steady sinusoidal signal of a certain magnitude and phase angle, the system response is another sinusoidal motion at the same excitation frequency, but with a different magnitude and phase shift. When the excitation is impulsive, such as a short-lived impact, the response of the system appears to be random, and continues well after the excitation is removed, and eventually dies out because of the damping that may exist in the system. It is from this type of excitation that most biomechanical signals are generated.

Frequency responses of most biomechanical systems, i.e., the plots of magnitude versus frequency, exhibit common features. Thus, there is always a D.C. term at zero frequency which, depending on the data acquisition equipment, may be the most prominent feature in the frequency spectrum. This occurs when the zero-bias in the signal amplifier is not removed. It could also occur when most of the signal lies on one side of the time axis, as in the case of contact forces. For most signals, however, this term is small and represents the mean of all the samples in the signal. Although the D.C. term is necessary for faithful reproduction of the original time signal, it may be ignored (i.e., assumed zero) for the purpose of characterizing the biomechanical system that generated the signal.

The response over the remainder of the spectrum, which extends to the Nyquist rate, typically decreases with frequency; that is, low-frequency components are more dominant than high-frequency ones. This behavior, characteristic of low-pass transfer functions, is typical of most mechanical systems, and may be explained in two ways.

Consider a signal that has been sampled at 8000 Hz. Spectral analysis of this signal extends to the Nyquist rate of 4000 Hz. Assume that, prior to digitizing, an SAE Channel Class 1000 was used as an anti-alias filter. Such a filter has a cutoff frequency of 1000 Hz and a corner of 1650 Hz. Because of the use of this anti-alias filter, all frequencies above the cutoff point of 1000 Hz have been gradually attenuated. Therefore, when examining the spectrum between 1000 and 4000 Hz, which *will* necessarily exhibit a "roll-off," it is not immediately obvious whether this attenuation is a characteristic of the mechanical system or is due to the anti-alias filter.

Assuming that the low-pass, anti-aliasing filter has a "flat" response up to its cutoff frequency, then any roll-off that is observed below this frequency may confidently be attributed to the mechanical system being measured. Of course, this further assumes that the instrumentation (transducers, conditioners, recorders, digitizers) does not alter the true response of the signal being monitored. It is this explanation that will enable us to characterize the biomechanical systems under consideration.

The approach taken in this study was simple but effective. Since most signals in the data base exhibited (as expected) a "low-pass" system behavior, a simple low-pass filter was used as a model to characterize specific groups of signals generated at various body parts. Because of the availability of the data, only responses of the head and chest were considered. The limitation imposed by the use of Channel Class 1000 as an anti-alias filter did not hinder the overall characterization, since most signals exhibited their roll-off behavior inside the useful range below 1000 Hz.

BUTTERWORTH FILTERS

One of the simplest low-pass filters that may be adopted as a model is the Butterworth filter, whose squared magnitude response function is given by:

$$|G(\omega)|^2 = 1 / [\ 1 + (\omega/\omega_c)^{2n}\ ]$$

where $G(\omega)$ is the filter's gain as a function of frequency, ω_c is the corner frequency, and n is the order of the filter. The appeal of the Butterworth filter lies in the simplicity and flexibility of its definition and digital simulation, as well as in its properties. The most distinctive property of these filters is that they are *maximally flat* in the passband. This and other properties are explored in the following paragraphs.

A simple computer program to simulate the frequency response of a Butterworth filter is listed in Figure 1. The filter is specified by its corner and rolloff slope from which its order may be derived. The number of samples and sampling rate are used only as a guideline to define the number of frequencies at which the filter gain is computed, as well as the interval between adjacent frequencies. In the version listed in Figure 1, the returned GAIN was set equal to the squared magnitude, SMAG, but could easily be modified to return the magnitude itself, GMAG, or its value in deciBels, DBEL. This is precisely what was done to generate the frequency responses shown in Figures 2, 3, and 4. Typically, however, the frequency response is displayed, as shown in Figure 5, on a semi-logarithmic paper, where the gain (deciBels) is plotted along the vertical linear axis, against the frequency (Hertz) along the horizontal logarithmic axis.

It is clear that, as the order of the Butterworth filter increases, its characteristics become sharper but the gain at the corner frequency remains the same. Because the power of a sinusoidal signal is proportional to its squared magnitude, and since the square magnitude function at the corner is equal to one-half regardless of the order, the corner frequency is usually referred to as the *half-power* point of the filter, where the gain is -3dB. In other words, frequencies passed by the filter that are below the corner will retain at least half of their power, while those that are above the corner will lose at least half of their power.

Another important property of Butterworth filters, which may be observed in Figure 5, is that the frequency response in the rolloff region is asymptotic to a straight line when the frequency is plotted along a logarithmic axis. The straight-line asymptote always intercepts the 0-dB line at the corner frequency, but its slope (in dB/decade or dB/octave) is proportional to the order n of the filter. Thus, the slope is -20 dB/decade for n=1, -40 dB/decade for n=2, and so on.

Unless the Butterworth filter is intended for analog implementation, there is no reason to restrict the order n to an integer. Thus, a rolloff slope of -50 dB/decade may be achieved by specifying n=2.5 for the order. This provides an appealing flexibility in the digital simulation of the Butterworth filter, especially when it is used as a model for unknown frequency responses. Consequently, it is more appropriate (as was done in the coding of BUTTER program, Figure 1) to specify the filter by its corner frequency and its rolloff slope, which may not necessarily be an integer multiple of 20 dB/decade. The parameter n, required for computing $G(\omega)$, is then simply derived from the specified slope as the ratio of slope over the 1st-order slope of 20 dB/decade.

Finally, since the asymptote always intercepts the 0-dB line at the corner frequency, a quick sketch of the actual response of the filter is possible, without elaborate computations, given only the corner and slope. Note, however, that the vertical separation between the actual curve and the asymptote, for frequencies above the corner, cannot exceed 3 dB, with the largest deviation (3 dB) always occurring at the corner, and decreasing as the frequency increases.

These properties allow the identification of the two filter parameters, given an experimentally measured frequency response curve of the filter. To do this, one would locate on the actual curve the frequency where the gain crosses the -3 dB level. This is the corner frequency of the filter, which also identifies the 0-dB intercept point of the asymptote. By drawing a straight line that passes through this point asymptotically to the rolloff portion of the given curve, the slope and, consequently, the order of the filter may be determined. This graphic identification procedure was the basis for the algorithm that was developed and used in the filter study.

IMPACT FREQUENCY RESPONSE

A linear and stable system being excited with a random white noise produces a response. Under some conditions, the squared magnitude response may be considered an adequate approximation of the power density spectrum (PDS), especially when the PDS is smooth and approaches zero at finite frequencies. Since the biomechanical signals were produced from an impulsive (non-white) input, the resulting PDS is "noisy" and must be smoothed prior to any further analysis. Therefore, approximation techniques were developed in this study to characterize the frequency response of the impact signals and to identify the parameters of the biomechanical systems in question.

The PDS of a typical biomechanical impact signal generally exhibits a roll-off characteristic at high frequencies and a noisy response over the entire spectrum. It is more convenient to base the system identification procedure on a smoother distribution derived from the experimentally generated PDS curve. Such a smooth distribution is the integral of the PDS, which may be shown to be also proportional to the power content in the signal over the frequency interval of integration.

The approximation procedure followed in this study may be illustrated by applying it to a well-understood system. Thus, consider the already-smooth PDS of a Butterworth filter whose corner is 500 Hz and rolloff is -20 dB/decade. The

PDS of this (500/-20) filter is shown in Figure 6 along with its cumulative PDS function. The frequencies of five landmarks on the cumulative PDS are then identified to serve as the basis for estimating the corner and rolloff slope of a low-pass system. These landmarks correspond to the 50, 75, 90, 95, and 99% levels of the cumulative PDS, which may be considered, for the purpose of approximation, as the 50, 25, 10, 5, and 1% respective power points in the low-pass system. In terms of deciBels, these translate into -3, -6, -10, -13, and -20 dB gains of the desired characterization.

Once these five landmarks have been identified, they may be used in an algorithm that corrects for deviations from a hypothetical asymptote (as discussed earlier) to produce approximate points on the asymptote. These corrected points are then fitted to a straight line whose intersection with the 0-dB line is the corner, and slope is the rolloff of the approximated low-pass Butterworth characterization. For the (500/-20) filter, this produced the approximation (549/-21) that is shown in Figure 6 as the dashed curve. Of course, for actual signals, the approximation may not be as close to the unknown characteristics as shown in the example, depending on the smoothness of the PDS curve, and on the order (rolloff) of the unknown system. However, given the information available for this study, it was felt that this procedure is adequate if care is exercised in interpreting the results.

This simple system parameter identification procedure may be repeated for several signals that were produced under similar test conditions of the same mechanical system. Then the resulting corners and rolloffs are averaged to obtain better estimates of the system parameters. Alternatively, the five landmarks obtained from different signals may be averaged first. Then an approximate filter may be derived from the five averaged landmarks. In this study, the 450 signals were first analyzed to extract the five landmarks, combined into 35 different groups of compatible signals, then averaged to produce 35 different sets of five landmarks.

Because of statistical variations of the landmark frequencies in each group, and since the resulting characterization was intended to preserve significant frequency components in current and future biomechanical signals, the straight-line fitting procedure was applied, not to the average landmark frequencies, but to frequencies that were *one standard deviation above the average*. This ensured that significant frequencies which were present in the signals would fall in the passband, and allowed for uncertainties and errors during the data acquisition and analysis phases of the signals. The resulting 35 low-pass filter characterizations are, therefore, *conservative estimates* that are not likely to filter out significant frequencies.

GROUPING OF SIGNALS

The system parameter identification procedure outlined in the previous sections was applied to the appropriate signals available in the data base. First, the selected signals were grouped by test type, restraint conditions and/or impact surface, and by transducer attachment location. A list of the sixty (60) tests from which these signals were obtained is given in Table 1. The results of the analysis of 35 groups of signals are presented in Appendices A and B, and are summarized in Tables 2 and 3.

In combining the available signals in the 35 groups, several factors were taken into account. First, the head and chest signals were separated to produce characterization of two physically separate body parts. Another consideration was the type of impact surface that produced the response. This is defined by the restraint system that was in contact with the chest during the tests, or by the padding, if any, that was added to the impactor in head and chest pendulum impacts. The velocity of impact, which affects the magnitude of the response but not its frequency content, was not considered as a factor in grouping the various signals. Similarly, the direction of the sensitive axis of the transducer was ignored in the grouping, since the vibration of the sensor reflects the underlying bony structure and would contain the same frequency information regardless of the sensing direction.

The third consideration was the proximity of the transducer mounting location to the impact site. It may be argued that, as the sensor is located farther away from the impact site, the response is attenuated but its frequency content should remain unchanged. While this may be true for a rigid or nearly-rigid body such as the head, the thorax is much more complicated and contains structures that may respond differently. Therefore, the chest signals were grouped by whether they were near the impact site, at the far and opposite side of the chest, or at mid-range between these two extremes. This necessitated dividing the tests into lateral (left-side) and frontal impacts, then grouping the signals as follows:

	Near Side	Mid Range	Far Side
LATERAL	LLR, LUR	LST, UST T01, T12	RLR, RUR
FRONTAL	LST, UST	LLR, LUR RLR, RUR	T01, T12

The last factor that was taken into account was whether a bone fracture occured at or near the transducer mount. This is an important consideration because, when the integrity of the bony structure is violated by a fracture, the response of the system becomes erratic and can no longer be attributed solely to the structural vibration of the biomechanical system. These groups are included in the results to demonstrate the frequency characteristics of fractured systems, but should not (and were not) used to draw conclusions about the chest or head frequency response.

This grouping scheme resulted in 35 separate characterizations of the available signals, of which 12 groups were ignored because they consisted of signals where fractures occurred. The remaining 23 "filters" are listed in Table 2 and are presented as six chest groups and one head group. The weighted logarithmic average of the corner frequencies in each group, as well as the weighted arithmetic average of the rolloff slopes, are also given. Those "filters" marked with an asterisk (*) were not included in the averaging because they were clearly low extremes and because their omission would not adversly affect the intended goal of preserving the high frequency components in signals. The averaging process reduced the number of filters to six for the chest, and one for the head. The average corners and slopes are shown in Table 2, in parenthesis, at the bottom of each group.

DISCUSSION AND RECOMMENDATIONS

An examination of the six Butterworth filter characterization of chest frequency response reveals that five of them are clustered near the (200/-15) filter, while one is near (500/-25) filter. Further reduction of the number of chest filters is obtained by an additional weighted averaging of the five-filter cluster to produce the (177/-15) filter. Note that the 177 Hz is a corner frequency at which the filter gain is -3 dB, and should not be confused with the SAE J211 Channel Class 180, which has its corner frequency at 300 Hz. Note also that, in obtaining the (177/-15) average, only five filters were used and did not include the (493/-27) filter. Even when this filter is included in the averaging, the result is a (186/-16) six-filter average that is not much higher than the five-filter average.

It is tempting to specify the overall average of (186/-16) as a do-it-all filter to be used during the data acquisition and analyses phases of all thoracic signals. It is more prudent, however, to allow for uncertainties in these phases and specify a filter that would preserve the highest frequency which may occur, without imposing unrealistic and unfounded restrictions. Therefore, the (500/-27) filter, i.e., the Butterwoth filter whose corner frequency is 500 Hertz and whose rolloff slope is -27 dB/decade, should be used during the instrumentation and data acquisition phases of biomechanical testing of the thorax. Once the data have been digitized, additional filtering using the (180/-15) filter may be applied to the thoracic signals when warranted. For head signals, a (550/-26) filter, which is almost identical to the one specified for chest signals, should be used during both the data acquisition and analyses phases. The frequency responses of these filters are given in Figures 7, 8, and 9. For convenience, these are overplotted in Figure 10.

FILTER IMPLEMENTATION

The two head and chest filters recommended for anti-aliasing during data acquisition are almost identical with corner frequencies near 500 Hz and rolloff slopes near -27 dB/decade. While such a filter may easily be realized in a digital simulation, it cannot be designed as an analog Butterworth filter since its order (27/20 or 1.35) requires 2.7 poles in the realization. The nearest analog filter that would have 3 poles for a rolloff slope of -30 dB/decade. If the (800/-30) filter were used as anti-alias filter, and if the sampling rate were 8000 Hz, as recommended in the SAE J211 instrumentation guideline, then the gain of frequencies above the Nyquist rate of 4000 Hz would be no higher than -20 dB, an adequate anti-aliasing attenuation. Higher sampling rates would, of course, produce additional anti-aliasing attenuation when the (500/-30) filter is used.

Digital implementation of any Butterworth filter is simple but requires that the filtering be done in the frequency domain. A Fast Fourier Transform (FFT) algorithm must therefore be available, in hardware or software, before filtering can be done. Using the FFT, the frequency spectrum of the time signal is first obtained. The gain of the desired filter is then computed at every frequency in the spectrum, then multiplied by the magnitude of corresponding signal component. The inverse FFT is then applied to the modified signal component to return to the time domain.

A listing of the Fortran subroutine FILTER is given in Figure 11. The program requires an algorithm (FFT) that performs the direct and inverse Fourier transforms. Input to this routine are the time signal (SIG) to be filtered, the number of samples (NPT), the sampling rate (SHZ), as well as the corner (CORN) and rolloff (ROLL) of the desired filter. The gain of the Butterworth filter is computed as filtering is performed. The routine returns, in the SIG array, the filtered time signal. Note that, in this simple implementation, the phase response is not applied to the signal but may, in a more sophisticated implementation, be applied by modifying differently the sine and cosine terms of the Fourier series. Other implementations may include a section where the signal is extended at either end to eliminate possible distortions, then "return" only the original time segment.

```
      SUBROUTINE BUTTER (NPT,SHZ, CORN,ROLL, GAIN,NFRQ)

C     Frequency response of a Butterworth filter

C    Input:      NPT  ... Number of samples in signal
C                SHZ  ... Sampling rate  (Hertz)
C                CORN ... Corner frequency  (Hertz)
C                ROLL ... Roll-off slope (dB/decade)

C    Output:     GAIN ... Magnitude response of filter
C                NFRQ ... Number of frequencies

      REAL*4 GAIN(1)

      FUNHZ = SHZ / NPT
      ORDER = ABS( ROLL / 20 )
      POWER = 2 * ORDER
      WFUND = FUNHZ / CORN
      NHALF = NPT / 2
      NFRQ  = NHALF + 1

      DO 10 K = 1, NFRQ

        W = (K-1) * WFUND
        DENOM = 1. + W ** POWER
        SMAG = 1. / DENOM
        GMAG = SQRT( SMAG )
        DBEL = 20. * ALOG10( GMAG )
        GAIN(K) = SMAG
C       GAIN(K) = GMAG
C       GAIN(K) = DBEL

10    CONTINUE

      RETURN
      END
```

Figure 1 - Listing of BUTTER subroutine to compute filter gain.

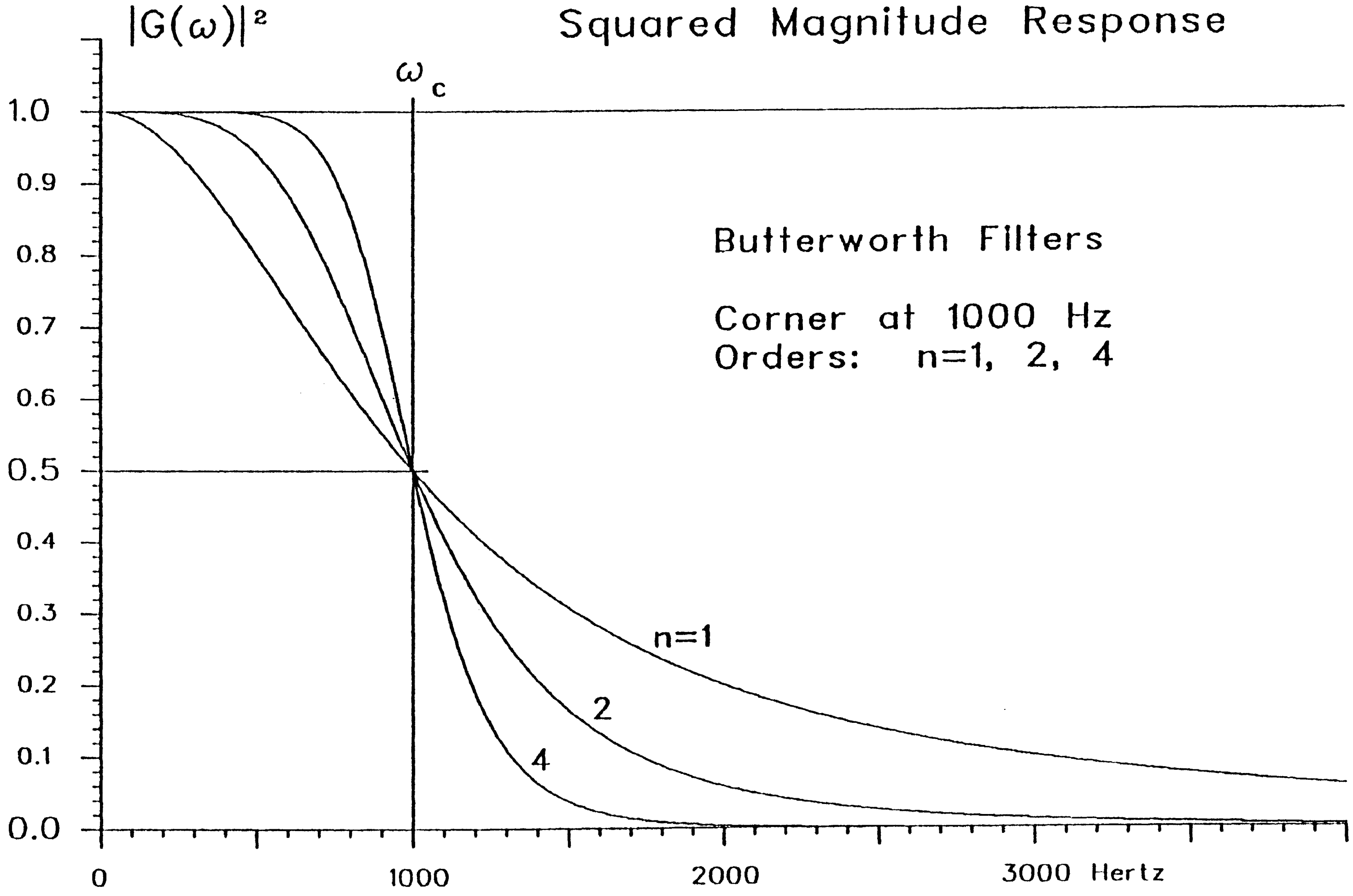


Figure 2 - Square magnitude responses of Butterworth filters.

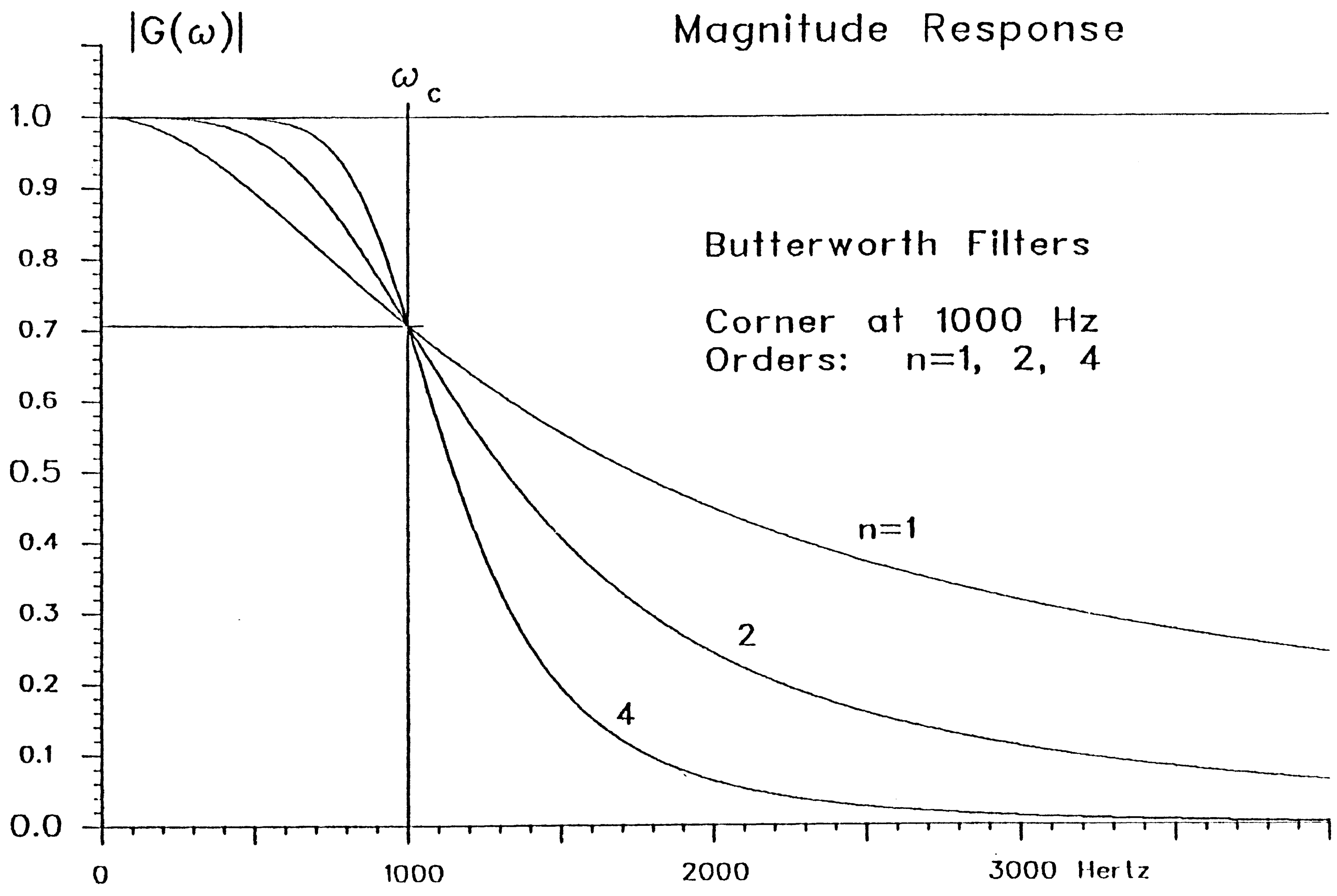


Figure 3 - Magnitude responses of Butterworth filters.

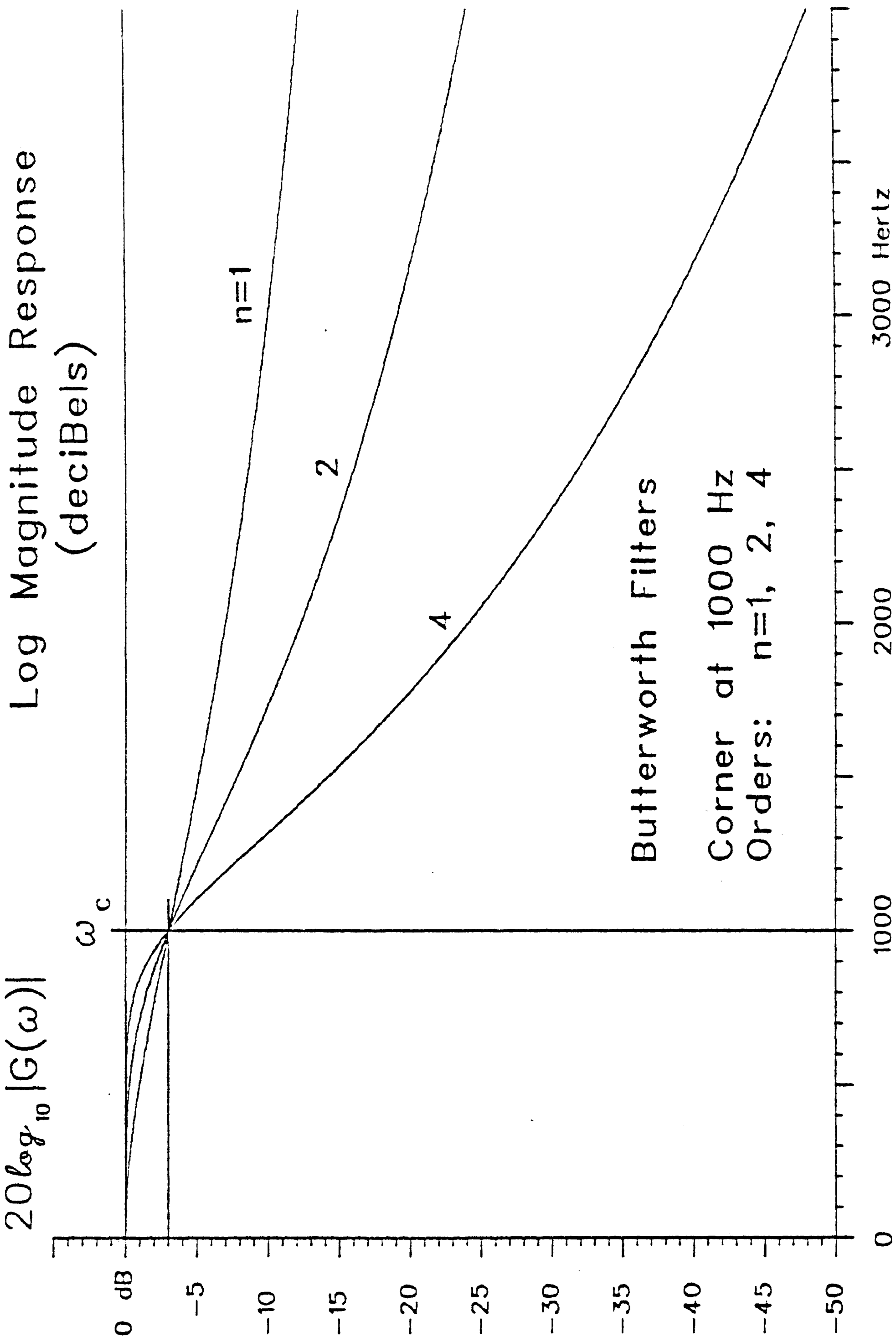


Figure 4 - Log magnitude responses of Butterworth filters.

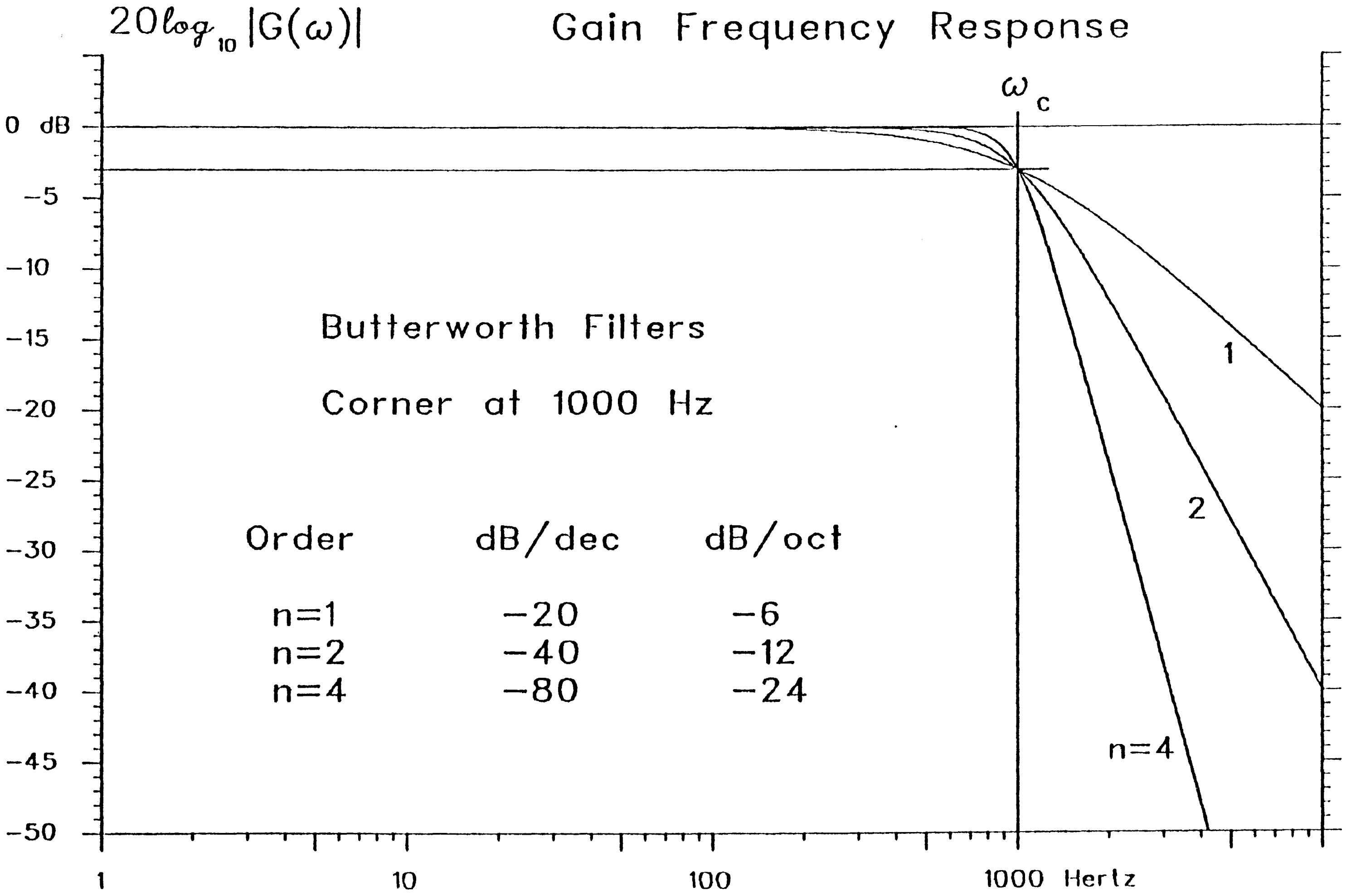


Figure 5 - Traditional gain-frequency plots of filters.

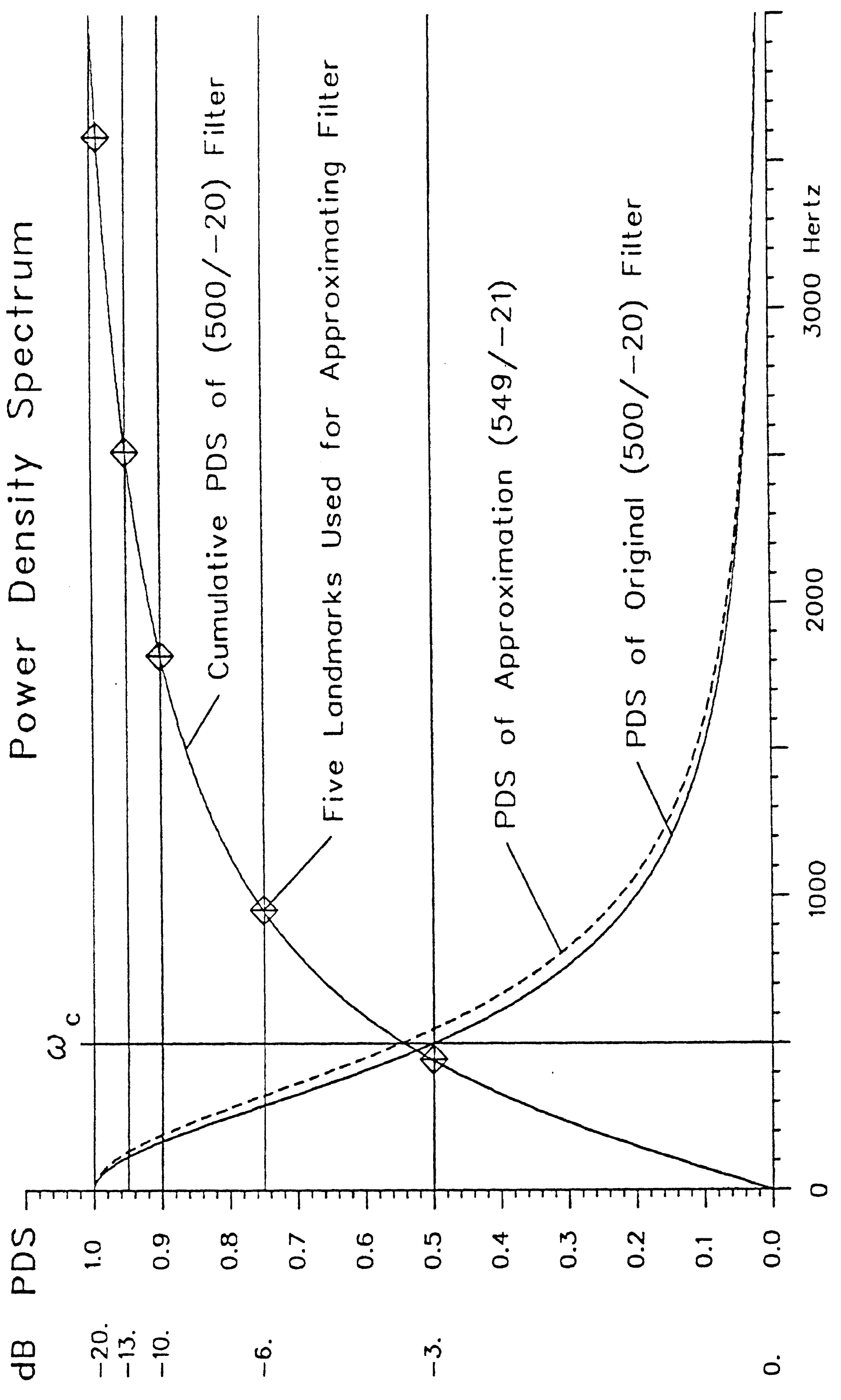


Figure 6 - Characterization of the power density spectrum.

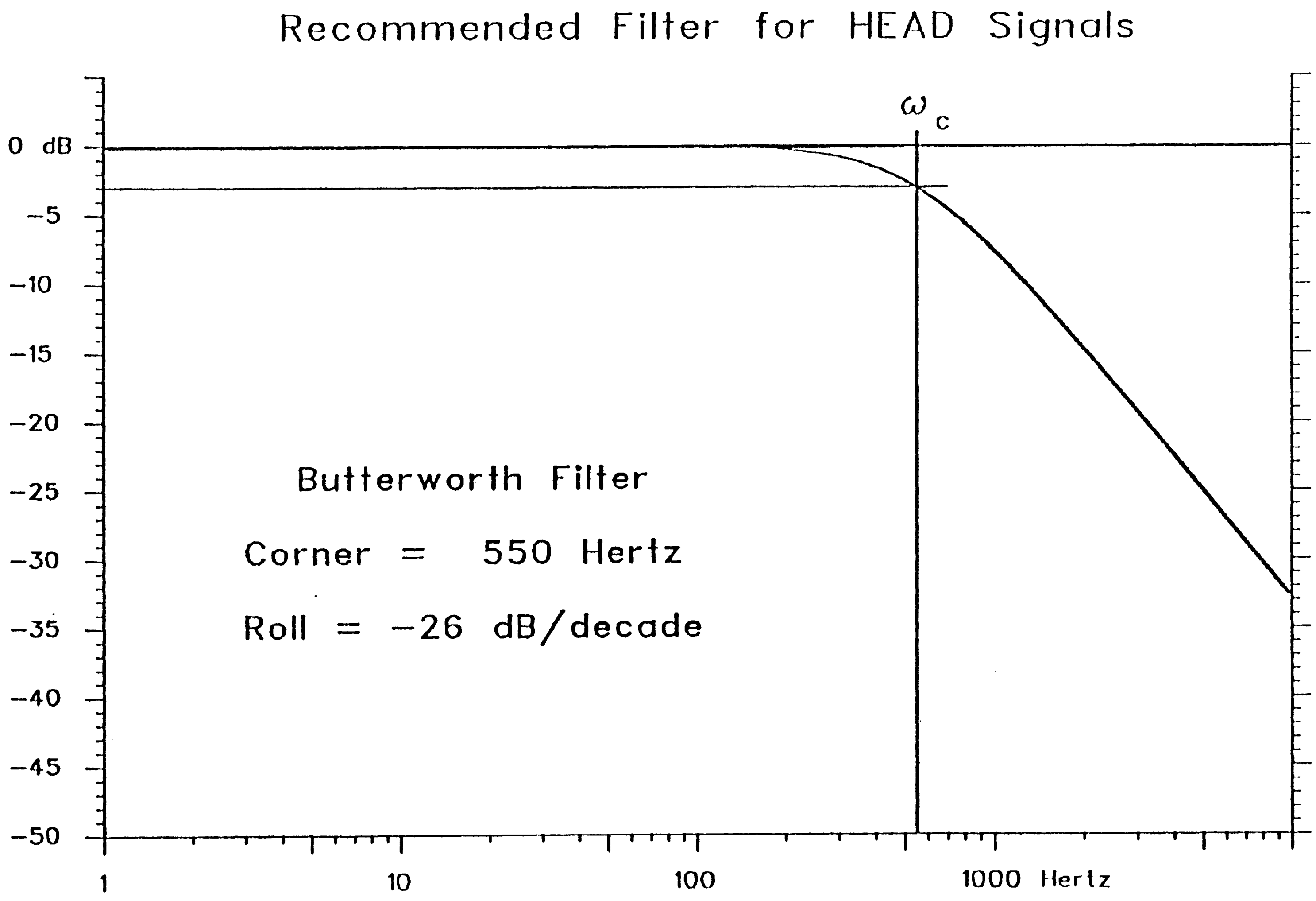


Figure 7 - Recommended filter for HEAD signals.

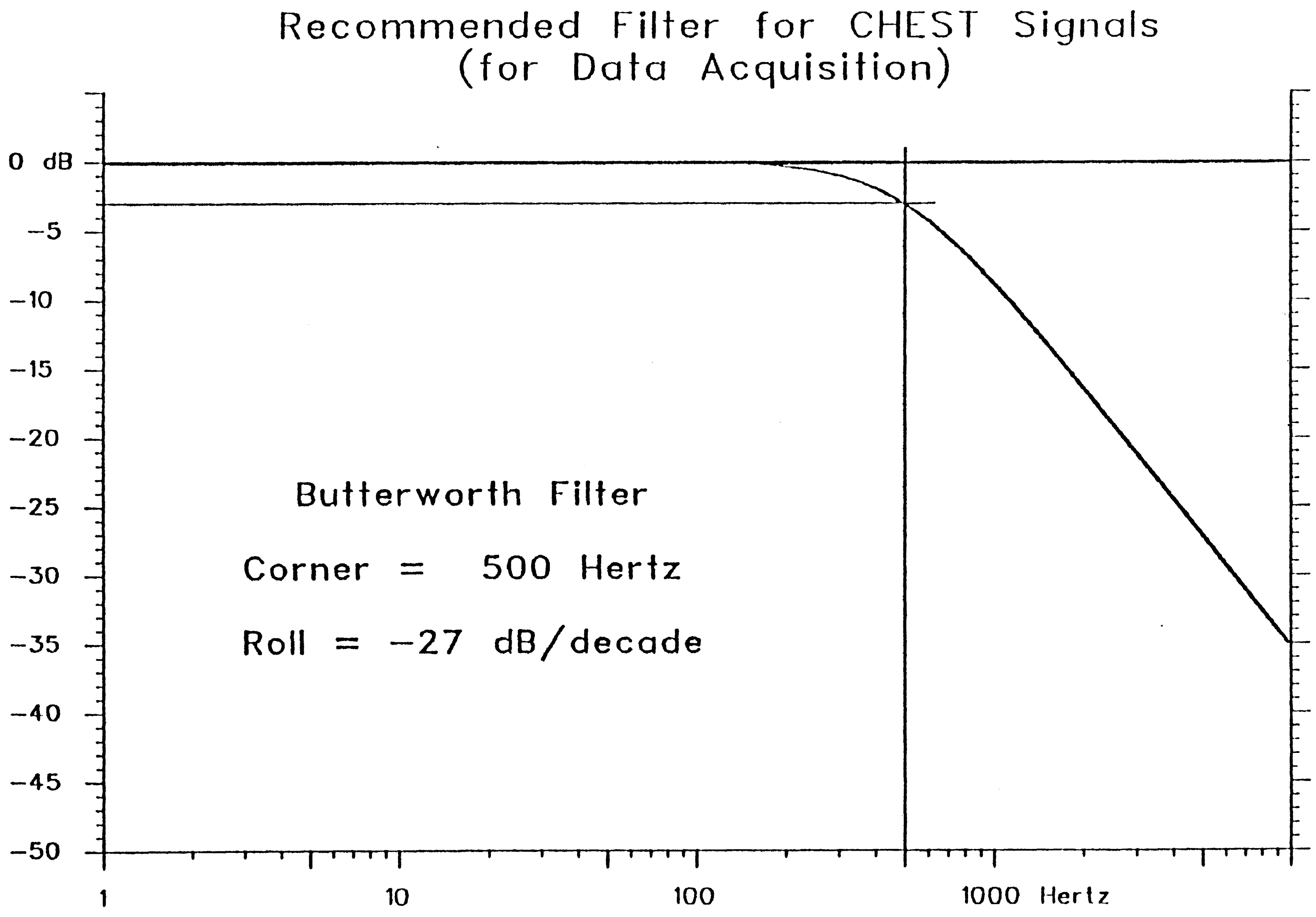


Figure 8 - Recommended data acquisition filter for CHEST signals.

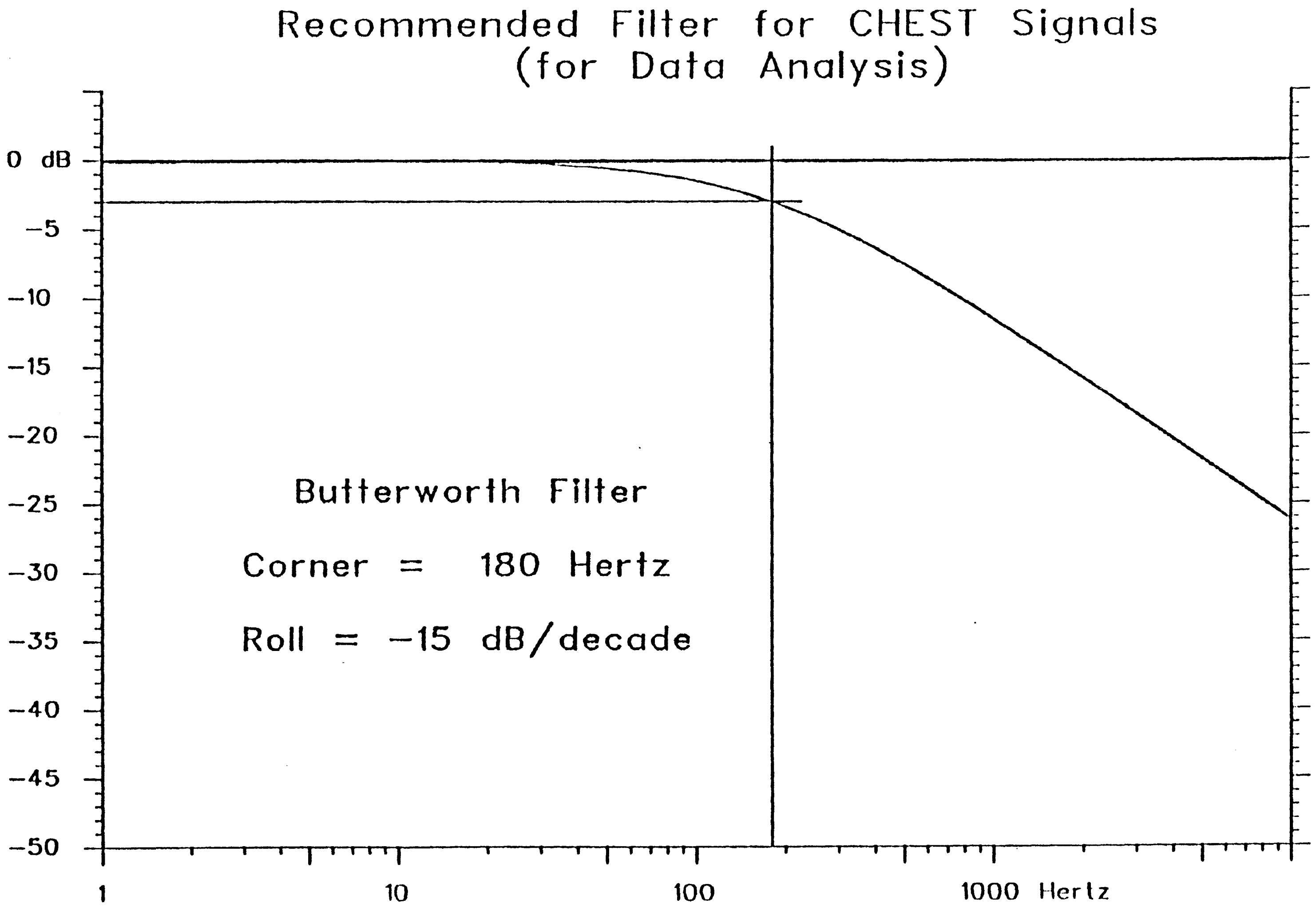


Figure 9 - Recommended data analysis filter for CHEST signals

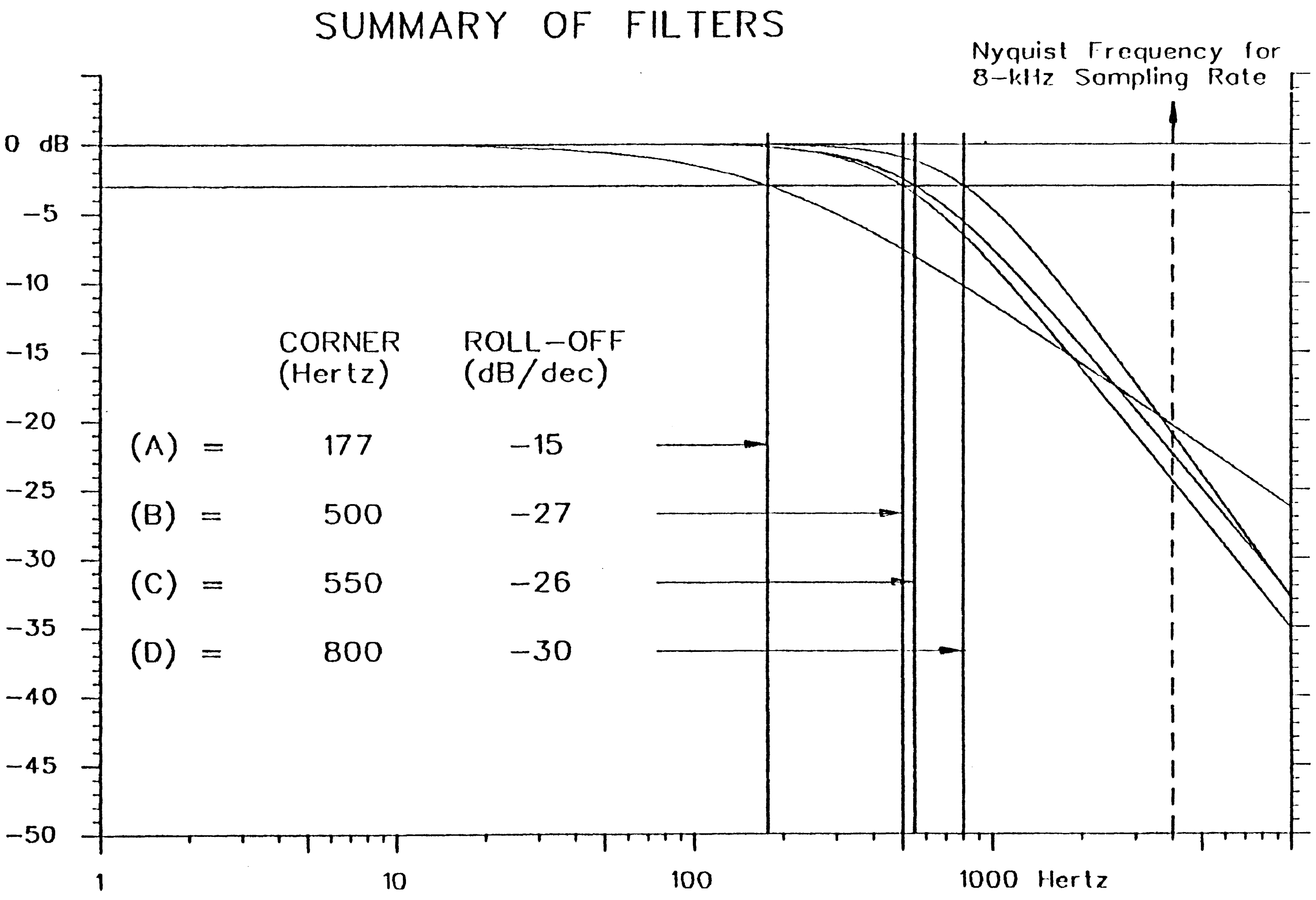


Figure 10 - Summary of recommended filters.

```
      SUBROUTINE FILTER ( SIG, NPT, SHZ, CORN, ROLL )

C     Purpose:   Apply a Butterworth filter to signal.

C     SIG  ... Time signal before/after filtering
C     NPT  ... Number of points (samples) in signal
C     SHZ  ... Sampling rate of signal, (Hertz)

C     CORN ... -3dB corner of desired filter, (Hertz)
C     ROLL ... Rolloff slope of filter, (dB/decade)

      REAL*4 SIG(1)

      FUNHZ = SHZ / NPT
      WFUND = FUNHZ / CORN

      ORDER = ABS ( ROLL / 20 )
      POWER = 2 * ORDER

      NFREQ = NPT / 2

C     Transform signal to frequency domain

      CALL FFT ( NPT, SIG, +1 )

C     Compute filter gain, then apply to signal

      DO 100 K = 1, NFREQ

        IB = 2 * K
        IA = IB - 1

        W = ( K-1 ) * WFUND
        GINV = 1 + W ** POWER
        GAIN = 1 / SQRT ( GINV )

        SIG ( IA ) = GAIN * SIG ( IA )
        SIG ( IB ) = GAIN * SIG ( IB )

100   CONTINUE


C     Transform signal back to time domain

      CALL FFT ( NPT, SIG, -1 )

      RETURN
      END
```

Figure 11 - Listing of FILTER subroutine to apply a Butterworth filter.

Table 1 - Pool of Impact Tests Used in Filter Study

Tape No. File No.	Signals	Test ID	Test: Type	Direction	Restraint	Subject: Age	Height	Weight	Performer	Test Date	Test Description
2.1021	28	82-04	OCC	999	3PT	40	62	132	HDL	01/13/82	FAT PROGRAM
2.1050	28	82-05	OCC	999	3PT	43	70	170	HDL	12/03/82	FAT PROGRAM
1.2154	20	A-877	SLD	0	3PT	76	59	88	HSR	06/20/75	EA COLUMN,LAP BELT PROD.
1.2175	20	A-880	SLD	0	3PT	74	67	106	HSR	06/27/75	EA COLUMN,LAP BELT PROD.
1.2214	18	A-883	SLD	0	LAP	74	61	166	HSR	07/07/75	EA COLUMN,LAP BELT PROD.
1.2233	19	A-884	SLD	0	LAP	60	70	198	HSR	07/10/75	EA COLMN,PAD INSRT&LAP BEL
1.2253	18	A-887	SLD	0	ABG	68	68	188	HSR	07/22/75	EA COL,AIRBAG INSRT,LAP BL
1.2272	22	A-923	SLD	0	ABG	69	65	81	HSR	09/17/75	EA COL,AIRBAG INSRT,LAP BL
1.2295	21	A-924	SLD	0	ABG	64	67	168	HSR	10/01/75	EA COL,AIRBAG INSRT,LAP BL
2.0570	24	A-925	SLD	999	3PT	99	70	171	HSR	09/26/75	WBR-7
2.0595	24	A-926	SLD	999	3PT	99	70	171	HSR	09/26/75	WBR-7
1.2317	20	A-927	SLD	0	ABG	72	64	177	HSR	10/08/75	EA COL,AIRBAG INSRT,LAP BL
1.2338	20	A-928	SLD	0	LAP	50	64	125	HSR	10/09/75	EA COL,SOFT INSRT,LAP BL
2.0620	24	A-934	SLD	999	3PT	99	68	132	HSR	11/14/75	WBR-8
1.2359	20	A-937	SLD	0	LAP	48	64	148	HSR	12/11/75	EA COL,SOFT INSRT,LAP BL
2.0694	23	A-938	SLD	999	3PT	99	68	137	HSR	12/15/75	WBR-9
2.0001	10	MS 91	OTH	13	999	69	99	999	APR	07/16/76	FACE DROP
2.0012	10	MS 92	OTH	0	999	69	99	999	APR	07/19/76	FACE DROP
1.3410	12	75A113	CAN	90	999	54	70	183	HSR	11/08/75	M PAD AIS=4
1.3423	12	75A116	CAN	90	999	66	59	97	HSR	12/10/75	F PAD AIS=0
1.3436	12	76A126	CAN	0	999	65	71	179	HSR	02/27/76	M PAD AIS=4
1.3449	11	76A133	CAN	0	999	54	69	179	HSR	03/03/76	M PAD AIS=3
1.3461	11	76A134	CAN	90	999	72	67	104	HSR	03/12/76	F PAD AIS=2
1.3473	11	76A135	CAN	180	999	68	63	140	HSR	03/17/76	F PAD AIS=0
1.3485	12	76A136	CAN	0	999	88	67	168	HSR	03/27/76	M PAD AIS=3
1.3510	12	76A144	CAN	0	999	45	66	166	HSR	04/29/76	M RIG AIS=2
1.3523	12	76A145	CAN	90	999	78	63	177	HSR	05/06/76	F RIG AIS=5
1.3536	12	76A152	CAN	90	999	66	63	99	HSR	05/11/76	F RIG AIS=5
2.0718	23	76B001	SLD	999	3PT	99	69	138	HSR	12/13/76	WBR-10
1.2380	17	76T003	SLD	270	RIG	60	71	225	HSR	01/27/76	LAT IMPACT RIG SURF
1.2398	25	76T008	SLD	0	3PT	74	64	156	HSR	03/25/76	3PT INFLAT.BELT,FRNT SLED
1.2424	20	76T009	SLD	270	RIG	75	61	97	HSR	04/06/76	LAT IMPACT RIG SURF
1.2445	20	76T010	SLD	270	RIG	84	63	193	HSR	04/15/76	LAT IMPACT RIG SURF
1.2466	20	76T011	SLD	270	RIG	69	67	165	HSR	04/23/76	LAT IMPACT RIG SURF
1.2487	25	76T020	SLD	0	ABG	78	62	140	HSR	06/03/76	FRNT SLED,EA COLMN,AIRBAG
1.2513	11	76T021	CAN	0	NON	55	63	95	HSR	06/14/76	THORACIC IMPACT,CANNON
1.2525	11	76T022	CAN	0	NON	85	64	132	HSR	06/22/76	THORACIC IMPACT,CANNON
1.2537	11	76T024	CAN	0	NON	75	66	167	HSR	06/25/76	THORACIC IMPACT,CANNON
1.2549	11	76T025	CAN	0	NON	66	68	153	HSR	06/30/76	THORACIC IMPACT,CANNON
1.2561	16	76T029	SLD	270	MCI	67	65	137	HSR	07/28/76	SLED,SIDE DOOR IMPCT
1.2578	18	76T034	SLD	270	MCI	62	72	130	HSR	08/12/76	SLED,SIDE DOOR IMPACT
1.2597	17	76T039	SLD	270	MCI	72	73	162	HSR	08/19/76	SLED,SIDE DOOR IMPACT
1.2196	17	76T042	SLD	270	MCI	58	70	142	HSR	08/23/76	SLED,SIDE DOOR IMPACT
1.2615	12	76T050	PEN	0	NON	61	69	184	HSR	10/28/76	PENDULUM,14FT/SEC FRNT IMP
1.2628	15	76T053	PEN	0	NON	63	68	231	HSR	11/11/76	PENDULUM 14FT/SEC FRNT IMP
1.2644	16	76T056	PEN	0	NON	40	99	154	HSR	12/03/76	PENDULUM 14FT/SEC FRNT IMP
1.2661	15	76T059	PEN	0	NON	76	99	194	HSR	12/07/76	PENDULUM 14FT/SEC FRNT IMP
1.2677	15	76T062	PEN	270	NON	69	68	110	HSR	12/16/76	PENDULUM 14FT/SEC SIDE IMP
1.2693	15	76T065	PEN	270	NON	63	99	209	HSR	12/21/76	PENDULUM 14FT/SEC SIDE IMP
1.2709	16	77T068	PEN	0	NON	52	68	136	HSR	07/08/77	PENDULM 14.33FT/S FRNT IMP
1.2726	16	77T071	PEN	270	NON	60	67	176	HSR	07/13/77	PENDULUM 14.3FT/S SIDE IMP
1.2743	16	77T074	PEN	270	NON	60	69	119	HSR	07/18/77	PENDULM 14.32FT/S SIDE IMP
1.2760	16	77T077	PEN	270	NON	79	69	162	HSR	07/22/77	PENDULUM 19.9FT/S SIDE IMP
1.2777	16	77T080	PEN	270	NON	64	67	89	HSR	08/10/77	PENDULUM 20FT/S SIDE IMP
1.2794	17	77T083	PEN	0	NON	60	61	140	HSR	08/30/77	PENDULUM 20FT/S FRNT IMP
1.2812	16	77T086	PEN	0	NON	54	64	172	HSR	09/08/77	PENDULUM 20FT/S FRNT IMP
1.2829	18	77T089	SLD	270	RIG	66	68	121	HSR	09/19/77	SLED RIG WALL SIDE IMP
1.2848	18	77T092	SLD	270	RIG	45	69	128	HSR	09/28/77	SLED RIG WALL SIDE IMP
1.2867	18	77T095	SLD	270	MCI	77	72	204	HSR	10/11/77	SLED PADDED WALL(REPORT)
1.2886	18	77T098	SLD	270	MCI	71	66	130	HSR	10/27/77	SLED PADDED WALL(REPORT)

Table 2 - Summary of Butterworth Characterization: Non-Fracture Signals

Filter Number	Corner (Hz)	Slope (dB/dec)	Sensors	Locations	Test Types
LP01	641.	-33.7	3	LLR	SLD/MCI
LP05	510.	-23.1	4	LLR	SLD/RIG
LP09	422.	-26.1	6	LUR LLR	PEN/L-R
Avg. =	(493. /	-26.9)		(Near-side)	(Lateral)
LP11	200.	-13.6	34	UST LST T01 T12	SLD/MCI
LP12	208.	-16.9	39	UST LST T01 T12	SLD/RIG
LP13	106.	-13.4	44	UST LST T01 T12	PEN/L-R
Avg. =	(160. /	-14.6)		(Mid-range)	(Lateral)
LP02	151.	-15.0	6	RUR RLR	SLD/MCI
LP06	257.	-17.7	9	RUR RLR	SLD/RIG
LP10 *	62.	-9.6	12	RUR RLR	PEN/L-R
Avg. =	(208. /	-16.6)		(Far-side)	(Lateral)
LP16 *	15.	-8.6	9	UST LST	SLD/ABG
LP22	155.	-15.1	8	UST LST	SLD/LAP
LP28	158.	-15.7	11	UST LST	PEN/A-P
Avg. =	(157. /	-15.4)		(Near-side)	(Frontal)
LP14	143.	-13.6	18	LUR LLR RUR RLR	SLD/ABG
LP18 *	21.	-6.6	2	LUR LLR	SLD/3PT
LP21	271.	-16.2	23	LUR LLR RUR RLR	SLD/LAP
LP26	492.	-26.9	6	LUR LLR RUR RLR	PEN/A-P
Avg. =	(229. /	-16.6)		(Mid-range)	(Frontal)
LP17	159.	-16.2	20	T01 T12	SLD/ABG
LP20 *	23.	-7.5	4	T01 T12	SLD/3PT
LP24	172.	-14.7	20	T01 T12	SLD/LAP
LP30	234.	-14.3	13	T01 T12	PEN/A-P
Avg. =	(180. /	-15.2)		(Far-side)	(Frontal)
LP33	547.	-25.7	33	HD1 HD2 HD3 HED	DIR NOPAD
LP34 *	49.	-11.8	18	HD1 HD2 HD3 HED	DIR W/PAD
LP35 *	17.	-14.1	15	HD1 HD2 HD3 HED	NO DIRECT IMPACT
Avg. =	(547. /	-25.7)			

Table 3 - Frequency Response of Signals Where Fractures Occurred

Filter Number	Corner (Hz)	Slope (dB/dec)	Sensors	Locations	Test Types
LP03	611.	-30.4	7	LUR LLR	SLD/MCI
LP04	212.	-13.6	4	RUR RLR	SLD/MCI
LP07	496.	-25.1	8	LUR LLR	SLD/RIG
LP08	658.	-31.0	3	RUR RLR	SLD/RIG
LP15	1012.	-46.6	2	RUR LUR	SLD/ABG
LP19	316.	-23.1	2	RUR RLR	SLD/3PT
LP23	74.	-8.7	3	UST	SLD/LAP
LP25	60.	-11.6	2	T01	SLD/LAP
LP27	658.	-31.4	2	RUR	PEN/A-P
LP29	65.	-14.2	3	LST UST	PEN/A-P
LP31	1303.	-19.9	28	HED HD1 HD2 HD3	DIR NOPAD
LP32	85.	-11.7	10	HD1 HD2 HD3 HED	DIR W/PAD

Appendix A

CHARACTERIZATION OF FREQUENCY RESPONSE

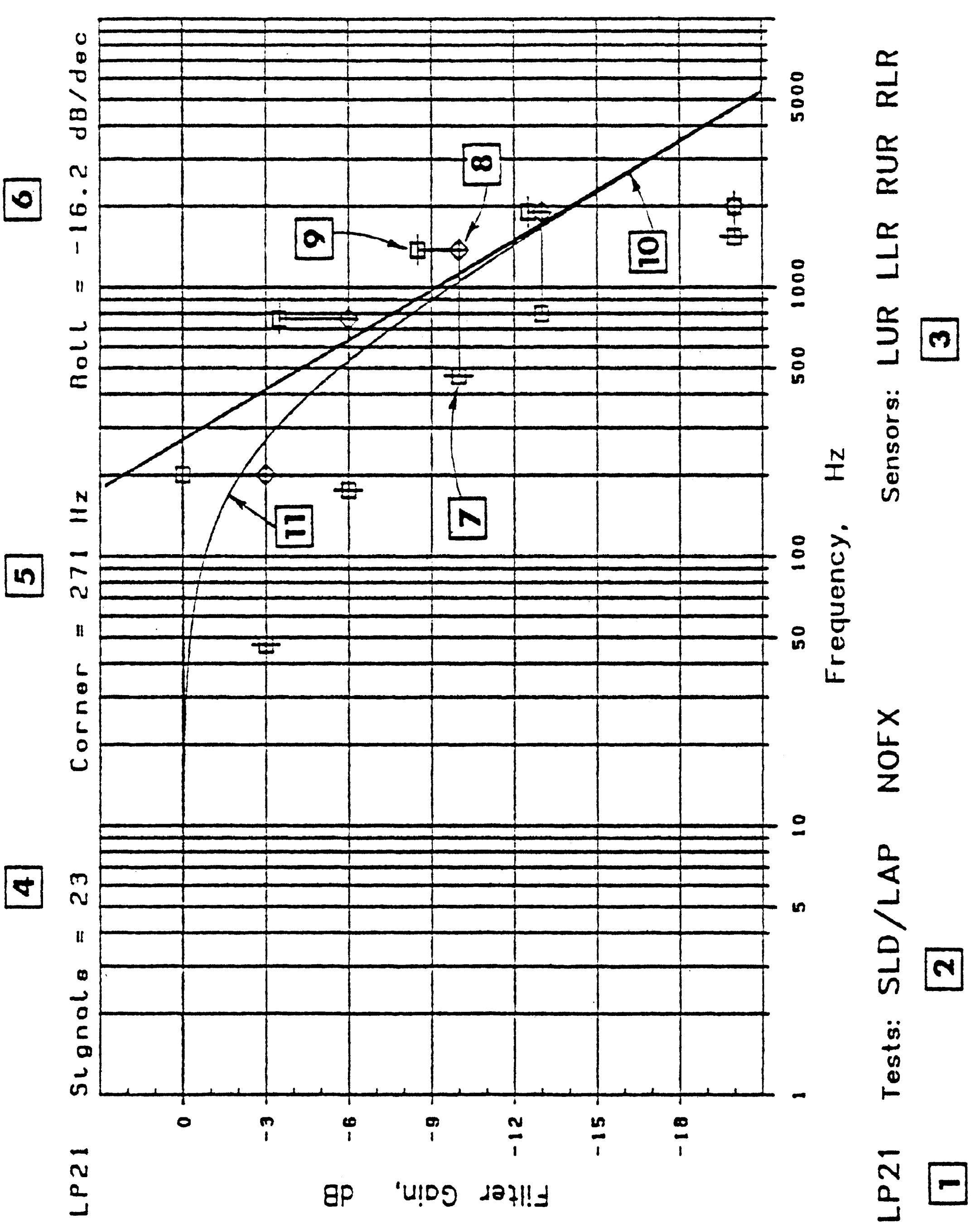
In this Appendix, the 35 low-pass Butterworth filter characterization of biomechanical signals from chest and head accelerometers are presented in graphical form. The information displayed on each figure documents the source of the signals, their group type and location, and the resulting system parameters. These are identified by boxed numbers on the LEGEND given on the next page.

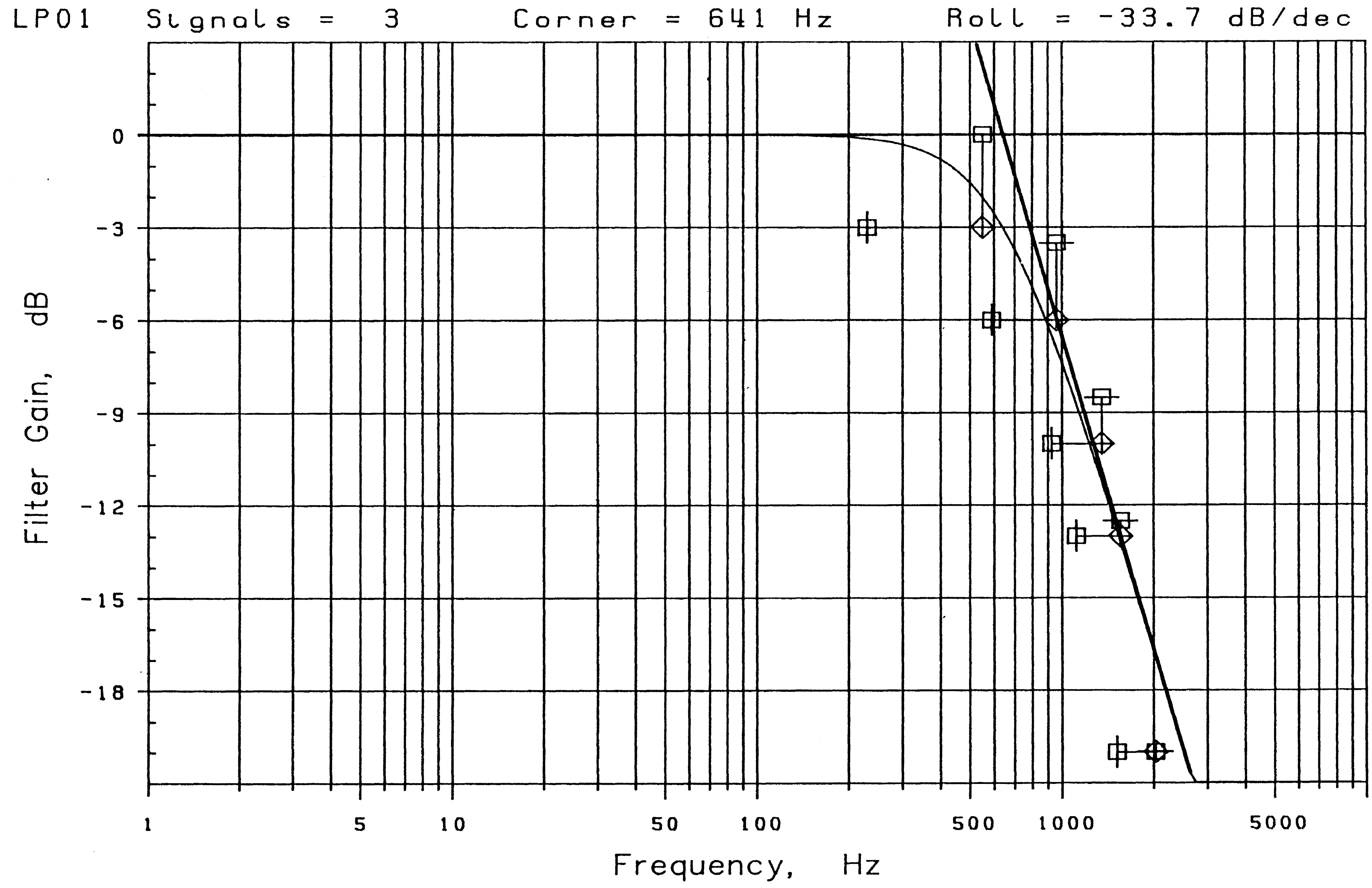
(1) Filter designation in this series, LP01 through LP35.

(2) Test conditions and type codes:
SLD ... Sled tests
PEN ... Pendulum and/or Cannon tests
DIR ... Direct head impacts
NO DIR ... Indirect head impact tests
MCI ... Padded side impact
RIG ... Rigid side impact
ABG ... Airbag frontal impact
3PT ... 3-Point restraint frontal test
LAP ... Lap belt only frontal impact
A-P ... Frontal pendulum/cannon impact
L-R ... Lateral pendulum/cannon impact
W/PAD ... Padded head impact
NOPAD ... Rigid head impact
FRAC ... Fracture at/near transducer location
NOFX ... No fracture at/near transducer

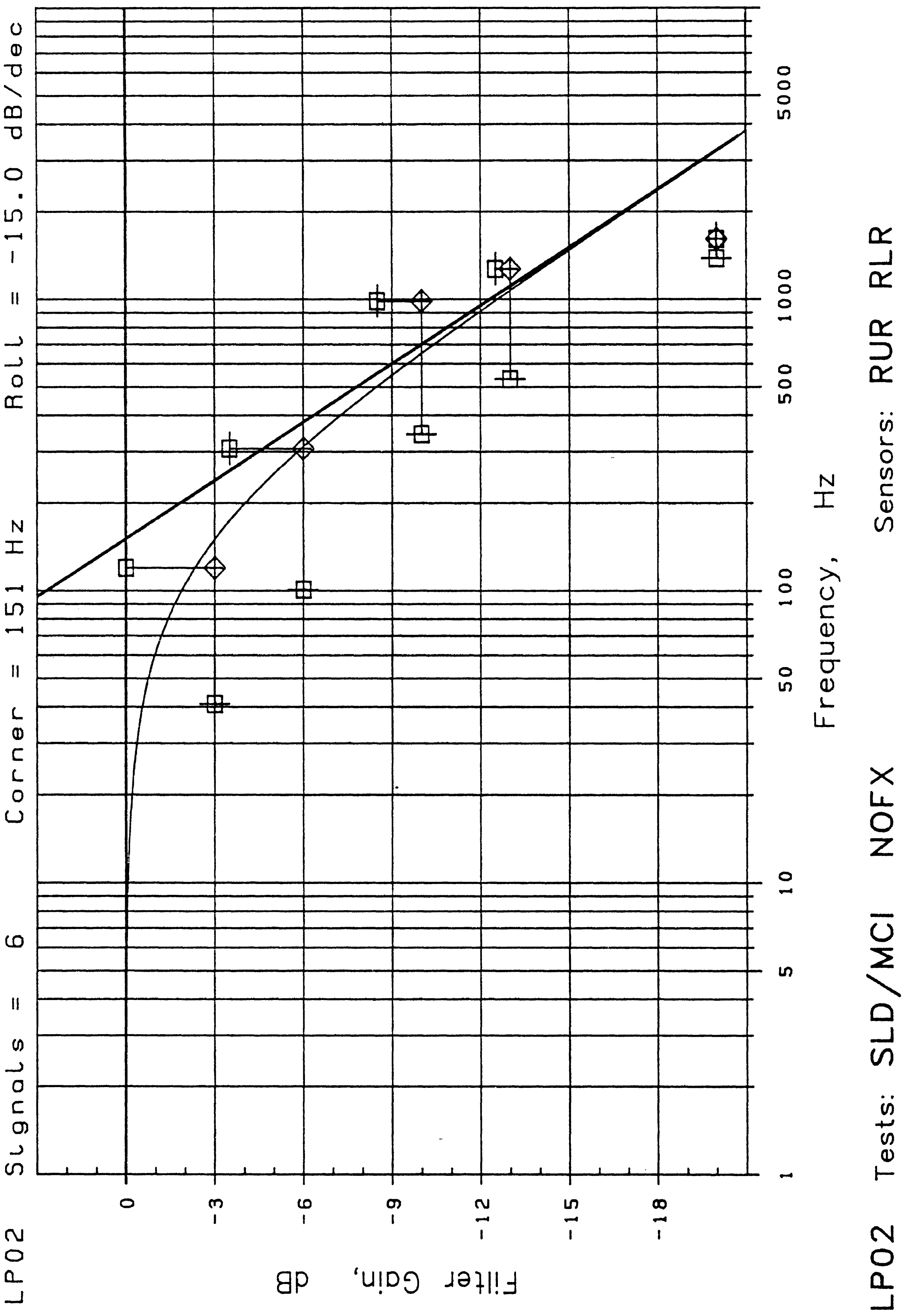
(3) Transducer location:
LUR ... Left upper rib
LLR ... Left lower rib
RUR ... Right upper rib
RLR ... Right lower rib
UST ... Upper sternum
LST ... Lower sternum
T01 ... Spinal vertebra T1
... Others: T06, T12, etc.
HED ... Head accelerometer
HD1 ... Head triax or biaxial number 1
HD2 ... Head traix or biaxial number 2
HD3 ... Head triax or biaxial number 3

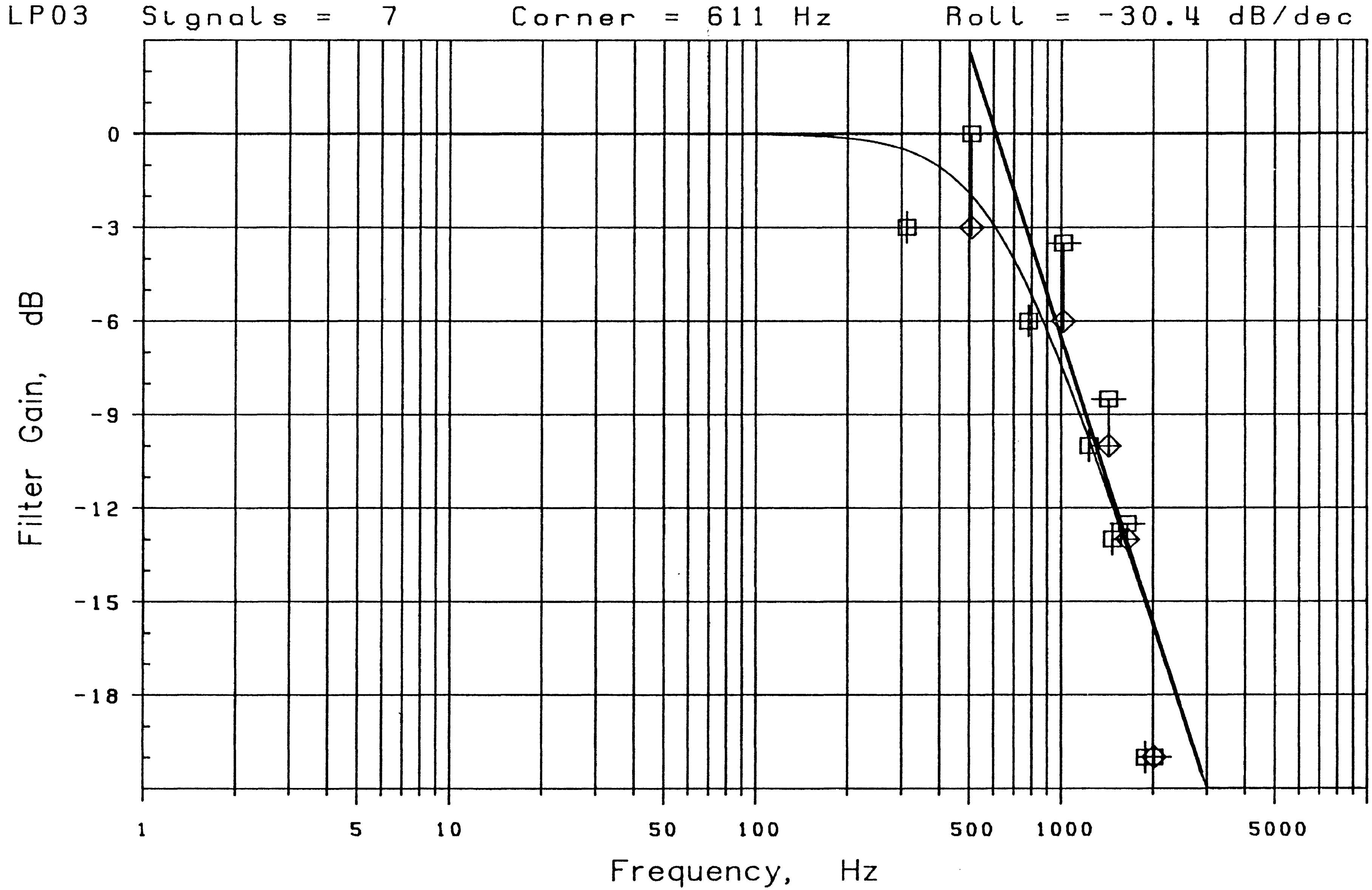
(4) Number of signals in the group
(5) Corner frequency of resulting filter approximation
(6) Rolloff slope of the resulting filter approximation
(7) Average frequency of landmarks at a given PDS level
(8) Average PLUS one standard deviation of landmarks
(9) Landmark corrected for deviation from asymptote
(10) Asymptote which best fits the 5 corrected landmarks
(11) Frequency response curve of approximate filter

LP21
Signals = 23
Corner = 271 Hz
Roll = -16.2 dB/dec
Filter Gain, dB
0
-3
-6
-9
-12
-15
-18
1
5
10
50
100
500
1000
5000
Frequency, Hz
LP21
Tests: SLD/LAP NOFX
Sensors: LUR LLR RUR RLR
1
2
3
4
5
6
7
8
9
10
11

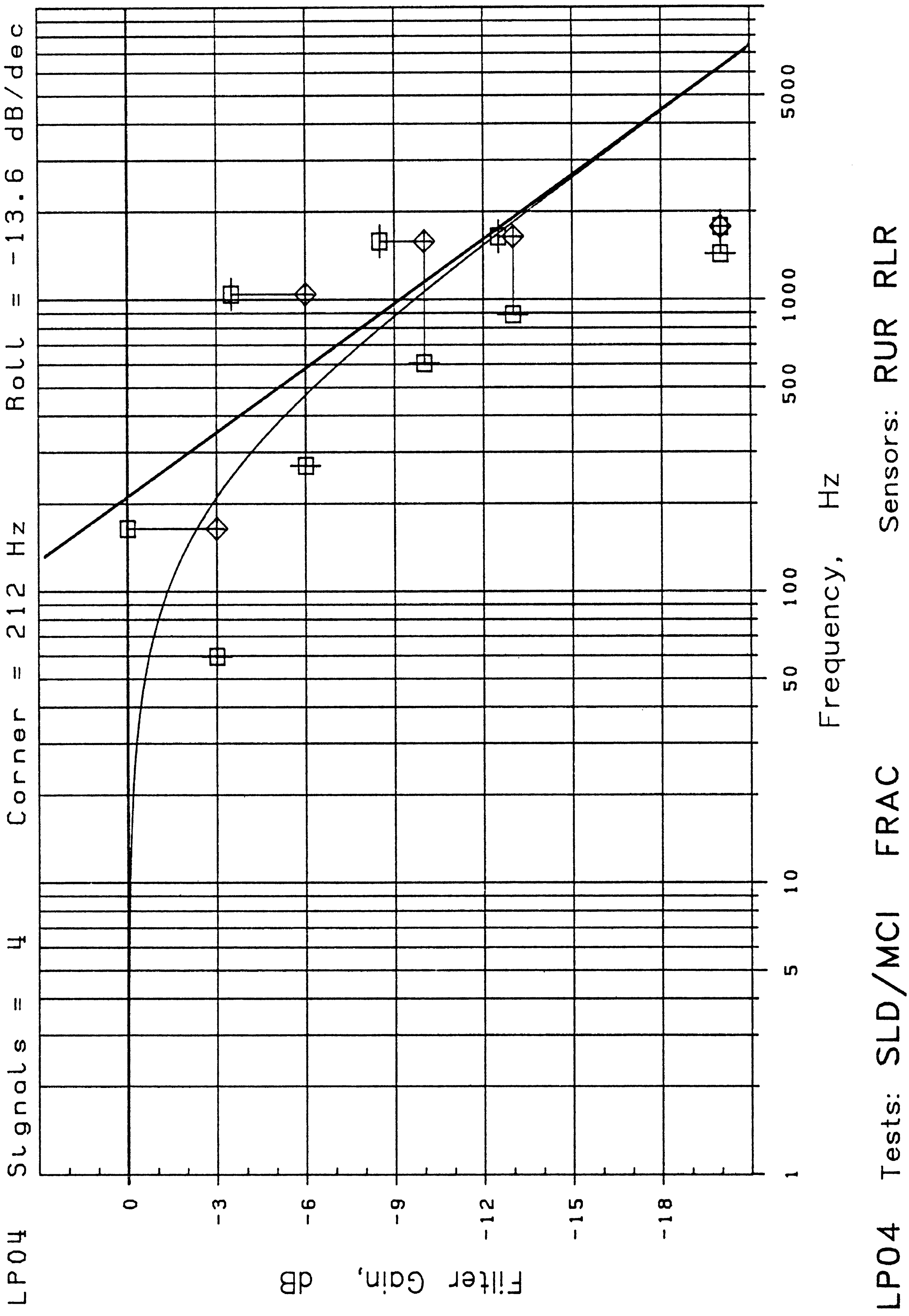


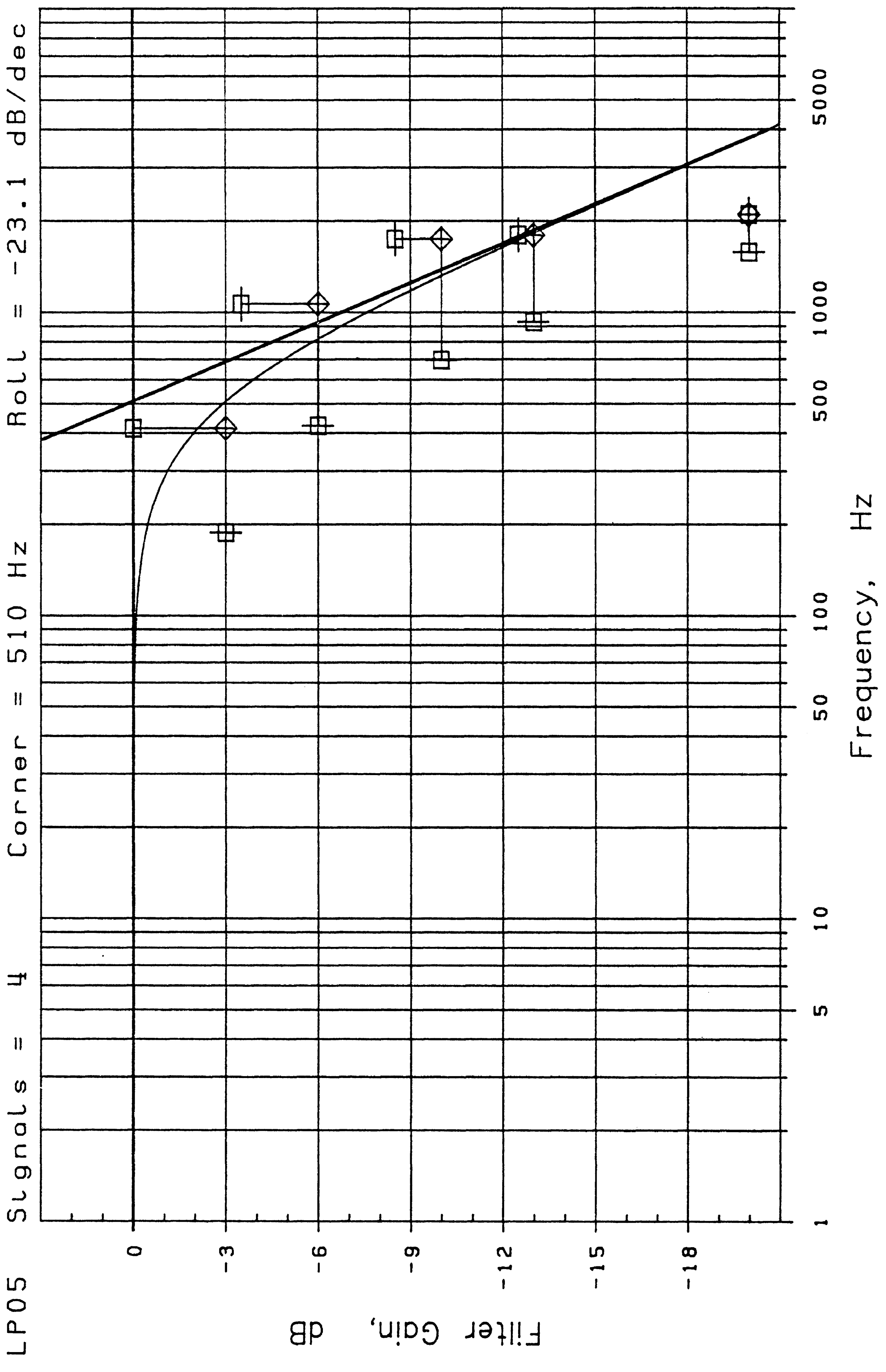
LP01 Tests: **SLD/MCI NOFX** Sensors: **LLR**


LP02
Signals = 6
Corner = 151 Hz
Roll = -15.0 dB/dec
Filter Gain, dB
0
-3
-6
-9
-12
-15
-18
1
5
10
50
100
500
1000
5000
Frequency, Hz
LP02
Tests: SLD/MCI NOFX
Sensors: RUR RLR

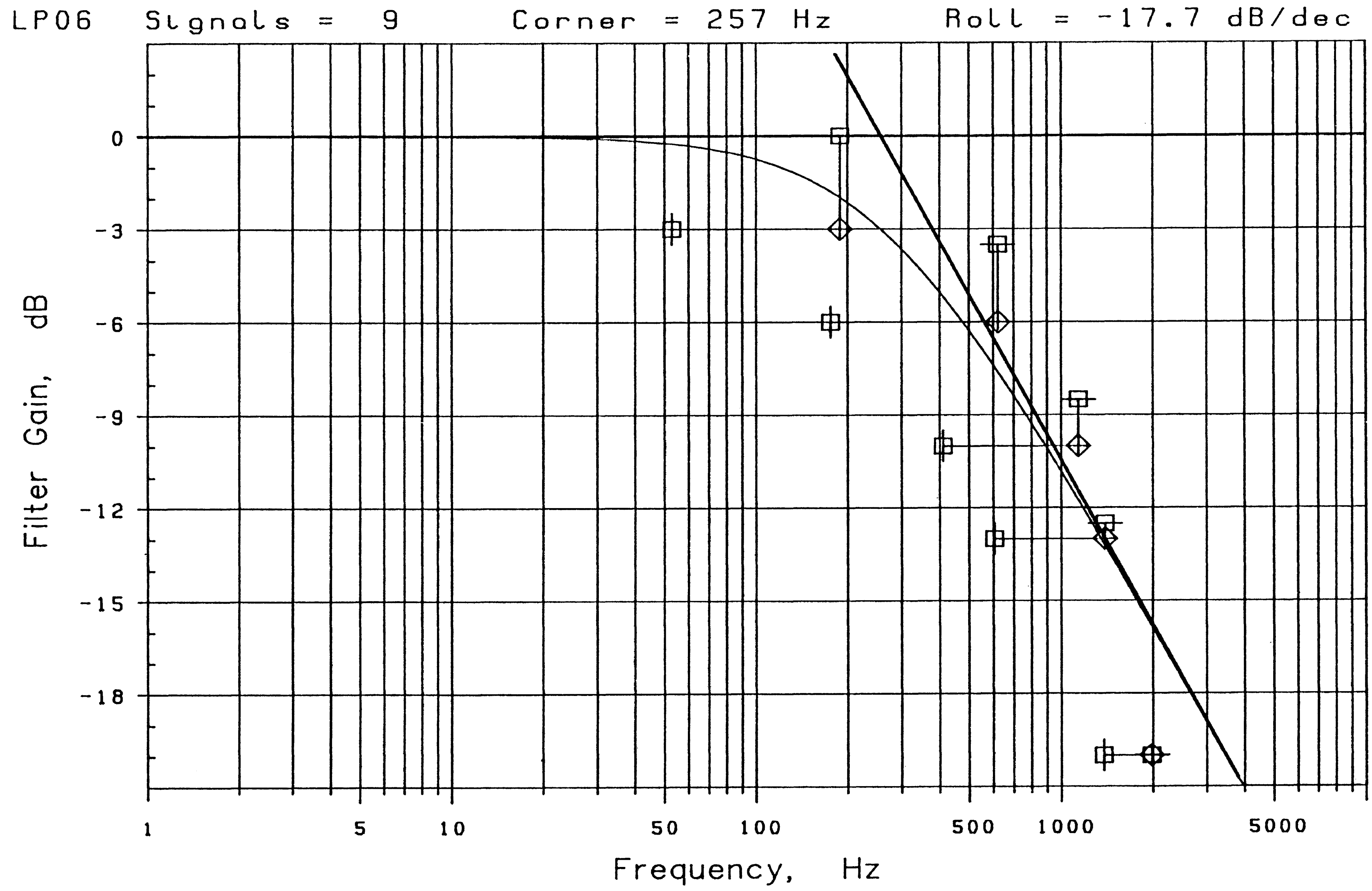


LP03 Tests: SLD/MCI FRAC Sensors: LUR LLR

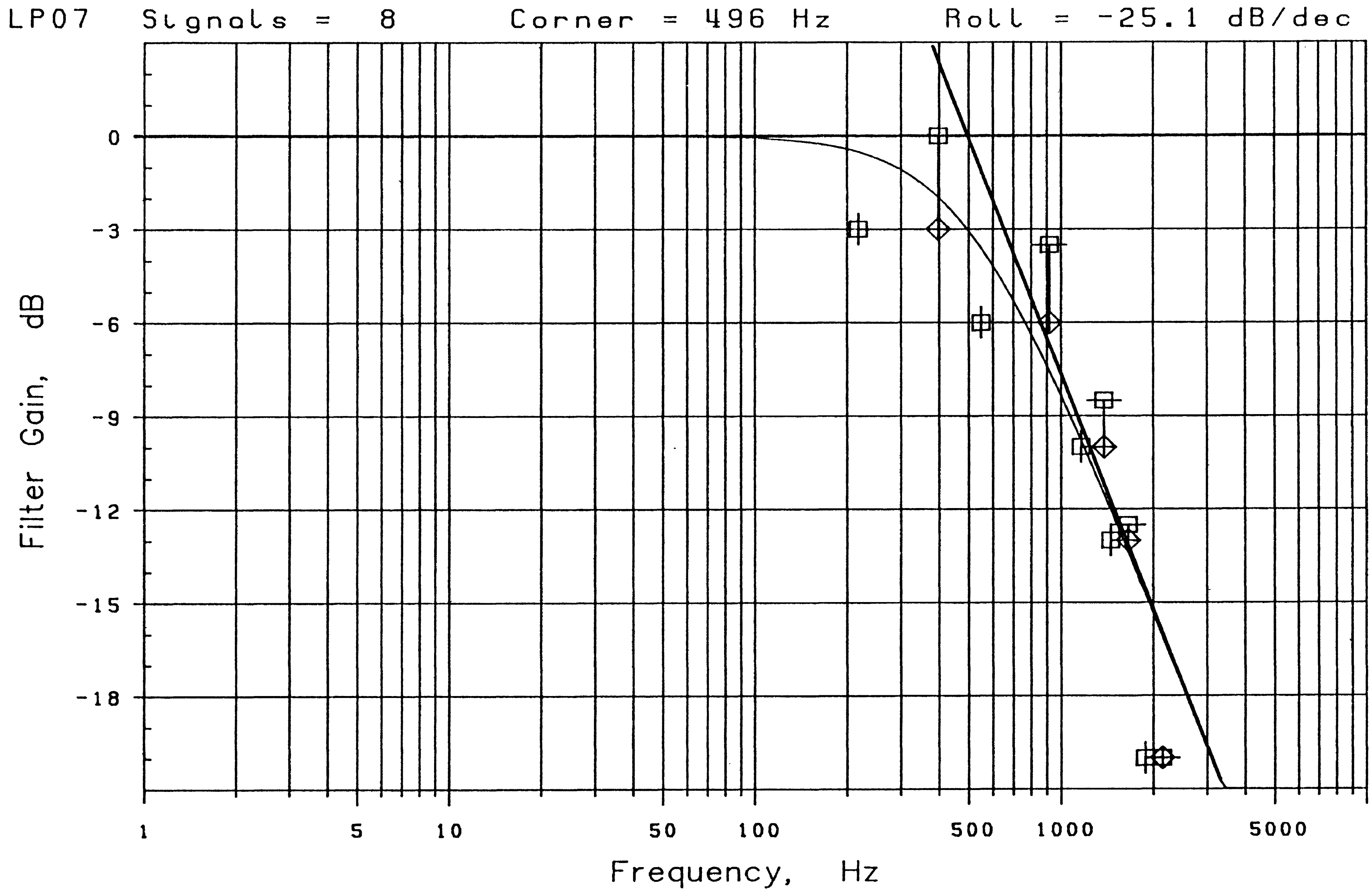

LP04
Signals = 4 Corner = 212 Hz Roll = -13.6 dB/dec
Filter Gain, dB
0
-3
-6
-9
-12
-15
-18
1
5
10
50
100
500
1000
5000
Frequency, Hz
LP04 Tests: SLD/MCI FRAC Sensors: RUR RLR



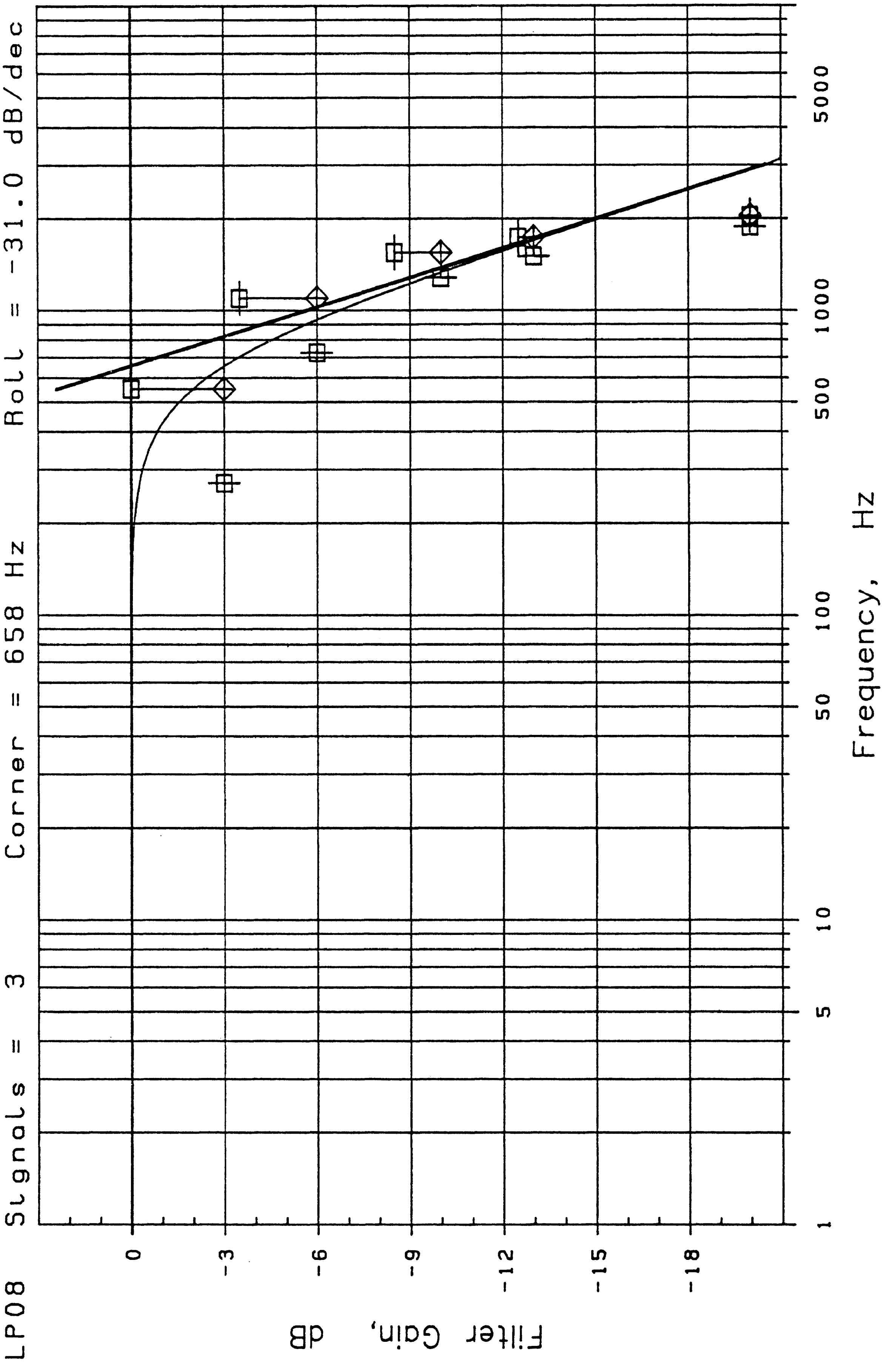
LP05 Tests: SLD/RIG NOFX Sensors: LLR



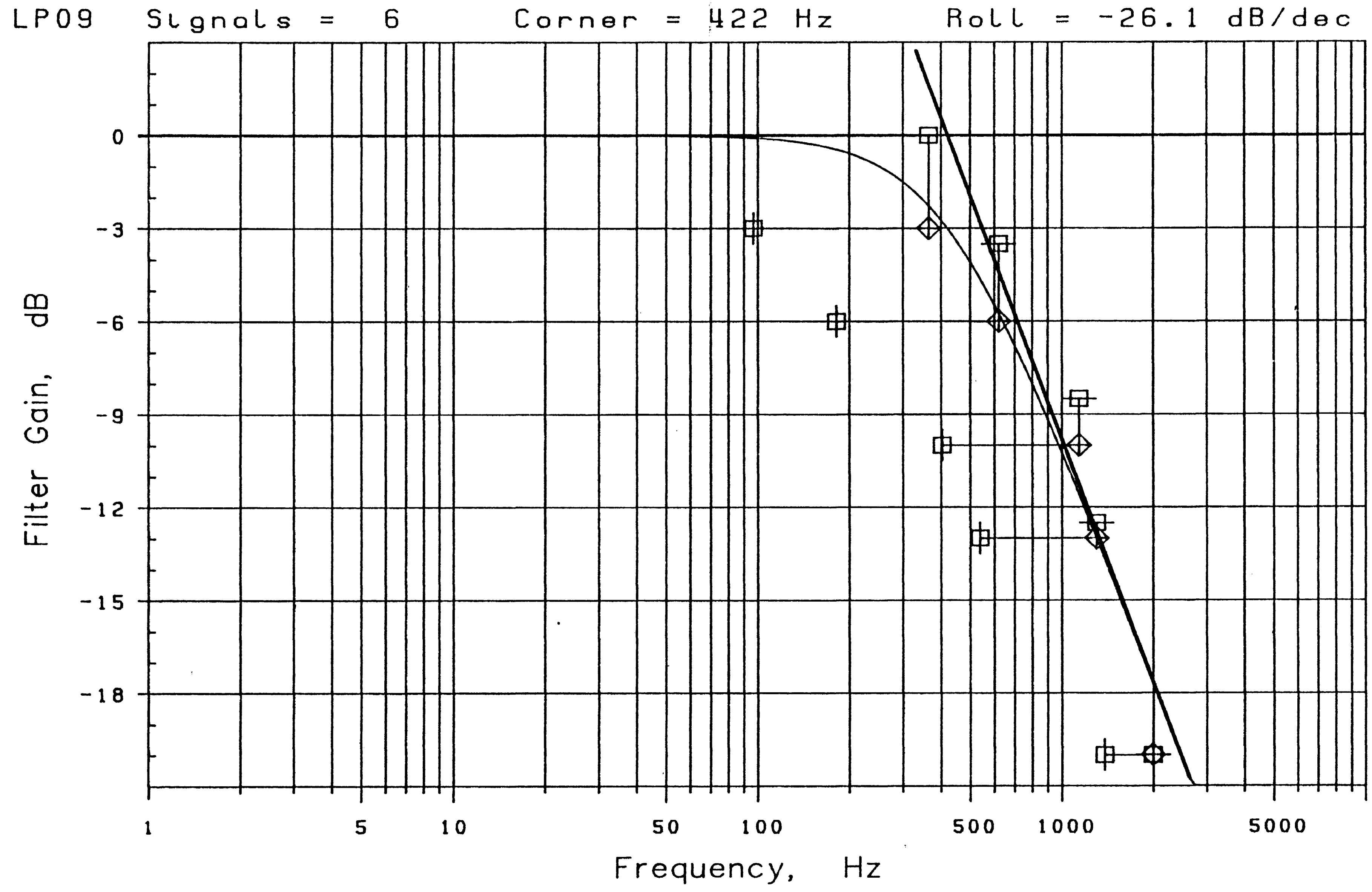
LP06 Tests: SLD/RIG NOFX Sensors: RUR RLR



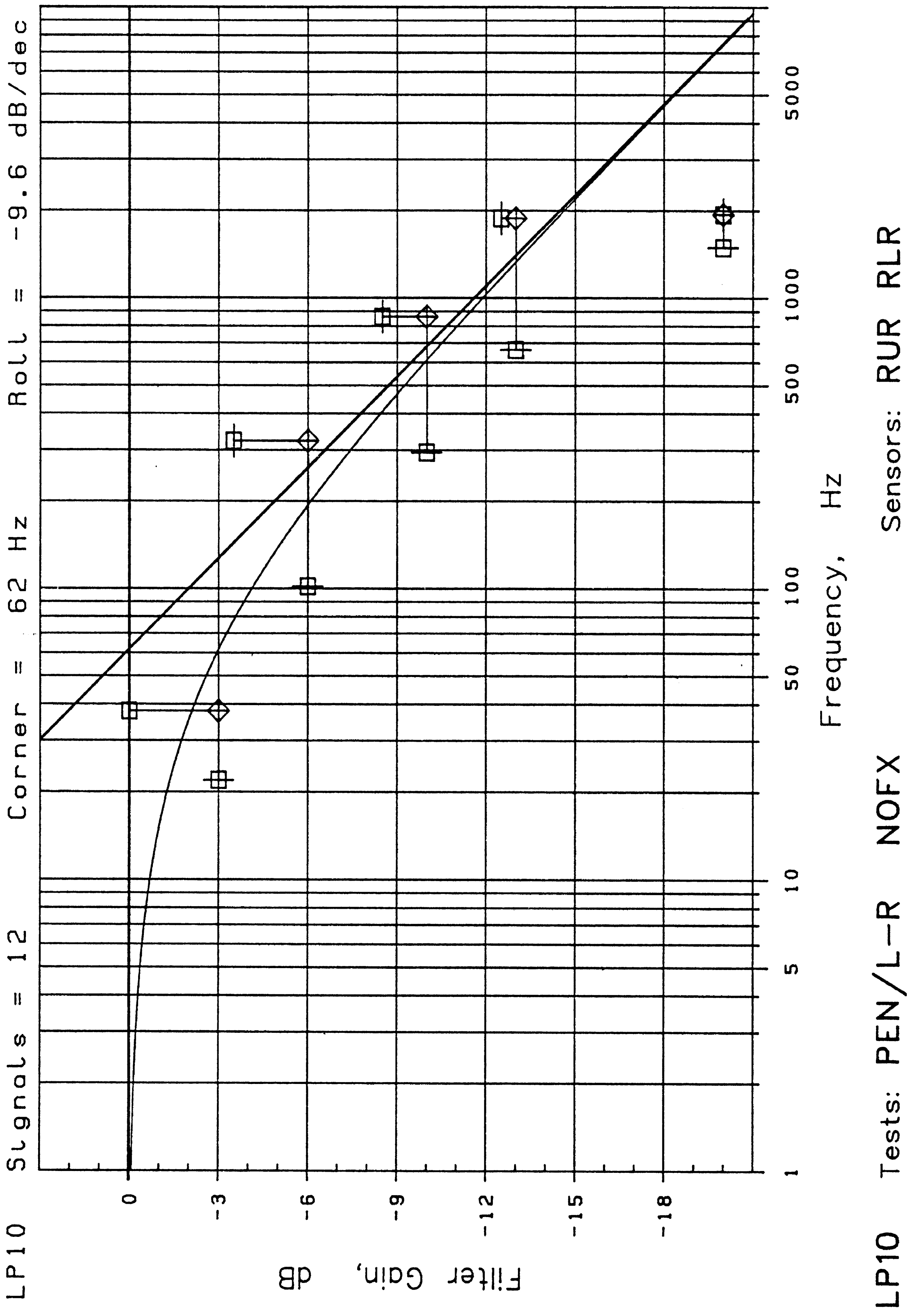
LP07 Tests: SLD/RIG FRAC Sensors: LUR LLR

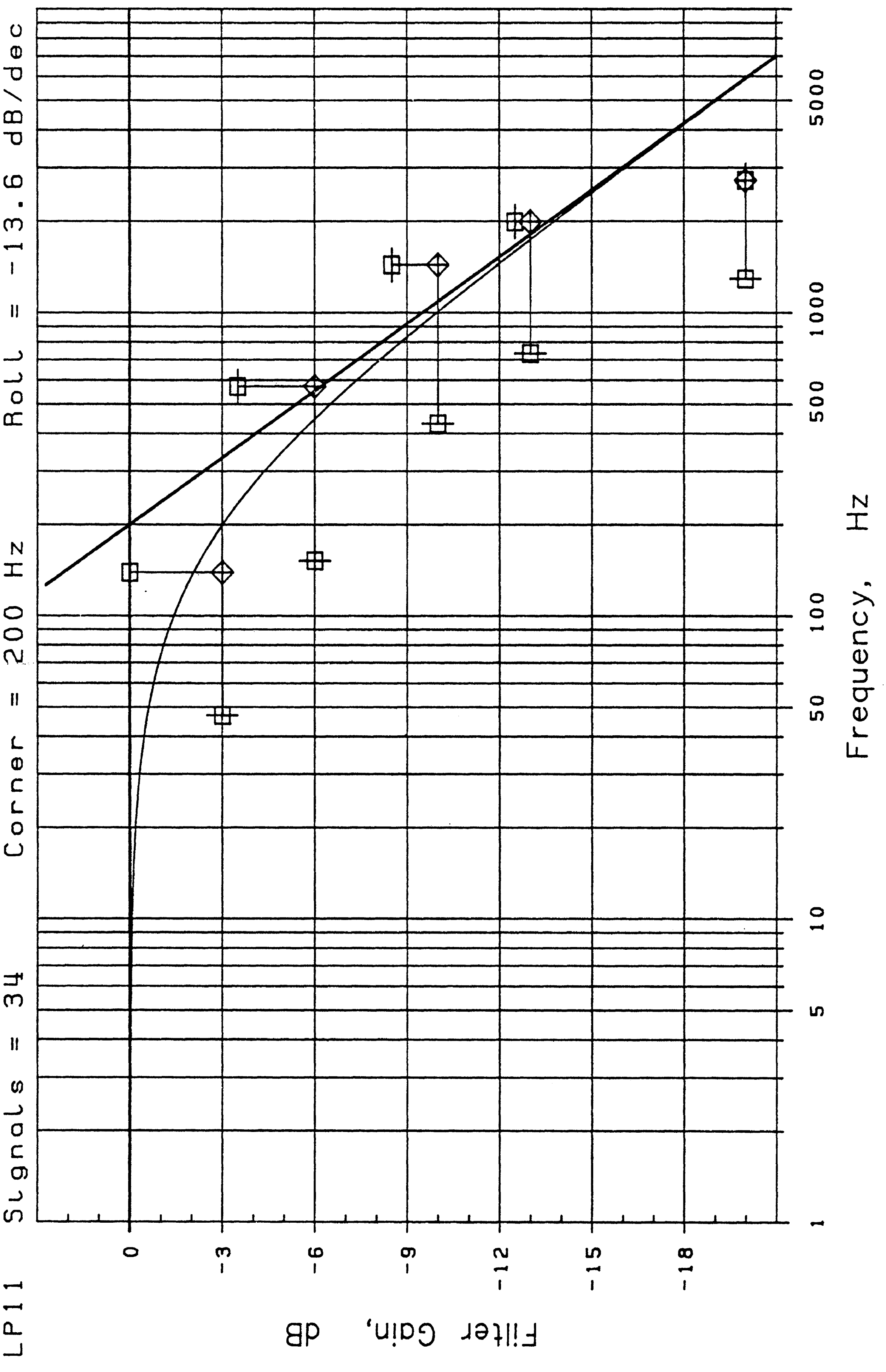


LP08 Tests: SLD/RIG FRAC Sensors: RUR RLR

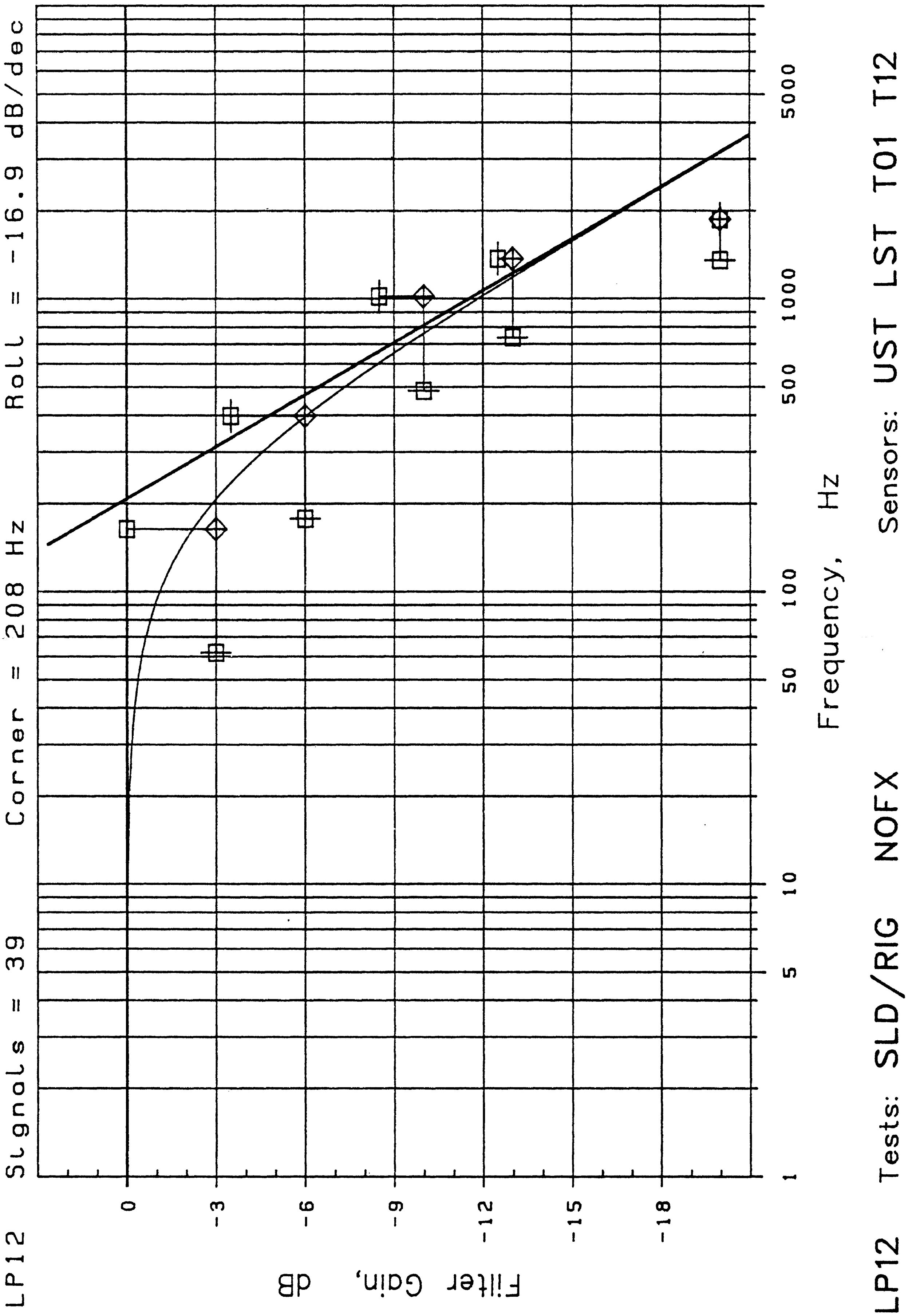


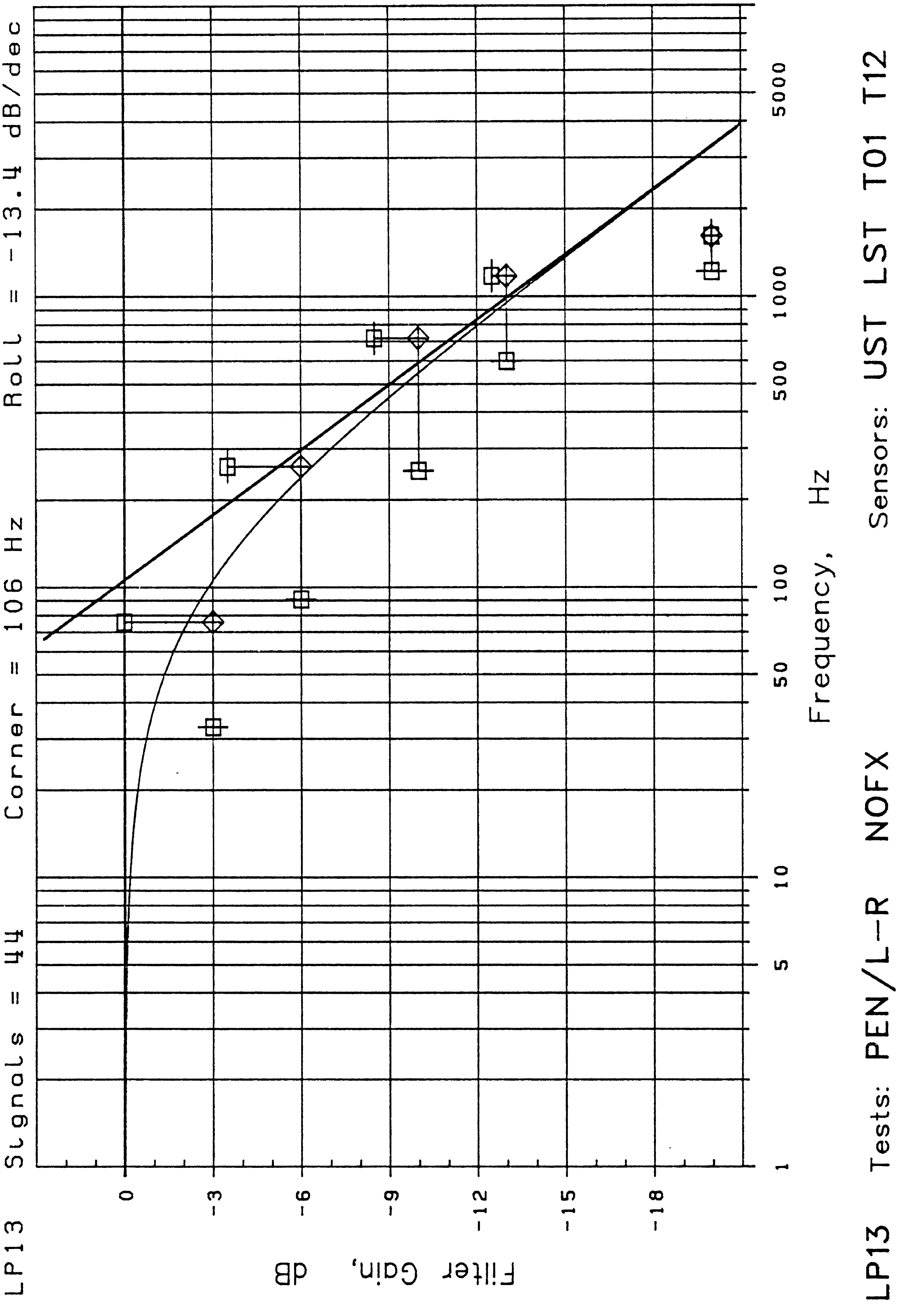
LP09 Tests: **PEN/L–R NOFX** Sensors: **LUR LLR**

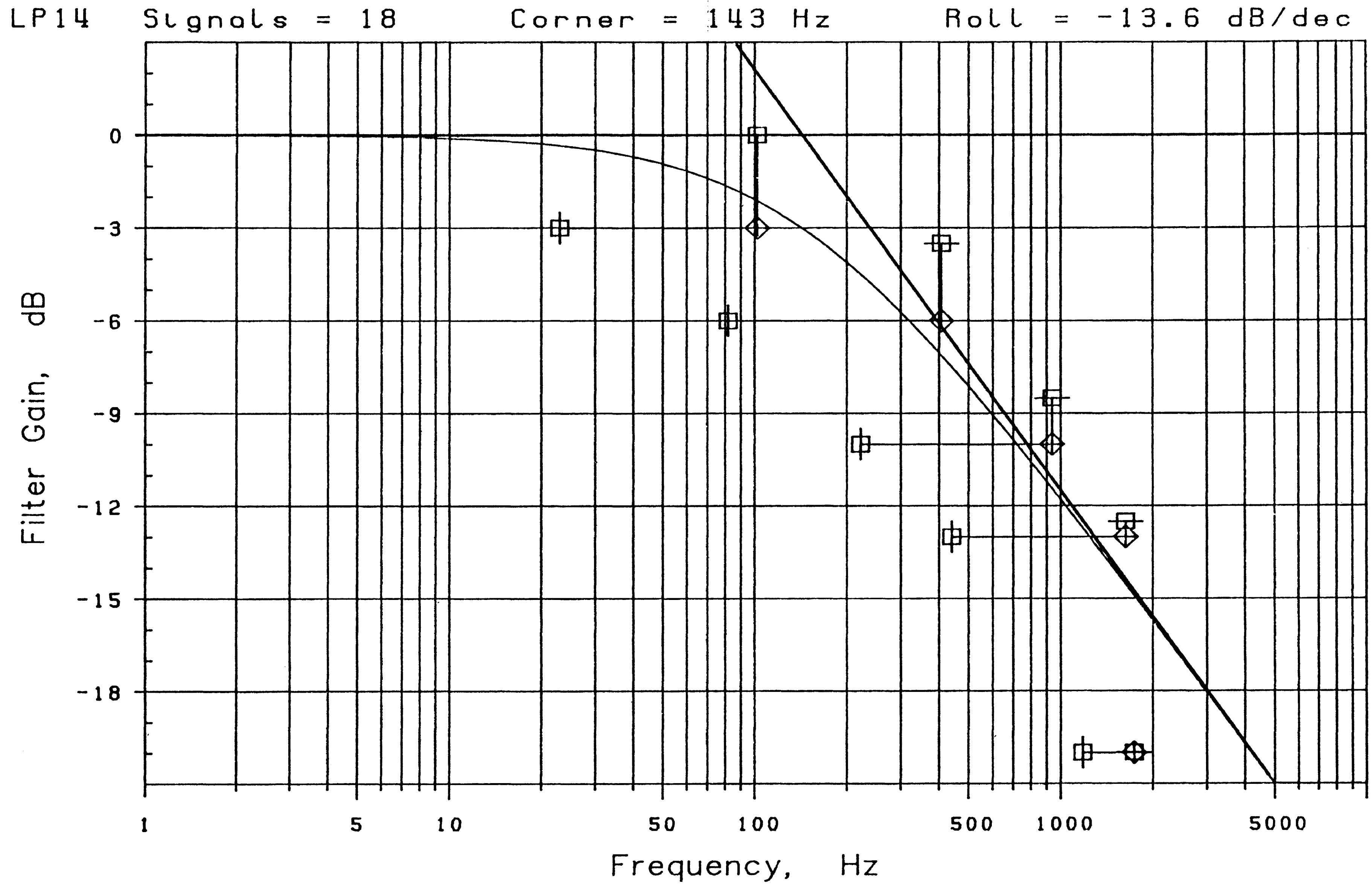

LP10
Signals = 12
Corner = 62 Hz
Roll = -9.6 dB/dec
Filter Gain, dB
0
-3
-6
-9
-12
-15
-18
1
5
10
50
100
500
1000
5000
Frequency, Hz
LP10
Tests: PEN/L-R NOFX
Sensors: RUR RLR



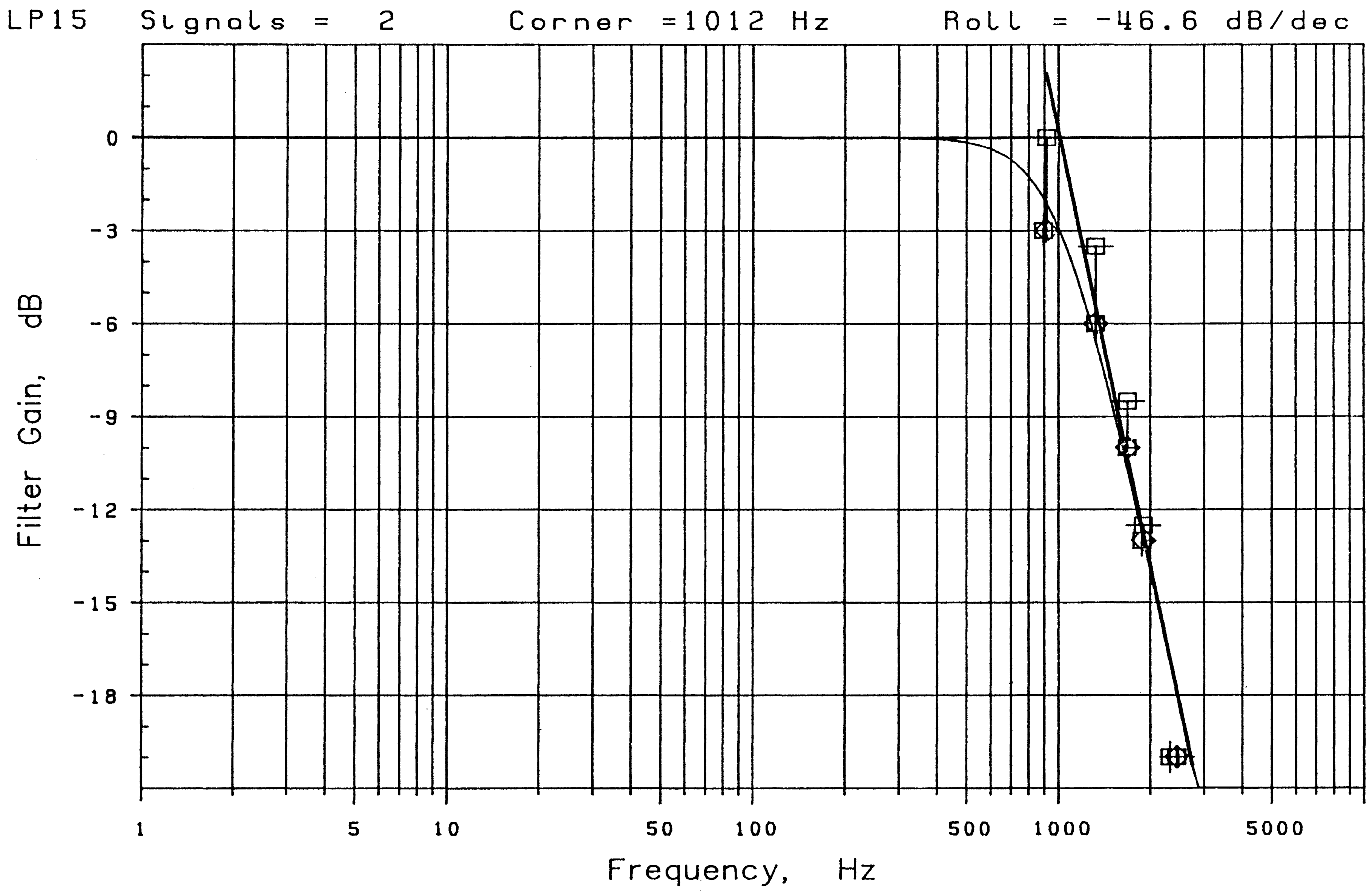
LP11 Tests: **SLD/MCI NOFX** Sensors: **UST LST T01 T12**


LP12
Signals = 39
Corner = 208 Hz
Roll = -16.9 dB/dec
Filter Gain, dB
0
-3
-6
-9
-12
-15
-18
1
5
10
50
100
500
1000
5000
Frequency, Hz
LP12
Tests: SLD/RIG NOFX
Sensors: UST LST T01 T12

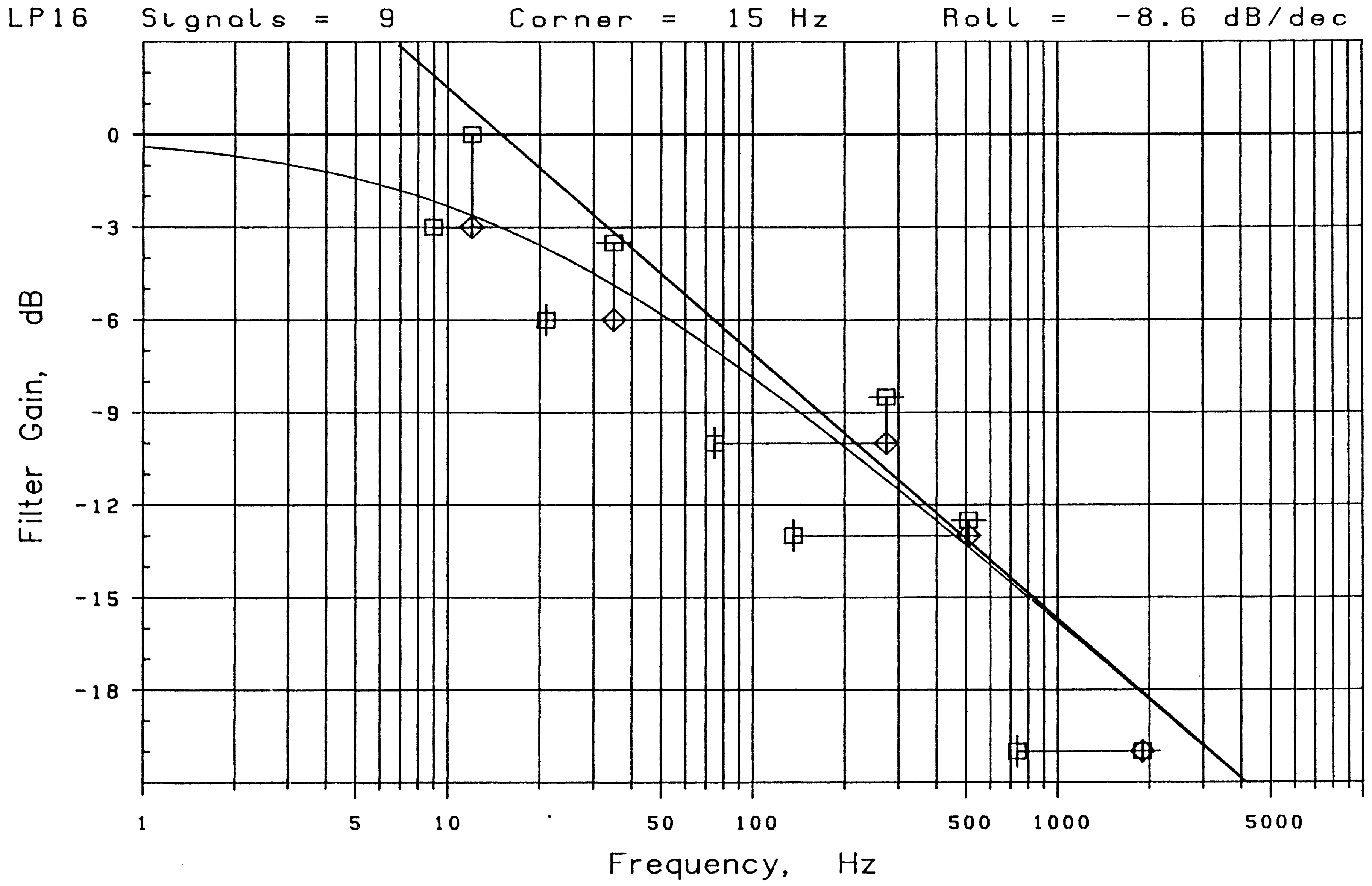

LP13
Signals = 44
Corner = 106 Hz
Roll = -13.4 dB/dec
Filter Gain, dB
0
-3
-6
-9
-12
-15
-18
1
5
10
50
100
500
1000
5000
Frequency, Hz
LP13 Tests: PEN/L-R NOFX
Sensors: UST LST T01 T12



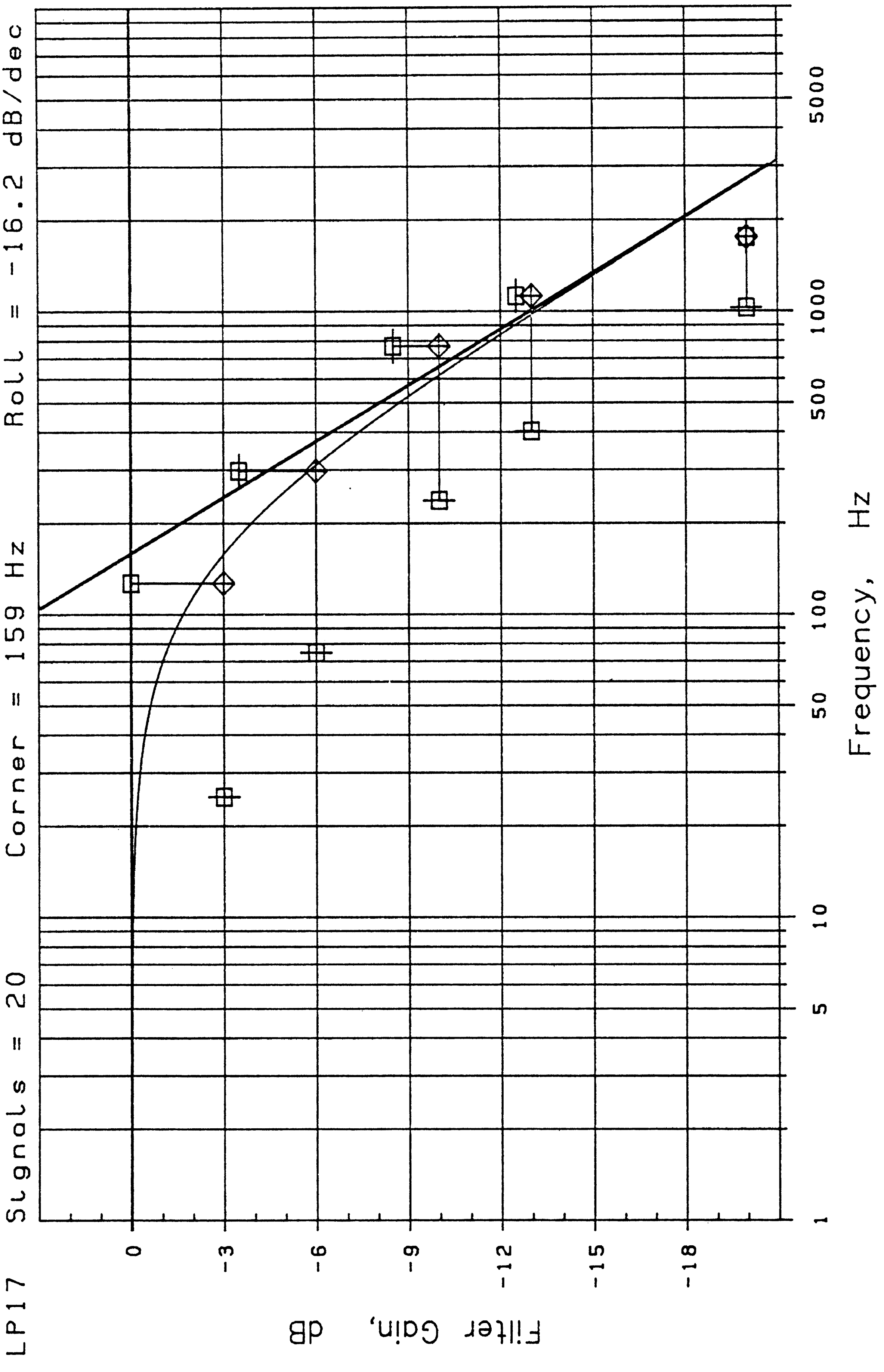
LP14 Tests: SLD/ABG NOFX Sensors: LUR LLR RUR RLR



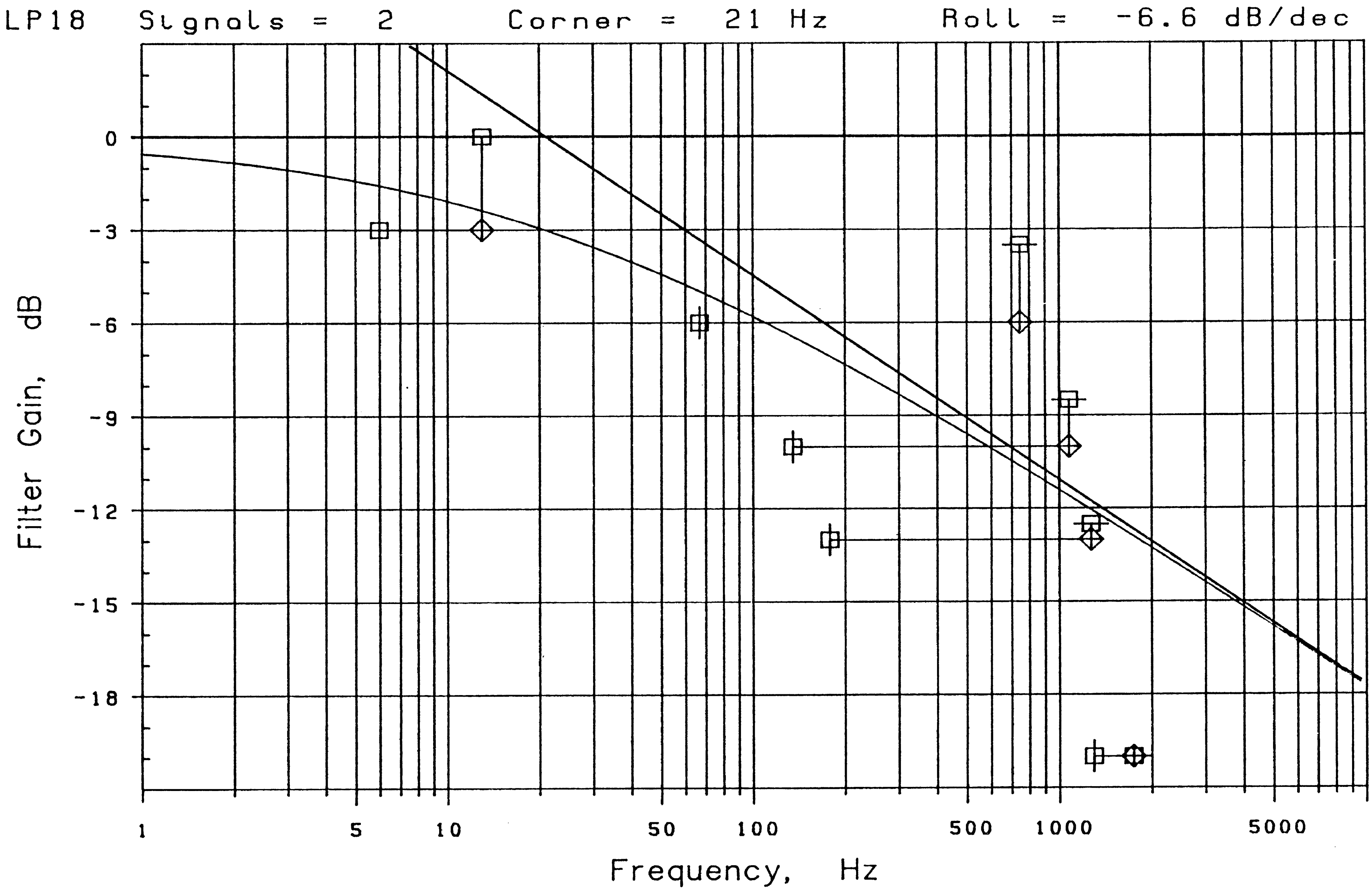
LP15 Tests: SLD/ABG FRAC Sensors: RUR LUR



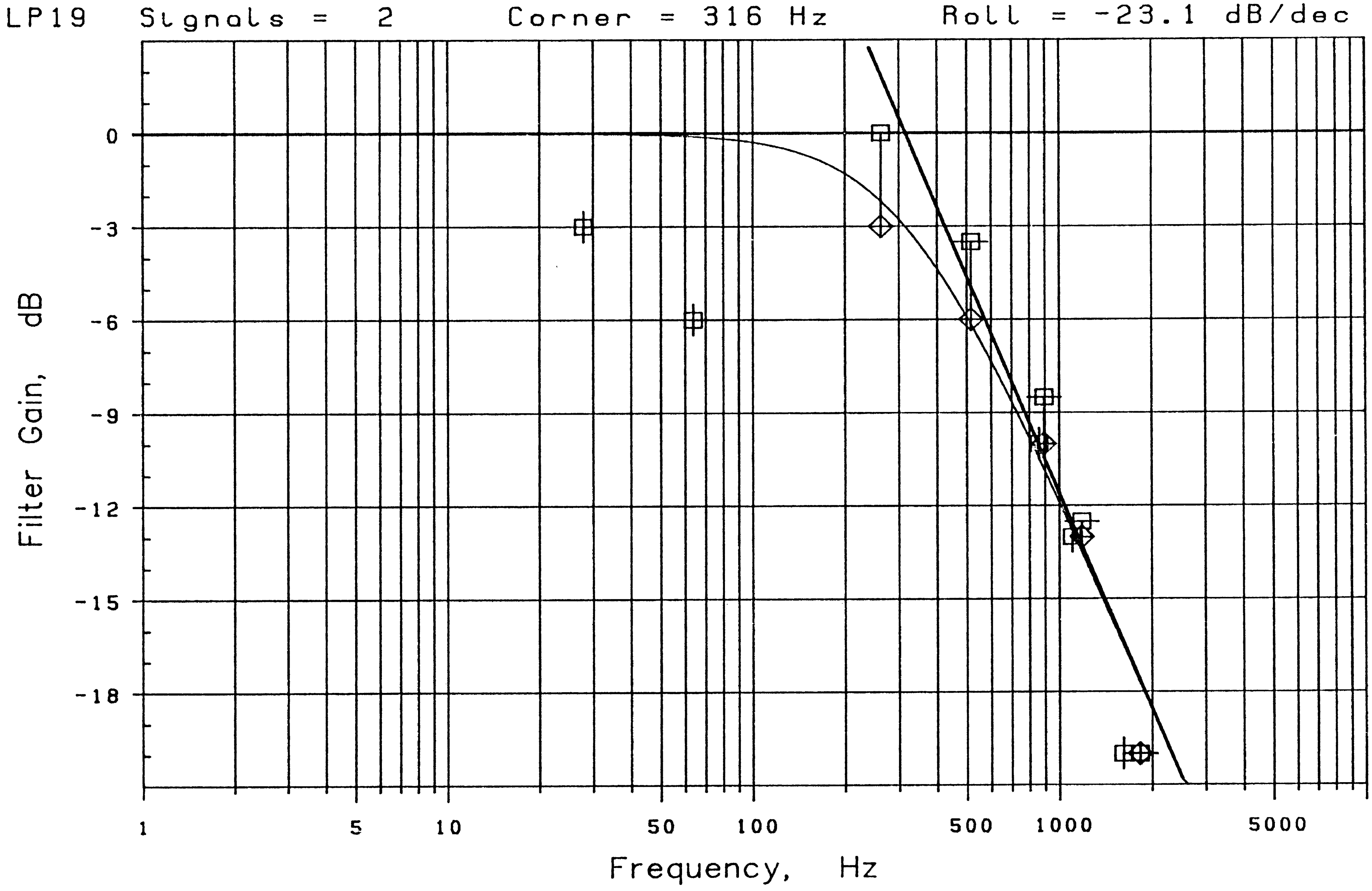
LP16 Tests: **SLD/ABG NOFX** Sensors: **UST LST**



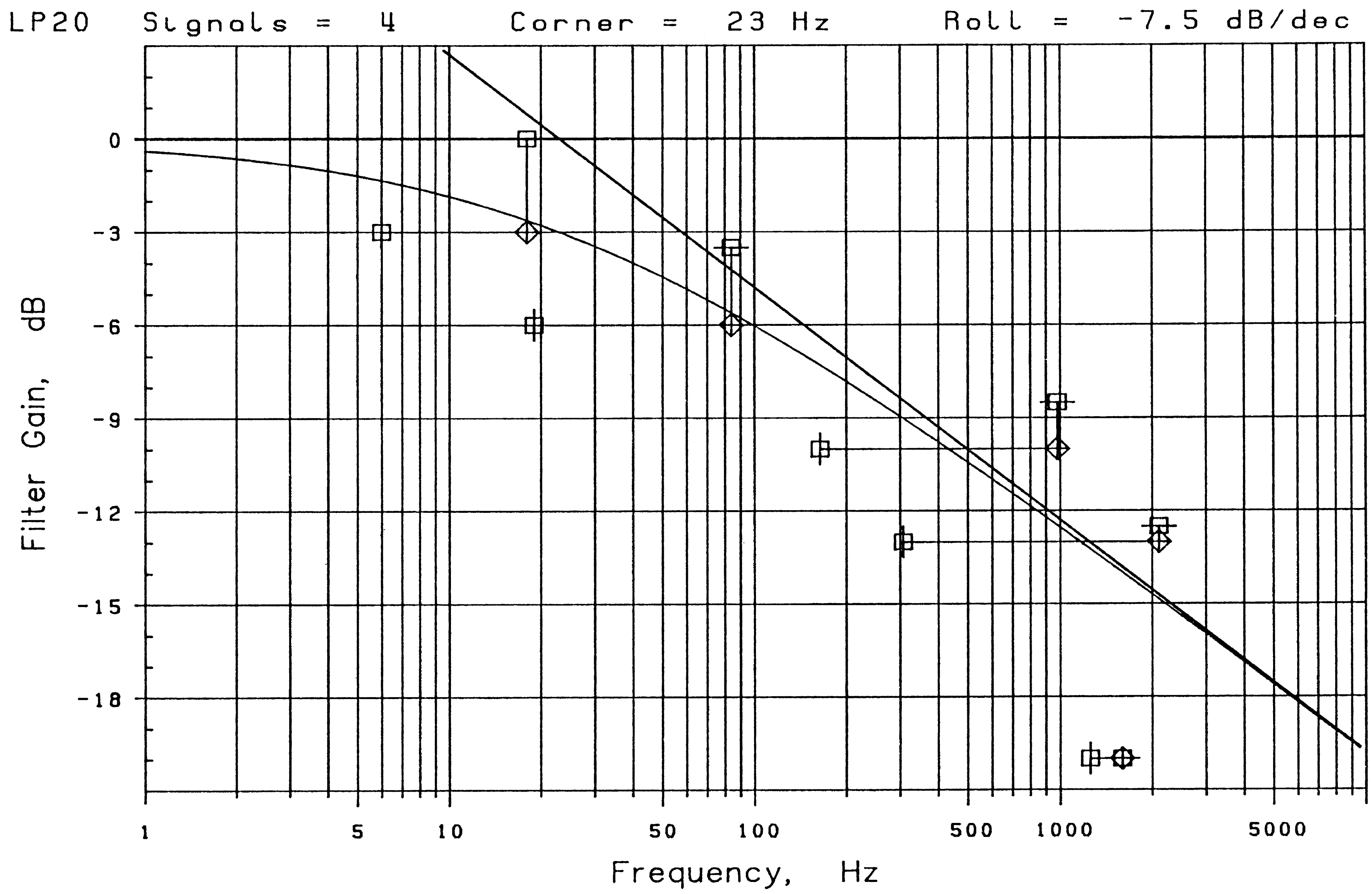
LP17 Tests: SLD/ABG NOFX Sensors: T01 T12



LP18 Tests: SLD/3PT NOFX Sensors: LUR LLR

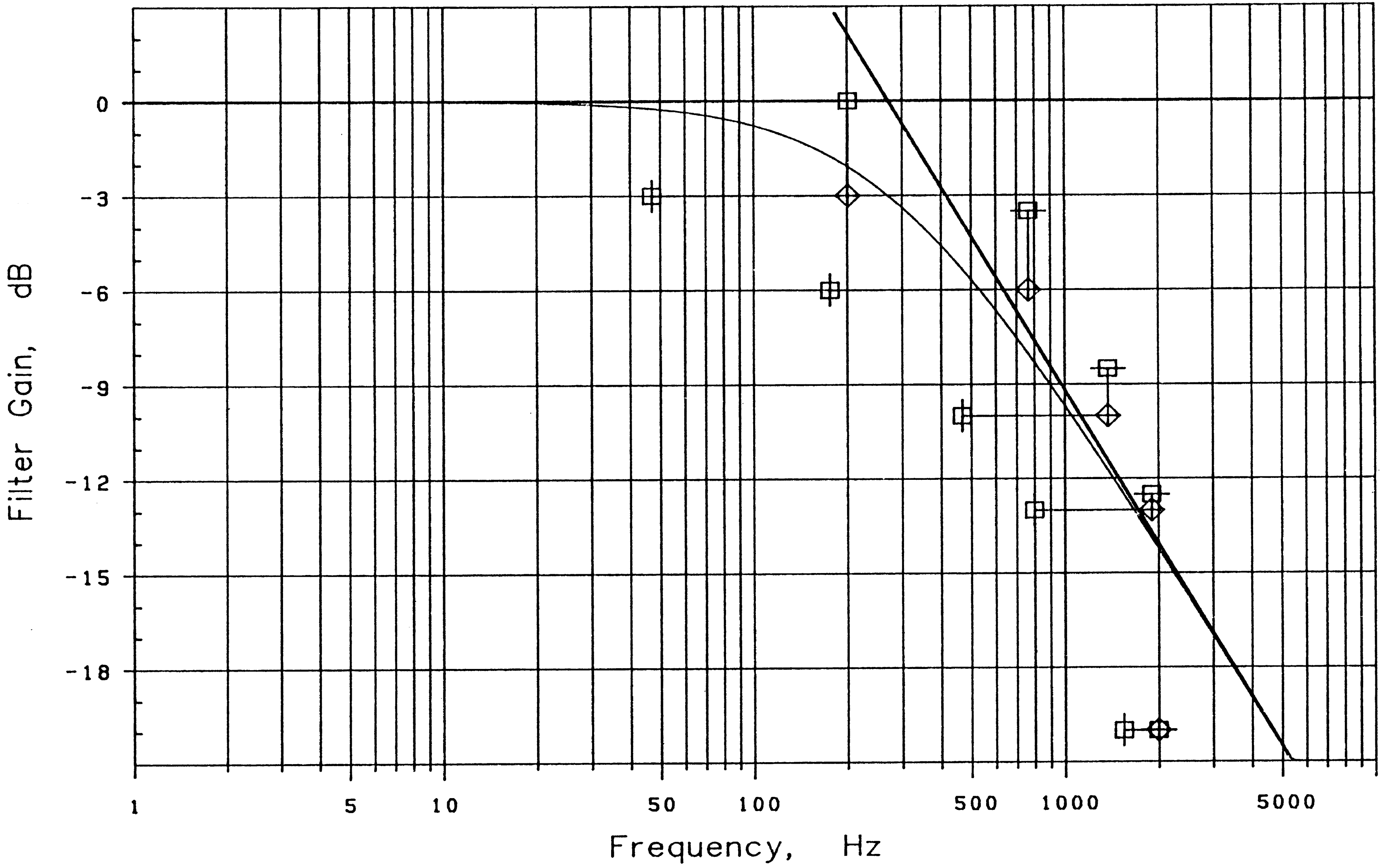


LP19 Tests: SLD/3PT FRAC Sensors: RUR RLR

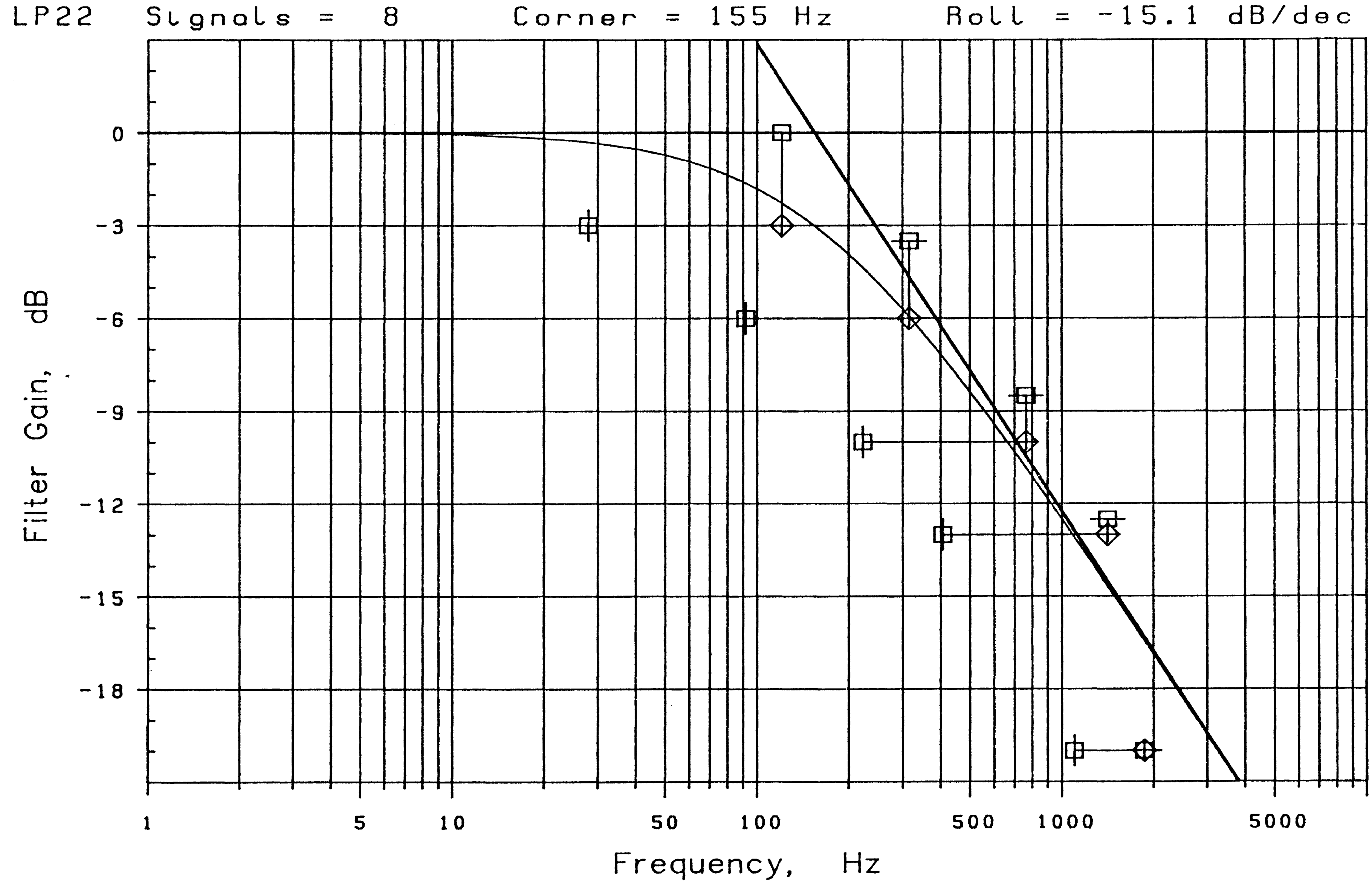


LP20 Tests: SLD/3PT NOFX Sensors: T01 T12

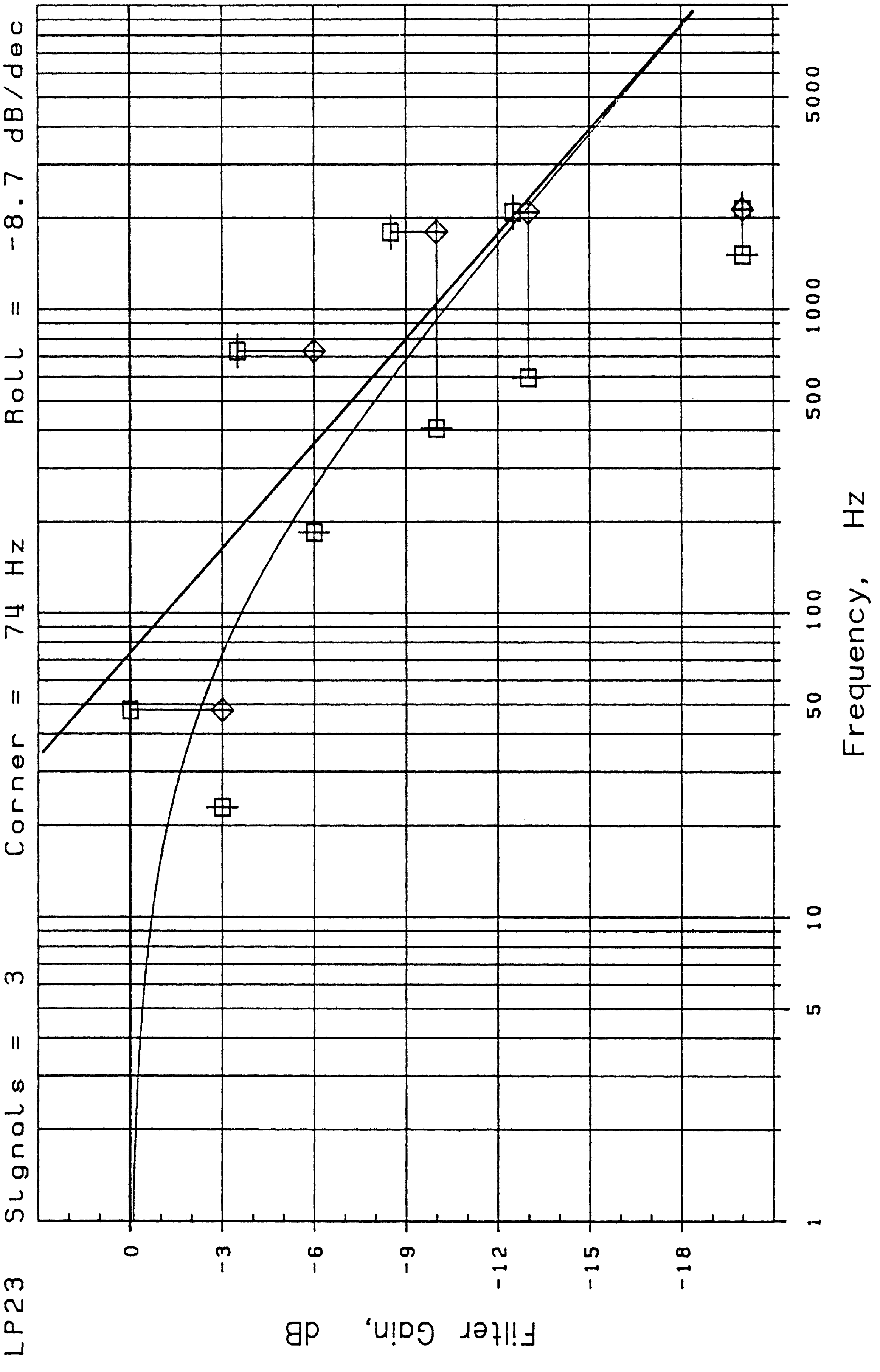
LP21 Signals = 23 Corner = 271 Hz Roll = -16.2 dB/dec



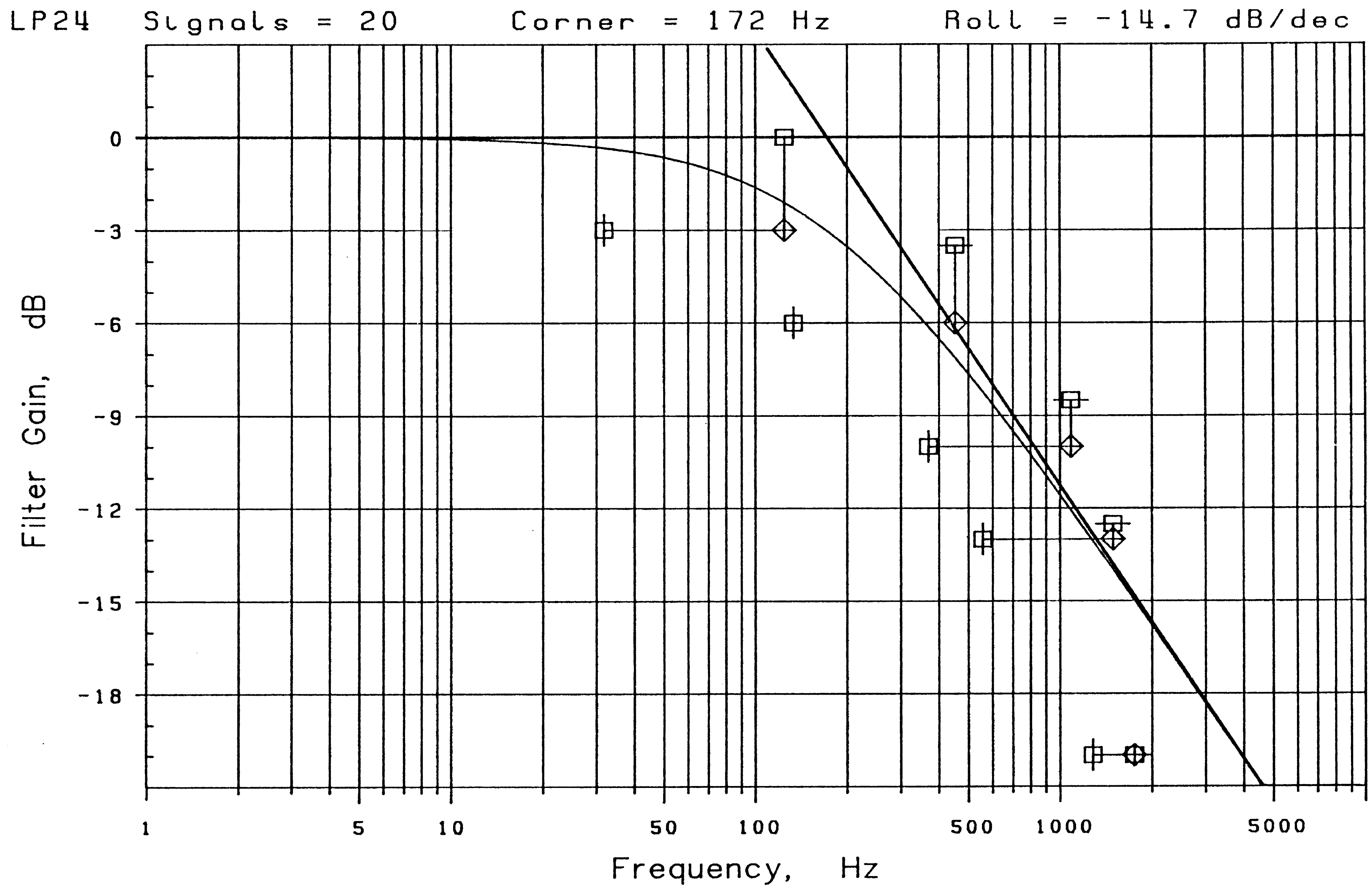
LP21 Tests: SLD/LAP NOFX Sensors: LUR LLR RUR RLR



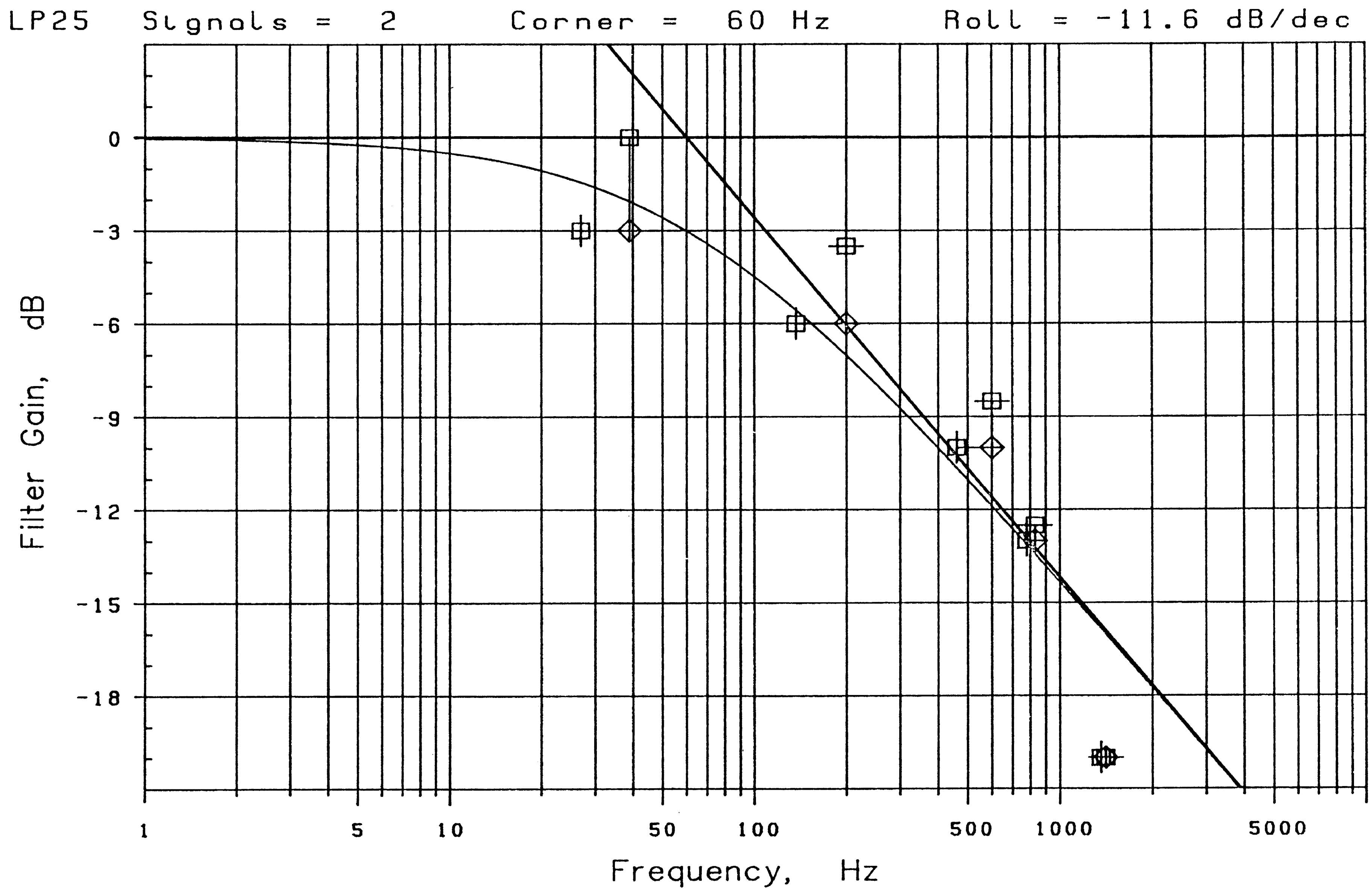
LP22 Tests: SLD/LAP NOFX Sensors: UST LST



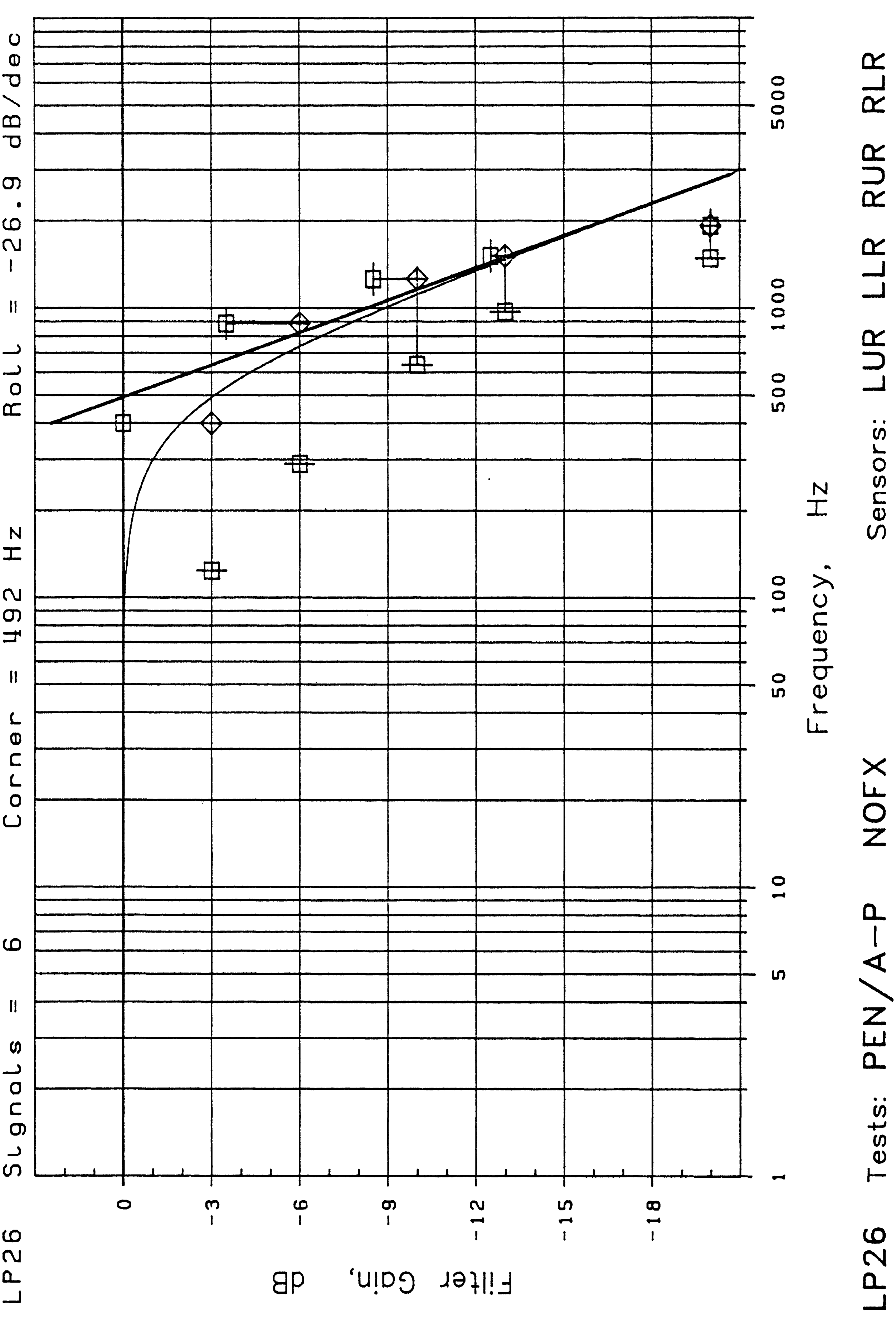
LP23 Tests: SLD/LAP FRAC Sensors: UST

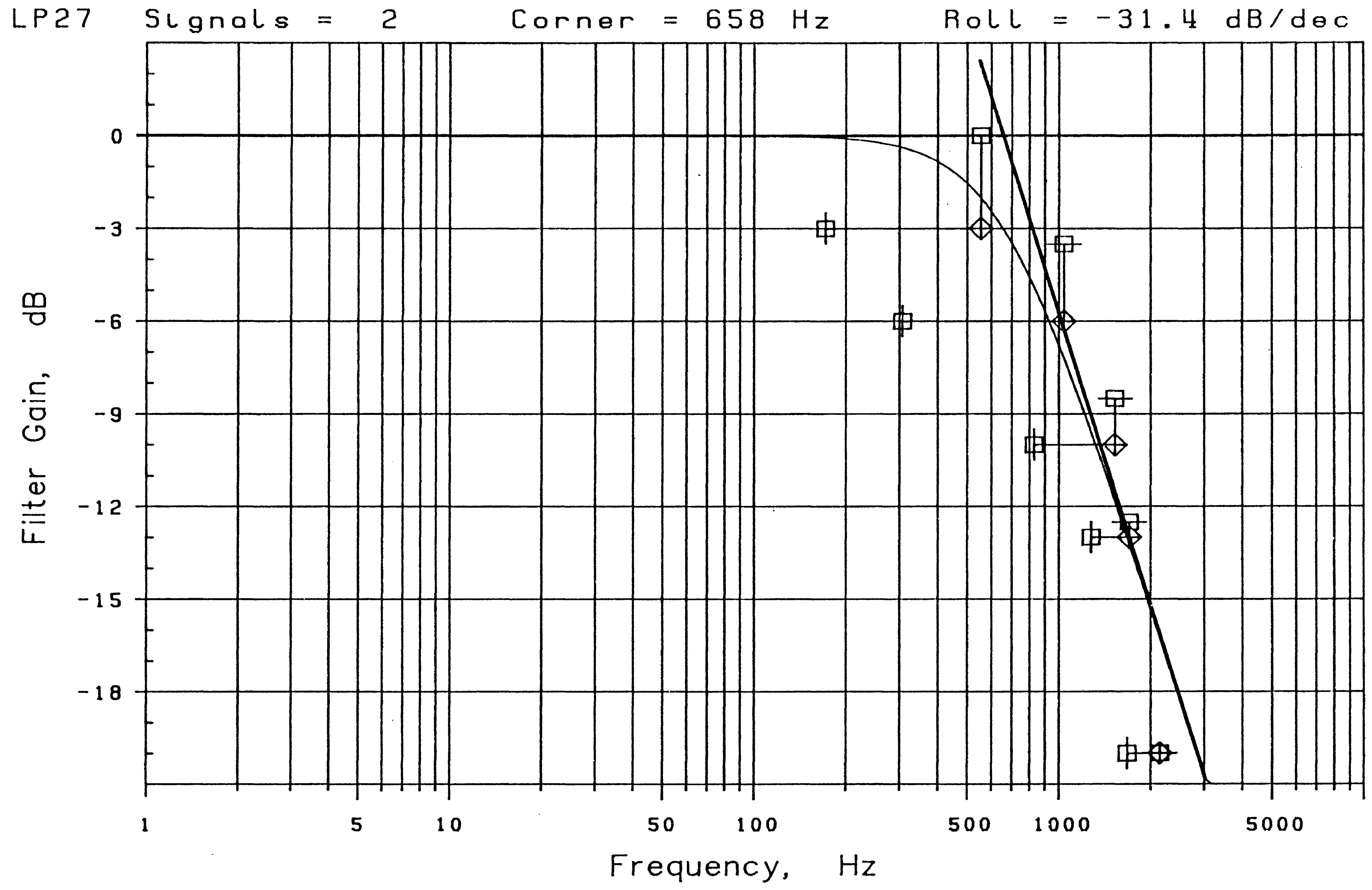


LP24 Tests: SLD/LAP NOFX Sensors: T01 T12

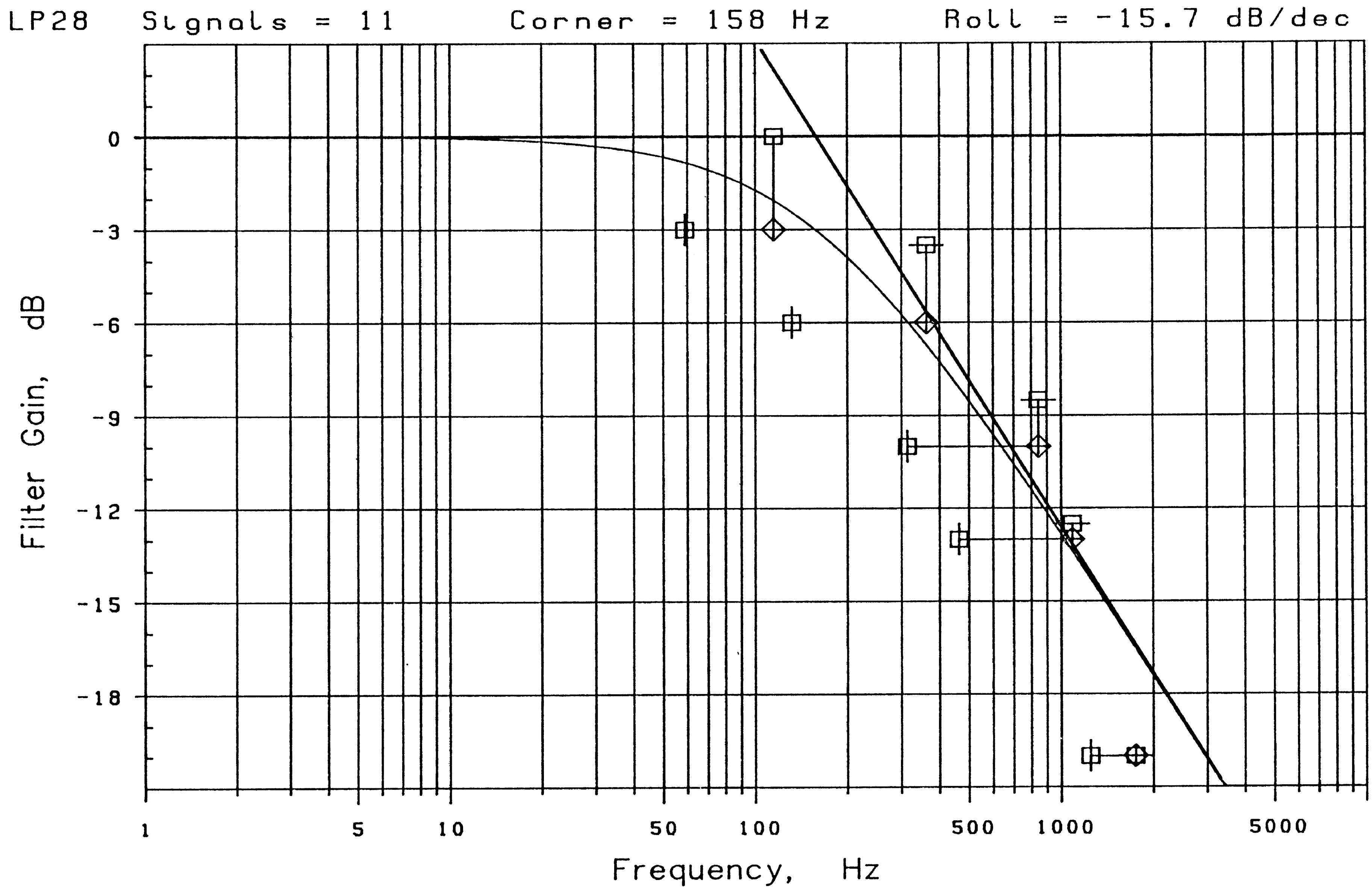


LP25 Tests: SLD/LAP FRAC Sensors: T01

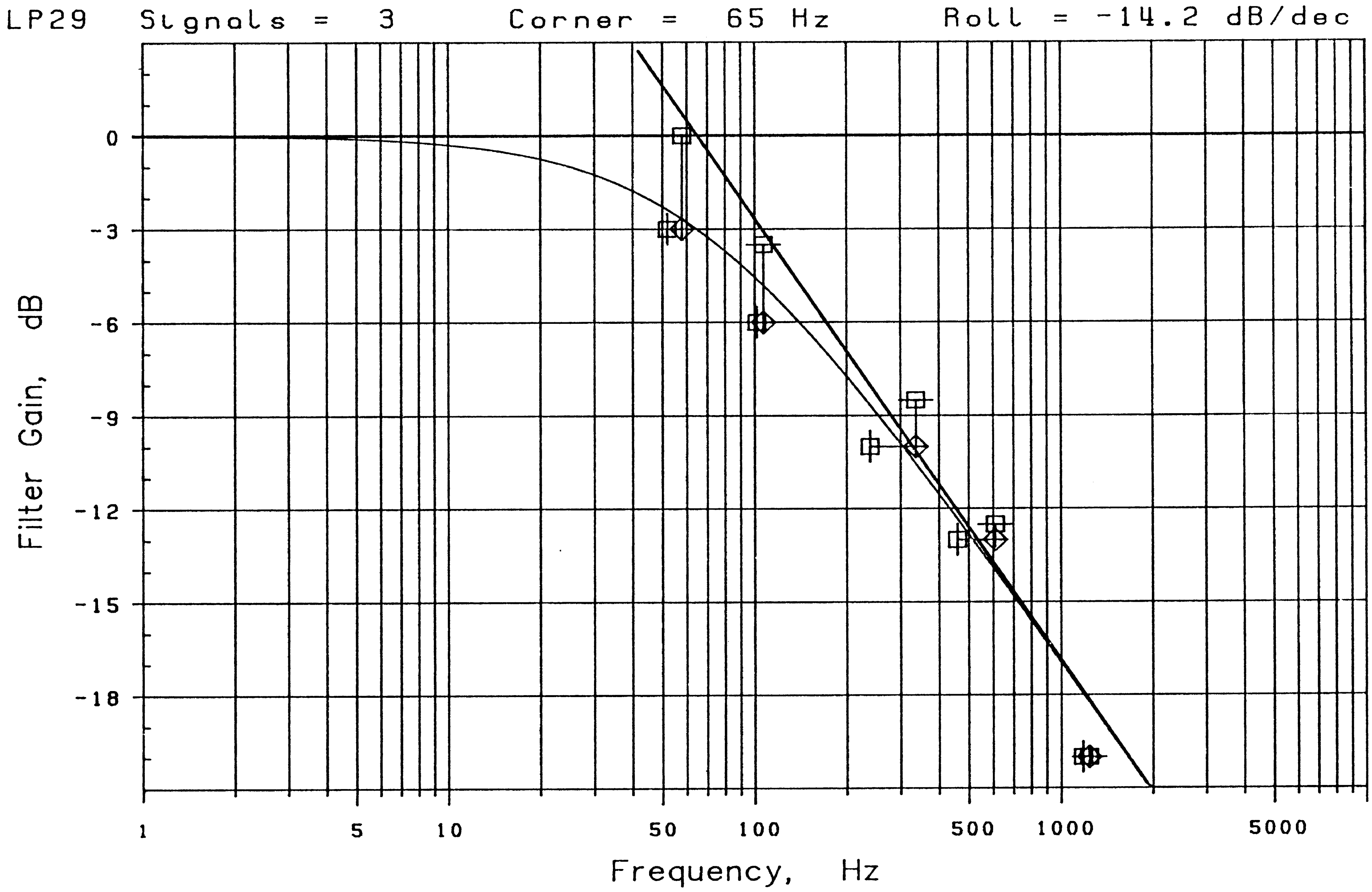

LP26
Signals = 6
Corner = 492 Hz
Roll = -26.9 dB/dec
Filter Gain, dB
0
-3
-6
-9
-12
-15
-18
Frequency, Hz
1
5
10
50
100
500
1000
5000
LP26
Tests: PEN/A-P NOFX
Sensors: LUR LLR RUR RLR



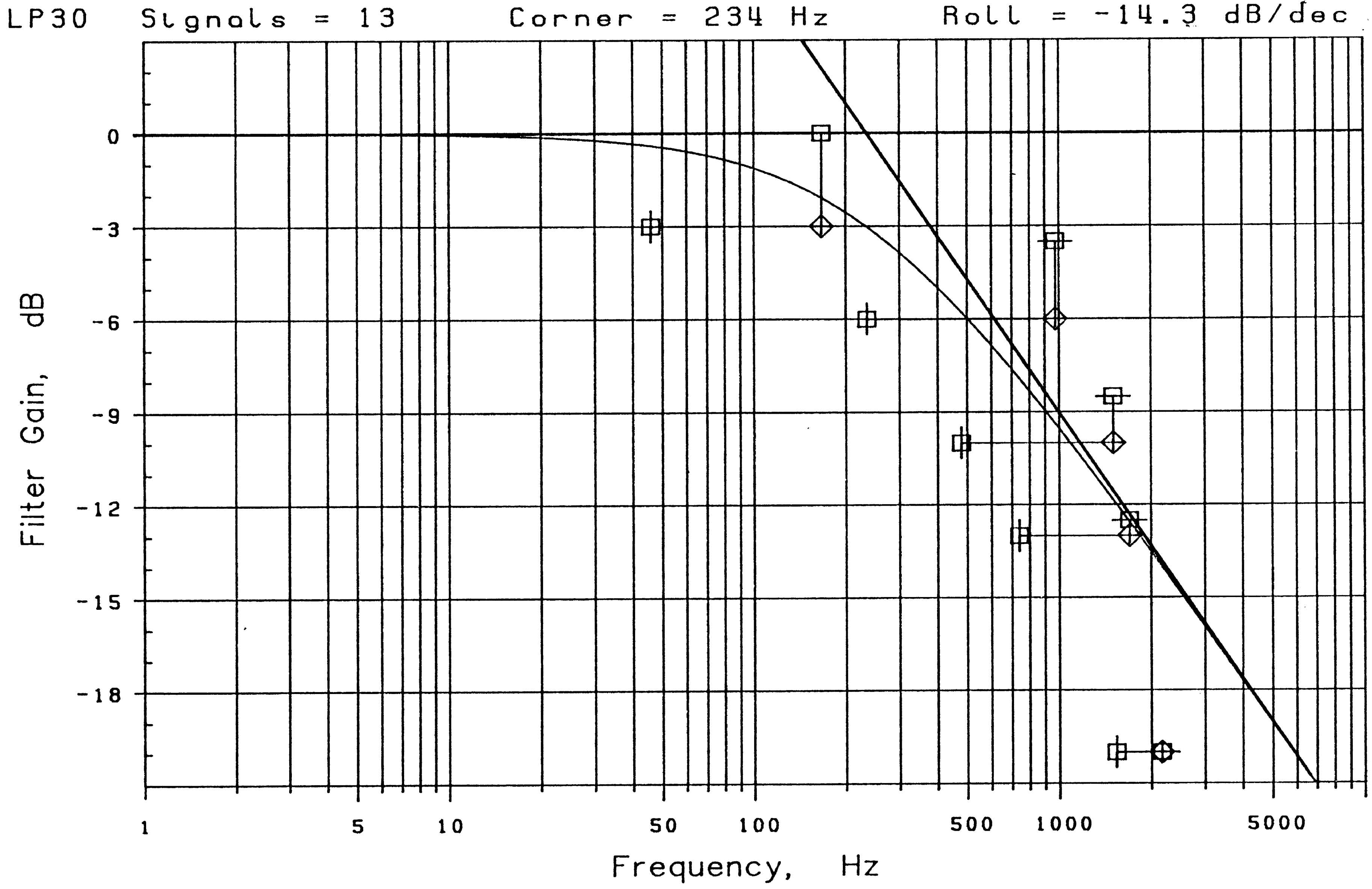
LP27 Tests: PEN/A-P FRAC Sensors: RUR



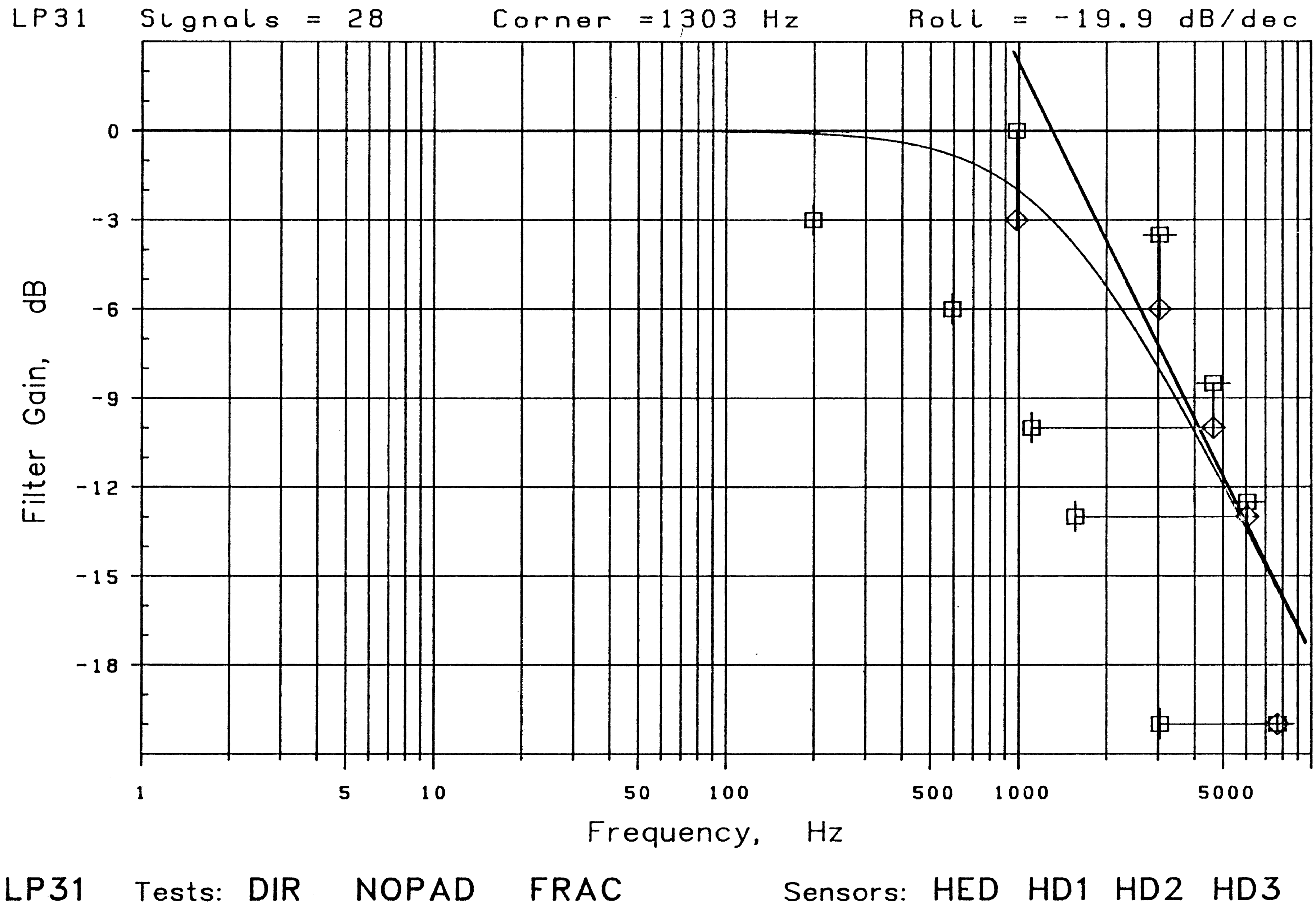
LP28 Tests: PEN/A-P NOFX Sensors: UST LST



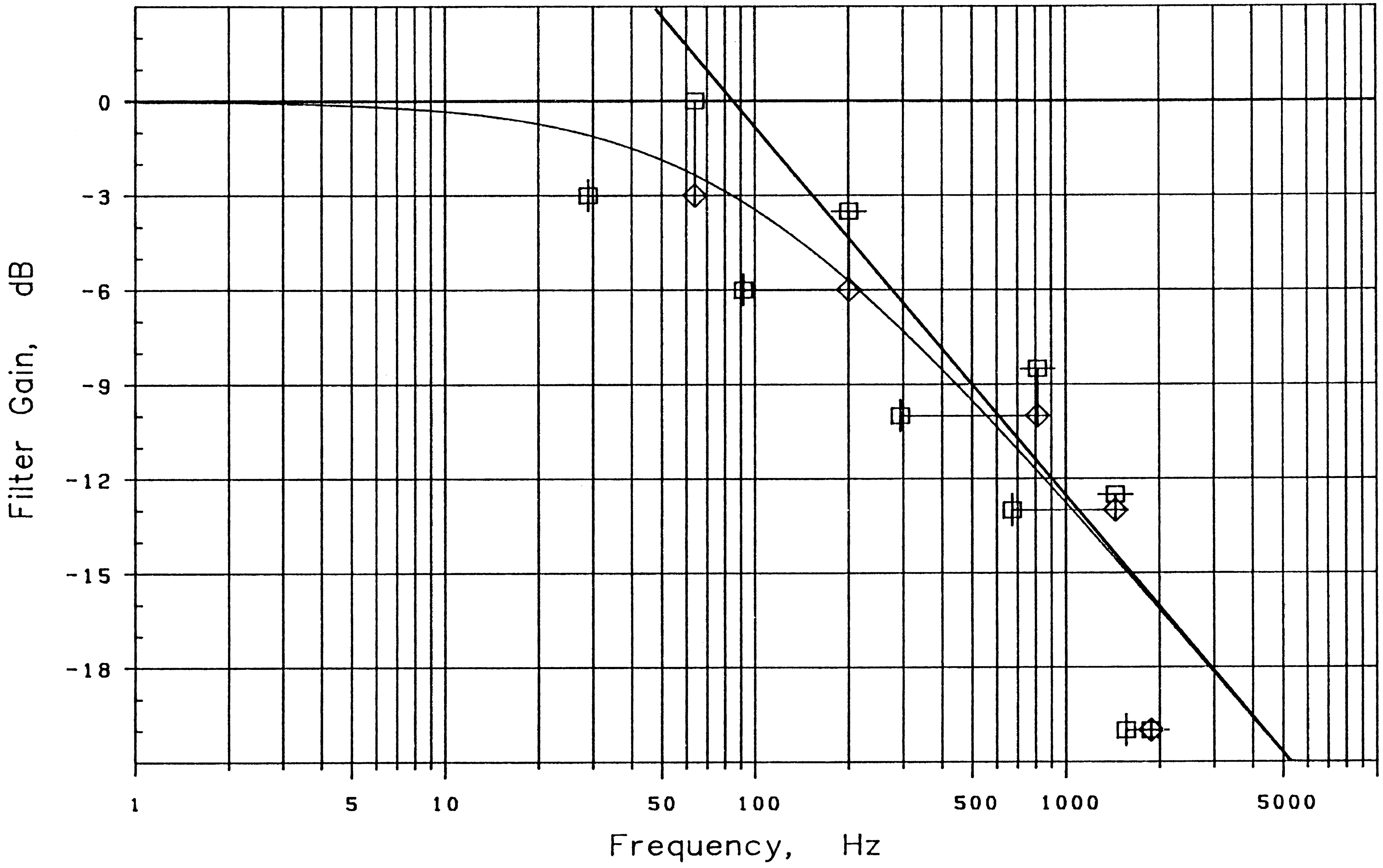
LP29 Tests: **PEN/A-P FRAC** Sensors: **LST UST**



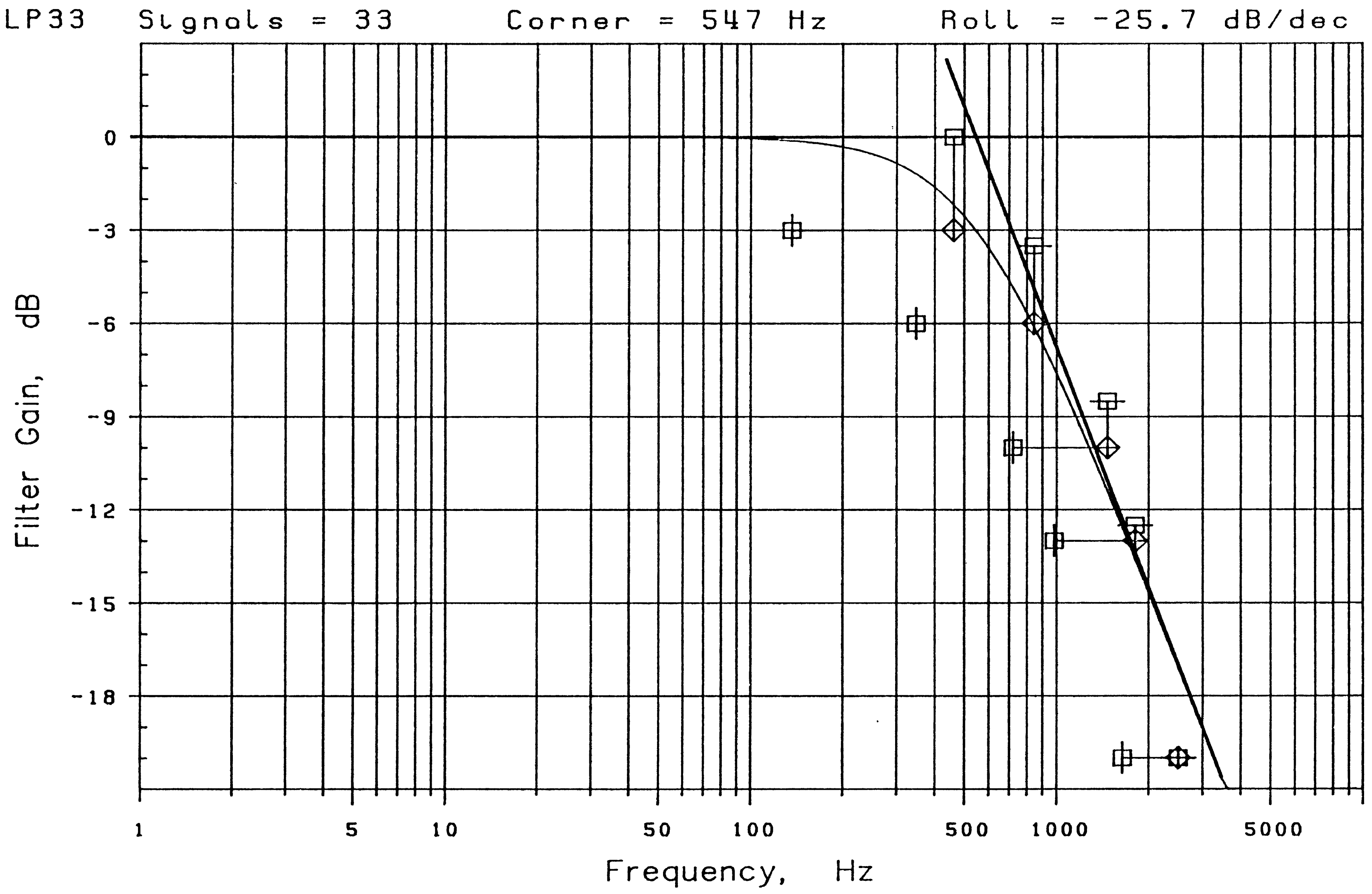
LP30 Tests: PEN/A-P NOFX Sensors: T01 T12


LP31
Signals = 28
Corner =1303 Hz
Roll = -19.9 dB/dec
Filter Gain, dB
0
-3
-6
-9
-12
-15
-18
1
5
10
50
100
500
1000
5000
Frequency, Hz
LP31
Tests: DIR NOPAD FRAC
Sensors: HED HD1 HD2 HD3

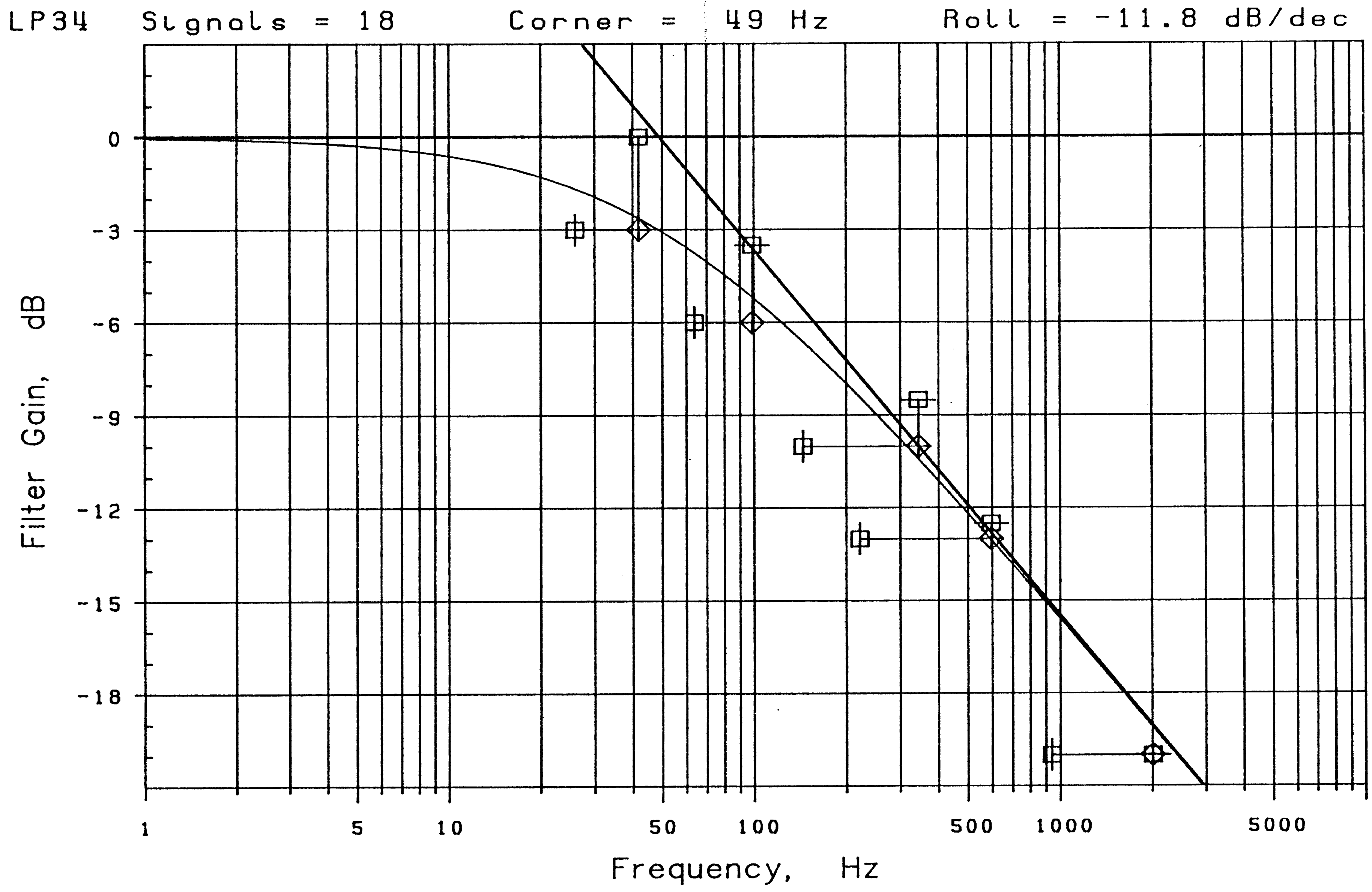
LP32 Signals = 10 Corner = 85 Hz Roll = -11.7 dB/dec



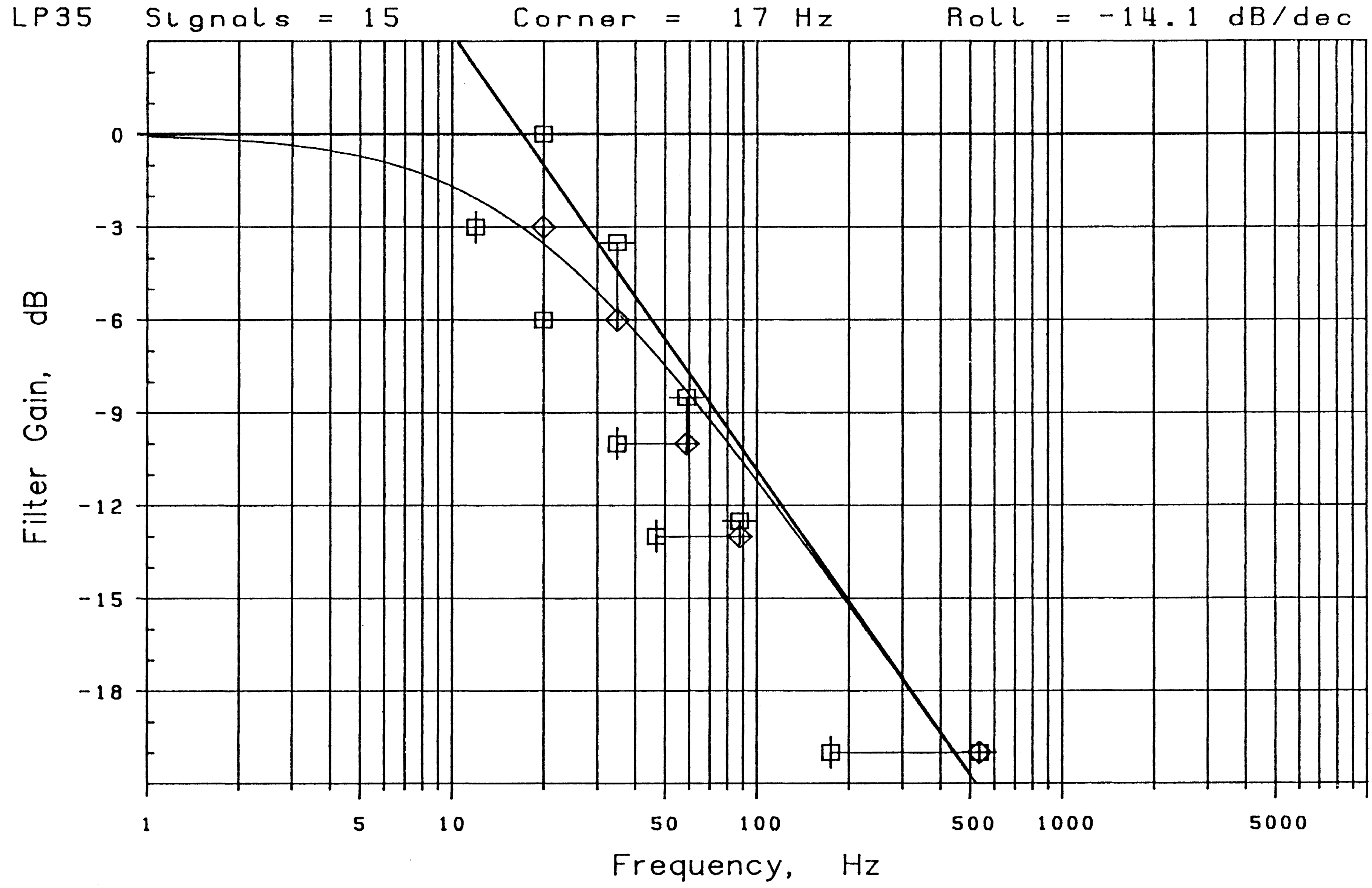
LP32 Tests: DIR W/PAD FRAC Sensors: HD1 HD2 HD3 HED



LP33 Tests: DIR NOPAD NOFX Sensors: HD1 HD2 HD3 HED



LP34 Tests: DIR W/PAD NOFX Sensors: HD1 HD2 HD3 HED



LP35 Tests: NO DIRECT IMPACT Sensors: HD1 HD2 HD3 HED

Appendix B

DETAILED OUTPUT OF CHARACTERIZATION

This Appendix is included to present the entire data used for characterizing the frequency response of the signals, as well as the intermediate and final results of the analysis. These are presented in 35 separate pages corresponding to the 35 analyzed groups of signals.

SUMMARY OF CHARACTERIZATIONS

Filter Number	Corner (Hz)	Slope (dB/dec)	Sensors		Test Type
LP01	641.	-33.7	3	LLR	SLD/MCI NOFX
LP02	151.	-15.0	6	RUR RLR	SLD/MCI NOFX
LP03	611.	-30.4	7	LUR LLR	SLD/MCI FRAC
LP04	212.	-13.6	4	RUR RLR	SLD/MCI FRAC
LP05	510.	-23.1	4	LLR	SLD/RIG NOFX
LP06	257.	-17.7	9	RUR RLR	SLD/RIG NOFX
LP07	496.	-25.1	8	LUR LLR	SLD/RIG FRAC
LP08	658.	-31.0	3	RUR RLR	SLD/RIG FRAC
LP09	422.	-26.1	6	LUR LLR	PEN/L-R NOFX
LP10	62.	-9.6	12	RUR RLR	PEN/L-R NOFX
LP11	200.	-13.6	34	UST LST T01 T12	SLD/MCI NOFX
LP12	208.	-16.9	39	UST LST T01 T12	SLD/RIG NOFX
LP13	106.	-13.4	44	UST LST T01 T12	PEN/L-R NOFX
LP14	143.	-13.6	18	LUR LLR RUR RLR	SLD/ABG NOFX
LP15	1012.	-46.6	2	RUR LUR	SLD/ABG FRAC
LP16	15.	-8.6	9	UST LST	SLD/ABG NOFX
LP17	159.	-16.2	20	T01 T12	SLD/ABG NOFX
LP18	21.	-6.6	2	LUR LLR	SLD/3PT NOFX
LP19	316.	-23.1	2	RUR RLR	SLD/3PT FRAC
LP20	23.	-7.5	4	T01 T12	SLD/3PT NOFX
LP21	271.	-16.2	23	LUR LLR RUR RLR	SLD/LAP NOFX
LP22	155.	-15.1	8	UST LST	SLD/LAP NOFX
LP23	74.	-8.7	3	UST	SLD/LAP FRAC
LP24	172.	-14.7	20	T01 T12	SLD/LAP NOFX
LP25	60.	-11.6	2	T01	SLD/LAP FRAC
LP26	492.	-26.9	6	LUR LLR RUR RLR	PEN/A-P NOFX
LP27	658.	-31.4	2	RUR	PEN/A-P FRAC
LP28	158.	-15.7	11	UST LST	PEN/A-P NOFX
LP29	65.	-14.2	3	LST UST	PEN/A-P FRAC
LP30	234.	-14.3	13	T01 T12	PEN/A-P NOFX
LP31	1303.	-19.9	28	HED HD1 HD2 HD3	DIR NOPAD FRAC
LP32	85.	-11.7	10	HD1 HD2 HD3 HED	DIR W/PAD FRAC
LP33	547.	-25.7	33	HD1 HD2 HD3 HED	DIR NOPAD NOFX
LP34	49.	-11.8	18	HD1 HD2 HD3 HED	DIR W/PAD NOFX
LP35	17.	-14.1	15	HD1 HD2 HD3 HED	NO DIRECT IMPACT

```
Tests =  SLD/MCI  NOFX                      Sensors =  LLR                 LP01

FILTER ESTIMATION            3 Signals              SUMMARY OF SPECTRAL ANALYSIS
                        Cumulative P.S.D.    (%) =    50    75    90    95    99
                        % of Signal Passed   (%) =    71    50    32    22    10
Best MEAN+1SD fit
                        Equivalent Filter   (dB) =    -3    -6   -10   -13   -20
CORNER @ ROLL-OFF       MEAN LOG Frequency  (Hz) =   230   589   926  1114  1517
 (Hz)     (dB/dec)      MEAN+1SD Frequency  (Hz) =   550   962  1353  1558  2031

 641.      -33.7  <---- Adjusted Asymptote  (Hz) =   788   967  1269  1559  2511
                        Best-Fit Filter     (Hz) =   641   888  1230  1535  2504

T-File  Ch     Signal      Test ID    Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2563  02.  AC LLR X G'S  76T029    1792  6410      121   360   648   798  1033
1-2599  02.  AC LLR X G'S  76T039    1760  6410      789  1149  1565  1764  2092
1-2889  03.  AC LLR X G'S  77T098    1856  6410      128   495   784   981  1617
```

```
Tests =  SLD/MCI  NOFX                 Sensors =  RUR RLR                 LP02

FILTER ESTIMATION        6 Signals                SUMMARY OF SPECTRAL ANALYSIS
                    Cumulative P.S.D.    (%) =    50     75     90     95     99
                    % of Signal Passed   (%) =    71     50     32     22     10
Best MEAN+1SD fit
                    Equivalent Filter   (dB) =    -3     -6    -10    -13    -20
CORNER @ ROLL-OFF   MEAN LOG Frequency  (Hz) =    41    101    345    532   1385
 (Hz)    (dB/dec)   MEAN+1SD Frequency  (Hz) =   120    308    987   1273   1614

 151.     -15.0  <----  Adjusted Asymptote (Hz) =   240    382    705   1119   3279
                    Best-Fit Filter     (Hz) =   151    315    657   1081   3257

T-File  Ch      Signal     Test ID    Sampling     Freq. (Hz) @ Cum. PSD Levels

1-2566  05.  AC RUR Y G'S  76T029   1792  6410       9     19     53    100   1391
1-2602  05.  AC RUR Y G'S  76T039   1760  6410      72    362   1361   1551   1883
1-2565  04.  AC RLR X G'S  76T029   1792  6410      58     81    200    358   1279
1-2582  04.  AC RLR X G'S  76T034   1522  6410     257    454    574    700   1307
1-2601  04.  AC RLR X G'S  76T039   1760  6410      20     97    756    984   1407
1-2872  05.  AC RLR X G'S  77T095   1904  6410      25     44    271    595   1144
```

```
Tests =  SLD/MCI  FRAC                 Sensors =  LUR LLR                  LP03

FILTER ESTIMATION        7 Signals                 SUMMARY OF SPECTRAL ANALYSIS
                         Cumulative P.S.D.   (%) =    50    75    90    95    99
                         % of Signal Passed  (%) =    71    50    32    22    10
Best MEAN+1SD fit
                         Equivalent Filter  (dB) =    -3    -6   -10   -13   -20
CORNER @ ROLL-OFF        MEAN LOG Frequency (Hz) =   313   784  1237  1476  1889
 (Hz)    (dB/dec)        MEAN+1SD Frequency (Hz) =   510  1020  1434  1650  2018

 611.     -30.4  <----   Adjusted Asymptote (Hz) =   767   964  1303  1637  2780
                         Best-Fit Filter    (Hz) =   611   876  1258  1609  2771

T-File  Ch     Signal      Test ID    Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2564  03.  AC LUR Y G'S  76T029    1792  6410      304   646   983  1252  1809
1-2581  03.  AC LUR Y G'S  76T034    1522  6410      199  1158  1516  1706  2044
1-2600  03.  AC LUR Y G'S  76T039    1760  6410      715  1160  1393  1573  1886
1-2869  02.  AC LUR Y G'S  77T095    1904  6410      363   751  1272  1613  2080
1-2888  02.  AC LUR Y G'S  77T098    1856  6410      136   556  1016  1255  1701
1-2580  02.  AC LLR X G'S  76T034    1522  6410      365   698  1327  1516  1809
1-2870  03.  AC LLR X G'S  77T095    1904  6410      377   720  1246  1477  1922
```

```
Tests =  SLD/MCI  FRAC                 Sensors =  RUR RLR                  LP04

FILTER ESTIMATION        4 Signals                SUMMARY OF SPECTRAL ANALYSIS
                   Cumulative P.S.D.    (%) =     50     75     90     95     99
                   % of Signal Passed   (%) =     71     50     32     22     10
Best MEAN+1SD fit
                   Equivalent Filter   (dB) =     -3     -6    -10    -13    -20
CORNER @ ROLL-OFF  MEAN LOG Frequency  (Hz) =     60    271    608    893   1438
 (Hz)    (dB/dec)  MEAN+1SD Frequency  (Hz) =    165   1048   1589   1649   1783

 212.     -13.6  <---- Adjusted Asymptote (Hz) =    353    588   1154   1920   6271
                   Best-Fit Filter     (Hz) =    212    476   1068   1849   6225

T-File  Ch      Signal     Test ID    Sampling     Freq. (Hz) @ Cum. PSD Levels

1-2583  05.  AC RUR Y G'S  76T034    1522  6410       72    837   1271   1469   1798
1-2871  04.  AC RUR Y G'S  77T095    1904  6410      266    571    890   1105   1380
1-2890  04.  AC RUR Y G'S  77T098    1856  6410       42    416   1034   1250   1671
1-2891  05.  AC RLR X G'S  77T098    1856  6410       16     27    117    313   1031
```

```
Tests =  SLD/RIG  NOFX                   Sensors =  LLR                   LP05

FILTER ESTIMATION       4 Signals                SUMMARY OF SPECTRAL ANALYSIS
                        Cumulative P.S.D.   (%) =   50    75    90    95    99
                        % of Signal Passed  (%) =   71    50    32    22    10
Best MEAN+1SD fit
                        Equivalent Filter  (dB) =   -3    -6   -10   -13   -20
CORNER @ ROLL-OFF       MEAN LOG Frequency (Hz) =  188   423   697   931  1578
 (Hz)     (dB/dec)      MEAN+1SD Frequency (Hz) =  415  1067  1745  1797  2098

 510.      -23.1  <---- Adjusted Asymptote (Hz) =  689   929  1381  1864  3737
                        Best-Fit Filter    (Hz) =  510   820  1320  1823  3720

T-File   Ch     Signal      Test ID    Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2384  04.  AC LLR X G'S  76T003    1616  6410     61    86   144   299   966
1-2428  04.  AC LLR X G'S  76T009    3568  6410    131   797  1238  1330  1862
1-2449  04.  AC LLR X G'S  76T010    1496  6410    382   631   977  1268  1786
1-2470  04.  AC LLR X G'S  76T011    1542  6410    410   743  1354  1487  1931
```

```
Tests =  SLD/RIG  NOFX                  Sensors =  RUR RLR                     LP06

FILTER ESTIMATION          9 Signals                SUMMARY OF SPECTRAL ANALYSIS
                   Cumulative P.S.D.   (%) =     50     75     90     95     99
                   % of Signal Passed  (%) =     71     50     32     22     10
Best MEAN+1SD fit
                   Equivalent Filter  (dB) =     -3     -6    -10    -13    -20
CORNER @ ROLL-OFF  MEAN LOG Frequency (Hz) =     53    176    411    606   1382
 (Hz)    (dB/dec)  MEAN+1SD Frequency (Hz) =    189    622   1141   1396   1983

 257.     -17.7  <----  Adjusted Asymptote (Hz) =    381    563    946   1399   3474
                   Best-Fit Filter    (Hz) =    257    478    891   1359   3454

T-File  Ch    Signal      Test ID   Sampling        Freq. (Hz) @ Cum. PSD Levels

1-2387  07.  AC RUR Y G'S  76T003    1616  6410      11     22     86    155    689
1-2452  07.  AC RUR Y G'S  76T010    1496  6410     264    728   1211   1521   2080
1-2833  04.  AC RUR Y G'S  77T089    1422  6410      22     39    103    203   1194
1-2852  04.  AC RUR Y G'S  77T092    1872  6410      25    249    801   1081   1704
1-2386  06.  AC RLR X G'S  76T003    1616  6410      19     58    167    271    919
1-2451  06.  AC RLR X G'S  76T010    1496  6410      20    106    244    487   1149
1-2472  06.  AC RLR X G'S  76T011    1542  6410     377    660    956   1218   2081
1-2834  05.  AC RLR X G'S  77T089    1422  6410     233    664   1064   1282   1649
1-2853  05.  AC RLR X G'S  77T092    1872  6410      64    385    945   1033   1746
```

Tests = SLD/RIG FRAC Sensors = LUR LLR LP07

FILTER ESTIMATION

Best MEAN+1SD fit

CORNER @ ROLL-OFF
(Hz) (dB/dec)

496. -25.1 <---- Adjusted Asymptote

8 Signals	SUMMARY OF SPECTRAL ANALYSIS				
Cumulative P.S.D. (%) =	50	75	90	95	99
% of Signal Passed (%) =	71	50	32	22	10
Equivalent Filter (dB) =	-3	-6	-10	-13	-20
MEAN LOG Frequency (Hz) =	218	550	1164	1454	1884
MEAN+1SD Frequency (Hz) =	398	919	1383	1659	2145
Adjusted Asymptote (Hz) =	654	863	1244	1640	3118
Best-Fit Filter (Hz) =	496	769	1193	1607	3106

T-File	Ch	Signal	Test ID	Sampling		Freq. (Hz) @ Cum. PSD Levels				
1-2385	05.	AC LUR Y G'S	76T003	1616	6410	296	662	975	1163	1581
1-2429	05.	AC LUR Y G'S	76T009	3568	6410	125	244	1127	1319	1484
1-2450	05.	AC LUR Y G'S	76T010	1496	6410	332	815	1233	1770	2125
1-2471	05.	AC LUR Y G'S	76T011	1542	6410	634	1136	1443	1656	2116
1-2831	02.	AC LUR Y G'S	77T089	1422	6410	91	465	861	1294	1903
1-2850	02.	AC LUR Y G'S	77T092	1872	6410	133	412	1067	1410	1839
1-2832	03.	AC LLR X G'S	77T089	1422	6410	313	944	1448	1581	2041
1-2851	03.	AC LLR X G'S	77T092	1872	6410	172	310	1293	1537	2105

```
Tests =  SLD/RIG  FRAC                   Sensors =  RUR RLR                    LP08

FILTER ESTIMATION        3 Signals                 SUMMARY OF SPECTRAL ANALYSIS
                         Cumulative P.S.D.    (%) =   50     75     90     95     99
                         % of Signal Passed   (%) =   71     50     32     22     10
Best MEAN+1SD fit
                         Equivalent Filter   (dB) =   -3     -6    -10    -13    -20
CORNER @ ROLL-OFF        MEAN LOG Frequency  (Hz) =  271    727   1286   1510   1886
 (Hz)    (dB/dec)        MEAN+1SD Frequency  (Hz) =  553   1100   1552   1741   2048

 658.      -31.0  <----  Adjusted Asymptote  (Hz) =  823   1029   1383   1729   2905
                         Best-Fit Filter     (Hz) =  658    938   1336   1701   2895

T-File  Ch      Signal     Test ID   Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2431  07.  AC RUR Y G'S  76T009  3568  6410      146    435    986   1235   1679
1-2473  07.  AC RUR Y G'S  76T011  1542  6410      737   1196   1493   1651   1977
1-2430  06.  AC RLR X G'S  76T009  3568  6410      185    740   1444   1689   2020
```

```
Tests =  PEN/L-R  NOFX                  Sensors =  LUR LLR                    LP09

FILTER ESTIMATION          6 Signals             SUMMARY OF SPECTRAL ANALYSIS
                     Cumulative P.S.D.    (%) =     50     75     90     95     99
                     % of Signal Passed   (%) =     71     50     32     22     10
Best MEAN+1SD fit
                     Equivalent Filter   (dB) =     -3     -6    -10    -13    -20
CORNER @ ROLL-OFF    MEAN LOG Frequency  (Hz) =     97    182    405    540   1385
 (Hz)    (dB/dec)    MEAN+1SD Frequency  (Hz) =    366    622   1142   1304   1999

 422.     -26.1 <----  Adjusted Asymptote (Hz) =   550    718   1019   1329   2462
                     Best-Fit Filter     (Hz) =    422    643    979   1303   2452

T-File  Ch     Signal      Test ID    Sampling       Freq. (Hz) @ Cum. PSD Levels

1-2695  02.  AC LUR Y G'S  76T065    1376  6410      34     58    131    191    961
1-2728  02.  AC LUR Y G'S  77T071    1232  6410      23     44    135    211    961
1-2696  03.  AC LLR X G'S  76T065    1376  6410      72    110    172    297    961
1-2736  10.  AC LLR X G'S  77T071    1232  6410      41    149    961    964   2133
1-2746  03.  AC LLR X G'S  77T074    1216  6410     718   1144   1388   1567   1948
1-2763  03.  AC LLR X G'S  77T077    1232  6410     493    764   1086   1374   1915
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Tests =  PEN/L-R  NOFX                   Sensors =  RUR RLR                  LP10

FILTER ESTIMATION        12 Signals                SUMMARY OF SPECTRAL ANALYSIS
                         Cumulative P.S.D.   (%) =   50    75    90    95    99
                         % of Signal Passed  (%) =   71    50    32    22    10
Best MEAN+1SD fit
                         Equivalent Filter  (dB) =   -3    -6   -10   -13   -20
CORNER @ ROLL-OFF        MEAN LOG Frequency (Hz) =   22   102   295   664  1492
 (Hz)    (dB/dec)        MEAN+1SD Frequency (Hz) =   38   323   864  1884  1942

  62.      -9.6  <----   Adjusted Asymptote (Hz) =  127   261   677  1392  7420
                         Best-Fit Filter    (Hz) =   62   193   606  1319  7342

T-File  Ch      Signal     Test ID    Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2681  04.  AC RUR Y G'S  76T062   1456  6410       17    49   125   961  1554
1-2697  04.  AC RUR Y G'S  76T065   1376  6410       16    30    58    75   962
1-2729  03.  AC RUR Y G'S  77T071   1232  6410       22   959   964  1225  2662
1-2747  04.  AC RUR Y G'S  77T074   1216  6410       25    52   454  1171  1617
1-2764  04.  AC RUR Y G'S  77T077   1232  6410       16    80   513   909  1443
1-2781  04.  AC RUR Y G'S  77T080   1232  6410       78   693  1399  1609  1939
1-2682  05.  AC RLR X G'S  76T062   1456  6410       16    72   211   842  1307
1-2698  05.  AC RLR X G'S  76T065   1376  6410       20    56   254   961  1383
1-2730  04.  AC RLR X G'S  77T071   1232  6410       14    20    38    59   962
1-2748  05.  AC RLR X G'S  77T074   1216  6410       14    92   182   958  1518
1-2765  05.  AC RLR X G'S  77T077   1232  6410       61   363   628   973  1574
1-2782  05.  AC RLR X G'S  77T080   1232  6410       17   113   814  1089  1628
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Tests = SLD/MCI NOFX Sensors = UST LST T01 T12 LP11

FILTER ESTIMATION			34 Signals	SUMMARY OF SPECTRAL ANALYSIS				
			Cumulative P.S.D. (%) =	50	75	90	95	99
			% of Signal Passed (%) =	71	50	32	22	10
Best MEAN+1SD fit								
			Equivalent Filter (dB) =	-3	-6	-10	-13	-20
CORNER @	ROLL-OFF		MEAN LOG Frequency (Hz) =	47	152	431	734	1294
(Hz)	(dB/dec)		MEAN+1SD Frequency (Hz) =	139	572	1437	1991	2723
200.	-13.6	<----	Adjusted Asymptote (Hz) =	334	557	1094	1822	5966
			Best-Fit Filter (Hz) =	200	450	1012	1754	5922

T-File	Ch	Signal	Test ID	Sampling		Freq. (Hz) @ Cum. PSD Levels				
1-2575	14.	AC UST X G'S	76T029	1790	6410	72	385	961	1050	1335
1-2592	14.	AC UST X G'S	76T034	1760	6410	174	1080	1496	1689	2413
1-2611	14.	AC UST X G'S	76T039	1760	6410	102	557	1120	1529	1883
1-2873	06.	AC UST X G'S	77T095	1904	6410	70	299	1031	1182	1588
1-2892	06.	AC UST X G'S	77T098	1856	6410	92	362	875	1003	1685
1-2576	15.	AC LST X G'S	76T029	1790	6410	31	69	793	1235	1689
1-2593	15.	AC LST X G'S	76T034	1760	6410	33	127	767	1216	1754
1-2612	15.	AC LST X G'S	76T039	1760	6410	5	9	14	17	27
1-2874	07.	AC LST X G'S	77T095	1904	6410	42	1055	1397	1559	1797
1-2893	07.	AC LST X G'S	77T098	1856	6410	41	72	516	706	1560
1-2567	06.	AC T01 X G'S	76T029	1792	6410	44	582	1019	1200	1629
1-2568	07.	AC T01 Z G'S	76T029	1792	6410	77	150	701	1185	1588
1-2584	06.	AC T01 X G'S	76T034	1522	6410	593	975	1344	1444	1850
1-2585	07.	AC T01 Z G'S	76T034	1522	6410	136	778	1027	1479	1736
1-2603	06.	AC T01 X G'S	76T039	1760	6410	167	471	798	1208	1621
1-2604	07.	AC T01 Z G'S	76T039	1760	6410	27	49	136	437	1013
1-2875	08.	AC T01 X G'S	77T095	1904	6410	438	994	1452	1742	2105
1-2876	09.	AC T01 Y G'S	77T095	1904	6410	20	149	363	833	1338
1-2877	10.	AC T01 Z G'S	77T095	1904	6410	147	410	948	1074	1570
1-2894	08.	AC T01 X G'S	77T098	1856	6410	83	222	653	1186	1515
1-2895	09.	AC T01 Y G'S	77T098	1856	6410	19	56	114	269	856
1-2896	10.	AC T01 Z G'S	77T098	1856	6410	95	177	499	983	1421
1-2569	08.	AC T12 X G'S	76T029	1792	6410	41	78	351	808	1393
1-2570	09.	AC T12 Y G'S	76T029	1792	6410	19	44	230	610	1282
1-2586	08.	AC T12 X G'S	76T034	1522	6410	80	271	1131	1404	1892
1-2587	09.	AC T12 Y G'S	76T034	1522	6410	17	44	64	136	812
1-2605	08.	AC T12 X G'S	76T039	1760	6410	8	13	28	64	437
1-2606	09.	AC T12 Y G'S	76T039	1760	6410	9	17	55	480	1505
1-2879	12.	AC T12 X G'S	77T095	1902	6410	41	102	746	1156	1740
1-2880	13.	AC T12 Y G'S	77T095	1902	6410	8	16	72	153	948
1-2881	14.	AC T12 Z G'S	77T095	1902	6410	22	78	460	961	1567
1-2898	12.	AC T12 X G'S	77T098	1856	6410	83	141	676	1171	1786
1-2899	13.	AC T12 Y G'S	77T098	1856	6410	17	50	144	554	1078
1-2900	14.	AC T12 Z G'S	77T098	1856	6410	50	559	962	1203	1740

Tests = SLD/RIG NOFX Sensors = UST LST T01 T12 LP12

FILTER ESTIMATION			39 Signals	SUMMARY OF SPECTRAL ANALYSIS				
			Cumulative P.S.D. (%) =	50	75	90	95	99
			% of Signal Passed (%) =	71	50	32	22	10
Best MEAN+1SD fit								
			Equivalent Filter (dB) =	-3	-6	-10	-13	-20
CORNER @	ROLL-OFF		MEAN LOG Frequency (Hz) =	62	178	486	738	1355
(Hz)	(dB/dec)		MEAN+1SD Frequency (Hz) =	164	399	1020	1372	1871
208.	-16.9	<----	Adjusted Asymptote (Hz) =	314	474	816	1231	3200
			Best-Fit Filter (Hz) =	208	399	767	1194	3180

T-File	Ch	Signal	Test ID	Sampling		Freq. (Hz) @ Cum. PSD Levels				
1-2382	02.	AC UST X G'S	76T003	1616	6410	78	678	1017	1247	1840
1-2447	02.	AC UST X G'S	76T010	1496	6410	52	257	981	1449	2027
1-2468	02.	AC UST X G'S	76T011	1542	6410	50	89	427	729	1327
1-2835	06.	AC UST X G'S	77T089	1422	6410	183	484	1063	1540	2052
1-2854	06.	AC UST X G'S	77T092	1872	6410	47	75	429	909	1613
1-2383	03.	AC LST X G'S	76T003	1616	6410	30	52	113	233	1216
1-2427	03.	AC LST X G'S	76T009	3568	6410	59	119	958	1077	1387
1-2448	03.	AC LST X G'S	76T010	1496	6410	28	81	285	825	1538
1-2469	03.	AC LST X G'S	76T011	1542	6410	41	70	103	180	1066
1-2836	07.	AC LST X G'S	77T089	1422	6410	45	103	424	931	1429
1-2855	07.	AC LST X G'S	77T092	1872	6410	45	166	507	681	1338
1-2388	08.	AC T01 X G'S	76T003	1616	6410	45	108	158	219	764
1-2389	09.	AC T01 Z G'S	76T003	1616	6410	110	156	199	255	454
1-2432	08.	AC T01 X G'S	76T009	3568	6410	183	321	911	1006	1670
1-2433	09.	AC T01 Z G'S	76T009	3568	6410	67	178	858	994	1676
1-2453	08.	AC T01 X G'S	76T010	1496	6410	45	85	213	693	1268
1-2454	09.	AC T01 Z G'S	76T010	1496	6410	74	105	266	405	961
1-2474	08.	AC T01 X G'S	76T011	1542	6410	125	236	387	933	1397
1-2475	09.	AC T01 Z G'S	76T011	1542	6410	99	368	757	950	1407
1-2837	08.	AC T01 X G'S	77T089	1422	6410	471	875	1228	1397	1756
1-2838	09.	AC T01 Y G'S	77T089	1422	6410	183	626	969	1243	1660
1-2839	10.	AC T01 Z G'S	77T089	1422	6410	352	761	1183	1347	1721
1-2856	08.	AC T01 X G'S	77T092	1872	6410	332	518	951	1216	1721
1-2857	09.	AC T01 Y G'S	77T092	1872	6410	44	239	512	629	1147
1-2858	10.	AC T01 Z G'S	77T092	1872	6410	238	321	435	692	1092
1-2390	10.	AC T12 X G'S	76T003	1616	6410	3	247	962	1031	2349
1-2391	11.	AC T12 Y G'S	76T003	1616	6410	9	219	961	1041	1737
1-2434	10.	AC T12 X G'S	76T009	3568	6410	135	379	961	1039	1454
1-2435	11.	AC T12 Y G'S	76T009	3568	6410	47	92	275	604	1225
1-2455	10.	AC T12 X G'S	76T010	1496	6410	53	91	958	1211	1634
1-2456	11.	AC T12 Y G'S	76T010	1496	6410	34	94	601	1238	1958
1-2476	10.	AC T12 X G'S	76T011	1542	6410	110	296	920	1224	1443
1-2477	11.	AC T12 Y G'S	76T011	1542	6410	64	194	476	829	1319
1-2841	12.	AC T12 X G'S	77T089	1232	6410	81	119	424	737	1254
1-2842	13.	AC T12 Y G'S	77T089	1232	6410	17	53	153	275	961
1-2843	14.	AC T12 Z G'S	77T089	1232	6410	56	405	820	1042	1487
1-2860	12.	AC T12 X G'S	77T092	1872	6410	41	88	141	228	962
1-2861	13.	AC T12 Y G'S	77T092	1872	6410	13	33	119	191	595
1-2862	14.	AC T12 Z G'S	77T092	1872	6410	45	196	654	995	1413

Tests = PEN/L-R NOFX Sensors = UST LST T01 T12 LP13

FILTER ESTIMATION	44 Signals	SUMMARY OF SPECTRAL ANALYSIS				
	Cumulative P.S.D. (%) =	50	75	90	95	99
	% of Signal Passed (%) =	71	50	32	22	10
Best MEAN+1SD fit						
	Equivalent Filter (dB) =	-3	-6	-10	-13	-20
CORNER @ ROLL-OFF	MEAN LOG Frequency (Hz) =	33	91	252	600	1219
(Hz) (dB/dec)	MEAN+1SD Frequency (Hz) =	76	261	720	1178	1615
106. -13.4 <----	Adjusted Asymptote (Hz) =	177	296	586	983	3259
	Best-Fit Filter (Hz) =	106	239	542	946	3234

T-File	Ch	Signal	Test ID	Sampling		Freq. (Hz) @ Cum. PSD Levels				
1-2683	06.	AC UST X G'S	76T062	1456	6410	44	74	172	455	1648
1-2699	06.	AC UST X G'S	76T065	1376	6410	30	44	58	72	394
1-2731	05.	AC UST X G'S	77T071	1232	6410	16	44	203	961	1449
1-2749	06.	AC UST X G'S	77T074	1216	6410	42	59	88	465	1207
1-2766	06.	AC UST X G'S	77T077	1232	6410	45	167	369	959	1505
1-2783	06.	AC UST X G'S	77T080	1232	6410	106	125	199	319	964
1-2684	07.	AC LST X G'S	76T062	1456	6410	42	67	225	599	1269
1-2732	06.	AC LST X G'S	77T071	1232	6410	30	49	75	91	961
1-2767	07.	AC LST X G'S	77T077	1232	6410	64	224	499	854	1336
1-2784	07.	AC LST X G'S	77T080	1232	6410	99	174	299	618	1022
1-2685	08.	AC T01 X G'S	76T062	1456	6410	2	36	274	834	1468
1-2701	08.	AC T01 X G'S	76T065	1376	6410	14	31	117	950	1346
1-2702	09.	AC T01 Z G'S	76T065	1376	6410	25	202	956	980	1603
1-2703	10.	AC T01 Y G'S	76T065	1376	6410	13	20	38	218	1013
1-2733	07.	AC T01 X G'S	77T071	1232	6410	34	63	562	867	1268
1-2734	08.	AC T01 Y G'S	77T071	1232	6410	23	116	959	962	1779
1-2735	09.	AC T01 Z G'S	77T071	1232	6410	9	17	39	883	1141
1-2751	08.	AC T01 X G'S	77T074	1216	6410	89	186	576	964	1692
1-2752	09.	AC T01 Y G'S	77T074	1216	6410	13	20	53	175	1028
1-2753	10.	AC T01 Z G'S	77T074	1216	6410	38	216	297	369	1221
1-2768	08.	AC T01 X G'S	77T077	1232	6410	131	186	390	959	1383
1-2769	09.	AC T01 Y G'S	77T077	1232	6410	13	34	147	216	962
1-2770	10.	AC T01 Z G'S	77T077	1232	6410	42	249	753	1036	1505
1-2785	08.	AC T01 X G'S	77T080	1232	6410	102	293	512	959	1496
1-2786	09.	AC T01 Y G'S	77T080	1232	6410	11	17	111	210	961
1-2787	10.	AC T01 Z G'S	77T080	1232	6410	110	221	319	393	962
1-2689	12.	AC T12 X G'S	76T062	1456	6410	28	39	260	931	1191
1-2690	13.	AC T12 Z G'S	76T062	1456	6410	63	178	505	851	983
1-2691	14.	AC T12 Y G'S	76T062	1456	6410	25	63	116	315	964
1-2705	12.	AC T12 X G'S	76T065	1374	6410	25	38	144	961	1448
1-2706	13.	AC T12 Z G'S	76T065	1374	6410	22	91	961	964	1618
1-2707	14.	AC T12 Y G'S	76T065	1374	6410	19	33	56	959	1025
1-2738	12.	AC T12 X G'S	77T071	1232	6410	23	31	44	490	966
1-2739	13.	AC T12 Y G'S	77T071	1232	6410	16	23	36	790	966
1-2740	14.	AC T12 Z G'S	77T071	1232	6410	28	66	823	962	1599
1-2755	12.	AC T12 X G'S	77T074	1214	6410	14	23	63	293	961
1-2756	13.	AC T12 Y G'S	77T074	1214	6410	45	808	962	966	2111
1-2757	14.	AC T12 Z G'S	77T074	1214	6410	45	80	441	815	1122
1-2772	12.	AC T12 X G'S	77T077	1232	6410	222	405	648	761	983
1-2773	13.	AC T12 Y G'S	77T077	1232	6410	56	950	964	1064	2108
1-2774	14.	AC T12 Z G'S	77T077	1232	6410	49	213	808	962	1302
1-2789	12.	AC T12 X G'S	77T080	1232	6410	55	202	782	966	1369
1-2790	13.	AC T12 Y G'S	77T080	1232	6410	27	407	568	762	1023
1-2791	14.	AC T12 Z G'S	77T080	1232	6410	47	396	814	962	1297

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Tests =  SLD/ABG  NOFX                    Sensors =  LUR LLR RUR RLR           LP14

FILTER ESTIMATION           18 Signals               SUMMARY OF SPECTRAL ANALYSIS
                        Cumulative P.S.D.     (%) =    50     75     90     95     99
                        % of Signal Passed    (%) =    71     50     32     22     10
Best MEAN+1SD fit
                        Equivalent Filter    (dB) =    -3     -6    -10    -13    -20
CORNER @ ROLL-OFF       MEAN LOG Frequency   (Hz) =    23     82    222    441   1183
 (Hz)     (dB/dec)      MEAN+1SD Frequency   (Hz) =   102    408    939   1633   1741

 143.      -13.6  <---- Adjusted Asymptote   (Hz) =   237    395    775   1291   4215
                        Best-Fit Filter      (Hz) =   143    320    717   1243   4184

T-File   Ch     Signal      Test ID     Sampling       Freq. (Hz) @ Cum. PSD Levels

1-2258   05.  AC LUR Y G'S  A-887     1958   6410        6      9     59    826   1110
1-2277   05.  AC LUR Y G'S  A-923     1796   6410       34     78    208    421    970
1-2300   05.  AC LUR Y G'S  A-924     1648   6410      188    900   1102   1277   1717
1-2322   05.  AC LUR Y G'S  A-927     1648   6410      662   1047   1372   1545   1837
1-2257   04.  AC LLR X G'S  A-887     1958   6410        6     13     19     27    961
1-2276   04.  AC LLR X G'S  A-923     1796   6410       20     33     58    116    513
1-2299   04.  AC LLR X G'S  A-924     1648   6410       13    164    551   1318   1715
1-2321   04.  AC LLR X G'S  A-927     1648   6410       31    189    884   1128   1471
1-2495   08.  AC LLR X G'S  76T020    1600   6410        8     34    725   1156   1679
1-2260   07.  AC RUR Y G'S  A-887     1958   6410        6     11     59    826   1277
1-2279   07.  AC RUR Y G'S  A-923     1796   6410       33     75    110    182    822
1-2302   07.  AC RUR Y G'S  A-924     1648   6410       11    609   1124   1282   1653
1-2498   11.  AC RUR Y G'S  76T020    1600   6410      712   1080   1372   1543   1864
1-2259   06.  AC RLR X G'S  A-887     1958   6410        6     13     19     23    961
1-2278   06.  AC RLR X G'S  A-923     1796   6410       19     45     75    114    521
1-2301   06.  AC RLR X G'S  A-924     1648   6410        6     41    371    621   1366
1-2323   06.  AC RLR X G'S  A-927     1648   6410       36    352    593    823   1369
1-2497   10.  AC RLR X G'S  76T020    1600   6410        6     22     77    268    964
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Tests =  SLD/ABG  FRAC                  Sensors =  RUR LUR                LP15

FILTER ESTIMATION       2 Signals           SUMMARY OF SPECTRAL ANALYSIS
                    Cumulative P.S.D.   (%) =  50     75     90     95     99
                    % of Signal Passed  (%) =  71     50     32     22     10
Best MEAN+1SD fit
                    Equivalent Filter  (dB) =  -3     -6    -10    -13    -20
CORNER @ ROLL-OFF   MEAN LOG Frequency (Hz) = 896   1325   1683   1880   2326
 (Hz)    (dB/dec)   MEAN+1SD Frequency (Hz) = 917   1326   1687   1903   2452

1012.     -46.6  <----  Adjusted Asymptote (Hz) = 1174   1362   1658   1924   2717
                    Best-Fit Filter    (Hz) = 1012   1280   1621   1903   2711

T-File  Ch     Signal      Test ID   Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2324  07.  AC RUR Y G'S  A-927     1648  6410     876   1324   1679   1858   2207
1-2496  09.  AC LUR Y G'S  76T020    1600  6410     917   1326   1687   1903   2452
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Tests =  SLD/ABG  NOFX                     Sensors =  UST LST                          LP16

FILTER ESTIMATION             9 Signals                SUMMARY OF SPECTRAL ANALYSIS
                         Cumulative P.S.D.     (%) =    50     75     90     95     99
                         % of Signal Passed    (%) =    71     50     32     22     10
Best MEAN+1SD fit
                         Equivalent Filter    (dB) =    -3     -6    -10    -13    -20
CORNER @ ROLL-OFF        MEAN LOG Frequency   (Hz) =     9     21     75    136    737
 (Hz)    (dB/dec)        MEAN+1SD Frequency   (Hz) =    12     35    274    510   1901

  15.      -8.6  <----   Adjusted Asymptote   (Hz) =    33     75    217    486   3168
                         Best-Fit Filter      (Hz) =    15     53    191    458   3131

T-File  Ch     Signal     Test ID     Sampling         Freq. (Hz) @ Cum. PSD Levels

1-2255  02.  AC UST X G'S  A-887    1958  6410          6      9     16     22    961
1-2274  02.  AC UST X G'S  A-923    1796  6410          6     17     44     55    153
1-2319  02.  AC UST X G'S  A-927    1648  6410          9     22     67    266   1311
1-2493  06.  AC UST X G'S  76T020   1600  6410         11     36    953   1352   1958
1-2256  03.  AC LST X G'S  A-887    1958  6410          9     17     38     56    961
1-2275  03.  AC LST X G'S  A-923    1796  6410          6     20     33     38    114
1-2298  03.  AC LST X G'S  A-924    1648  6410         13     53    598    786   1416
1-2320  03.  AC LST X G'S  A-927    1648  6410         14     30     59    106    959
1-2494  07.  AC LST X G'S  76T020   1600  6410          8     14     38    213   1147
```

```
Tests =  SLD/ABG  NOFX                 Sensors =  T01 T12                  LP17

FILTER ESTIMATION          20 Signals               SUMMARY OF SPECTRAL ANALYSIS
                       Cumulative P.S.D.    (%) =    50     75     90     95     99
                       % of Signal Passed   (%) =    71     50     32     22     10
Best MEAN+1SD fit
                       Equivalent Filter   (dB) =    -3     -6    -10    -13    -20
CORNER @ ROLL-OFF      MEAN LOG Frequency  (Hz) =    25     75    238    403   1029
 (Hz)     (dB/dec)     MEAN+1SD Frequency  (Hz) =   127    298    770   1125   1759

 159.      -16.2  <----  Adjusted Asymptote (Hz) =   244    375    660   1012   2731
                       Best-Fit Filter     (Hz) =   159    314    618    980   2714

T-File  Ch      Signal      Test ID    Sampling         Freq. (Hz) @ Cum. PSD Levels

1-2265  12.   AC T01 X G'S  A-887     1536  6410       959    962   1509   1912   2886
1-2266  13.   AC T01 Z G'S  A-887     1536  6410         8     25     63    235   1117
1-2285  13.   AC T01 X G'S  A-923     1648  6410         8     22     58     89    419
1-2286  14.   AC T01 Z G'S  A-923     1648  6410        19     50    205    230    419
1-2308  13.   AC T01 X G'S  A-924     1648  6410       169    279    463    823   1509
1-2309  14.   AC T01 Z G'S  A-924     1648  6410        17    200    283    377    898
1-2330  13.   AC T01 X G'S  A-927     1648  6410        25    122    222    376   1019
1-2331  14.   AC T01 Z G'S  A-927     1648  6410         6     22    102    260    682
1-2489  02.   AC T01 X G'S  76T020    1600  6410         5     17    160    493   1019
1-2490  03.   AC T01 Z G'S  76T020    1600  6410        50    221    343    668   1164
1-2267  14.   AC T12 X G'S  A-887     1536  6410         5     11     22     52    967
1-2268  15.   AC T12 Y G'S  A-887     1536  6410        58     88    718    962   1659
1-2287  15.   AC T12 X G'S  A-923     1648  6410         5     13     30     42    341
1-2288  16.   AC T12 Y G'S  A-923     1648  6410        31     39    106    177    584
1-2310  15.   AC T12 X G'S  A-924     1648  6410         3     23    147    408    962
1-2311  16.   AC T12 Y G'S  A-924     1648  6410        58    257    670    967   1981
1-2332  15.   AC T12 X G'S  A-927     1648  6410       294    626   1019   1183   1466
1-2333  16.   AC T12 Y G'S  A-927     1648  6410       172    219    556    862   1527
1-2491  04.   AC T12 X G'S  76T020    1600  6410         3     14    732    959   1374
1-2492  05.   AC T12 Y G'S  76T020    1600  6410        81    365    875    967   1504
```

```
Tests =  SLD/3PT  NOFX                   Sensors =  LUR LLR                   LP18

FILTER ESTIMATION        2 Signals                 SUMMARY OF SPECTRAL ANALYSIS
                       Cumulative P.S.D.    (%) =   50    75    90    95    99
                       % of Signal Passed   (%) =   71    50    32    22    10
Best MEAN+1SD fit
                       Equivalent Filter   (dB) =   -3    -6   -10   -13   -20
CORNER @ ROLL-OFF      MEAN LOG Frequency  (Hz) =    6    67   135   178  1296
 (Hz)    (dB/dec)      MEAN+1SD Frequency  (Hz) =   13   746  1077  1271  1745

  21.        -6.6  <----  Adjusted Asymptote (Hz) =   60   172   690  1970 22550
                       Best-Fit Filter     (Hz) =   21   111   588  1823 22210

T-File  Ch      Signal      Test ID    Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2407  09.  AC LUR Y G'S  76T008    1488  6410       13   746  1077  1271  1745
1-2406  08.  AC LLR X G'S  76T008    1488  6410        3     6    17    25   962
```

```
Tests =  SLD/3PT  FRAC                  Sensors =  RUR RLR                 LP19

FILTER ESTIMATION        2 Signals               SUMMARY OF SPECTRAL ANALYSIS
                 Cumulative P.S.D.     (%) =     50     75     90     95     99
                 % of Signal Passed    (%) =     71     50     32     22     10
Best MEAN+1SD fit
                 Equivalent Filter    (dB) =     -3     -6    -10    -13    -20
CORNER @ ROLL-OFF MEAN LOG Frequency  (Hz) =     28     64    863   1107   1618
 (Hz)    (dB/dec) MEAN+1SD Frequency  (Hz) =    263    518    897   1189   1831

 316.    -23.1  <---- Adjusted Asymptote (Hz) = 426    576    856   1155   2318
                 Best-Fit Filter      (Hz) =    316    508    817   1130   2307

T-File  Ch    Signal      Test ID   Sampling     Freq. (Hz) @ Cum. PSD Levels

1-2409  11.  AC RUR Y G'S  76T008   1488  6410    263    518    897   1031   1430
1-2408  10.  AC RLR X G'S  76T008   1488  6410      3      8    831   1189   1831
```

```
Tests =  SLD/3PT  NOFX                  Sensors =  T01 T12              LP20

FILTER ESTIMATION        4 Signals                 SUMMARY OF SPECTRAL ANALYSIS
                        Cumulative P.S.D.   (%) =   50    75    90    95    99
                        % of Signal Passed  (%) =   71    50    32    22    10
Best MEAN+1SD fit
                        Equivalent Filter  (dB) =   -3    -6   -10   -13   -20
CORNER @ ROLL-OFF       MEAN LOG Frequency (Hz) =    6    19   164   307  1255
 (Hz)    (dB/dec)       MEAN+1SD Frequency (Hz) =   18    84   981  2107  1599

  23.      -7.5  <----  Adjusted Asymptote (Hz) =   57   143   484  1216 10340
                        Best-Fit Filter    (Hz) =   23    98   420  1136 10202

T-File  Ch      Signal     Test ID   Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2400  02.  AC T01 X G'S  76T008   1488  6410      2     9   285   803  1421
1-2401  03.  AC T01 Z G'S  76T008   1488  6410      9    34   385  1025  1429
1-2402  04.  AC T12 X G'S  76T008   1488  6410      2     3     8    11   825
1-2403  05.  AC T12 Y G'S  76T008   1488  6410     30   153   829   986  1479
```

```
Tests =  SLD/LAP  NOFX                    Sensors =  LUR LLR RUR RLR           LP21

FILTER ESTIMATION        23 Signals             SUMMARY OF SPECTRAL ANALYSIS
                        Cumulative P.S.D.   (%) =   50    75    90    95    99
                        % of Signal Passed  (%) =   71    50    32    22    10
Best MEAN+1SD fit
                        Equivalent Filter   (dB) =  -3    -6   -10   -13   -20
CORNER @ ROLL-OFF       MEAN LOG Frequency (Hz) =   47   176   468   798  1541
 (Hz)     (dB/dec)      MEAN+1SD Frequency (Hz) =  201   765  1376  1904  1995

 271.      -16.2  <---- Adjusted Asymptote (Hz) =  415   636  1118  1713  4614
                        Best-Fit Filter     (Hz) =  271   533  1048  1660  4586

T-File  Ch     Signal     Test ID    Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2159  05.  AC LUR Y G'S  A-877    2462  6410      50   186   490   923  1679
1-2180  05.  AC LUR Y G'S  A-880    1588  6410      86   462   890  1150  1598
1-2237  04.  AC LUR Y G'S  A-884    1760  6410     454   951  1335  1567  1961
1-2343  05.  AC LUR Y G'S  A-928    1648  6410      50   288   962  1161  1998
1-2364  05.  AC LUR Y G'S  A-937    1616  6410      94   473  1038  1474  1905
1-2158  04.  AC LLR X G'S  A-877    2462  6410      11    22    97   388  1072
1-2179  04.  AC LLR X G'S  A-880    1588  6410      94   562  1222  1379  1715
1-2218  04.  AC LLR X G'S  A-883    2016  6410      16   236   706  1023  1582
1-2236  03.  AC LLR X G'S  A-884    1760  6410       3    14   338   900  1404
1-2342  04.  AC LLR X G'S  A-928    1648  6410      27    41    50    67   962
1-2363  04.  AC LLR X G'S  A-937    1616  6410      36    55   169   565  1308
1-2161  07.  AC RUR Y G'S  A-877    2462  6410     424  1016  1404  1637  2230
1-2182  07.  AC RUR Y G'S  A-880    1588  6410     139   207   588   809  1247
1-2221  07.  AC RUR Y G'S  A-883    2016  6410    1002  1341  1646  1828  2258
1-2239  06.  AC RUR Y G'S  A-884    1760  6410     352   808  1158  1521  2089
1-2345  07.  AC RUR Y G'S  A-928    1648  6410      20    34   175   961  1354
1-2366  07.  AC RUR Y G'S  A-937    1616  6410      16   883  1358  1538  1887
1-2160  06.  AC RLR X G'S  A-877    2462  6410       8    16    88   166   962
1-2181  06.  AC RLR X G'S  A-880    1588  6410     169  1086  1368  1504  1717
1-2220  06.  AC RLR X G'S  A-883    2016  6410      17    66   324   621  1404
1-2238  05.  AC RLR X G'S  A-884    1760  6410      11   290   937  1172  1681
1-2344  06.  AC RLR X G'S  A-928    1648  6410      28    42    85   111   961
1-2365  06.  AC RLR X G'S  A-937    1616  6410      13    44   158   970  1621
```

```
Tests =  SLD/LAP  NOFX                 Sensors =  UST LST                  LP22

FILTER ESTIMATION            8 Signals               SUMMARY OF SPECTRAL ANALYSIS
                       Cumulative P.S.D.    (%) =     50     75     90     95     99
                       % of Signal Passed   (%) =     71     50     32     22     10
Best MEAN+1SD fit
                       Equivalent Filter   (dB) =     -3     -6    -10    -13    -20
CORNER @ ROLL-OFF      MEAN LOG Frequency  (Hz) =     28     92    223    408   1103
 (Hz)    (dB/dec)      MEAN+1SD Frequency  (Hz) =    121    316    766   1418   1870

 155.     -15.1  <---- Adjusted Asymptote  (Hz) =    245    387    709   1120   3241
                       Best-Fit Filter     (Hz) =    155    320    661   1082   3219

T-File  Ch       Signal       Test ID   Sampling       Freq. (Hz) @ Cum. PSD Levels

1-2156  02.  AC UST X G'S  A-877     2462  6410       19    182    613    945   1432
1-2361  02.  AC UST X G'S  A-937     1616  6410       19     41     50     69    341
1-2157  03.  AC LST X G'S  A-877     2462  6410       41    189    573    961   1573
1-2178  03.  AC LST X G'S  A-880     1588  6410       27     56    271    815   1437
1-2217  03.  AC LST X G'S  A-883     2016  6410        9     25     39     66    804
1-2235  02.  AC LST X G'S  A-884     1760  6410     1020   1341   1621   1853   2147
1-2341  03.  AC LST X G'S  A-928     1648  6410       16     67    249    879   1243
1-2362  03.  AC LST X G'S  A-937     1616  6410        6     30     83    139    925
```

```
Tests =  SLD/LAP  FRAC                  Sensors =  UST                       LP23

FILTER ESTIMATION        3 Signals                SUMMARY OF SPECTRAL ANALYSIS
                     Cumulative P.S.D.    (%) =    50     75     90     95     99
                     % of Signal Passed   (%) =    71     50     32     22     10
Best MEAN+1SD fit
                     Equivalent Filter   (dB) =    -3     -6    -10    -13    -20
CORNER @ ROLL-OFF    MEAN LOG Frequency  (Hz) =    23    185    407    598   1511
 (Hz)    (dB/dec)    MEAN+1SD Frequency  (Hz) =    48    732   1802   2091   2134

  74.      -8.7  <----  Adjusted Asymptote (Hz) =  164    363   1038   2298  14535
                     Best-Fit Filter     (Hz) =    74    261    920   2166  14369

T-File  Ch     Signal     Test ID    Sampling        Freq. (Hz) @ Cum. PSD Levels

1-2177  02.  AC UST X G'S  A-880    1588  6410       64    371   1000   1351   1615
1-2216  02.  AC UST X G'S  A-883    2016  6410       17    629   1349   1552   2222
1-2340  02.  AC UST X G'S  A-928    1648  6410       11     27     50    102    962
```

```
Tests =  SLD/LAP  NOFX                  Sensors =  T01 T12              LP24

FILTER ESTIMATION        20 Signals                 SUMMARY OF SPECTRAL ANALYSIS
                         Cumulative P.S.D.    (%) =   50    75    90    95    99
                         % of Signal Passed   (%) =   71    50    32    22    10
Best MEAN+1SD fit
                         Equivalent Filter   (dB) =   -3    -6   -10   -13   -20
CORNER @ ROLL-OFF        MEAN LOG Frequency  (Hz) =   32   134   371   559  1287
 (Hz)    (dB/dec)        MEAN+1SD Frequency  (Hz) =  125   454  1092  1496  1757

 172.     -14.7  <----   Adjusted Asymptote  (Hz) =  275   442   826  1325  3972
                         Best-Fit Filter     (Hz) =  172   363   768  1279  3944

T-File  Ch    Signal      Test ID   Sampling        Freq. (Hz) @ Cum. PSD Levels

1-2167  13.  AC T01 X G'S  A-877    2064  6410        16    25   246   427   854
1-2168  14.  AC T01 Z G'S  A-877    2064  6410        69   239   426   668  1038
1-2245  12.  AC T01 X G'S  A-884    1472  6410        13   269   905  1191  1631
1-2246  13.  AC T01 Z G'S  A-884    1472  6410         8   254   941  1211  1678
1-2351  13.  AC T01 X G'S  A-928    1630  6410        30    49    59   174   964
1-2352  14.  AC T01 Z G'S  A-928    1630  6410        17    27    44    56   959
1-2372  13.  AC T01 X G'S  A-937    1616  6410        38    64   357   435  1042
1-2373  14.  AC T01 Z G'S  A-937    1616  6410        17    41   311   421   948
1-2169  15.  AC T12 X G'S  A-877    2064  6410        33   105   214   344   964
1-2170  16.  AC T12 Y G'S  A-877    2064  6410        50   318   480   919  1352
1-2190  15.  AC T12 X G'S  A-880    1664  6410        16    52   397   488   950
1-2191  16.  AC T12 Y G'S  A-880    1664  6410       124   402   596   809  1233
1-2227  13.  AC T12 X G'S  A-883    1660  6410         9   205   326   565  1341
1-2228  14.  AC T12 Y G'S  A-883    1660  6410        36   316   895  1125  1718
1-2247  14.  AC T12 X G'S  A-884    1472  6410         5   286   939  1208  1648
1-2248  15.  AC T12 Y G'S  A-884    1472  6410       277   779  1213  1443  1894
1-2353  15.  AC T12 X G'S  A-928    1630  6410        11    19    25    44   962
1-2354  16.  AC T12 Y G'S  A-928    1630  6410       959   962  1462  1989  2887
1-2374  15.  AC T12 X G'S  A-937    1616  6410         9    23   394   967  1399
1-2375  16.  AC T12 Y G'S  A-937    1616  6410       308   552   829  1016  1654
```

```
Tests =  SLD/LAP  FRAC                     Sensors =  T01                   LP25

FILTER ESTIMATION          2 Signals            SUMMARY OF SPECTRAL ANALYSIS
                   Cumulative P.S.D.     (%) =    50     75     90     95     99
                   % of Signal Passed    (%) =    71     50     32     22     10
Best MEAN+1SD fit
                   Equivalent Filter    (dB) =    -3     -6    -10    -13    -20
CORNER @ ROLL-OFF  MEAN LOG Frequency   (Hz) =    27    137    461    780   1362
 (Hz)    (dB/dec)  MEAN+1SD Frequency   (Hz) =    39    200    601    831   1410

  60.     -11.6  <---- Adjusted Asymptote (Hz) =   110    199    439    797   3184
                   Best-Fit Filter      (Hz) =    60    155    400    762   3156

T-File   Ch      Signal     Test ID    Sampling       Freq. (Hz) @ Cum. PSD Levels

1-2188   13.  AC T01 X G'S  A-880     1664  6410       39     94    354    732   1410
1-2189   14.  AC T01 Z G'S  A-880     1664  6410       19    200    601    831   1316
```

```
Tests =  PEN/A-P  NOFX                     Sensors =  LUR LLR RUR RLR          LP26

FILTER ESTIMATION        6 Signals                SUMMARY OF SPECTRAL ANALYSIS
                         Cumulative P.S.D.   (%) =   50    75    90    95    99
                         % of Signal Passed  (%) =   71    50    32    22    10
Best MEAN+1SD fit
                         Equivalent Filter  (dB) =   -3    -6   -10   -13   -20
CORNER @ ROLL-OFF        MEAN LOG Frequency (Hz) =  124   290   637   972  1484
 (Hz)    (dB/dec)        MEAN+1SD Frequency (Hz) =  400   886  1259  1511  1924

 492.      -26.9  <----  Adjusted Asymptote (Hz) =  636   823  1157  1496  2719
                         Best-Fit Filter    (Hz) =  492   740  1112  1467  2708

T-File  Ch     Signal     Test ID    Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2520  07.  AC LUR Y G'S  76T021    1440  6410     449  1144  1545  1767  2167
1-2532  07.  AC LUR Y G'S  76T022    1824  6410     401   748  1106  1277  1560
1-2544  07.  AC LUR Y G'S  76T024    1952  6410      42    99   246   455   898
1-2556  07.  AC LUR Y G'S  76T025    1568  6410     347   687  1041  1221  1480
1-2617  02.  AC LUR Y G'S  76T050    2144  6410      44    59   322   961  1606
1-2630  02.  AC LUR Y G'S  76T053    1402  6410      31   174   473   700  1480
```

```
Tests =  PEN/A-P  FRAC                    Sensors =  RUR                    LP27

FILTER ESTIMATION        2 Signals                SUMMARY OF SPECTRAL ANALYSIS
                       Cumulative P.S.D.    (%) =   50    75    90    95    99
                       % of Signal Passed   (%) =   71    50    32    22    10
Best MEAN+1SD fit
                       Equivalent Filter   (dB) =   -3    -6   -10   -13   -20
CORNER @ ROLL-OFF      MEAN LOG Frequency  (Hz) =  172   308   831  1280  1679
 (Hz)     (dB/dec)     MEAN+1SD Frequency  (Hz) =  556  1041  1531  1706  2146

 658.      -31.4  <----  Adjusted Asymptote (Hz) =  821  1024  1371  1711  2858
                       Best-Fit Filter     (Hz) =  658   934  1326  1683  2849

T-File  Ch     Signal     Test ID   Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2534  09.  AC RUR Y G'S  76T022   1824  6410      53    91   451   961  1313
1-2816  04.  AC RUR Y G'S  77T086   1246  6410     556  1041  1531  1706  2146
```

```
Tests =  PEN/A-P  NOFX                  Sensors =  UST LST                  LP28

FILTER ESTIMATION         11 Signals                SUMMARY OF SPECTRAL ANALYSIS
                       Cumulative P.S.D.     (%) =     50     75     90     95     99
                       % of Signal Passed    (%) =     71     50     32     22     10
Best MEAN+1SD fit
                       Equivalent Filter    (dB) =     -3     -6    -10    -13    -20
CORNER @ ROLL-OFF      MEAN LOG Frequency   (Hz) =     59    132    314    464   1248
 (Hz)     (dB/dec)     MEAN+1SD Frequency   (Hz) =    115    363    846   1090   1755

 158.      -15.7  <----  Adjusted Asymptote (Hz) =    246    382    685   1066   2973
                       Best-Fit Filter      (Hz) =    158    318    640   1032   2954

T-File   Ch      Signal      Test ID     Sampling       Freq. (Hz) @ Cum. PSD Levels

1-2621   06.   AC UST X G'S   76T050     2144  6410       22     42    961    962   1920
1-2634   06.   AC UST X G'S   76T053     1402  6410      307   1690   1923   1925   1934
1-2650   06.   AC UST X G'S   76T056     1246  6410       53     97    186    426    970
1-2667   06.   AC UST X G'S   76T059     1312  6410       36     64    158    290    961
1-2800   06.   AC UST X G'S   77T083     1232  6410       41     80    131    418   1078
1-2818   06.   AC UST X G'S   77T086     1246  6410       45     80    122    150    800
1-2635   07.   AC LST X G'S   76T053     1402  6410       50     91    128    161    962
1-2651   07.   AC LST X G'S   76T056     1246  6410       49     97    185    272    881
1-2668   07.   AC LST X G'S   76T059     1312  6410       66    130   1014   1488   2130
1-2715   06.   AC LST X G'S   77T068     1232  6410      128    573    853   1034   1626
1-2819   07.   AC LST X G'S   77T086     1246  6410       66    110    164    221   1310
```

```
Tests =  PEN/A-P  FRAC                        Sensors =  LST UST                     LP29

FILTER ESTIMATION            3 Signals              SUMMARY OF SPECTRAL ANALYSIS
                        Cumulative P.S.D.   (%) =     50     75     90     95     99
                        % of Signal Passed  (%) =     71     50     32     22     10
Best MEAN+1SD fit
                        Equivalent Filter  (dB) =     -3     -6    -10    -13    -20
CORNER @ ROLL-OFF       MEAN LOG Frequency (Hz) =     52    102    239    460   1181
 (Hz)     (dB/dec)      MEAN+1SD Frequency (Hz) =     58    107    337    611   1237

  65.      -14.2  <---- Adjusted Asymptote (Hz) =    106    173    329    537   1670
                        Best-Fit Filter    (Hz) =     65    141    305    518   1658

T-File  Ch     Signal     Test ID    Sampling        Freq. (Hz) @ Cum. PSD Levels

1-2622  07.  AC LST X G'S  76T050    2144  6410       55    108    205    338   1160
1-2801  07.  AC LST X G'S  77T083    1232  6410       58    103    172    430   1258
1-2714  05.  AC UST X G'S  77T068    1232  6410       45     95    385    670   1128
```

```
Tests =  PEN/A-P  NOFX                    Sensors =  T01 T12                LP30

FILTER ESTIMATION       13 Signals               SUMMARY OF SPECTRAL ANALYSIS
                        Cumulative P.S.D.   (%) =   50     75     90     95    99
                        % of Signal Passed  (%) =   71     50     32     22    10
Best MEAN+1SD fit
                        Equivalent Filter  (dB) =   -3     -6    -10    -13   -20
CORNER @ ROLL-OFF       MEAN LOG Frequency (Hz) =   46    235    479    742  1541
 (Hz)     (dB/dec)      MEAN+1SD Frequency (Hz) =  167    975   1509   1703  2169

 234.      -14.3  <---- Adjusted Asymptote (Hz) =  379    616   1170   1899  5855
                        Best-Fit Filter    (Hz) =  234    504   1086   1832  5814

T-File  Ch      Signal    Test ID   Sampling      Freq. (Hz) @ Cum. PSD Levels

1-2515  02.  AC T01 X G'S  76T021   1440  6410     105    598    962   1105  1762
1-2516  03.  AC T01 Z G'S  76T021   1440  6410     196    582    962   1033  1444
1-2527  02.  AC T01 X G'S  76T022   1824  6410      17    961    962   1028  2421
1-2528  03.  AC T01 Z G'S  76T022   1824  6410      17    825    962    967  2297
1-2539  02.  AC T01 X G'S  76T024   1952  6410       2      6     16     58   776
1-2540  03.  AC T01 Z G'S  76T024   1952  6410      45    236    601    787  1149
1-2551  02.  AC T01 X G'S  76T025   1568  6410      41     64    279    962  1601
1-2552  03.  AC T01 Z G'S  76T025   1568  6410     280    623   1305   1407  1662
1-2623  08.  AC T01 X G'S  76T050   2144  6410     117    961    962   1316  2565
1-2624  09.  AC T01 Z G'S  76T050   2144  6410     185    330    534    961  1352
1-2636  08.  AC T01 X G'S  76T053   1402  6410      19     88    189    271   964
1-2637  09.  AC T01 Z G'S  76T053   1402  6410      30     61    249    797  1288
1-2638  10.  AC T01 Y G'S  76T053   1402  6410      53    258    962   1075  1905
```

```
Tests =  DIR  NOPAD  FRAC             Sensors =  HED HD1 HD2 HD3          LP31

FILTER ESTIMATION         28 Signals              SUMMARY OF SPECTRAL ANALYSIS
                       Cumulative P.S.D.    (%) =    50     75     90     95     99
                       % of Signal Passed   (%) =    71     50     32     22     10
Best MEAN+1SD fit
                       Equivalent Filter   (dB) =    -3     -6    -10    -13    -20
CORNER @ ROLL-OFF      MEAN LOG Frequency  (Hz) =   199    595   1110   1569   3053
 (Hz)    (dB/dec)      MEAN+1SD Frequency  (Hz) =   985   3043   4645   6072   7690

1303.     -19.9  <---- Adjusted Asymptote  (Hz) =  1846   2615   4145   5874  13191
                       Best-Fit Filter     (Hz) =  1303   2263   3931   5724  13124
```

T-File	Ch	Signal	Test ID	Sampling		Freq. (Hz) @ Cum. PSD Levels				
2-1068	18.	AC HED Y G'S	82-05	2500	10000	5	12	32	76	728
2-1069	19.	AC HED Z G'S	82-05	2500	10000	17	24	49	66	288
2-1068	18.	AC HED Y G'S	82-05	2500	10000	5	12	32	76	728
2-1069	19.	AC HED Z G'S	82-05	2500	10000	17	24	49	66	288
1-2438	14.	AC HED X G'S	76T009	1376	6410	537	844	1139	1305	1609
1-2439	15.	AC HED Z G'S	76T009	1376	6410	210	834	1164	1545	1930
1-2440	16.	AC HED Y G'S	76T009	1376	6410	111	466	942	1164	1626
1-2479	13.	AC HED X G'S	76T011	1520	6410	504	1607	1934	1995	2086
1-2480	14.	AC HED Z G'S	76T011	1520	6410	243	393	1199	1715	1994
1-2481	15.	AC HED Y G'S	76T011	1520	6410	58	136	861	1310	2002
1-3525	02.	AC HD1 X G'S	76A145	2560	25000	488	729	1993	2478	5276
1-3526	03.	AC HD1 Y G'S	76A145	2560	25000	391	684	1355	1642	4642
1-3527	04.	AC HD1 Z G'S	76A145	2560	25000	739	1364	2170	3809	5060
1-3538	02.	AC HD1 X G'S	76A152	2560	25000	165	1266	2255	2509	4257
1-3539	03.	AC HD1 Y G'S	76A152	2560	25000	259	2194	2707	4004	6375
1-3540	04.	AC HD1 Z G'S	76A152	2560	25000	134	1395	2142	3299	5927
1-3528	05.	AC HD2 Z G'S	76A145	2560	25000	55	1593	2676	4263	5795
1-3529	06.	AC HD2 X G'S	76A145	2560	25000	76	183	1138	1306	3467
1-3530	07.	AC HD2 Y G'S	76A145	2560	25000	1898	2521	4062	4807	6290
1-3541	05.	AC HD2 Z G'S	76A152	2560	25000	253	2441	3430	4843	7999
1-3542	06.	AC HD2 X G'S	76A152	2560	25000	1501	2136	2505	3409	4846
1-3543	07.	AC HD2 Y G'S	76A152	2560	25000	638	2945	3644	5484	7425
1-3531	08.	AC HD3 Y G'S	76A145	2560	25000	833	1074	1334	1965	4593
1-3532	09.	AC HD3 Z G'S	76A145	2560	25000	958	1212	1379	1501	4041
1-3533	10.	AC HD3 X G'S	76A145	2560	25000	1108	1273	1529	2463	4703
1-3544	08.	AC HD3 Y G'S	76A152	2560	25000	131	2371	4749	5164	6863
1-3545	09.	AC HD3 Z G'S	76A152	2560	25000	1633	2557	3241	5042	6146
1-3546	10.	AC HD3 X G'S	76A152	2560	25000	119	693	2338	4794	7587

```
Tests =  DIR  W/PAD  FRAC               Sensors =  HD1 HD2 HD3 HED         LP32

FILTER ESTIMATION        10 Signals              SUMMARY OF SPECTRAL ANALYSIS
                       Cumulative P.S.D.    (%) =   50     75     90     95     99
                       % of Signal Passed   (%) =   71     50     32     22     10
Best MEAN+1SD fit
                       Equivalent Filter   (dB) =   -3     -6    -10    -13    -20
CORNER @ ROLL-OFF      MEAN LOG Frequency  (Hz) =   29     92    294    673   1562
 (Hz)     (dB/dec)     MEAN+1SD Frequency  (Hz) =   64    201    813   1445   1878

  85.      -11.7  <----  Adjusted Asymptote  (Hz) =  154    278    609   1099   4339
                       Best-Fit Filter     (Hz) =   85    217    556   1052   4301

T-File  Ch      Signal      Test ID    Sampling       Freq. (Hz) @ Cum. PSD Levels

1-3438  02.  AC HD1 X G'S  76A126   1024 10000       29     66    103    144    950
1-3439  03.  AC HD1 Y G'S  76A126   1024 10000       12     24    117    732   1677
1-3440  04.  AC HD1 Z G'S  76A126   1024 10000       12     98    818   1145   1799
1-3441  05.  AC HD2 Z G'S  76A126   1024 10000       42     76    132    217   1523
1-3442  06.  AC HD2 X G'S  76A126   1024 10000       17     59    120    425   1533
1-3443  07.  AC HD2 Y G'S  76A126   1024 10000       54    139   1060   1436   1885
1-3445  09.  AC HD3 Z G'S  76A126   1024 10000       15     49    122    796   1477
1-3446  10.  AC HD3 X G'S  76A126   1024 10000       17     81    215    820   1538
1-2212  16.  AC HED X G'S  76T042   1744  6410       69    315   1351   1579   1828
1-2213  17.  AC HED Z G'S  76T042   1744  6410      144    357    826   1164   1648
```

Tests = DIR NOPAD NOFX Sensors = HD1 HD2 HD3 HED LP33

FILTER ESTIMATION	33 Signals	SUMMARY OF SPECTRAL ANALYSIS				
	Cumulative P.S.D. (%) =	50	75	90	95	99
	% of Signal Passed (%) =	71	50	32	22	10
Best MEAN+1SD fit						
	Equivalent Filter (dB) =	-3	-6	-10	-13	-20
CORNER @ ROLL-OFF	MEAN LOG Frequency (Hz) =	137	349	723	986	1649
(Hz) (dB/dec)	MEAN+1SD Frequency (Hz) =	463	847	1475	1814	2508
547. -25.7 <----	Adjusted Asymptote (Hz) =	716	937	1338	1752	3275
	Best-Fit Filter (Hz) =	547	838	1284	1717	3262

T-File	Ch	Signal	Test ID	Sampling		Freq. (Hz) @ Cum. PSD Levels				
1-3512	02.	AC HD1 X G'S	76A144	1024	10000	156	408	828	1340	2178
1-3513	03.	AC HD1 Y G'S	76A144	1024	10000	227	491	2043	2383	2754
1-3514	04.	AC HD1 Z G'S	76A144	1024	10000	269	518	1858	2212	2581
2-0002	01.	AC HD1 X G'S	MS 91	640	10000	66	239	432	652	1182
2-0003	02.	AC HD1 Y G'S	MS 91	640	10000	49	93	183	266	974
2-0004	03.	AC HD1 Z G'S	MS 91	640	10000	745	1006	1250	1487	1980
2-0013	01.	AC HD1 X G'S	MS 92	640	10000	117	171	249	383	835
2-0014	02.	AC HD1 Y G'S	MS 92	640	10000	98	164	232	493	1917
2-0015	03.	AC HD1 Z G'S	MS 92	640	10000	669	1008	1179	1509	2715
1-3515	05.	AC HD2 Z G'S	76A144	1024	10000	212	410	784	1096	2212
1-3516	06.	AC HD2 X G'S	76A144	1024	10000	105	552	1321	1902	2095
1-3517	07.	AC HD2 Y G'S	76A144	1024	10000	596	2039	2268	2432	3245
2-0005	04.	AC HD2 X G'S	MS 91	640	10000	44	73	159	242	503
2-0006	05.	AC HD2 Y G'S	MS 91	640	10000	63	266	425	576	1472
2-0007	06.	AC HD2 Z G'S	MS 91	640	10000	730	933	1106	1292	2173
2-0016	04.	AC HD2 X G'S	MS 92	640	10000	105	173	339	444	820
2-0017	05.	AC HD2 Y G'S	MS 92	640	10000	120	164	549	725	1377
2-0018	06.	AC HD2 Z G'S	MS 92	640	10000	178	818	1003	1216	1687
1-3519	09.	AC HD3 Z G'S	76A144	1024	10000	686	874	1099	1719	2051
1-3520	10.	AC HD3 X G'S	76A144	1024	10000	798	991	1467	1565	1826
2-0008	07.	AC HD3 X G'S	MS 91	640	10000	49	100	369	745	1265
2-0009	08.	AC HD3 Y G'S	MS 91	640	10000	315	586	1138	1497	1873
2-0010	09.	AC HD3 Z G'S	MS 91	640	10000	66	352	474	579	713
2-0019	07.	AC HD3 X G'S	MS 92	640	10000	85	244	933	1211	2527
2-0020	08.	AC HD3 Y G'S	MS 92	640	10000	391	693	1174	1411	2239
2-0021	09.	AC HD3 Z G'S	MS 92	640	10000	39	139	398	581	2024
1-2458	13.	AC HED X G'S	76T010	1536	6410	1590	1673	1811	1847	2080
1-2459	14.	AC HED Z G'S	76T010	1536	6410	228	659	1435	1840	2127
1-2460	15.	AC HED Y G'S	76T010	1536	6410	89	332	695	992	1854
2-1039	18.	AC HED Y G'S	82-04	2500	10000	12	208	952	1206	1528
2-1040	19.	AC HED Z G'S	82-04	2500	10000	29	100	374	632	1226
2-1039	18.	AC HED Y G'S	82-04	2500	10000	12	208	952	1206	1528
2-1040	19.	AC HED Z G'S	82-04	2500	10000	29	100	374	632	1226

Tests = DIR W/PAD NOFX Sensors = HD1 HD2 HD3 HED LP34

FILTER ESTIMATION		18 Signals	SUMMARY OF SPECTRAL ANALYSIS				
		Cumulative P.S.D. (%) =	50	75	90	95	99
		% of Signal Passed (%) =	71	50	32	22	10
Best MEAN+1SD fit							
		Equivalent Filter (dB) =	-3	-6	-10	-13	-20
CORNER @	ROLL-OFF	MEAN LOG Frequency (Hz) =	26	64	145	222	942
(Hz)	(dB/dec)	MEAN+1SD Frequency (Hz) =	42	99	345	598	2017
49.	-11.8 <----	Adjusted Asymptote (Hz) =	88	159	347	625	2459
		Best-Fit Filter (Hz) =	49	124	317	598	2438

T-File	Ch	Signal	Test ID	Sampling		Freq. (Hz) @ Cum. PSD Levels				
1-3425	02.	AC HD1 X G'S	75A116	2560	25000	31	64	110	146	2972
1-3426	03.	AC HD1 Y G'S	75A116	2560	25000	40	73	113	156	3287
1-3427	04.	AC HD1 Z G'S	75A116	2560	25000	18	58	1382	3751	5185
1-3412	02.	AC HD1 X G'S	75A113	1024	10000	34	61	90	112	801
1-3413	03.	AC HD1 Y G'S	75A113	1024	10000	34	63	90	115	715
1-3414	04.	AC HD1 Z G'S	75A113	1024	10000	7	27	83	186	957
1-3451	02.	AC HD1 X G'S	76A133	1024	10000	44	93	273	378	491
1-3452	03.	AC HD1 Y G'S	76A133	1024	10000	12	212	1033	1189	1326
1-3453	04.	AC HD1 Z G'S	76A133	1024	10000	22	115	447	928	1274
1-3463	02.	AC HD1 X G'S	76A134	1024	10000	22	63	103	127	740
1-3464	03.	AC HD1 Y G'S	76A134	1024	10000	39	68	100	125	654
1-3465	04.	AC HD1 Z G'S	76A134	1024	10000	22	42	81	122	1160
1-3475	02.	AC HD1 X G'S	76A135	1024	10000	34	54	73	95	759
1-3476	03.	AC HD1 Y G'S	76A135	1024	10000	34	54	81	100	347
1-3477	04.	AC HD1 Z G'S	76A135	1024	10000	15	37	76	90	232
1-3487	02.	AC HD1 X G'S	76A136	1024	10000	46	83	127	217	718
1-3488	03.	AC HD1 Y G'S	76A136	1024	10000	32	66	117	305	1289
1-3489	04.	AC HD1 Z G'S	76A136	1024	10000	24	51	98	181	466

```
Tests =  NO DIRECT IMPACT                Sensors =  HD1 HD2 HD3 HED         LP35

FILTER ESTIMATION        15 Signals               SUMMARY OF SPECTRAL ANALYSIS
                     Cumulative P.S.D.    (%) =     50     75     90     95     99
                     % of Signal Passed   (%) =     71     50     32     22     10
Best MEAN+1SD fit
                     Equivalent Filter   (dB) =     -3     -6    -10    -13    -20
CORNER @ ROLL-OFF    MEAN LOG Frequency  (Hz) =     12     20     35     47    175
 (Hz)    (dB/dec)    MEAN+1SD Frequency  (Hz) =     20     35     59     88    537

  17.     -14.1  <---- Adjusted Asymptote (Hz) =    28     45     86    141    441
                     Best-Fit Filter     (Hz) =     17     37     80    135    437

T-File  Ch      Signal      Test ID    Sampling        Freq. (Hz) @ Cum. PSD Levels

2-0572  02.  AC HD1 X G'S  A-925     2048  8000         41     72    119    254    760
2-0573  03.  AC HD1 Y G'S  A-925     2048  8000         14     20     25     29    137
2-0574  04.  AC HD1 Z G'S  A-925     2048  8000          6     18     27     35    156
2-0597  02.  AC HD1 X G'S  A-926     2048  8000         10     16     31     57    977
2-0598  03.  AC HD1 Y G'S  A-926     2048  8000         16     21     31     45    852
2-0599  04.  AC HD1 Z G'S  A-926     2048  8000         10     21     37     51    854
2-0622  02.  AC HD1 X G'S  A-934     2048  8000          6     16     23     27     37
2-0623  03.  AC HD1 Y G'S  A-934     2048  8000          8     14     27     33    119
2-0624  04.  AC HD1 Z G'S  A-934     2048  8000          8     14     21     25     31
2-0696  02.  AC HD1 X G'S  A-938     2048  8000         12     21     27     33     59
2-0697  03.  AC HD1 Y G'S  A-938     2048  8000         14     20     25     29     63
2-0698  04.  AC HD1 Z G'S  A-938     2048  8000         16     23     27     31     86
2-0720  02.  AC HD1 X G'S  76B001    2048  8000          6      6     27     45    143
2-0721  03.  AC HD1 Y G'S  76B001    2048  8000         23     35     86    107    264
2-0722  04.  AC HD1 Z G'S  76B001    2048  8000         20     37     86    105    238
```

Appendix C

SAMPLES OF SIGNALS AND POWER DENSITY SPECTRA

This Appendix is included to provide samples of the biomechanical signals used in the filter study, and to show their power density spectra as well as the cumulative PDS functions. The label P.S.D. was inadvertantly used to refer to the PDS. To conserve space, not all 450 signals and spectra are included. Those that are included are most typical of all biomechanical signals, and demonstrate the variety of responses that may be found.

The following contains a LEGEND of the features and information found on each of the subsequent graphs. The keys to these information are the circled numbers which correspond to the following.

(1) Tape number (1 or 2) where the raw signal may be found. The data base from which these signals were obtained consisted of two magnetic tapes that are formatted in the NHTSA Biomechanics Tape Format (old version).

(2) File number on that tape which contains the sensor data.

(3) Channel number, i.e., the sequential order of the sensor data in the digitized and formatted test.

(4) Test ID or reference number to which the signal belongs.

(5) Sensor type. Here, all are accelerometer (AC) signals.

(6) Sensor attachment location. See Appendix A for a list of these codes, or consult the NHTSA Biomechanics Tape Format guideline.

(7) Direction of sensitive axis of the sensor.

(8) Peak-to-peak range and units of the signal. The signal is always scaled to fit this range over the entire vertical scale.

(9) Duration of the signal in milliseconds. The signal is always scaled to fit this duration over the entire time axis.

(10) Number of samples in the signal.

(11) Sampling rate, in Hertz, of the signal.

(12) Peak value of the PDS which is used to normalized the PDS curve.

(13) Last value of the cumulative PDS curve that occurs at the Nyquist rate or half the sapmling rate described in (10) above. Note that the maximum frequency on the plots vary but are not necessarily equal to the Nyquist rate. This is done to expand the curves at low frequencies where most of the "action" takes place.

(14) Vertical scale for both the normalized PDS and its cumulative function, which ranges from 0 to 100 percent. Note that the 50, 75, 90, and 95% levels are shown, but not the 99% level.

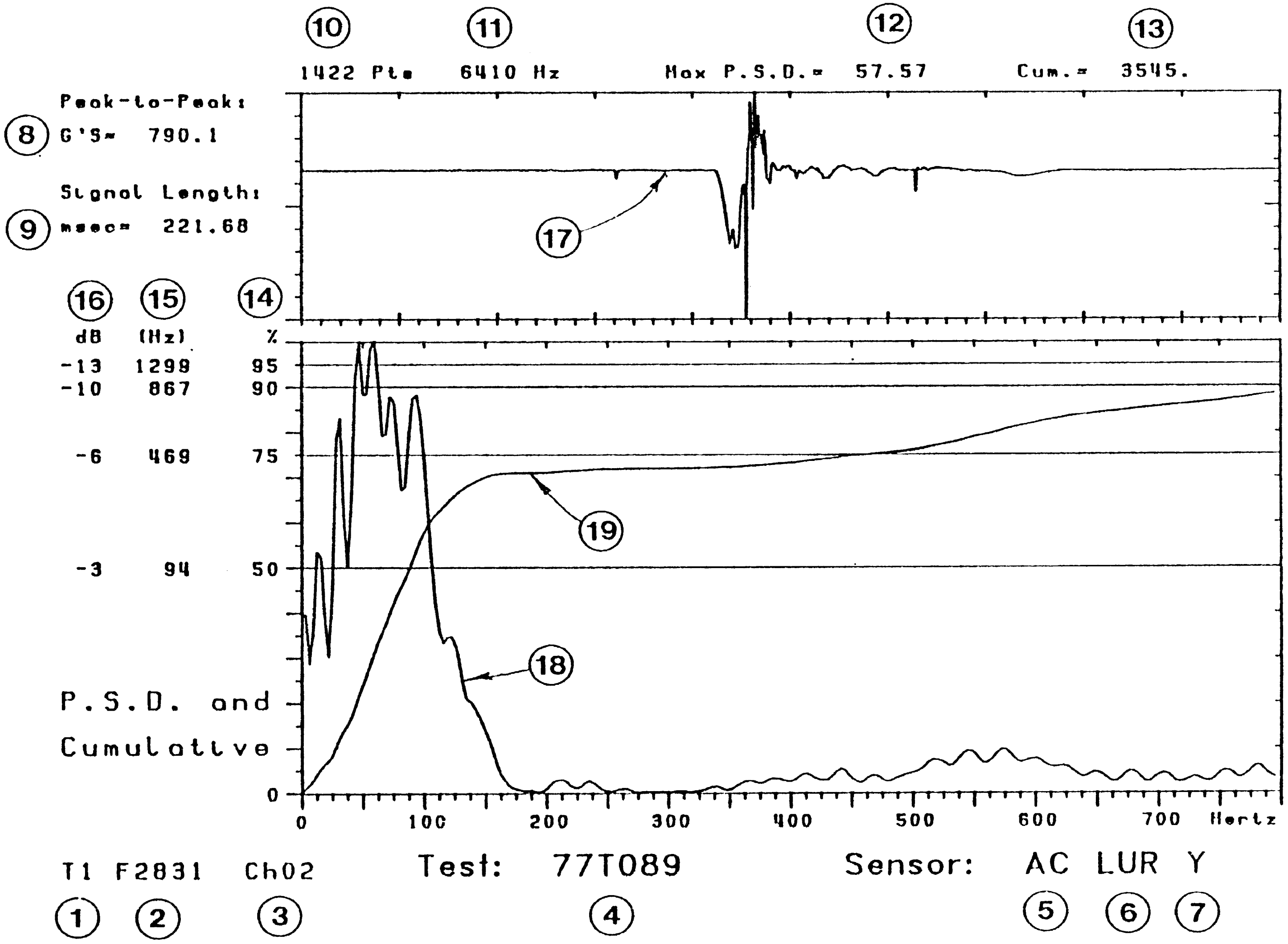
(15) Frequencies at which the cumulative PDS curve crosses the four indicated levels. The fifth landmark (at 99%) is not shown for clarity, but was is listed in Appendix B.

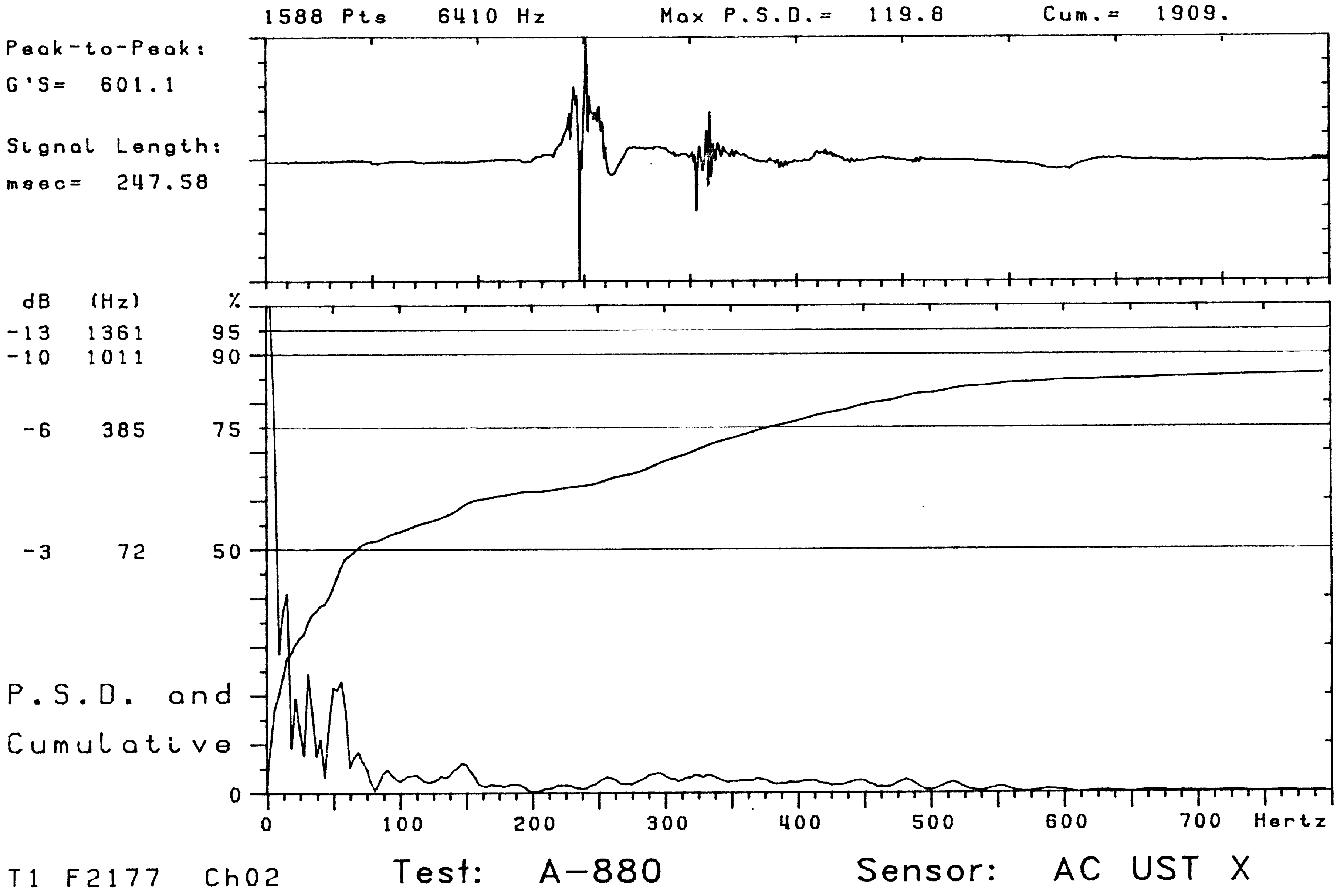
(16) Gains (in deciBels) corresponding to the 4 levels of the cumulative PDS.

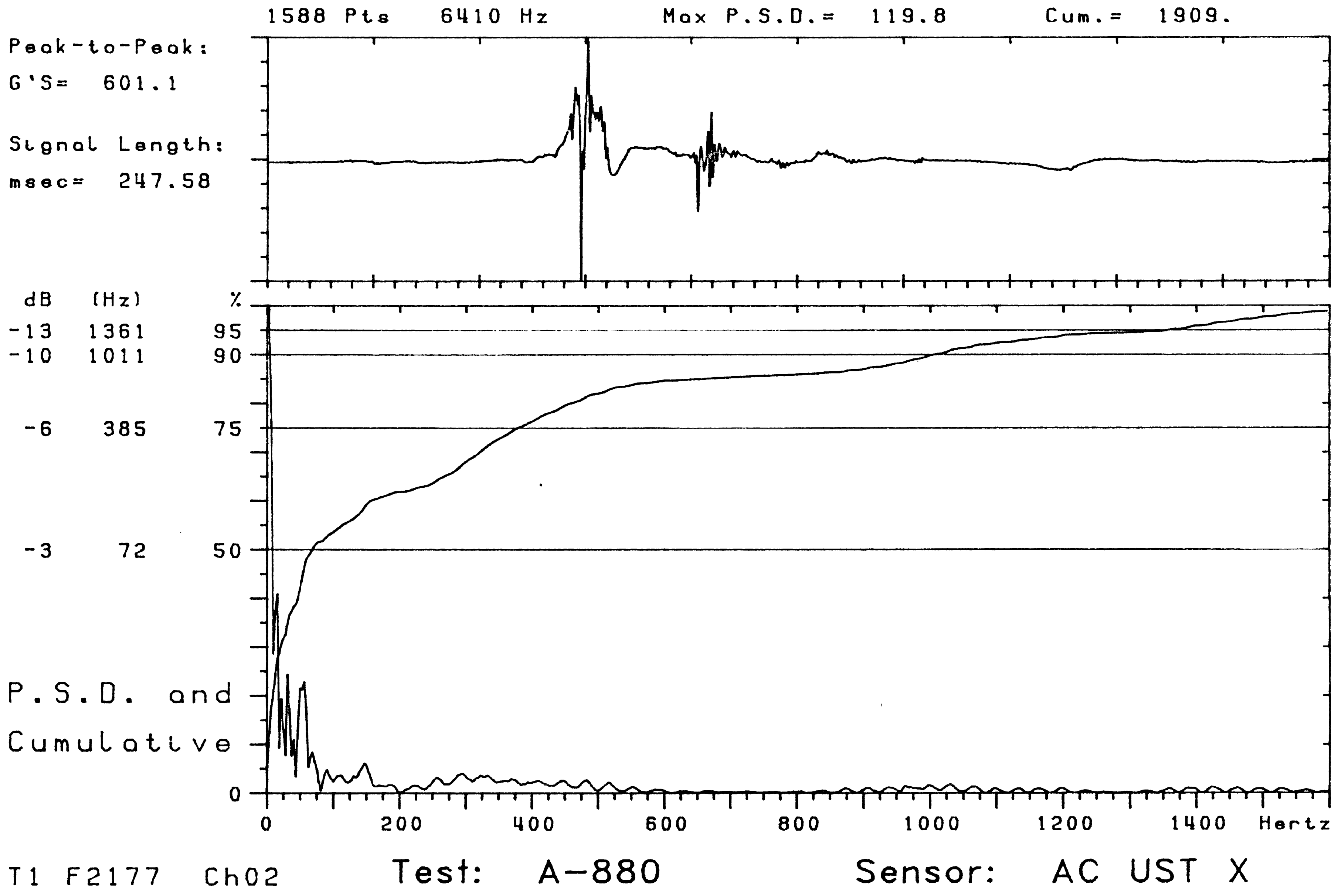
(17) Time history of the raw signal, which has been scaled vertically and horizontally to fit the entire plotting region. Generally, this signal would have been filtered with SAE Channel Class 1000 filter before being digitized, but is considered "unfiltered" for the purposes of this study.

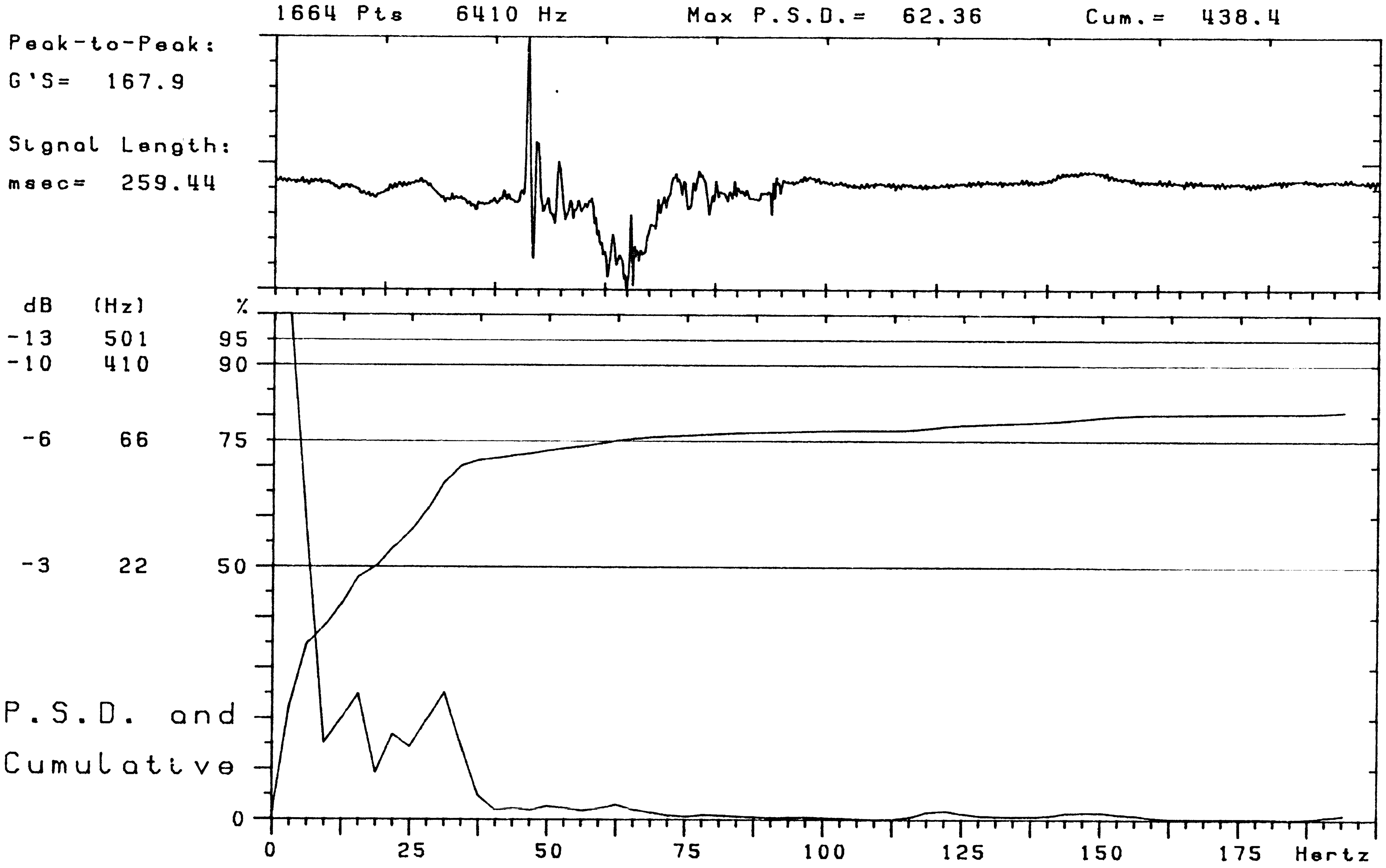
(18) The power density spectrum, obtained by normalizing the squared magnitude of the signal which, in turn, was obtained from the FFT of the signal. Note that the peak occurs, in general, at a low frequency, and that the PDS is a noisy curve which does not necessarily approach zero at high frequencies.

(19) The cumulative PDS curve, obtained at each frequency by simple summation of the PDS values of all previous frequencies, then normalized to 100% at the last accumulated value. Note that this curve will always be positive, increasing, and monotonous, which allows successfull detection of the 5 landmark levels.

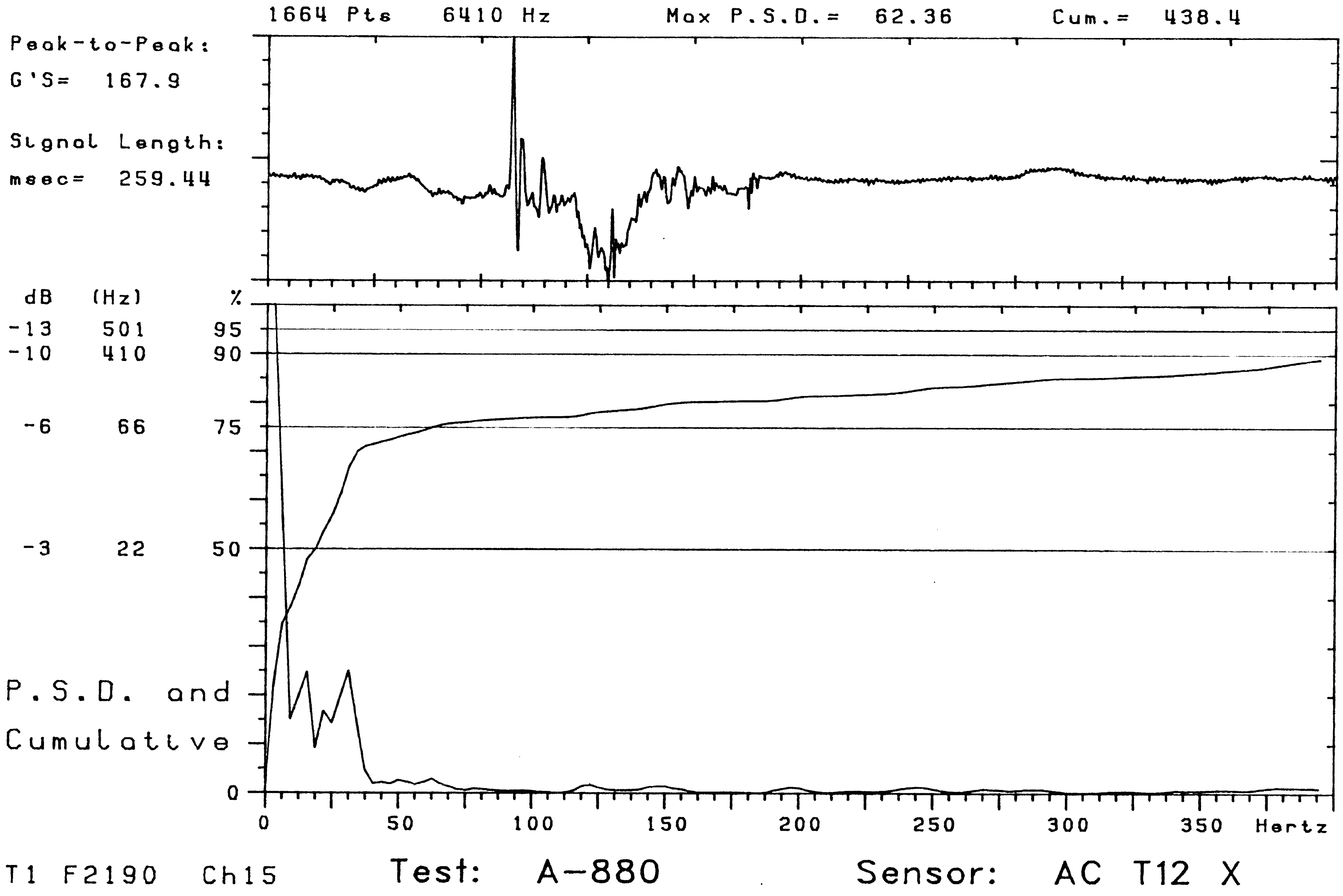

⑩ 1422 Pts
⑪ 6410 Hz
⑫ Max P.S.D.= 57.57
⑬ Cum.= 3545.
Peak-to-Peak:
⑧ G'S= 790.1
Signal Length:
⑨ msec= 221.68
⑰
⑯ dB
⑮ (Hz)
⑭ %
-13
1299
95
-10
867
90
-6
469
75
-3
94
50
0
⑲
⑱
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2831 Ch02
Test: 77T089
Sensor: AC LUR Y
①
②
③
④
⑤
⑥
⑦

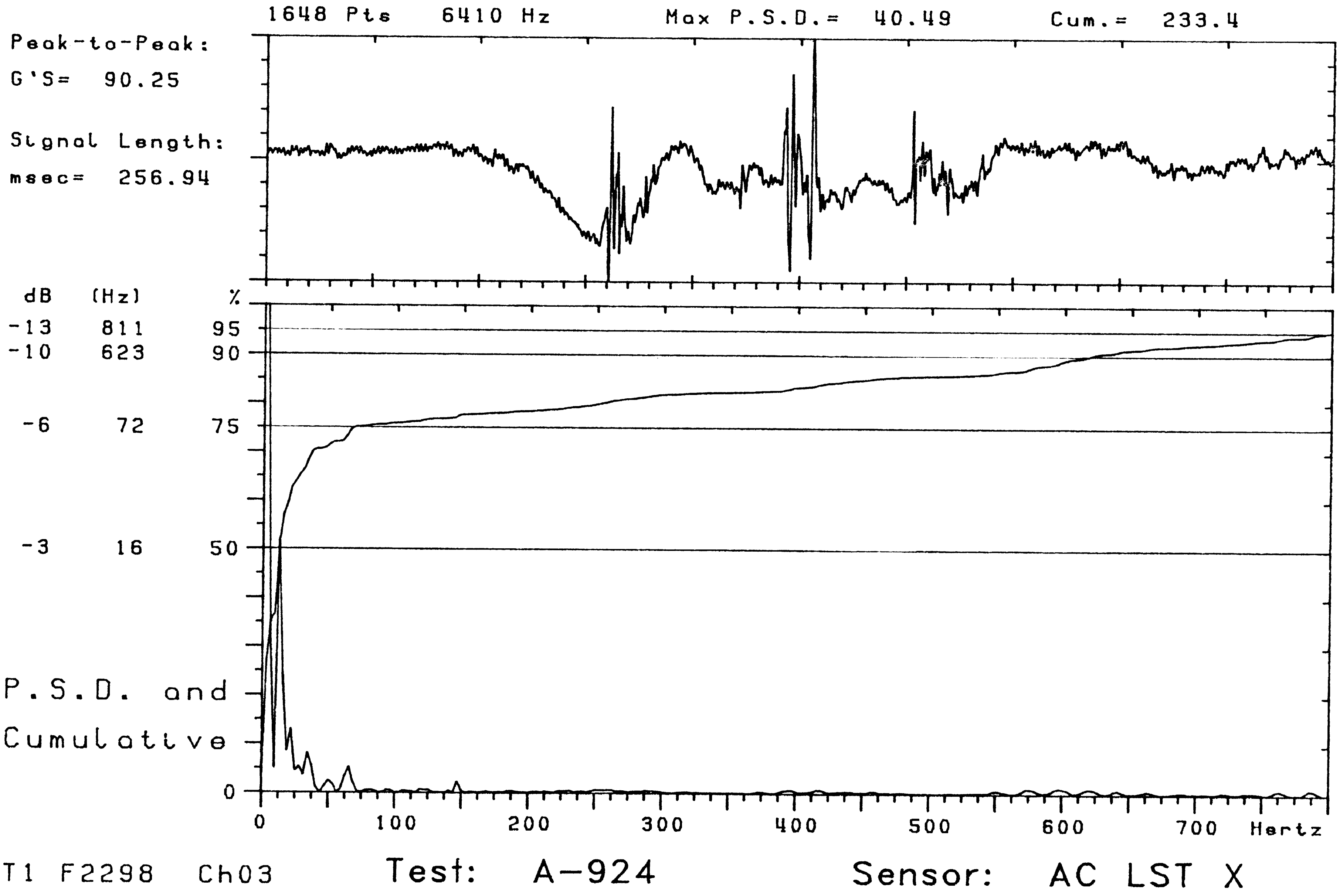

1588 Pts
6410 Hz
Max P.S.D.= 119.8
Cum.= 1909.
Peak-to-Peak:
G'S= 601.1
Signal Length:
msec= 247.58
dB (Hz)
-13 1361
-10 1011
-6 385
-3 72
%
95
90
75
50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2177 Ch02
Test: A-880
Sensor: AC UST X

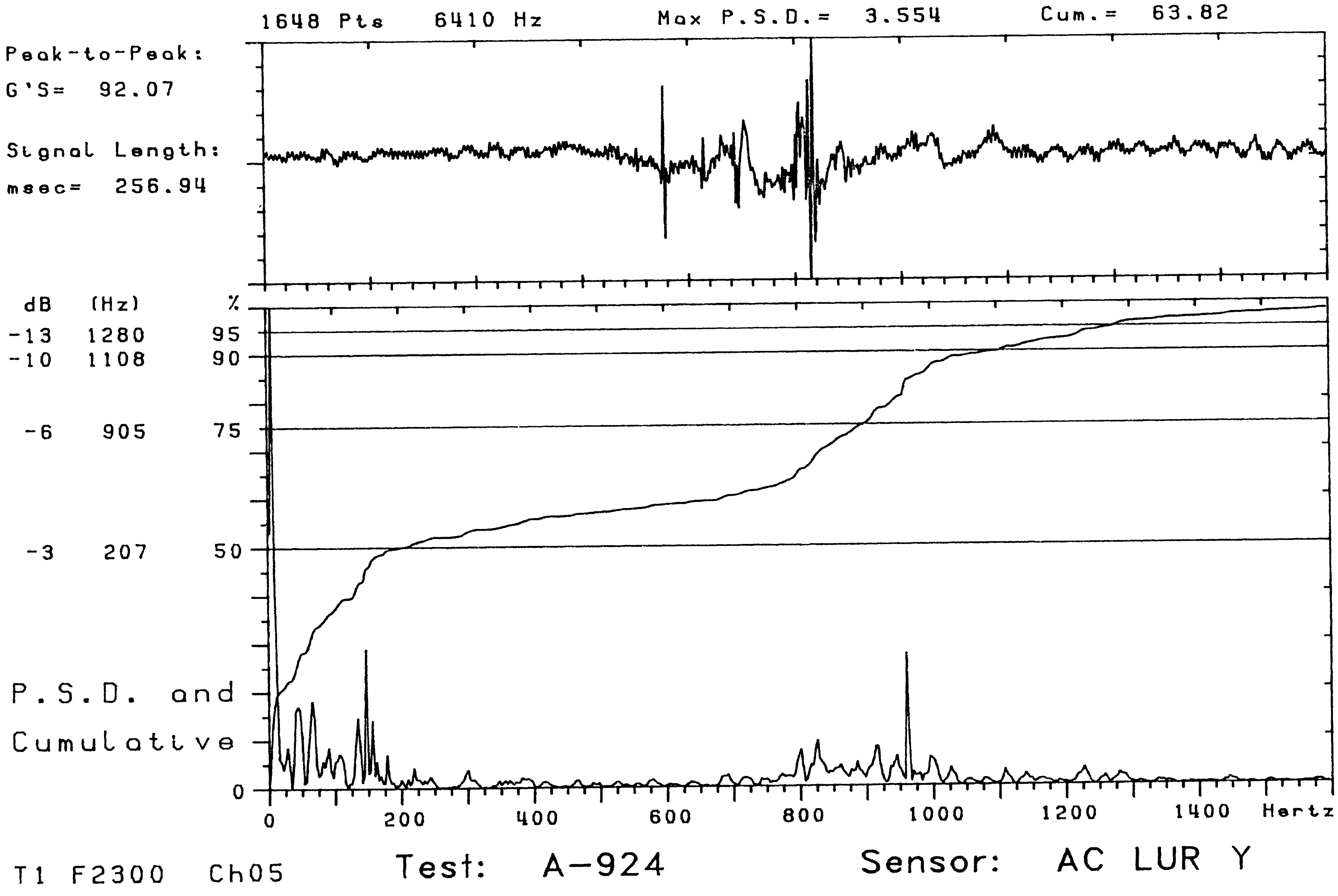

1588 Pts
6410 Hz
Max P.S.D.= 119.8
Cum.= 1909.
Peak-to-Peak:
G'S= 601.1
Signal Length:
msec= 247.58
dB (Hz) %
-13 1361 95
-10 1011 90
-6 385 75
-3 72 50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2177 Ch02
Test: A-880
Sensor: AC UST X

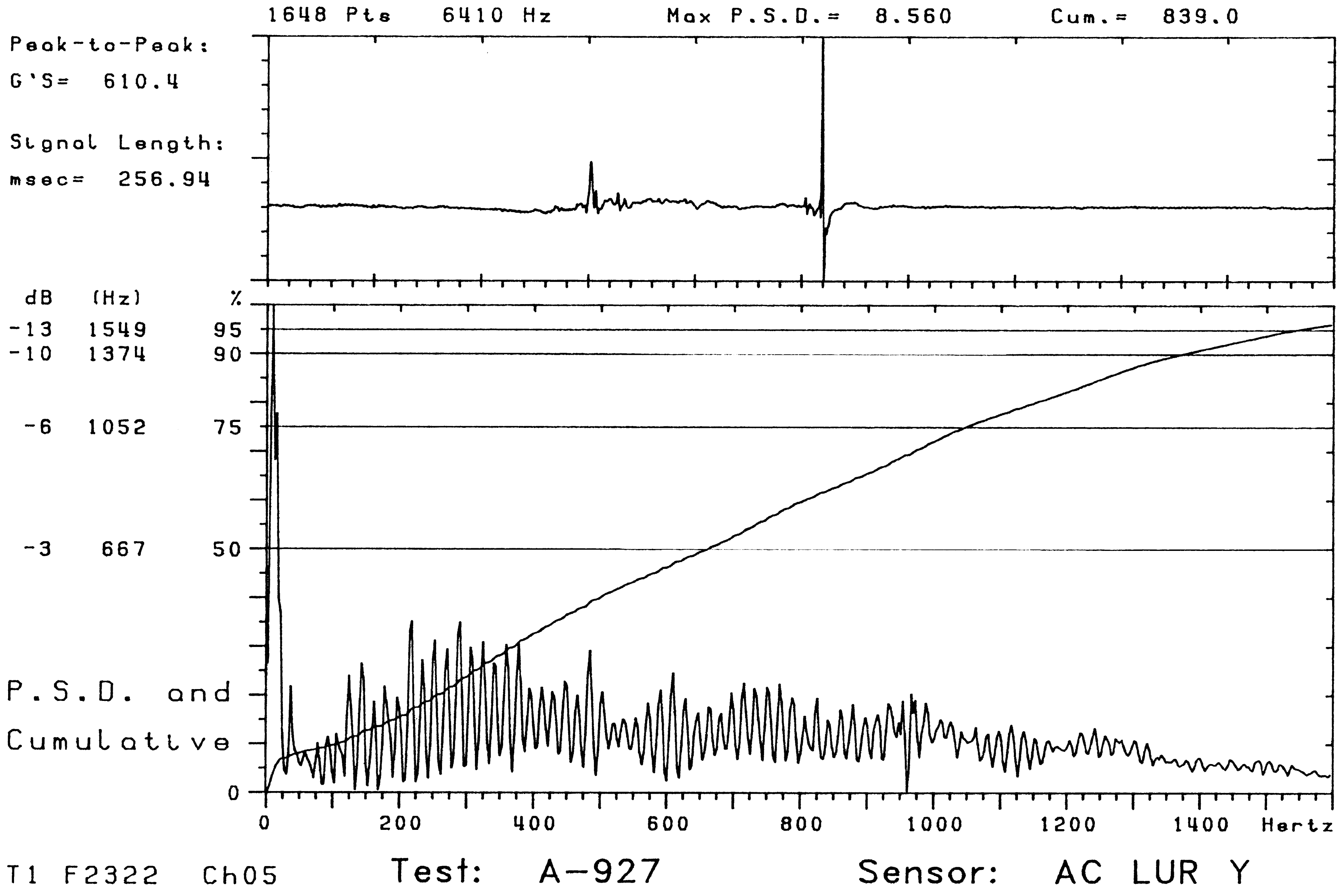


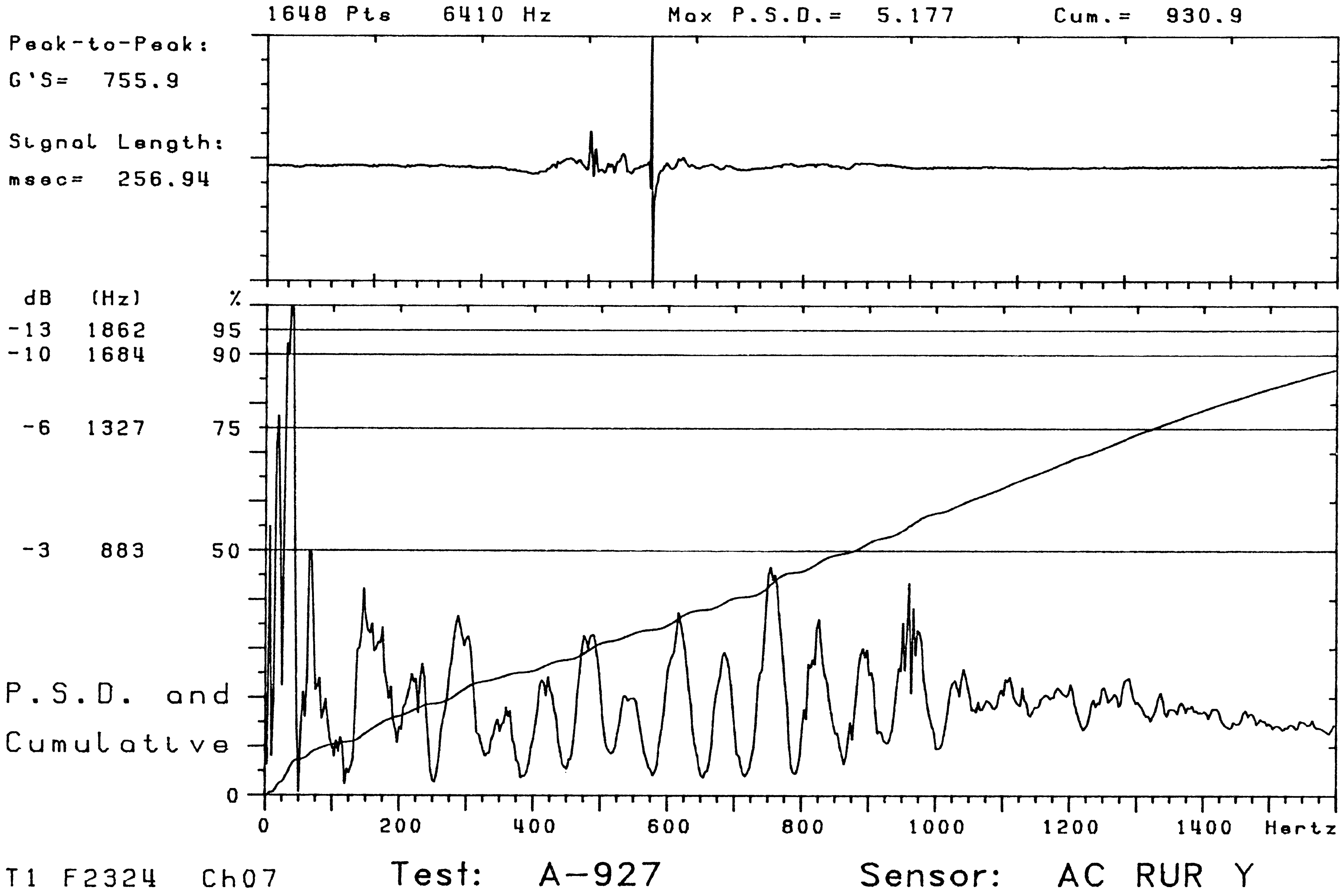
T1 F2190 Ch15 Test: A-880 Sensor: AC T12 X

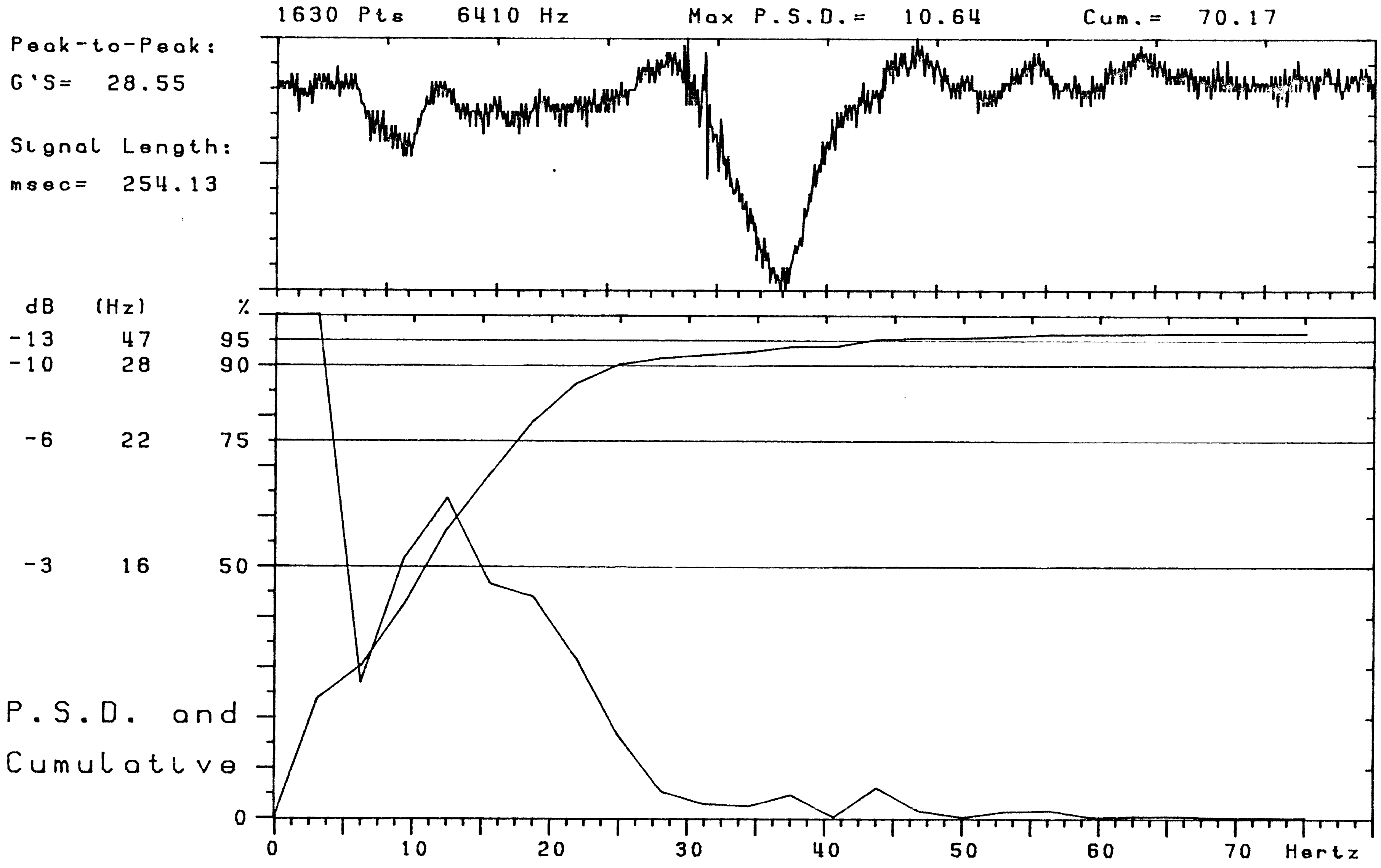

1664 Pts
6410 Hz
Max P.S.D.= 62.36
Cum.= 438.4
Peak-to-Peak:
G'S= 167.9
Signal Length:
msec= 259.44
dB
(Hz)
%
-13
501
95
-10
410
90
-6
66
75
-3
22
50
P.S.D. and
Cumulative
0
0
50
100
150
200
250
300
350
Hertz
T1 F2190 Ch15
Test: A-880
Sensor: AC T12 X


1648 Pts
6410 Hz
Max P.S.D.= 40.49
Cum.= 233.4
Peak-to-Peak:
G'S= 90.25
Signal Length:
msec= 256.94
dB
(Hz)
%
-13
811
95
-10
623
90
-6
72
75
-3
16
50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2298 Ch03
Test: A-924
Sensor: AC LST X

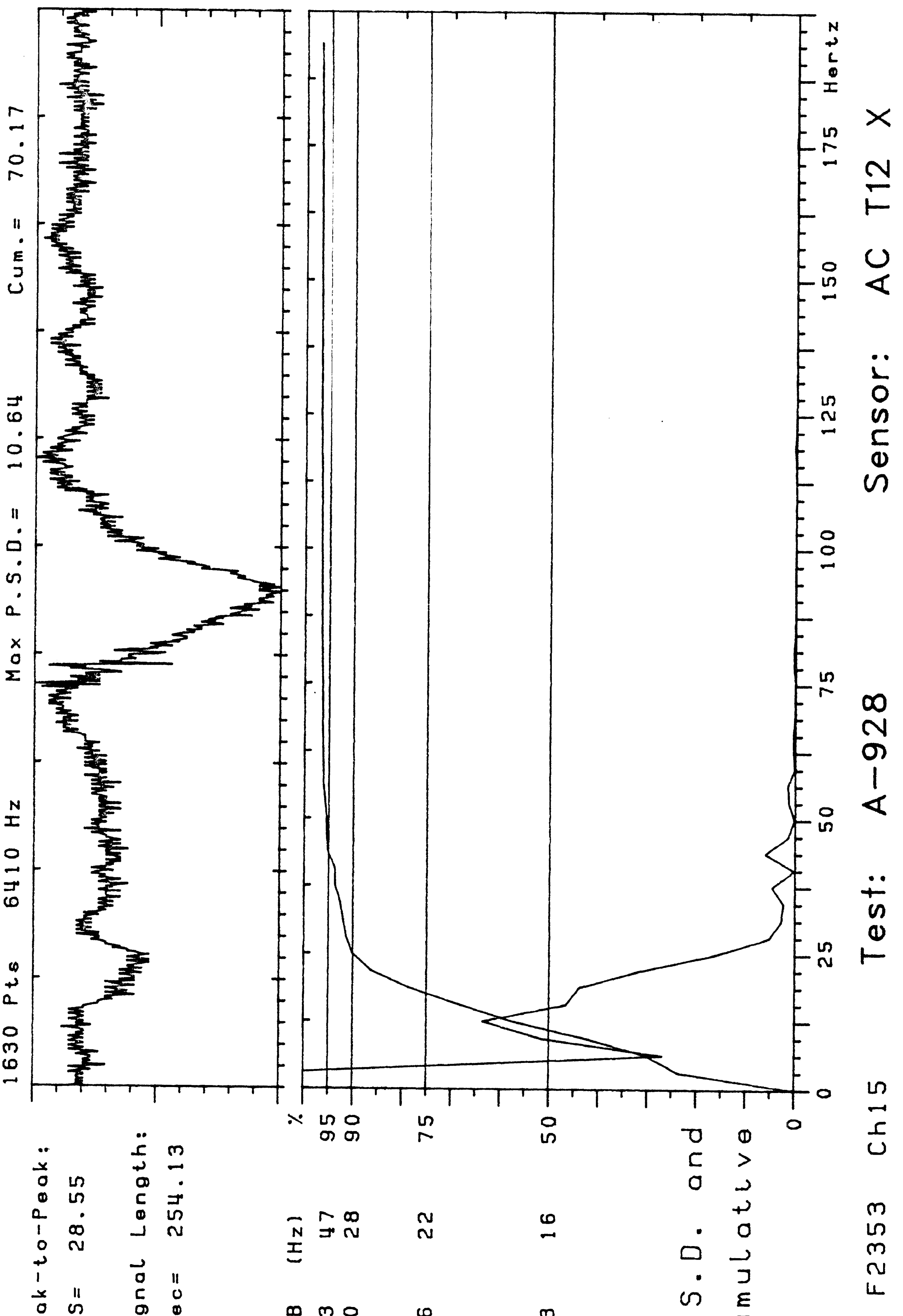

1648 Pts 6410 Hz
Max P.S.D.= 3.554
Cum.= 63.82
Peak-to-Peak:
G'S= 92.07
Signal Length:
msec= 256.94
dB (Hz) %
-13 1280 95
-10 1108 90
-6 905 75
-3 207 50
P.S.D. and
Cumulative
0
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2300 Ch05
Test: A-924
Sensor: AC LUR Y


1648 Pts
6410 Hz
Max P.S.D.= 8.560
Cum.= 839.0
Peak-to-Peak:
G'S= 610.4
Signal Length:
msec= 256.94
dB (Hz)
-13 1549
-10 1374
-6 1052
-3 667
%
95
90
75
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2322 Ch05
Test: A-927
Sensor: AC LUR Y


1648 Pts 6410 Hz
Max P.S.D.= 5.177
Cum.= 930.9
Peak-to-Peak:
G'S= 755.9
Signal Length:
msec= 256.94
dB (Hz) %
-13 1862 95
-10 1684 90
-6 1327 75
-3 883 50
P.S.D. and
Cumulative
0
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2324 Ch07
Test: A-927
Sensor: AC RUR Y



T1 F2353 Ch15 Test: A-928 Sensor: AC T12 X

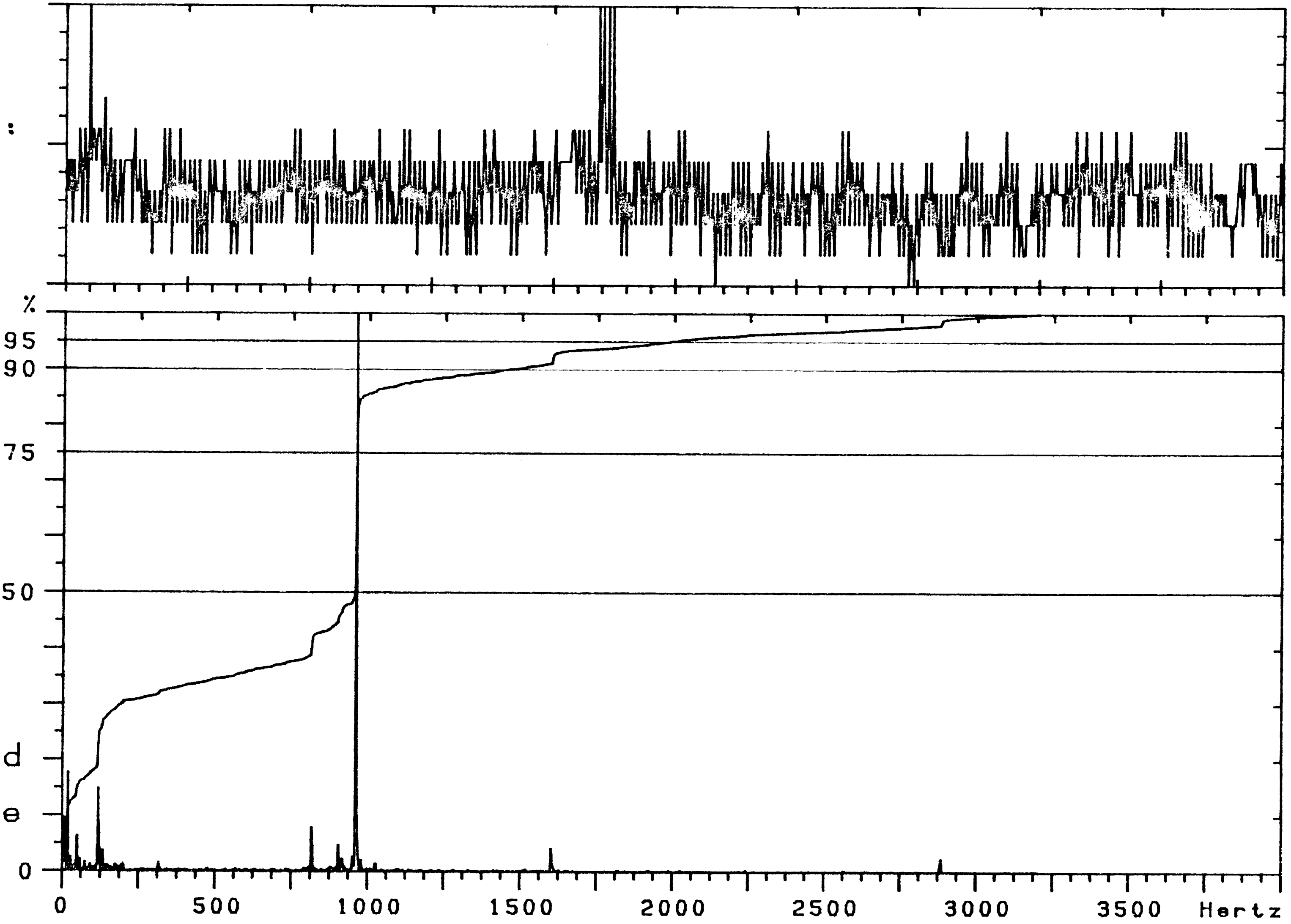

1630 Pts 6410 Hz Max P.S.D.= 10.64 Cum.= 70.17
Peak-to-Peak:
G'S= 28.55
Signal Length:
msec= 254.13
dB (Hz) %
-13 47 95
-10 28 90
-6 22 75
-3 16 50
0
P.S.D. and
Cumulative
0 25 50 75 100 125 150 175 Hertz
T1 F2353 Ch15 Test: A-928 Sensor: AC T12 X

1630 Pts   6410 Hz   Max P.S.D.= 0.3235   Cum.= 1.834

Peak-to-Peak:
G'S= 7.093

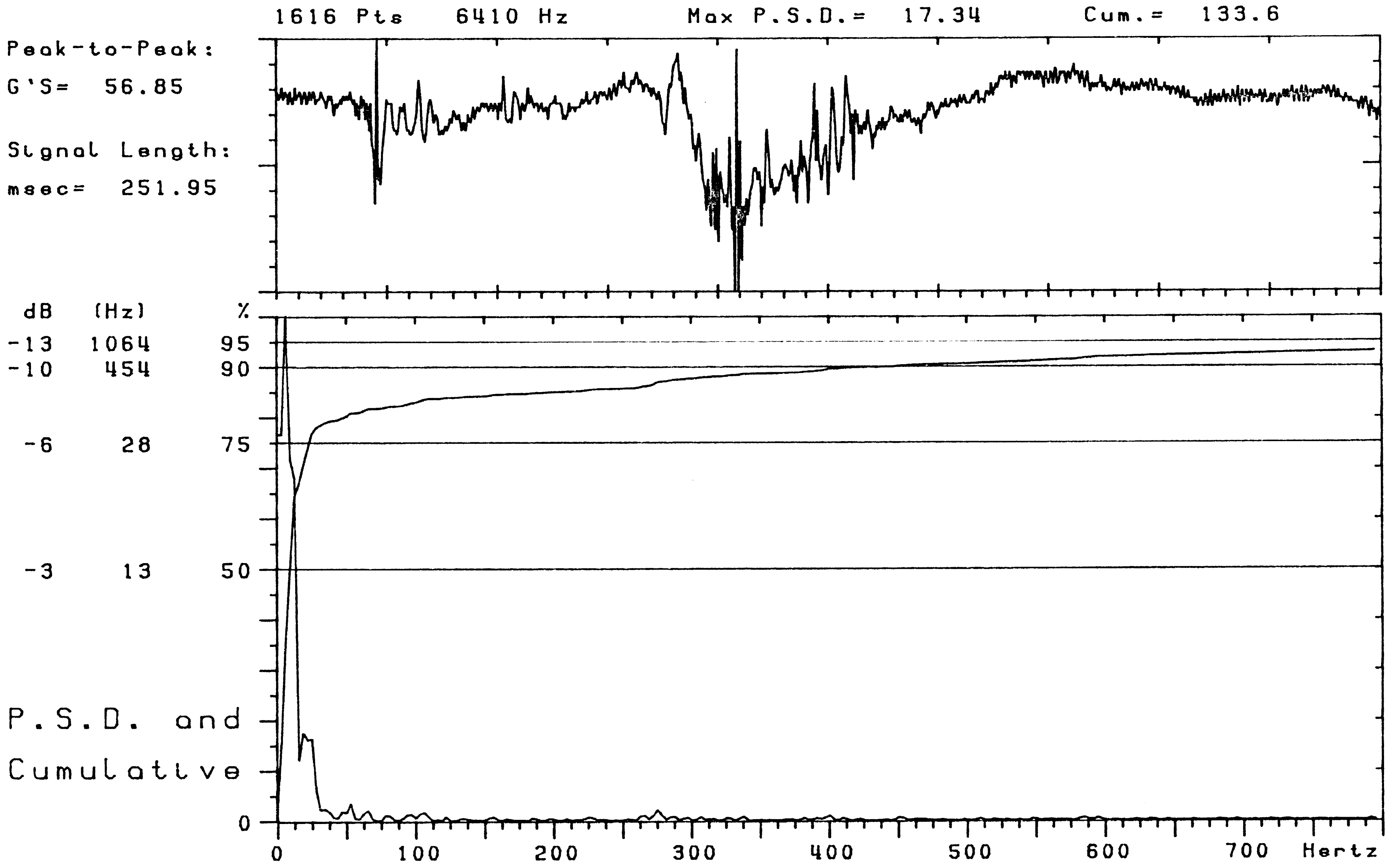
Signal Length:
msec= 254.13

dB	(Hz)
-13	1991
-10	1465
-6	964
-3	964

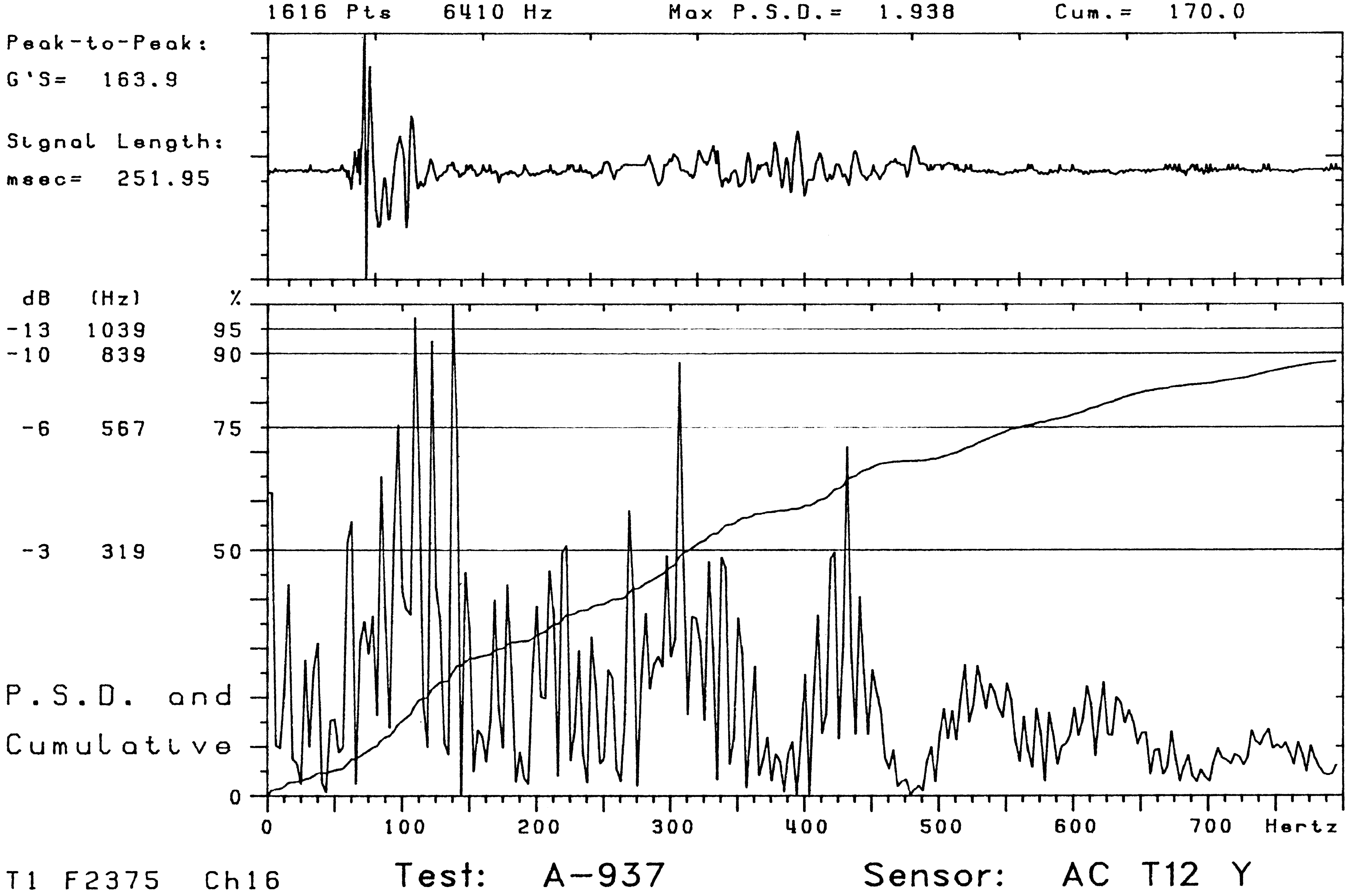


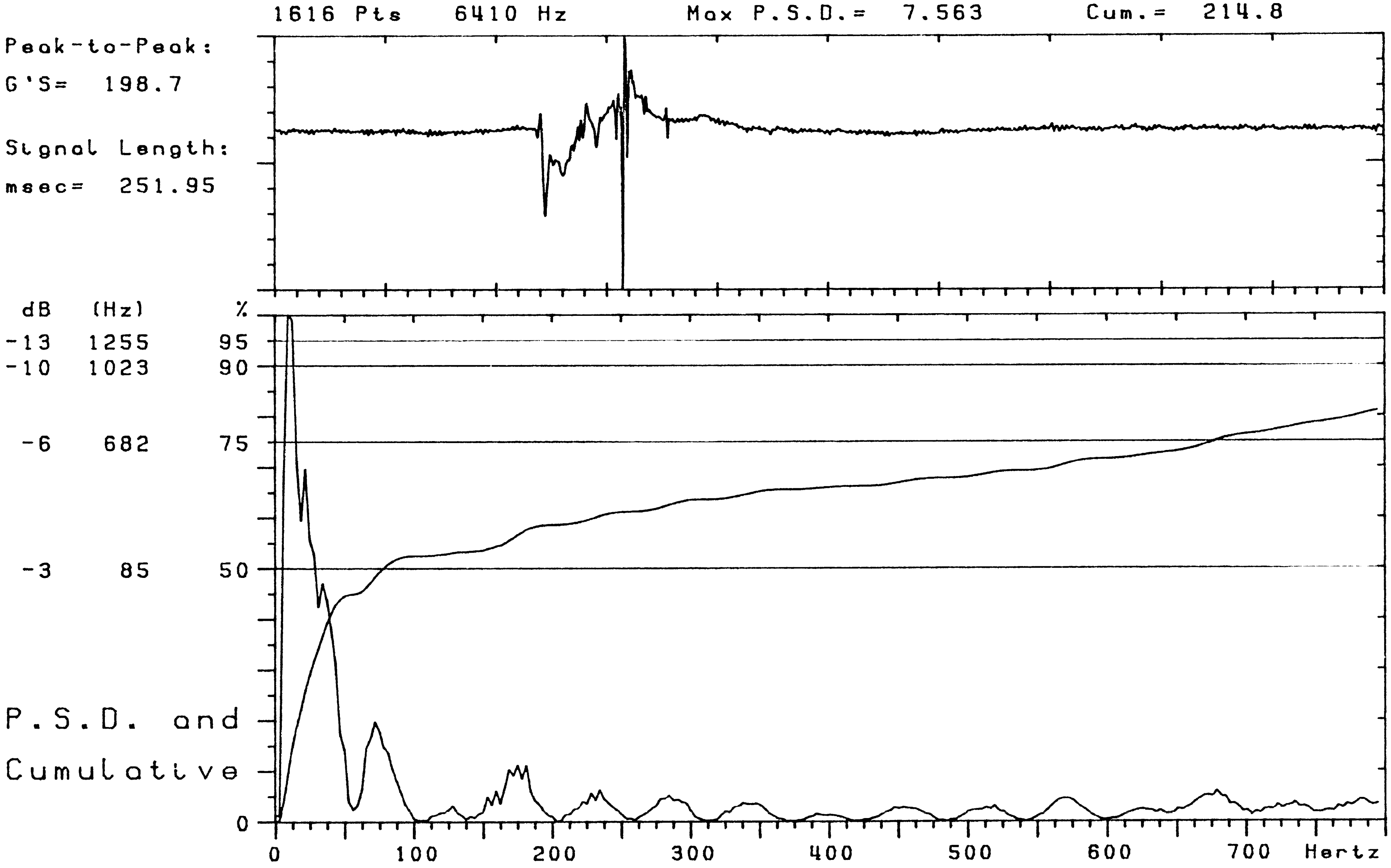
P.S.D. and
Cumulative

T1 F2354 Ch16   Test: A-928   Sensor: AC T12 Y

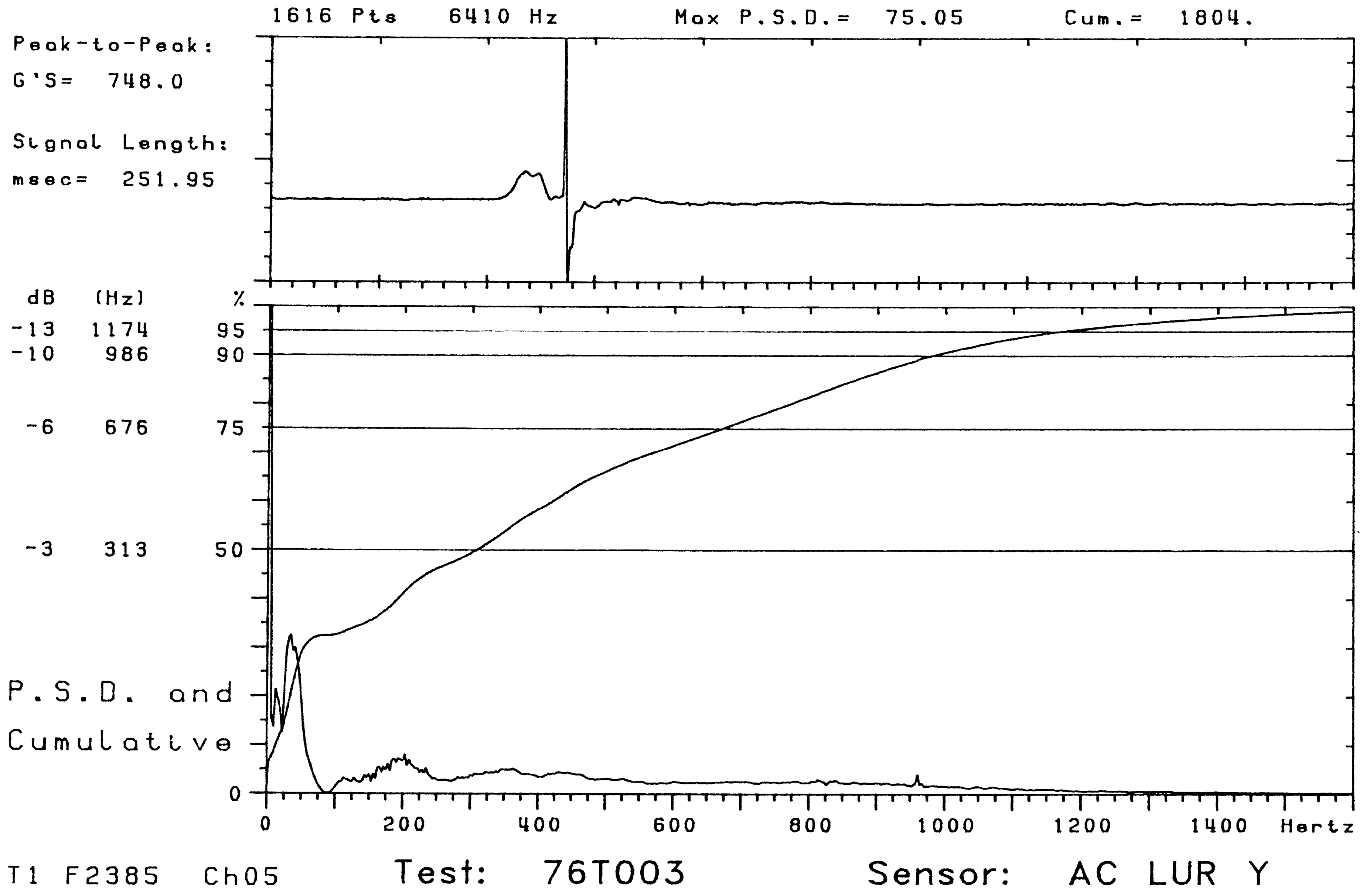


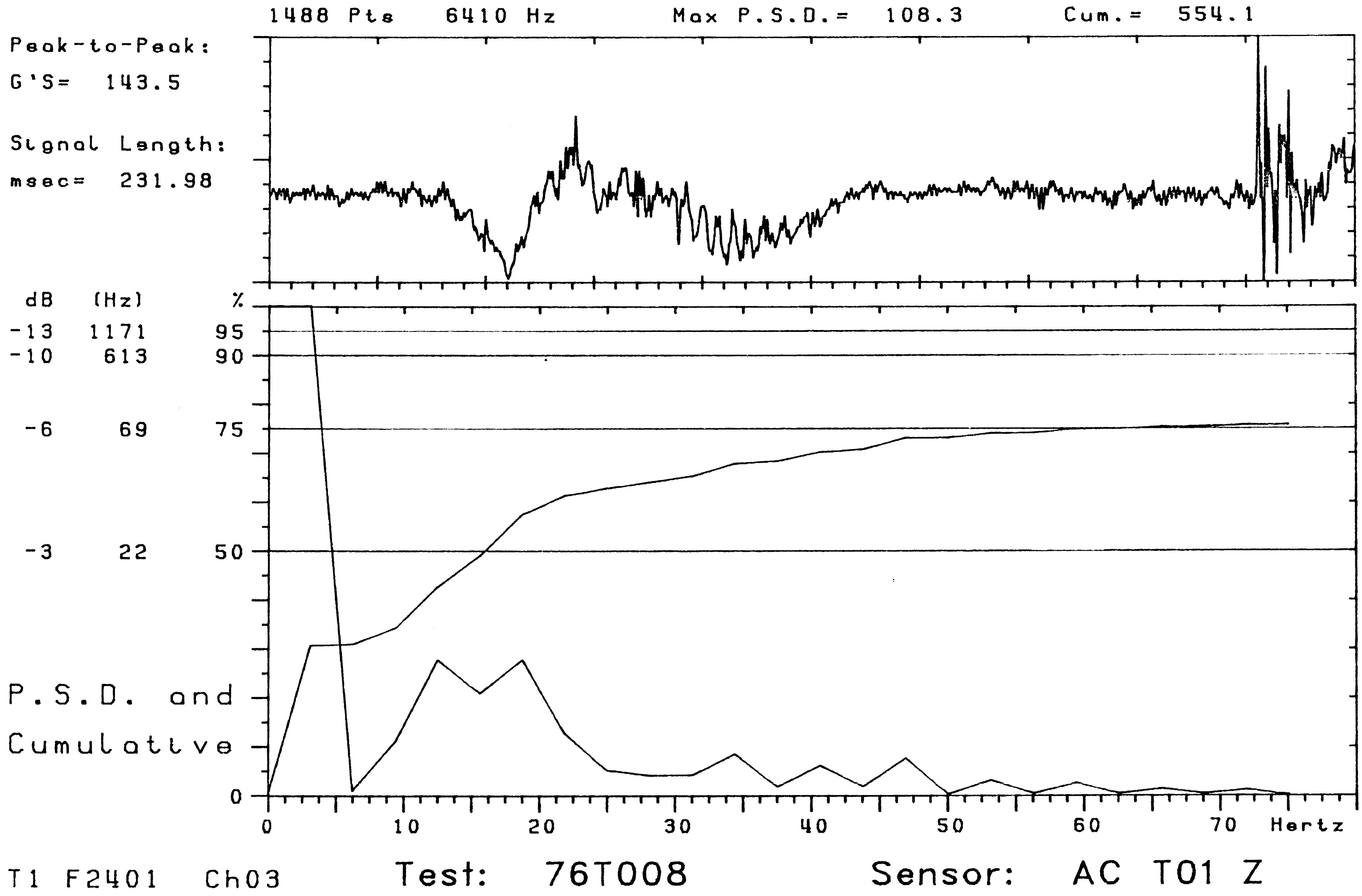
T1 F2374 Ch15 Test: A-937 Sensor: AC T12 X

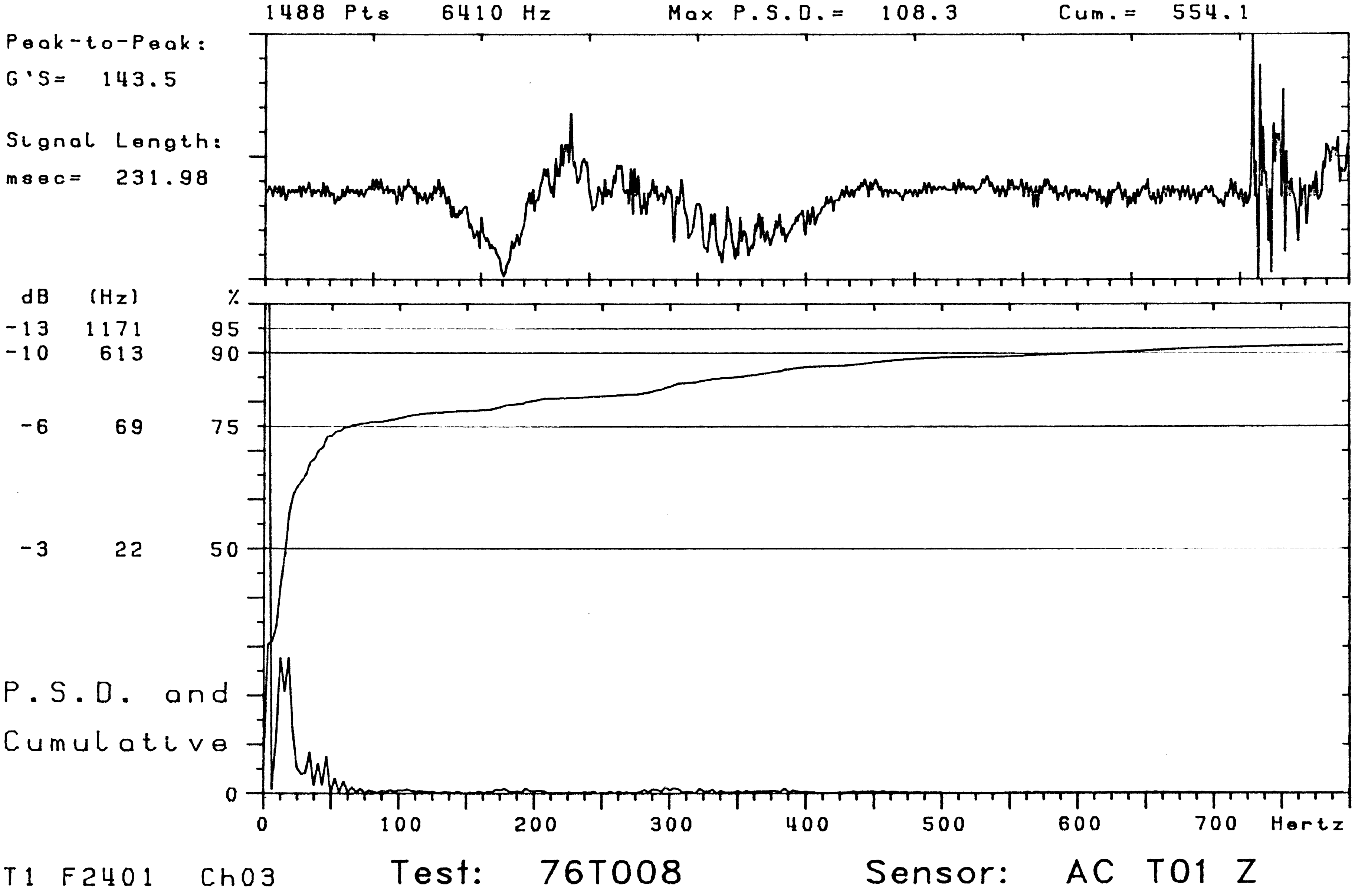

1616 Pts 6410 Hz Max P.S.D.= 1.938 Cum.= 170.0
Peak-to-Peak:
G'S= 163.9
Signal Length:
msec= 251.95
dB (Hz) %
-13 1039 95
-10 839 90
-6 567 75
-3 319 50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2375 Ch16
Test: A-937
Sensor: AC T12 Y

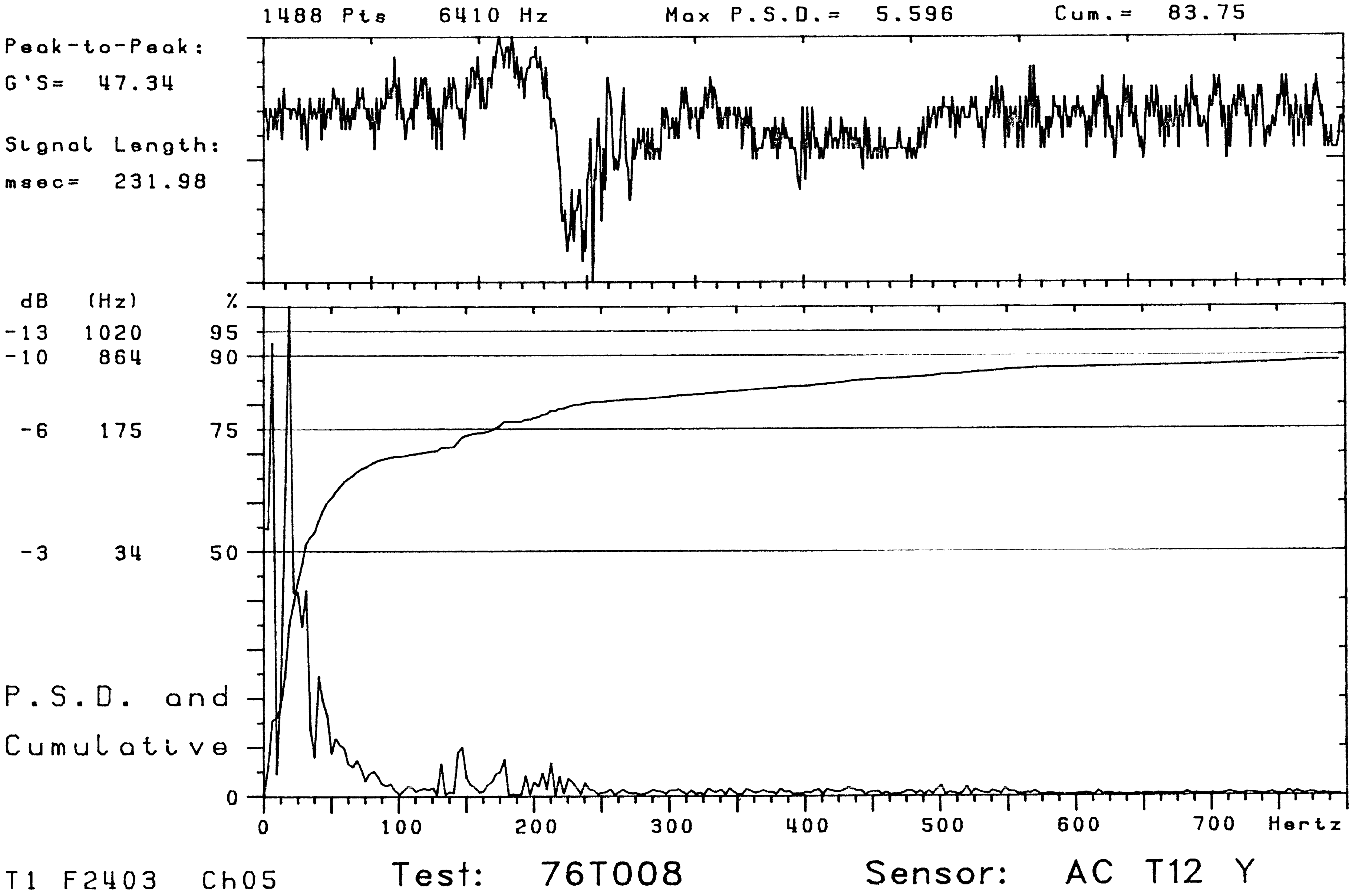


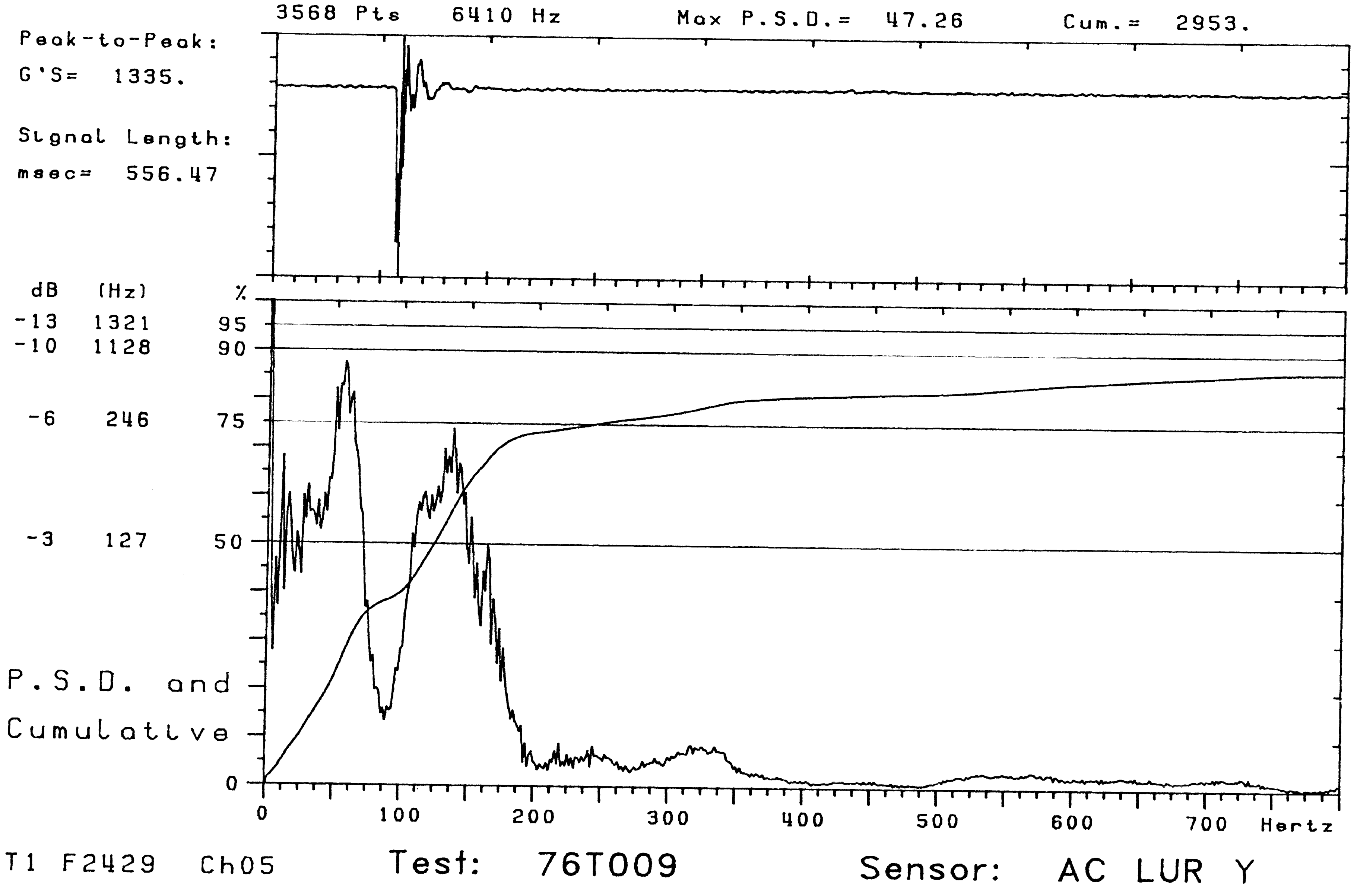
T1 F2382 Ch02 Test: 76T003 Sensor: AC UST X

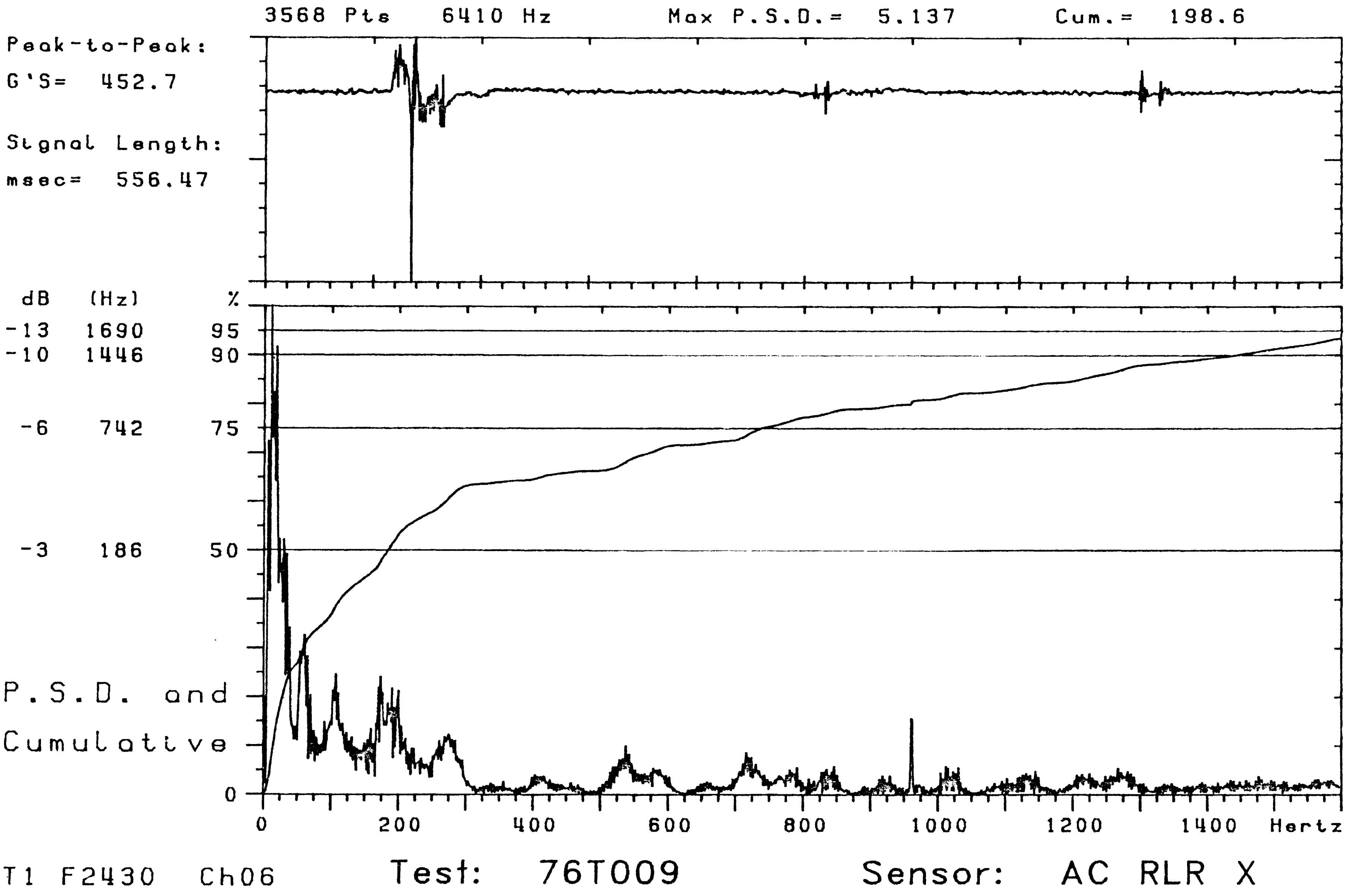

1616 Pts
6410 Hz
Max P.S.D.= 75.05
Cum.= 1804.
Peak-to-Peak:
G'S= 748.0
Signal Length:
msec= 251.95
dB
(Hz)
%
-13
1174
95
-10
986
90
-6
676
75
-3
313
50
P.S.D. and
Cumulative
0
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2385
Ch05
Test: 76T003
Sensor: AC LUR Y

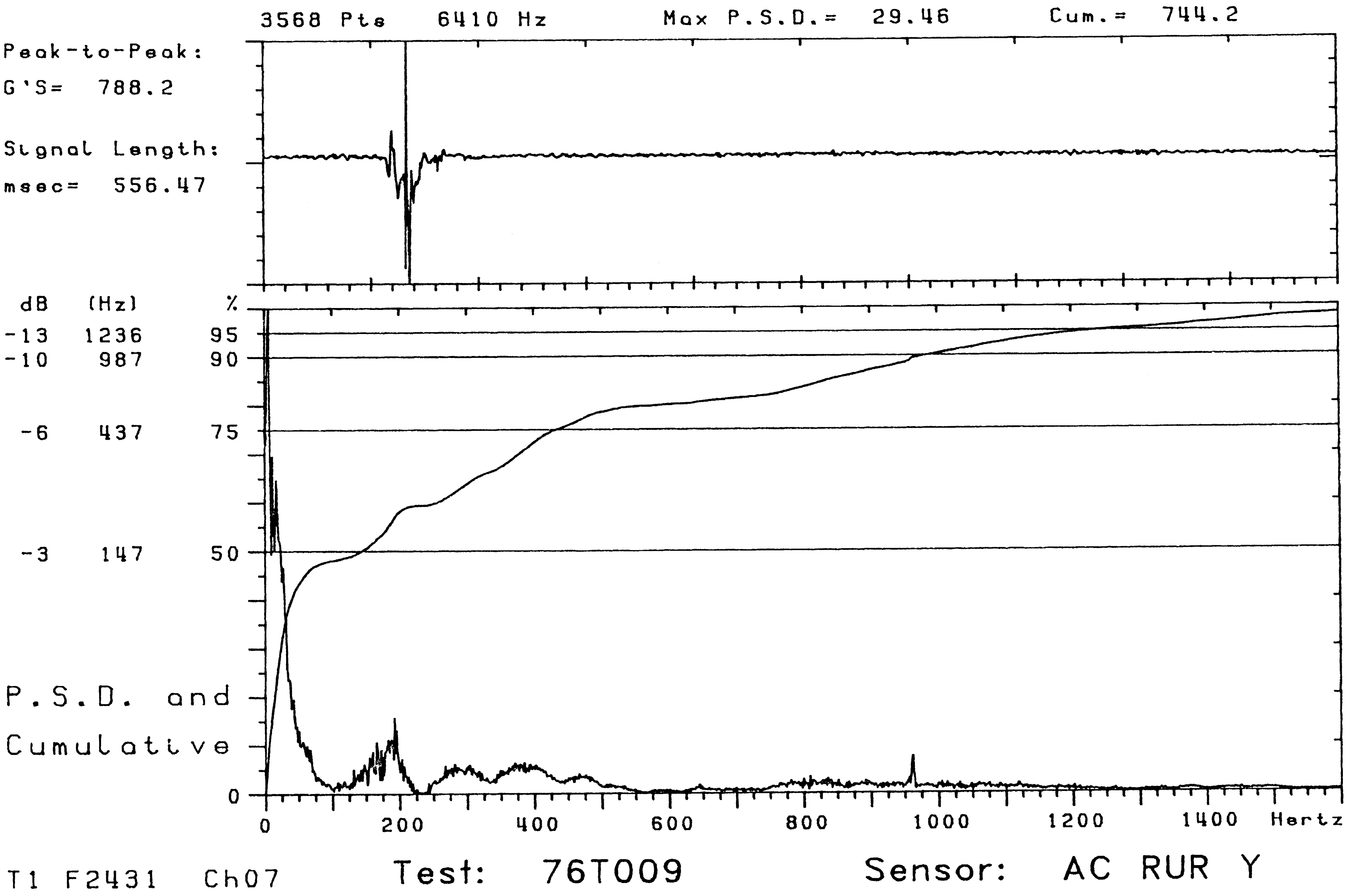

1488 Pts
6410 Hz
Max P.S.D.= 108.3
Cum.= 554.1
Peak-to-Peak:
G'S= 143.5
Signal Length:
msec= 231.98
dB
(Hz)
%
-13
1171
95
-10
613
90
-6
69
75
-3
22
50
P.S.D. and
Cumulative
0
0
10
20
30
40
50
60
70
Hertz
T1 F2401
Ch03
Test: 76T008
Sensor: AC T01 Z

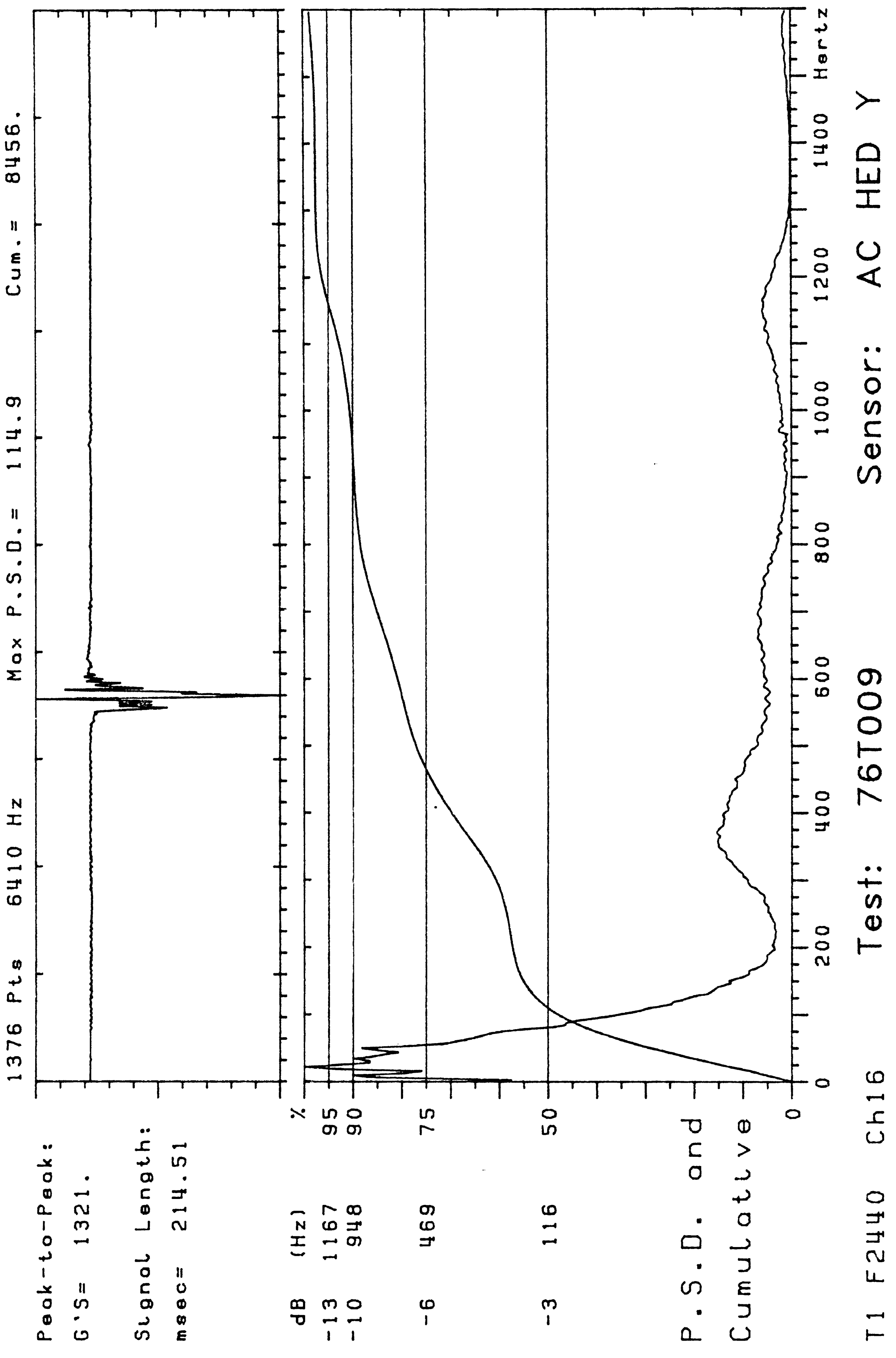

1488 Pts 6410 Hz
Max P.S.D.= 108.3
Cum.= 554.1
Peak-to-Peak:
G'S= 143.5
Signal Length:
msec= 231.98
dB (Hz) %
-13 1171 95
-10 613 90
-6 69 75
-3 22 50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2401 Ch03
Test: 76T008
Sensor: AC T01 Z

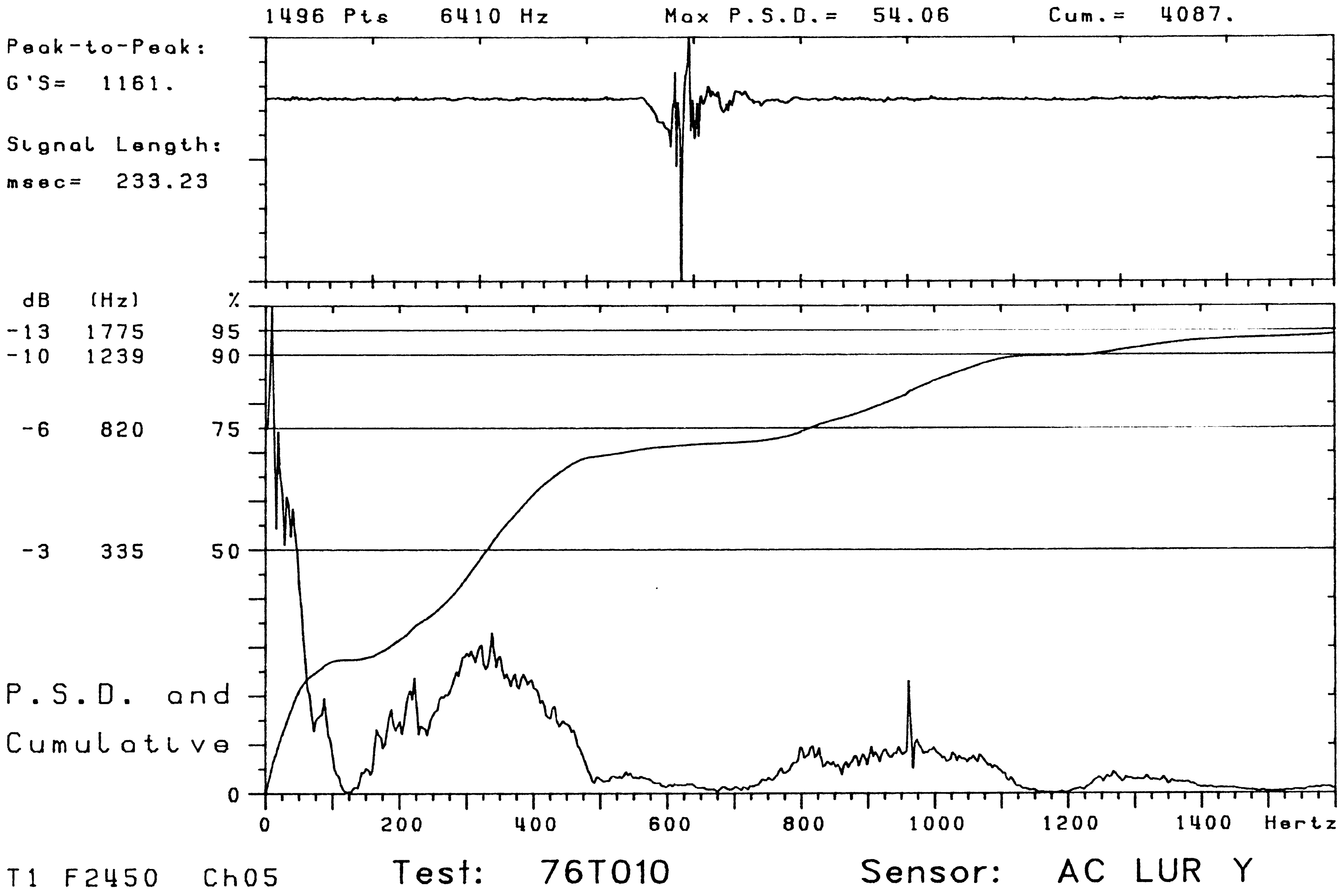

1488 Pts
6410 Hz
Max P.S.D.= 5.596
Cum.= 83.75
Peak-to-Peak:
G'S= 47.34
Signal Length:
msec= 231.98
dB
(Hz)
%
-13
1020
95
-10
864
90
-6
175
75
-3
34
50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2403 Ch05
Test: 76T008
Sensor: AC T12 Y

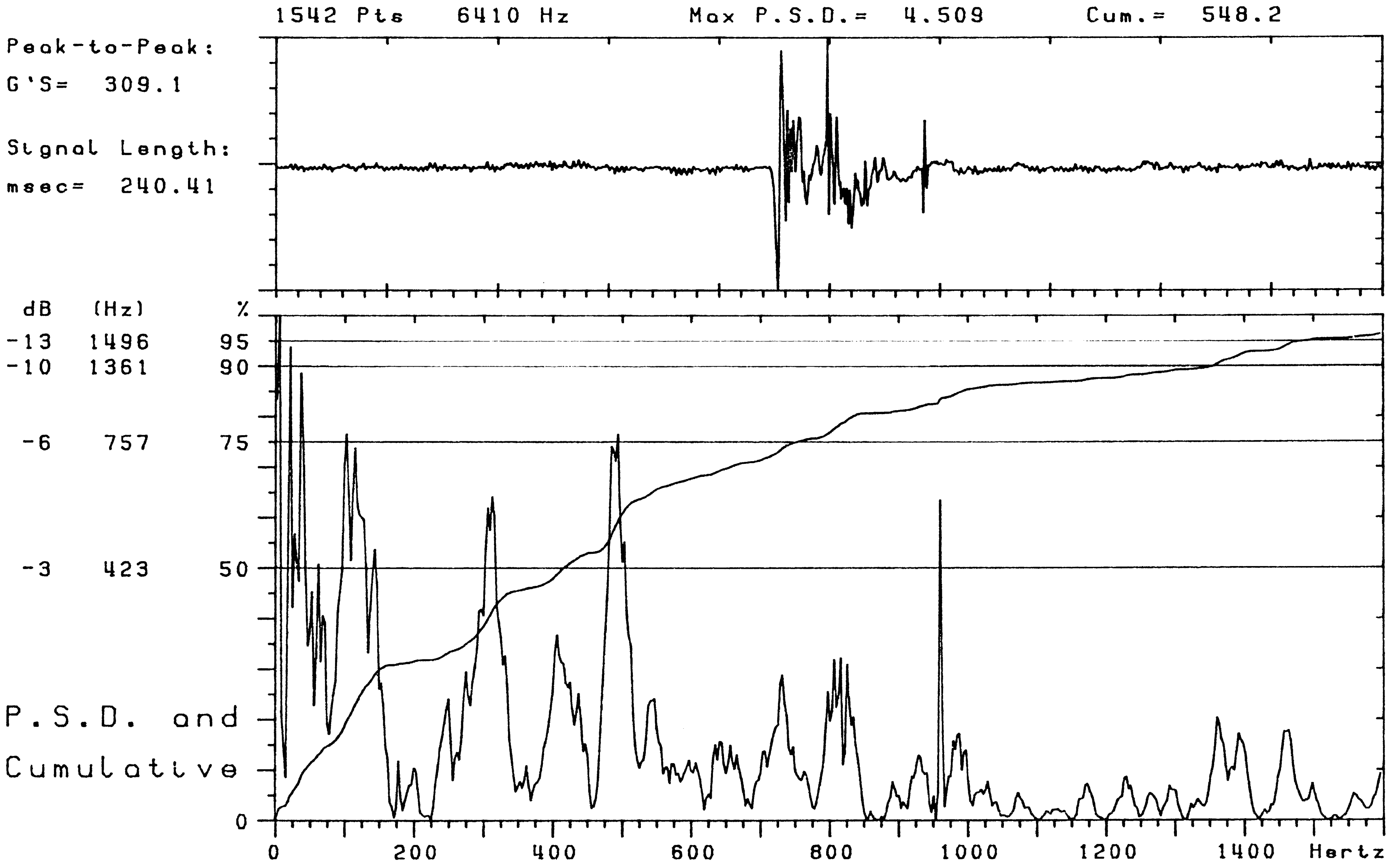

3568 Pts
6410 Hz
Max P.S.D.= 47.26
Cum.= 2953.
Peak-to-Peak:
G'S= 1335.
Signal Length:
msec= 556.47
dB
(Hz)
%
-13
1321
95
-10
1128
90
-6
246
75
-3
127
50
P.S.D. and
Cumulative
0
0
100
200
300
400
500
600
700
Hertz
T1 F2429
Ch05
Test: 76T009
Sensor: AC LUR Y


3568 Pts 6410 Hz Max P.S.D.= 5.137 Cum.= 198.6
Peak-to-Peak:
G'S= 452.7
Signal Length:
msec= 556.47
dB (Hz) %
-13 1690 95
-10 1446 90
-6 742 75
-3 186 50
P.S.D. and
Cumulative
0
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2430 Ch06
Test: 76T009
Sensor: AC RLR X

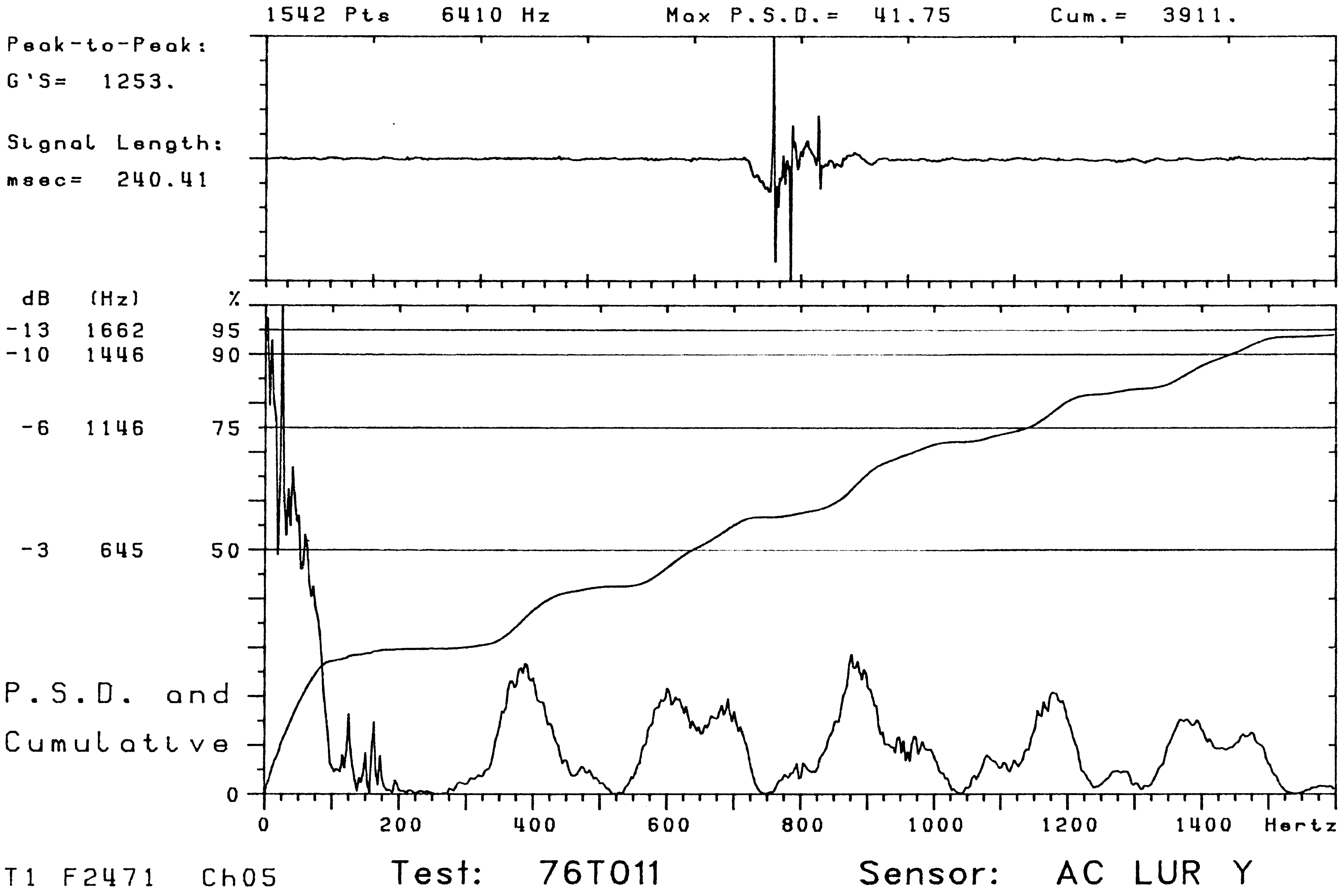

3568 Pts
6410 Hz
Max P.S.D.= 29.46
Cum.= 744.2
Peak-to-Peak:
G'S= 788.2
Signal Length:
msec= 556.47
dB
(Hz)
%
-13
1236
95
-10
987
90
-6
437
75
-3
147
50
P.S.D. and
Cumulative
0
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2431 Ch07
Test: 76T009
Sensor: AC RUR Y

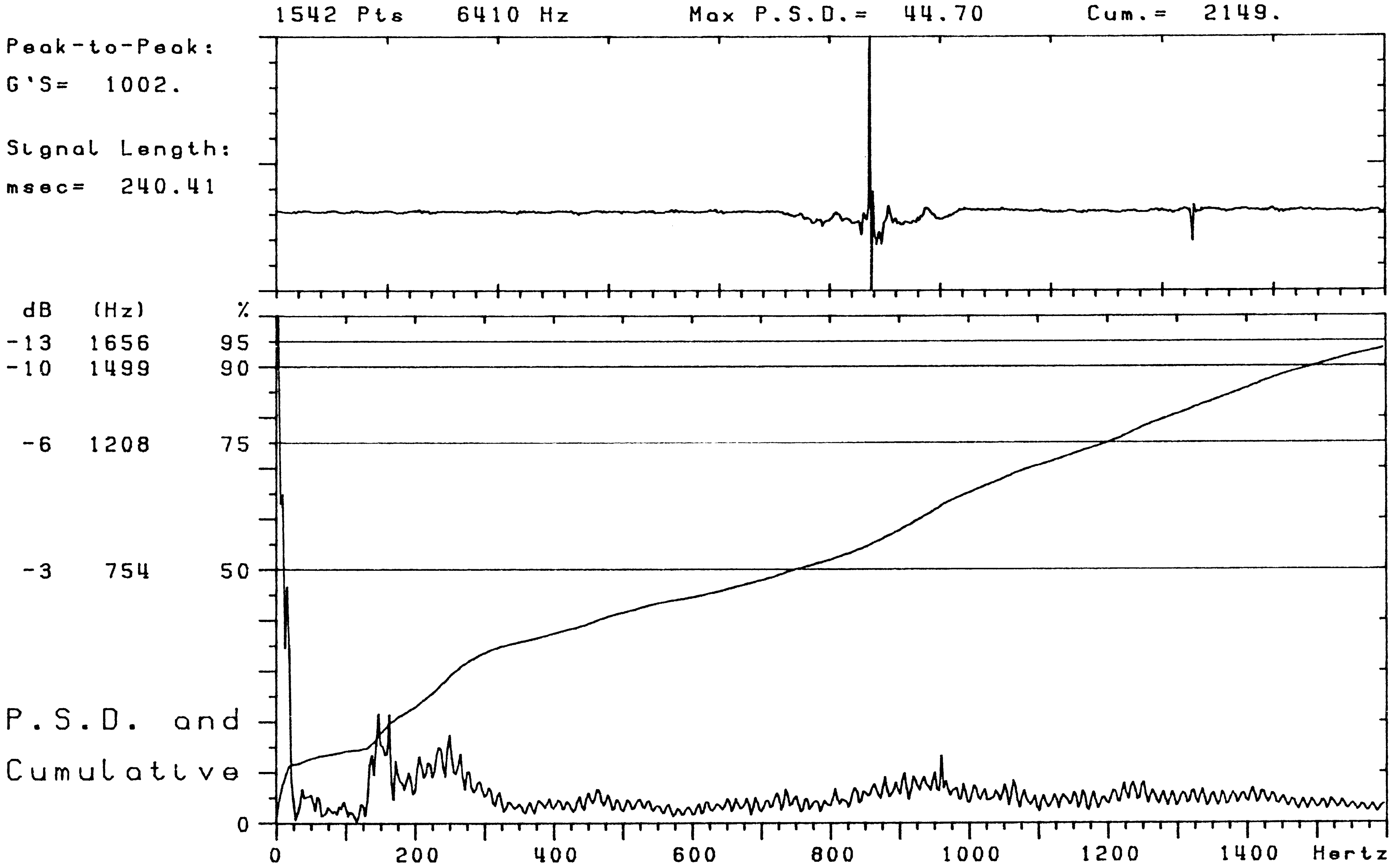

1376 Pts 6410 Hz Max P.S.D.= 114.9 Cum.= 8456.
Peak-to-Peak:
G'S= 1321.
Signal Length:
msec= 214.51
dB (Hz)
-13 1167
-10 948
-6 469
-3 116
P.S.D. and
Cumulative
%
95
90
75
50
0
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2440 Ch16
Test: 76T009 Sensor: AC HED Y


1496 Pts 6410 Hz
Max P.S.D.= 54.06
Cum.= 4087.
Peak-to-Peak:
G'S= 1161.
Signal Length:
msec= 233.23
dB (Hz) %
-13 1775 95
-10 1239 90
-6 820 75
-3 335 50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2450 Ch05
Test: 76T010
Sensor: AC LUR Y

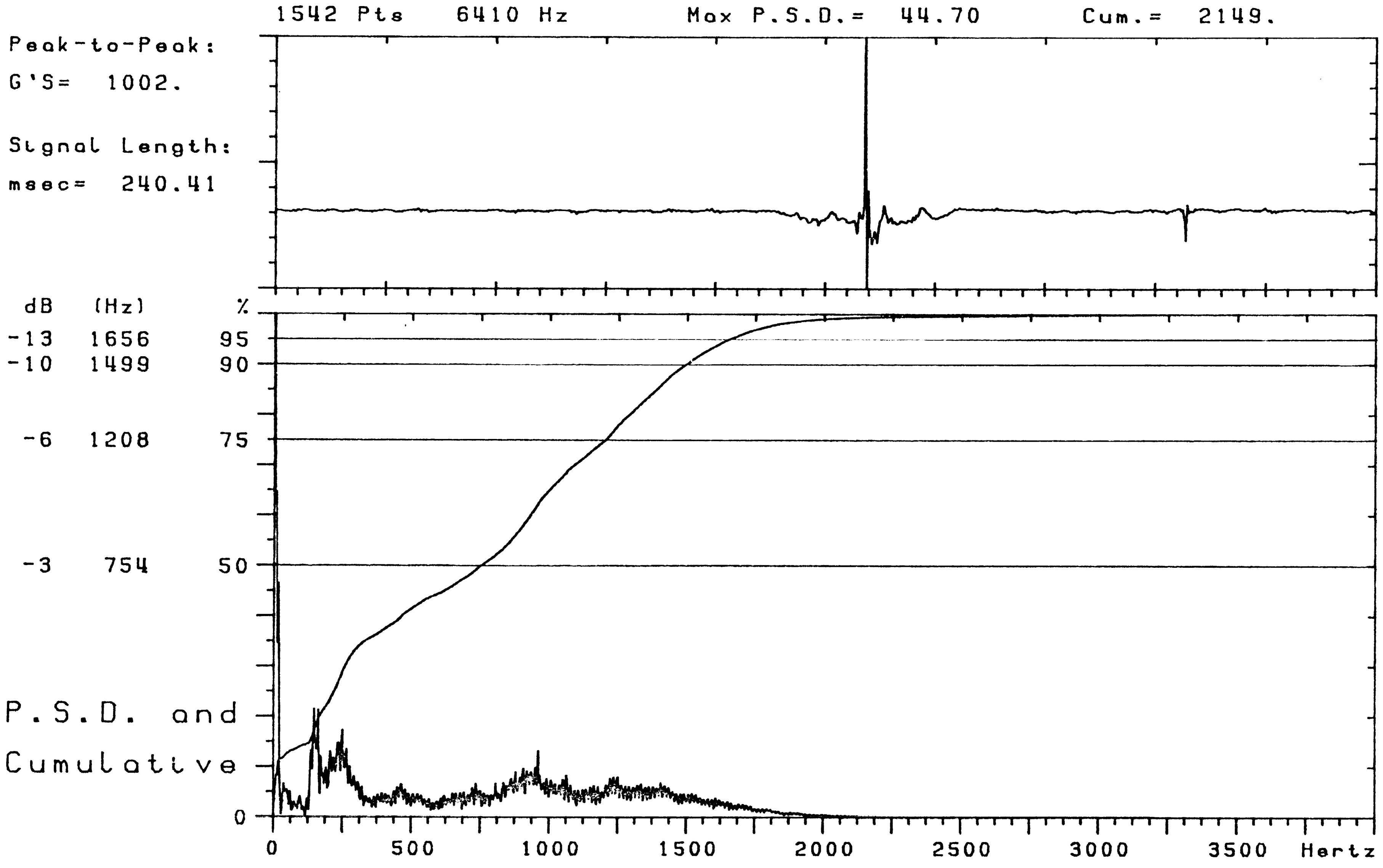


T1 F2470 Ch04 Test: 76T011 Sensor: AC LLR X

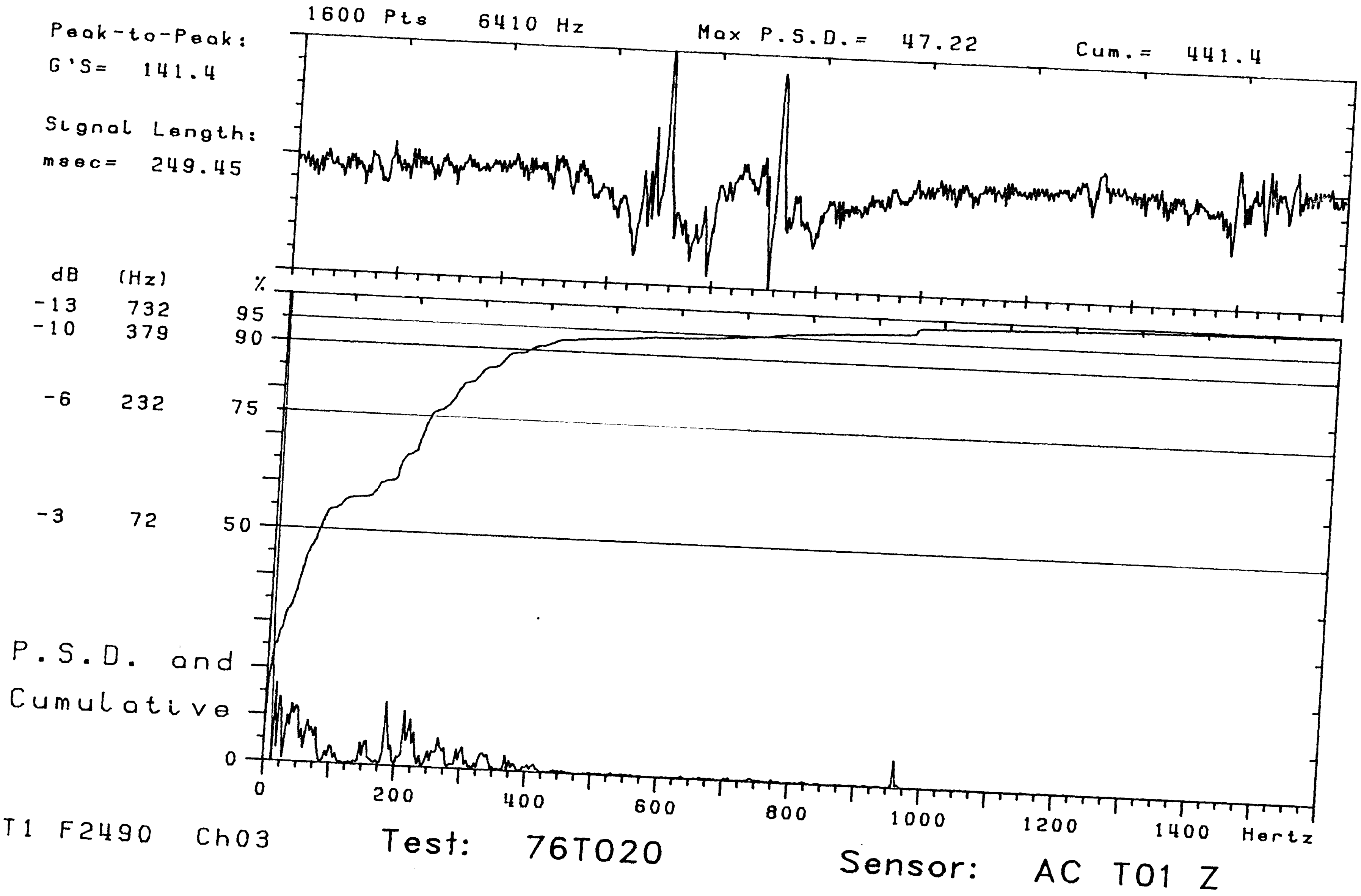

1542 Pts 6410 Hz
Max P.S.D.= 41.75
Cum.= 3911.
Peak-to-Peak:
G'S= 1253.
Signal Length:
msec= 240.41
dB (Hz) %
-13 1662 95
-10 1446 90
-6 1146 75
-3 645 50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2471 Ch05
Test: 76T011
Sensor: AC LUR Y

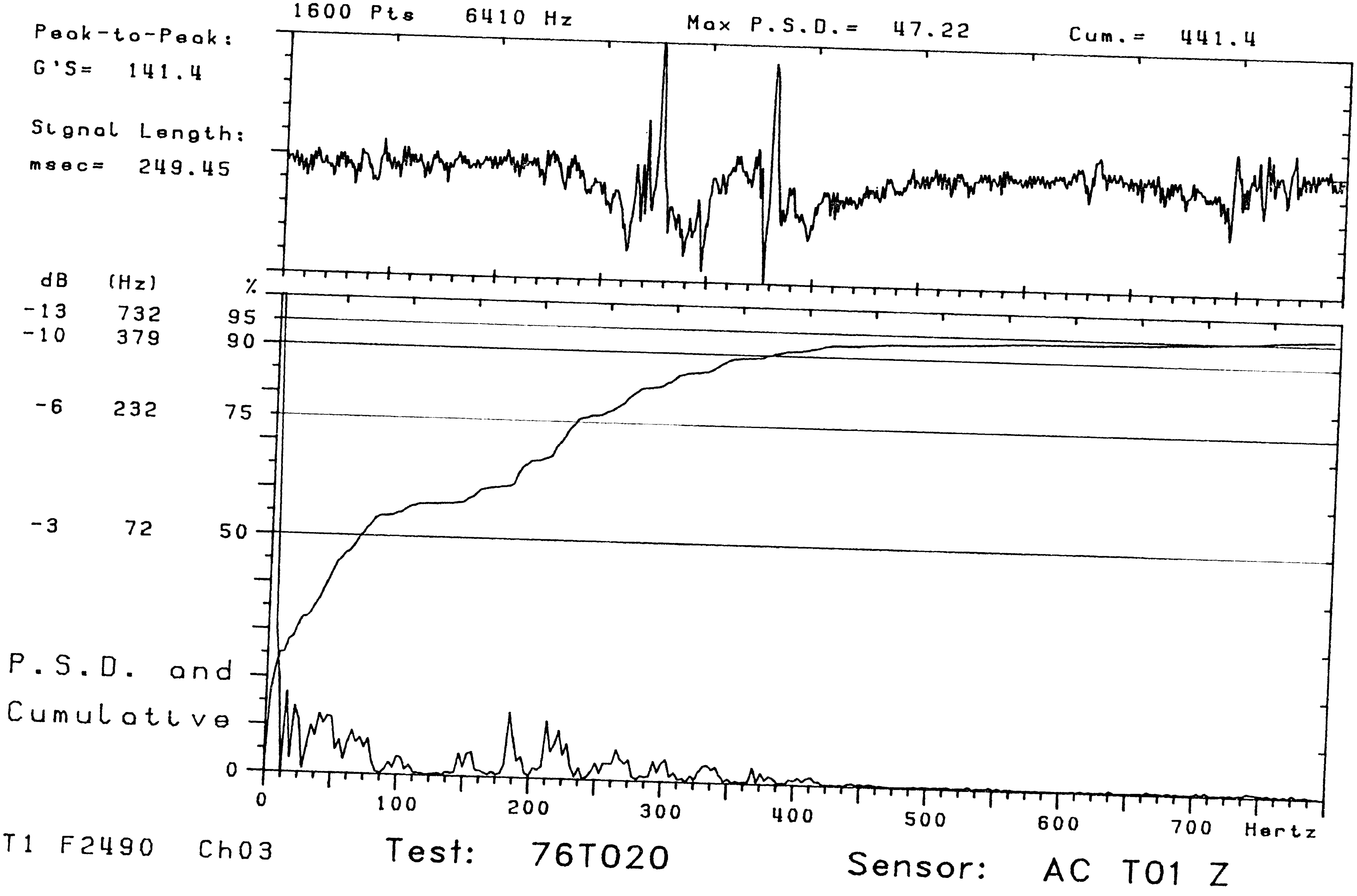


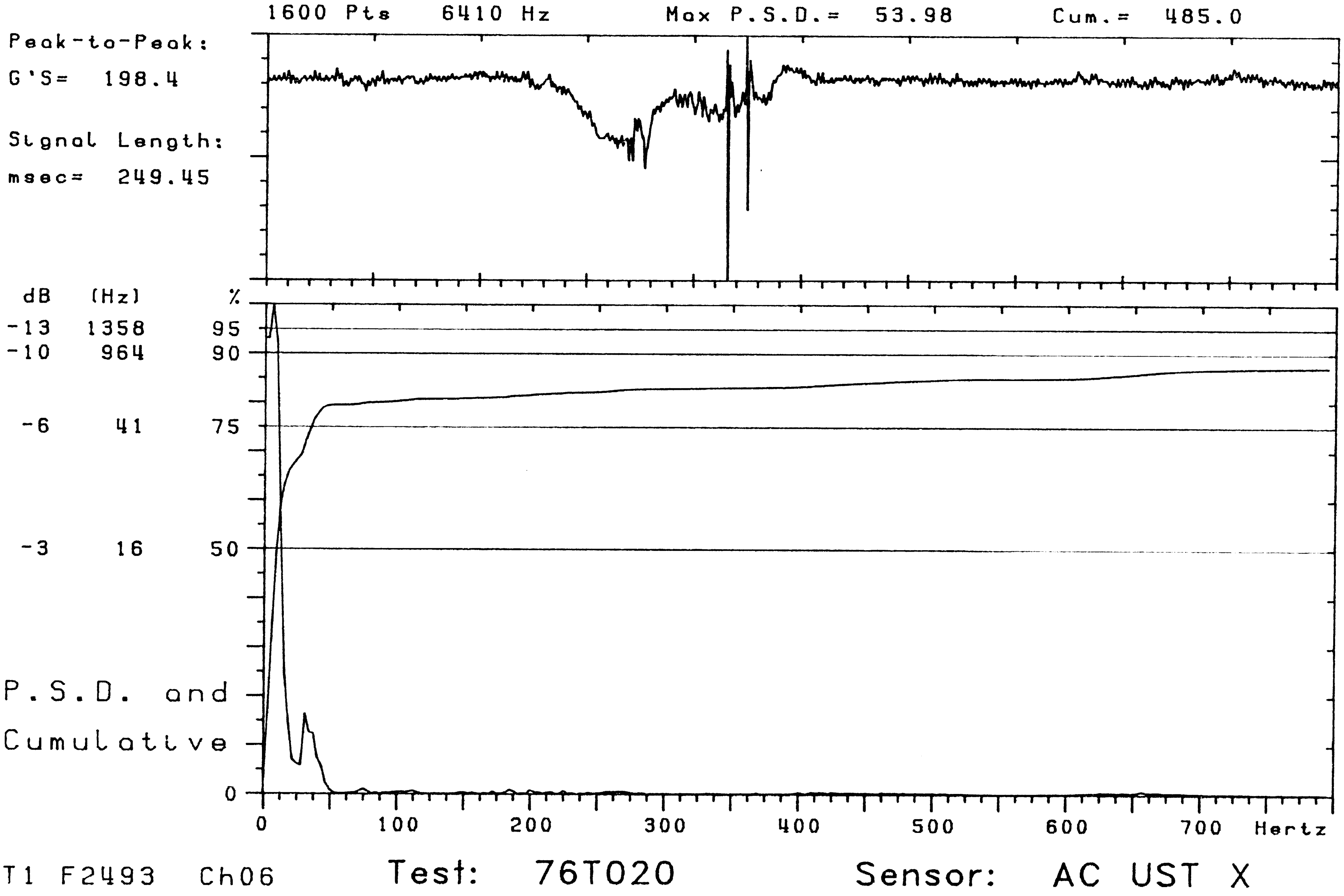
T1 F2473 Ch07 Test: 76T011 Sensor: AC RUR Y

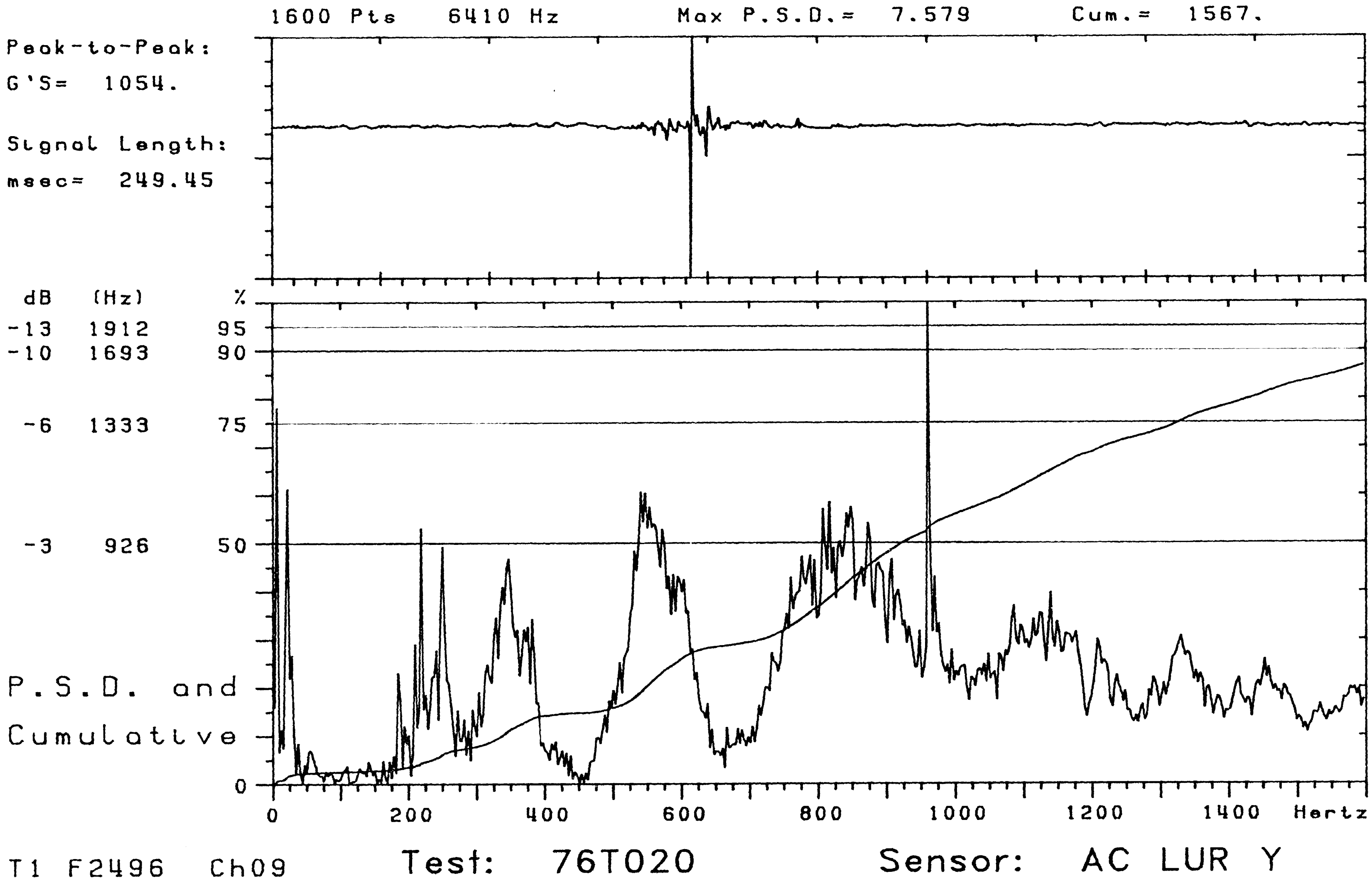


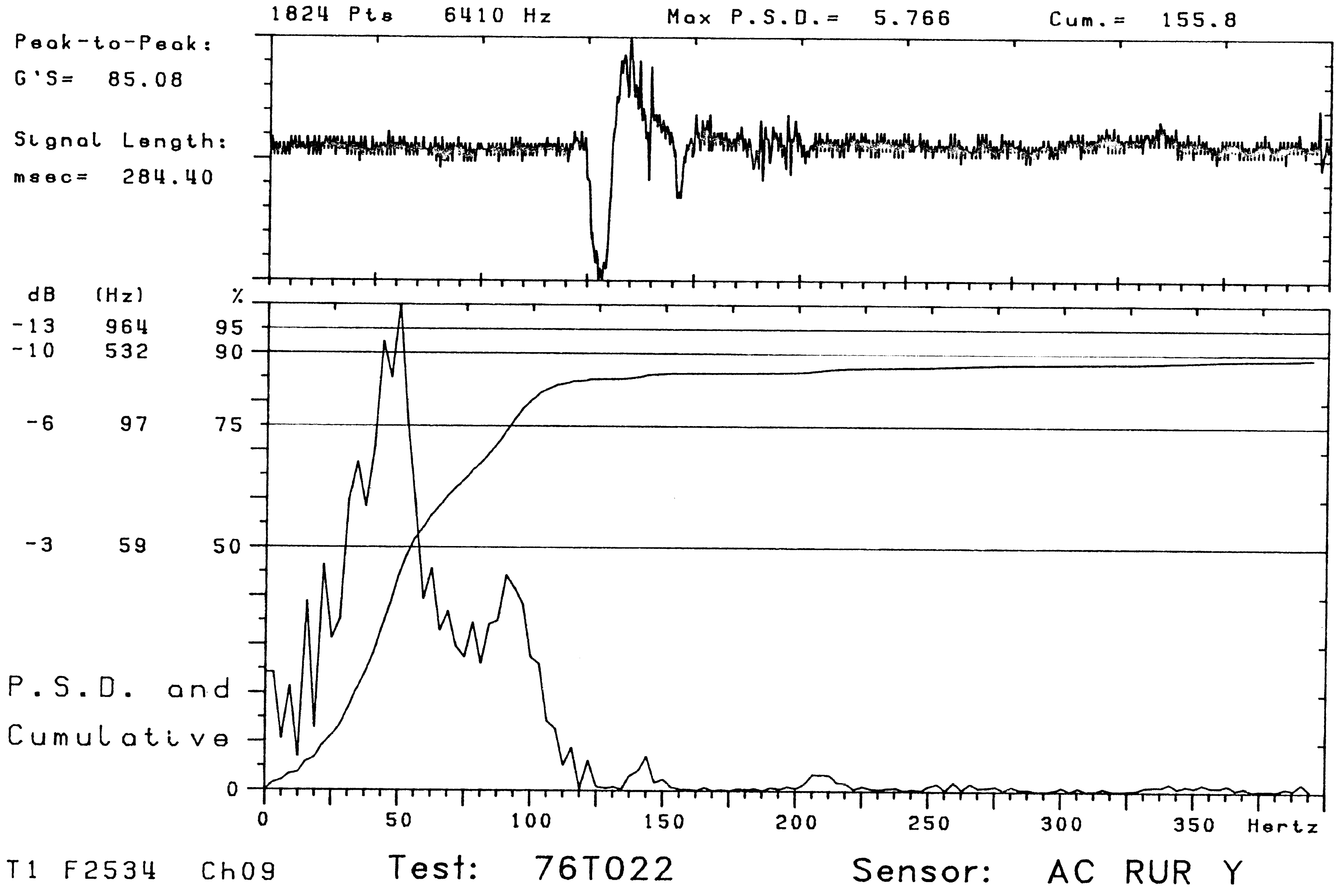
T1 F2473 Ch07 Test: 76T011 Sensor: AC RUR Y

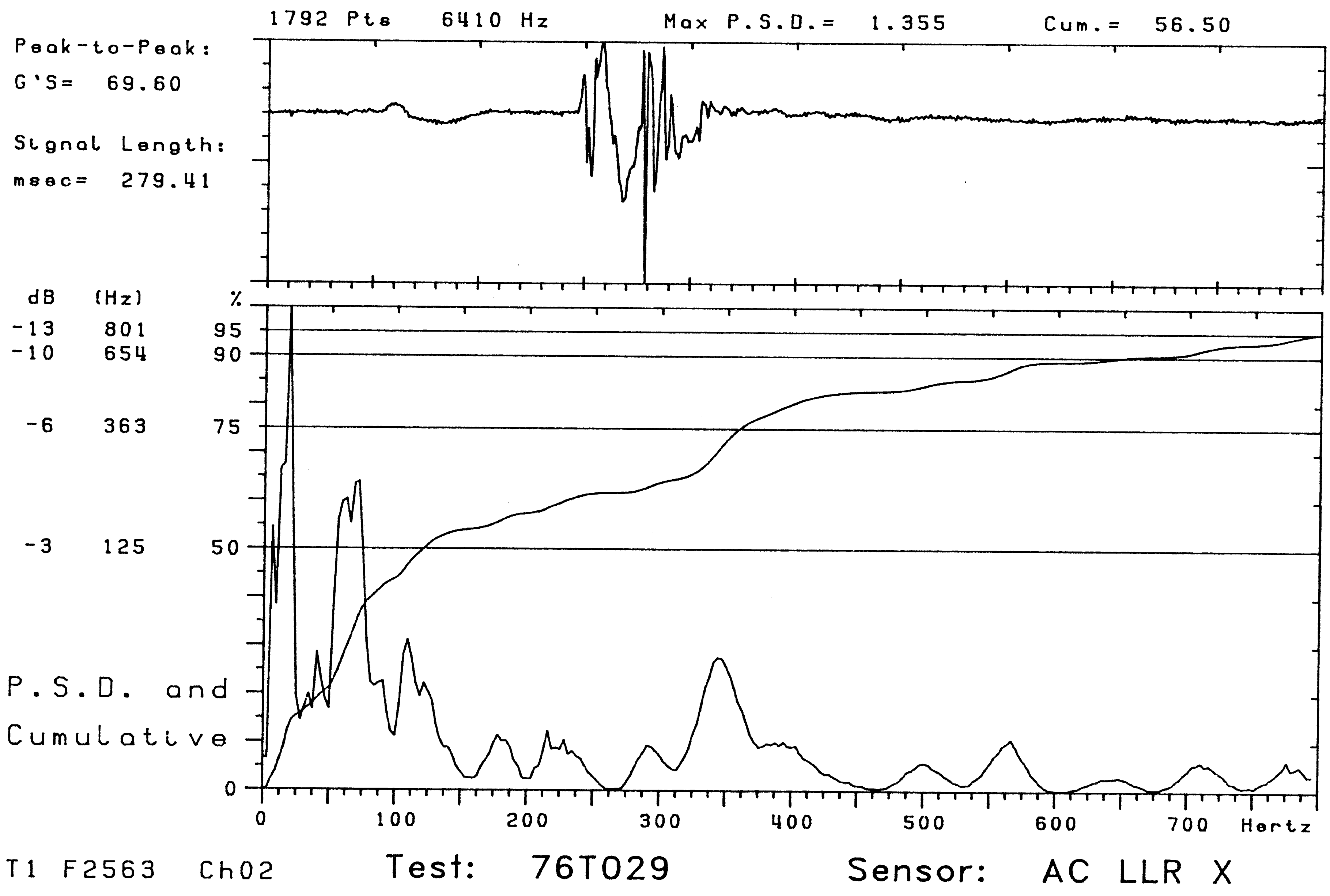

Peak-to-Peak:
G'S= 141.4
Signal Length:
msec= 249.45
1600 Pts 6410 Hz
Max P.S.D.= 47.22
Cum.= 441.4
dB (Hz)
-13 732
-10 379
-6 232
-3 72
%
95
90
75
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2490 Ch03
Test: 76T020
Sensor: AC T01 Z

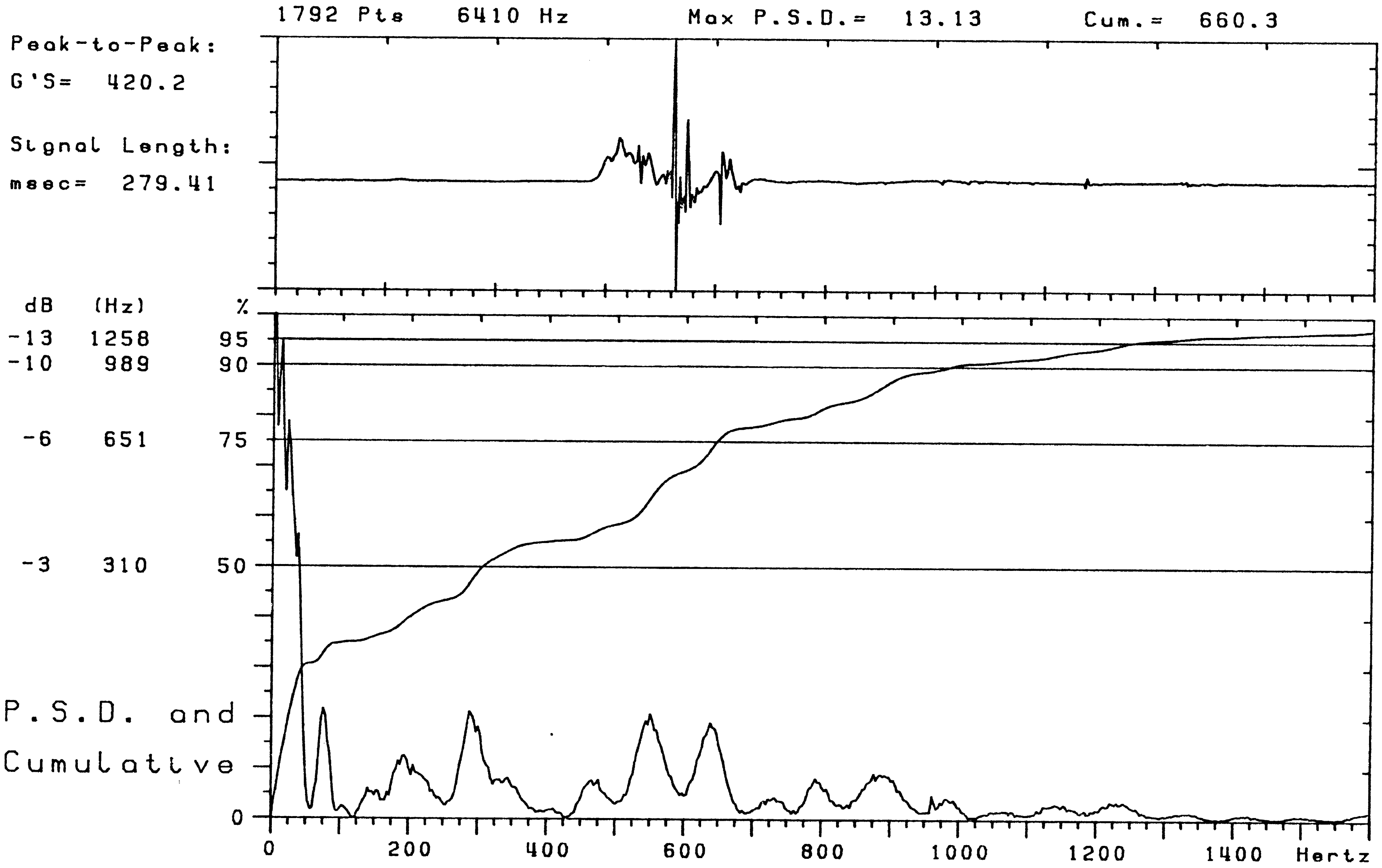

1600 Pts
6410 Hz
Max P.S.D.= 47.22
Cum.= 441.4
Peak-to-Peak:
G'S= 141.4
Signal Length:
msec= 249.45
dB
(Hz)
%
-13
732
95
-10
379
90
-6
232
75
-3
72
50
P.S.D. and
Cumulative
0
0
100
200
300
400
500
600
700
Hertz
T1 F2490
Ch03
Test: 76T020
Sensor: AC T01 Z


1600 Pts
6410 Hz
Max P.S.D.= 53.98
Cum.= 485.0
Peak-to-Peak:
G'S= 198.4
Signal Length:
msec= 249.45
dB
(Hz)
%
-13
1358
95
-10
964
90
-6
41
75
-3
16
50
P.S.D. and
Cumulative
0
0
100
200
300
400
500
600
700
Hertz
T1 F2493 Ch06
Test: 76T020
Sensor: AC UST X

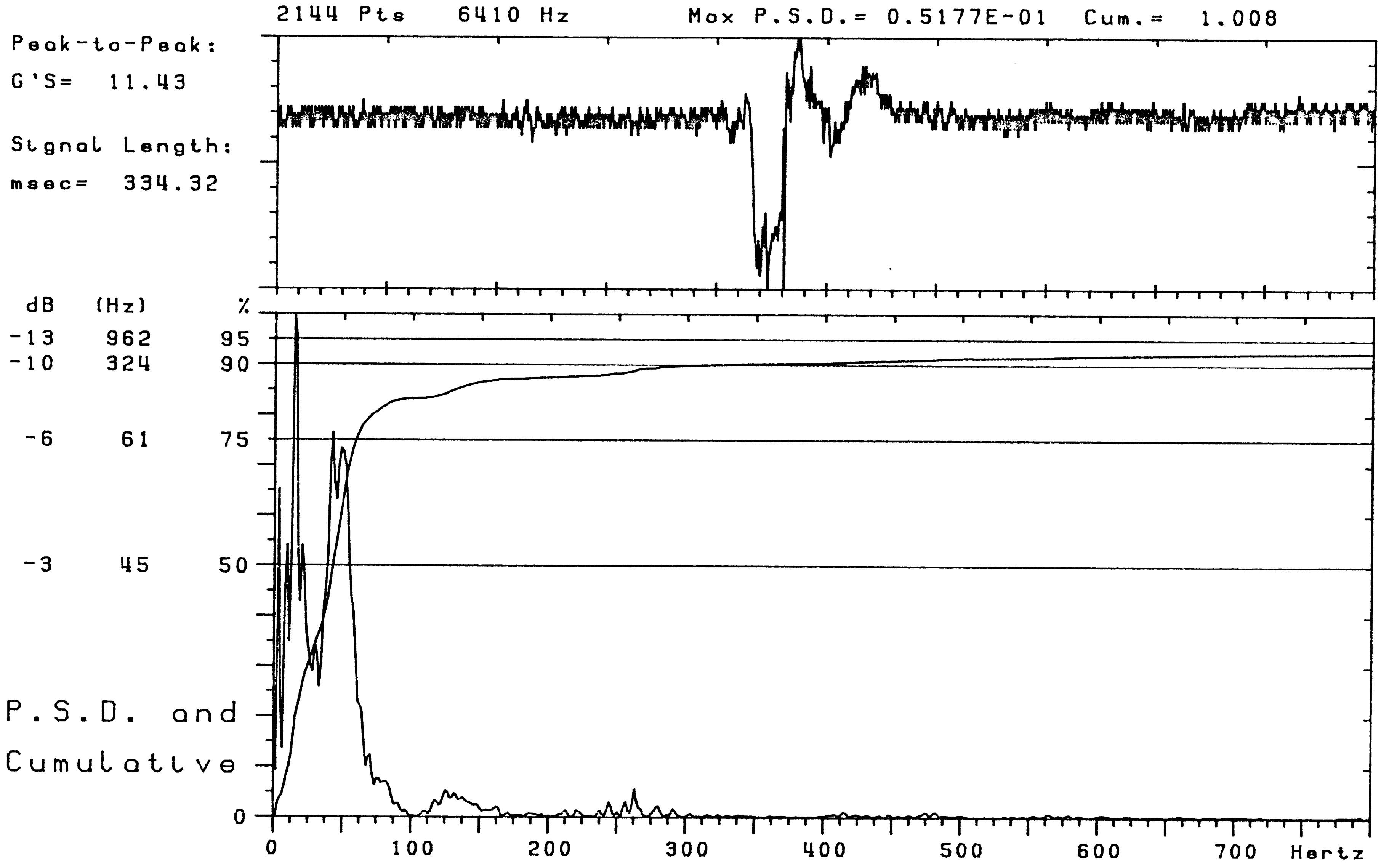

1600 Pts 6410 Hz
Max P.S.D.= 7.579
Cum.= 1567.
Peak-to-Peak:
G'S= 1054.
Signal Length:
msec= 249.45
dB (Hz)
-13 1912
-10 1693
-6 1333
-3 926
%
95
90
75
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2496 Ch09
Test: 76T020
Sensor: AC LUR Y


1824 Pts
6410 Hz
Max P.S.D.= 5.766
Cum.= 155.8
Peak-to-Peak:
G'S= 85.08
Signal Length:
msec= 284.40
dB
(Hz)
%
-13
964
95
-10
532
90
-6
97
75
-3
59
50
P.S.D. and
Cumulative
0
0
50
100
150
200
250
300
350
Hertz
T1 F2534 Ch09
Test: 76T022
Sensor: AC RUR Y

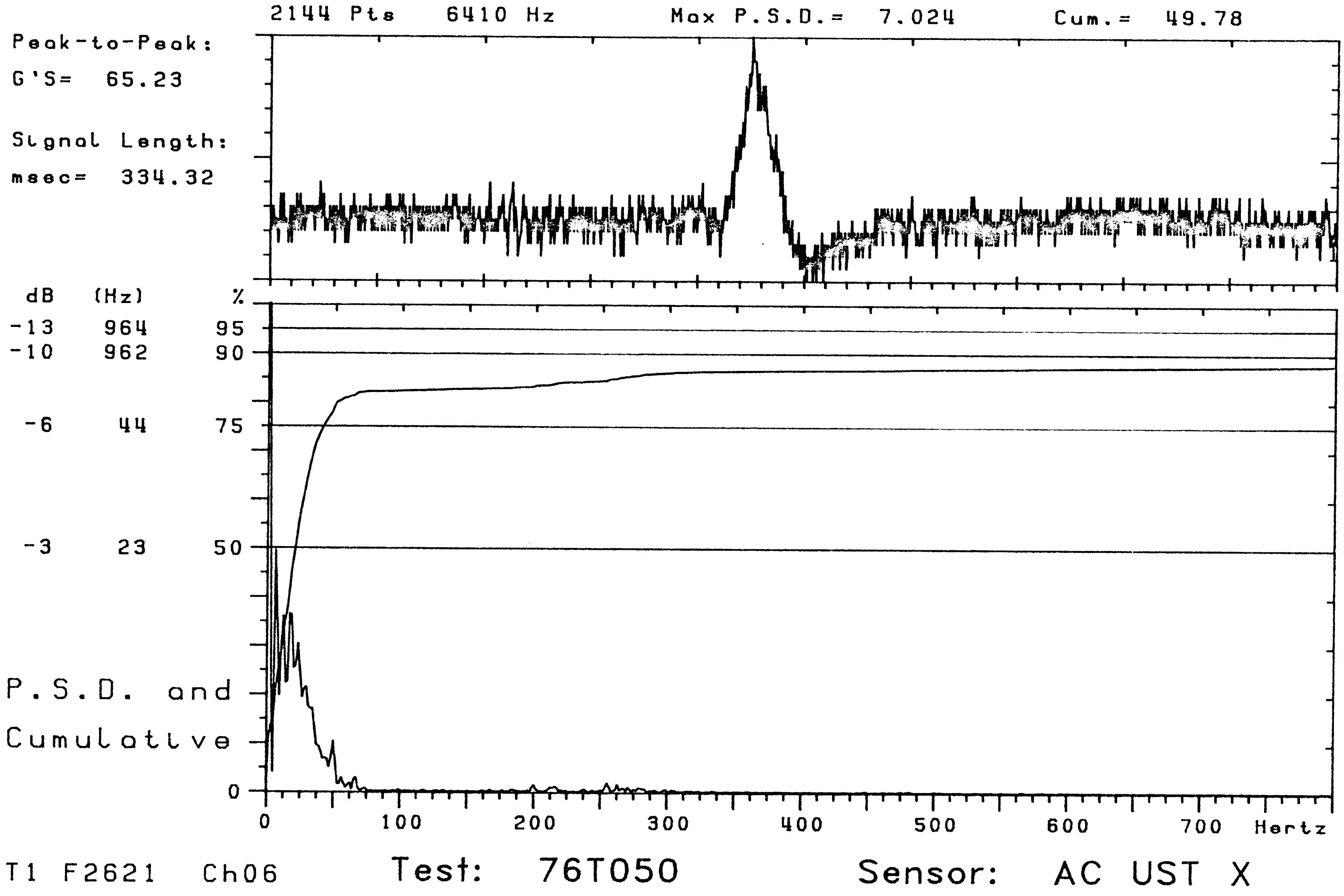

1792 Pts 6410 Hz
Max P.S.D.= 1.355
Cum.= 56.50
Peak-to-Peak:
G'S= 69.60
Signal Length:
msec= 279.41
dB (Hz) %
-13 801 95
-10 654 90
-6 363 75
-3 125 50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2563 Ch02
Test: 76T029
Sensor: AC LLR X

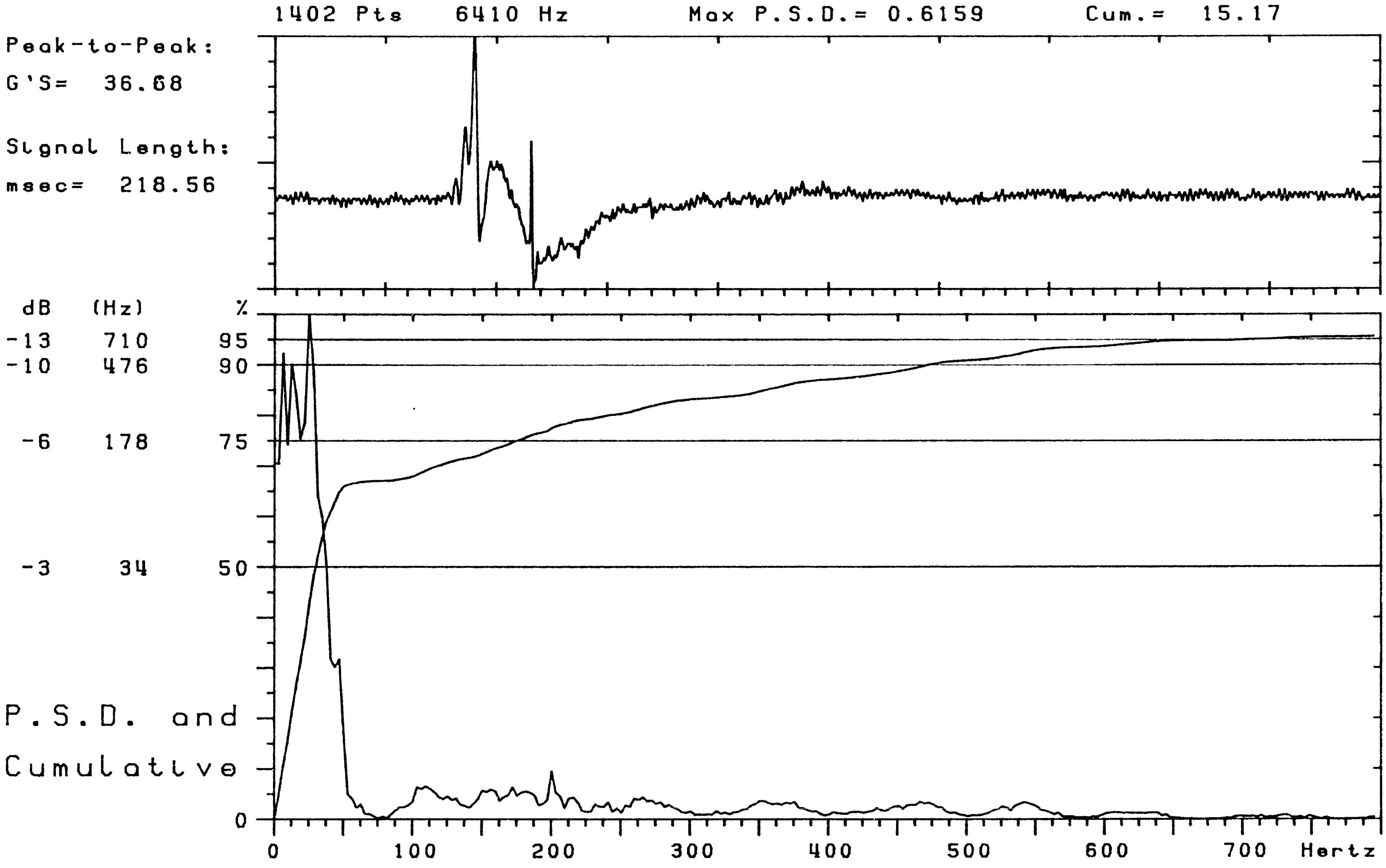


T1 F2564 Ch03 **Test: 76T029** **Sensor: AC LUR Y**

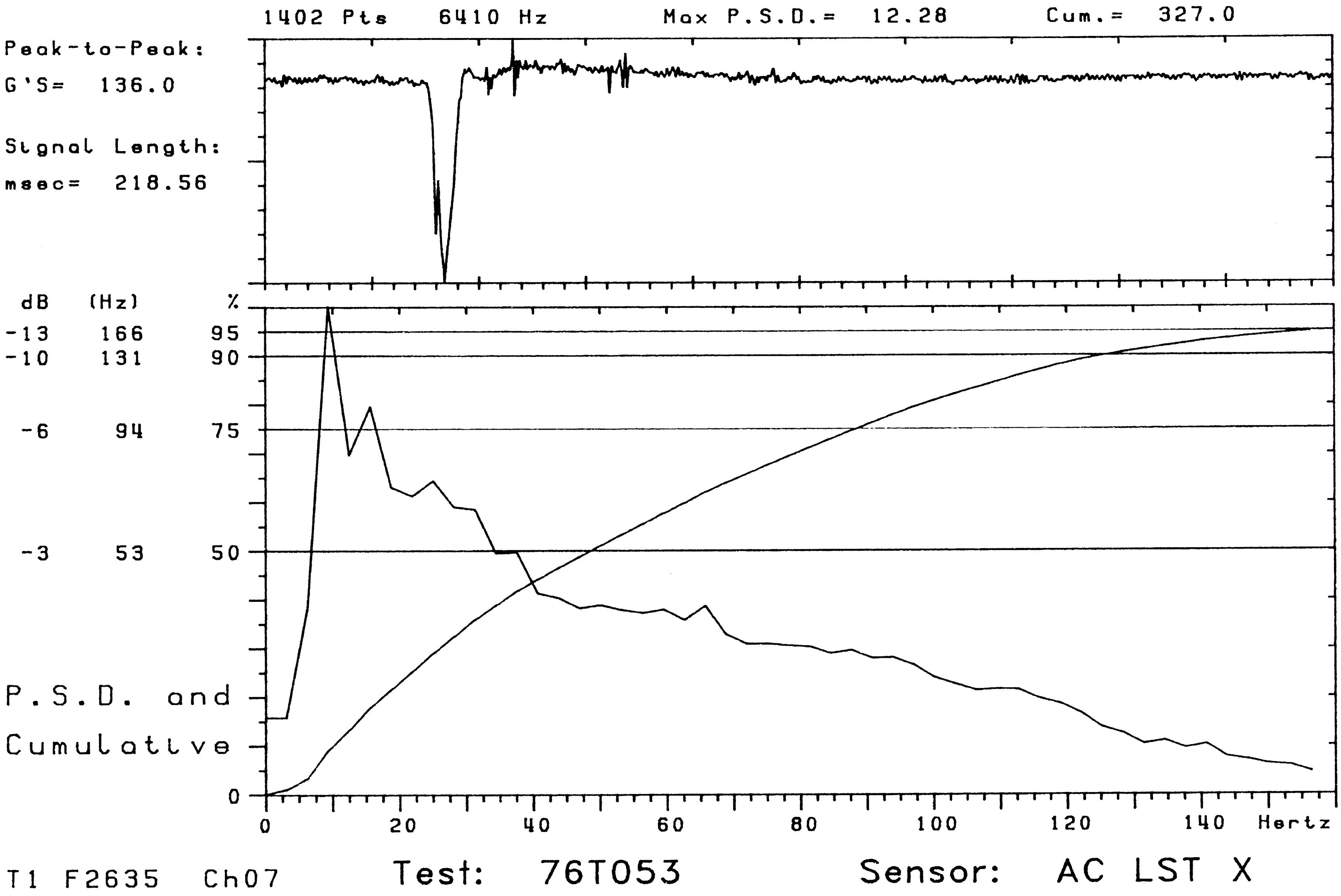


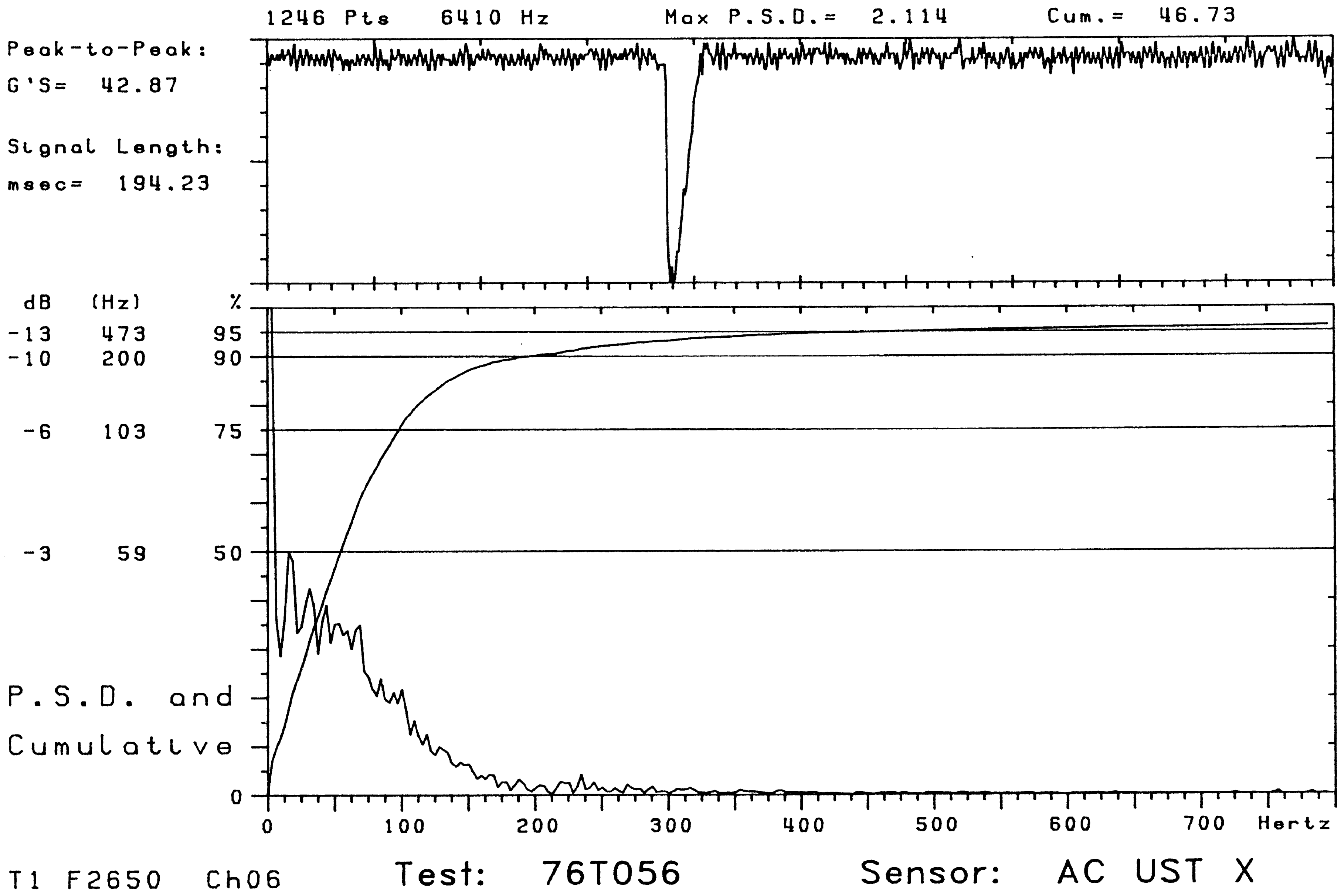
T1 F2617 Ch02 Test: 76T050 Sensor: AC LUR Y

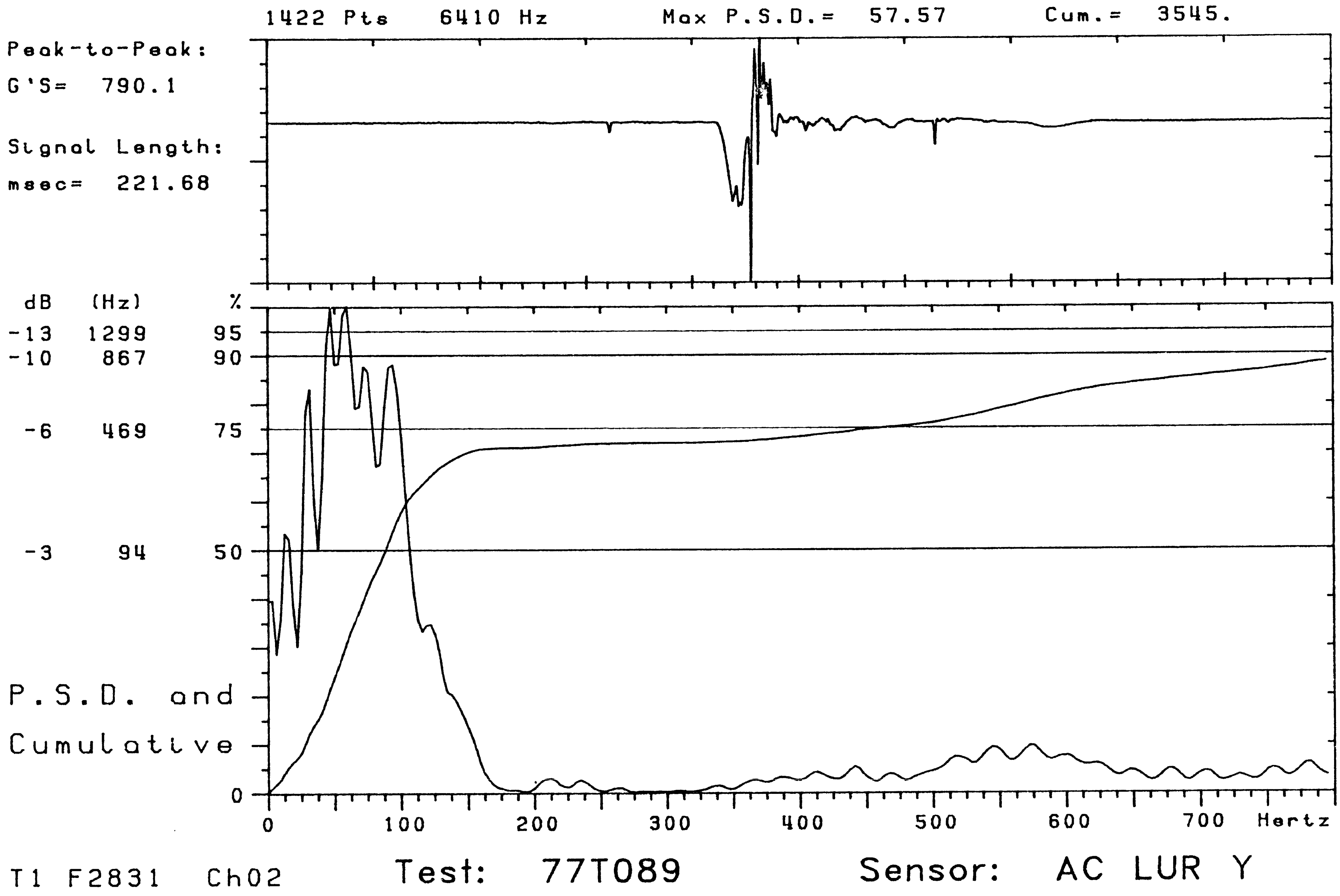

2144 Pts
6410 Hz
Max P.S.D.= 7.024
Cum.= 49.78
Peak-to-Peak:
G'S= 65.23
Signal Length:
msec= 334.32
dB (Hz)
-13 964
-10 962
-6 44
-3 23
%
95
90
75
50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2621 Ch06
Test: 76T050
Sensor: AC UST X

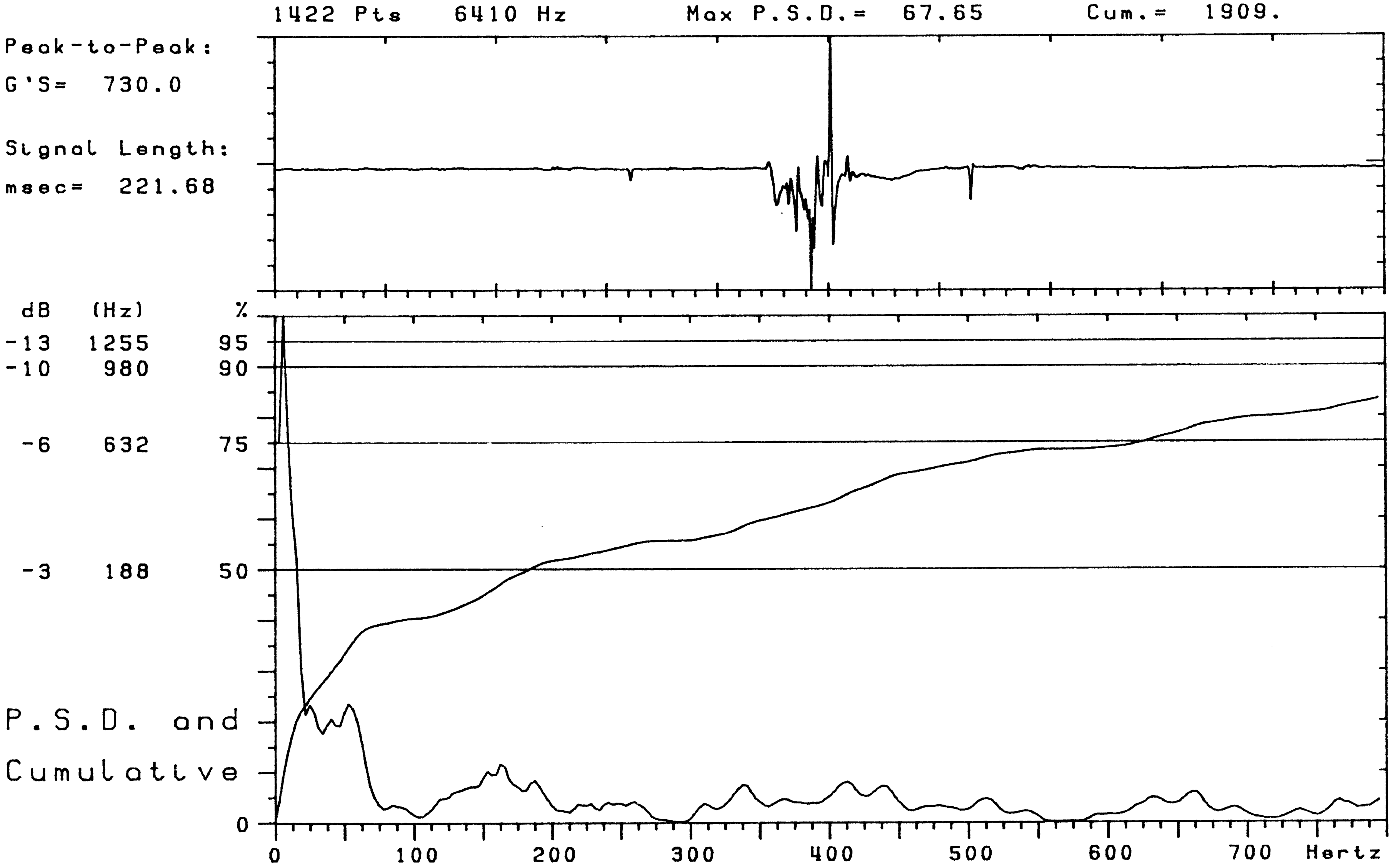


T1 F2630 Ch02 Test: 76T053 Sensor: AC LUR Y

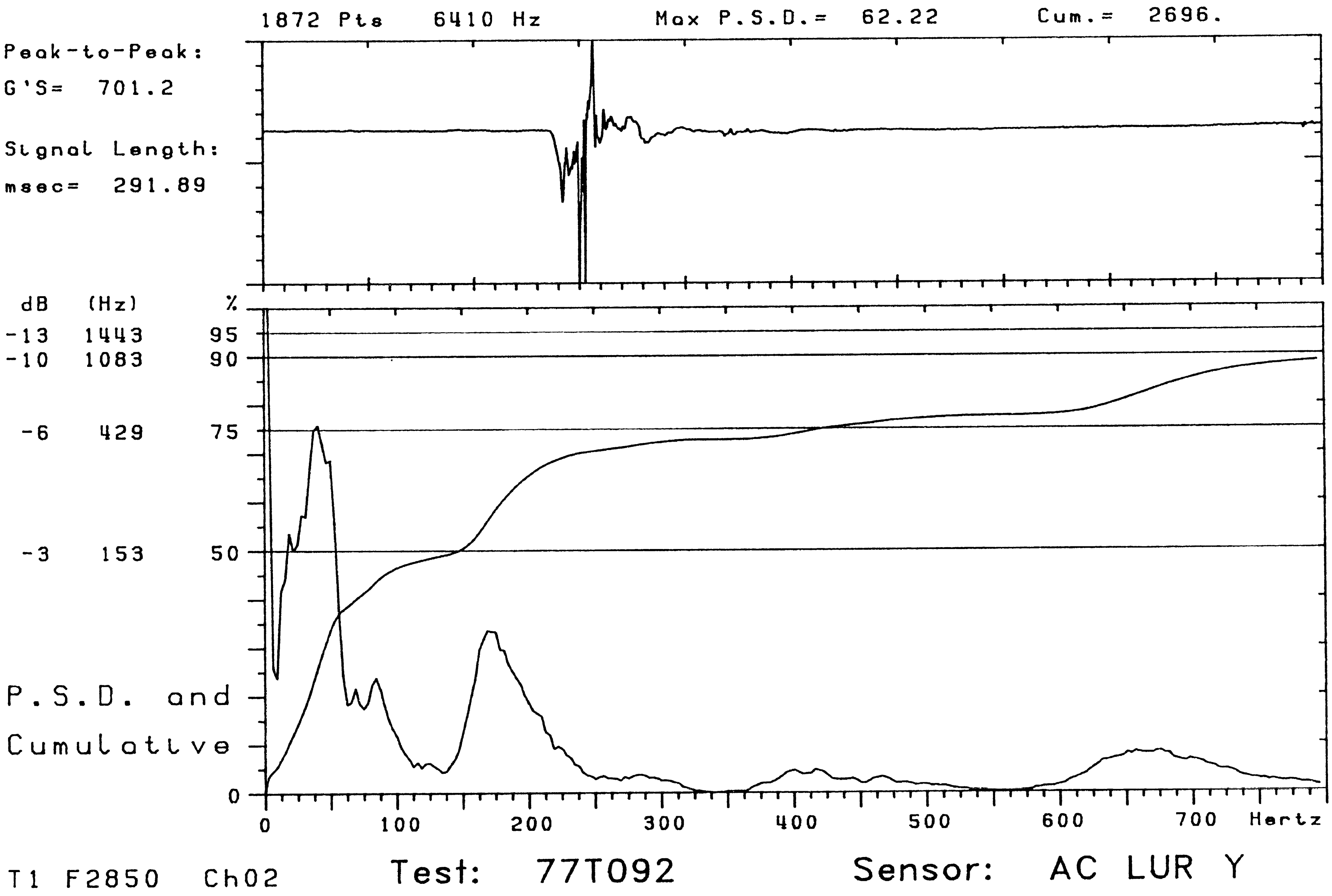

1402 Pts
6410 Hz
Max P.S.D.= 12.28
Cum.= 327.0
Peak-to-Peak:
G'S= 136.0
Signal Length:
msec= 218.56
dB (Hz) %
-13 166 95
-10 131 90
-6 94 75
-3 53 50
0
P.S.D. and
Cumulative
0
20
40
60
80
100
120
140
Hertz
T1 F2635 Ch07
Test: 76T053
Sensor: AC LST X

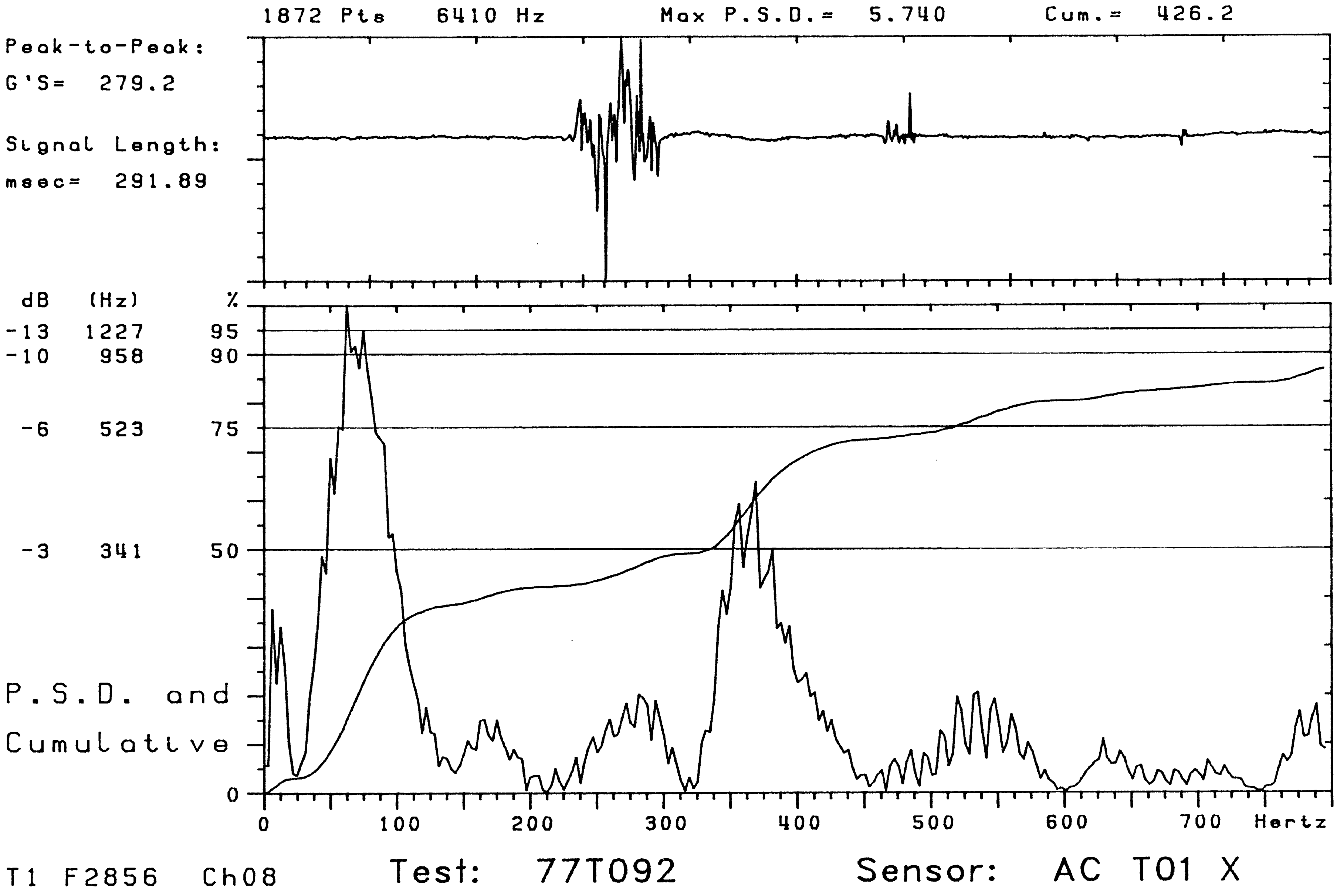

1246 Pts 6410 Hz
Max P.S.D.= 2.114
Cum.= 46.73
Peak-to-Peak:
G'S= 42.87
Signal Length:
msec= 194.23
dB (Hz) %
-13 473 95
-10 200 90
-6 103 75
-3 59 50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2650 Ch06
Test: 76T056
Sensor: AC UST X

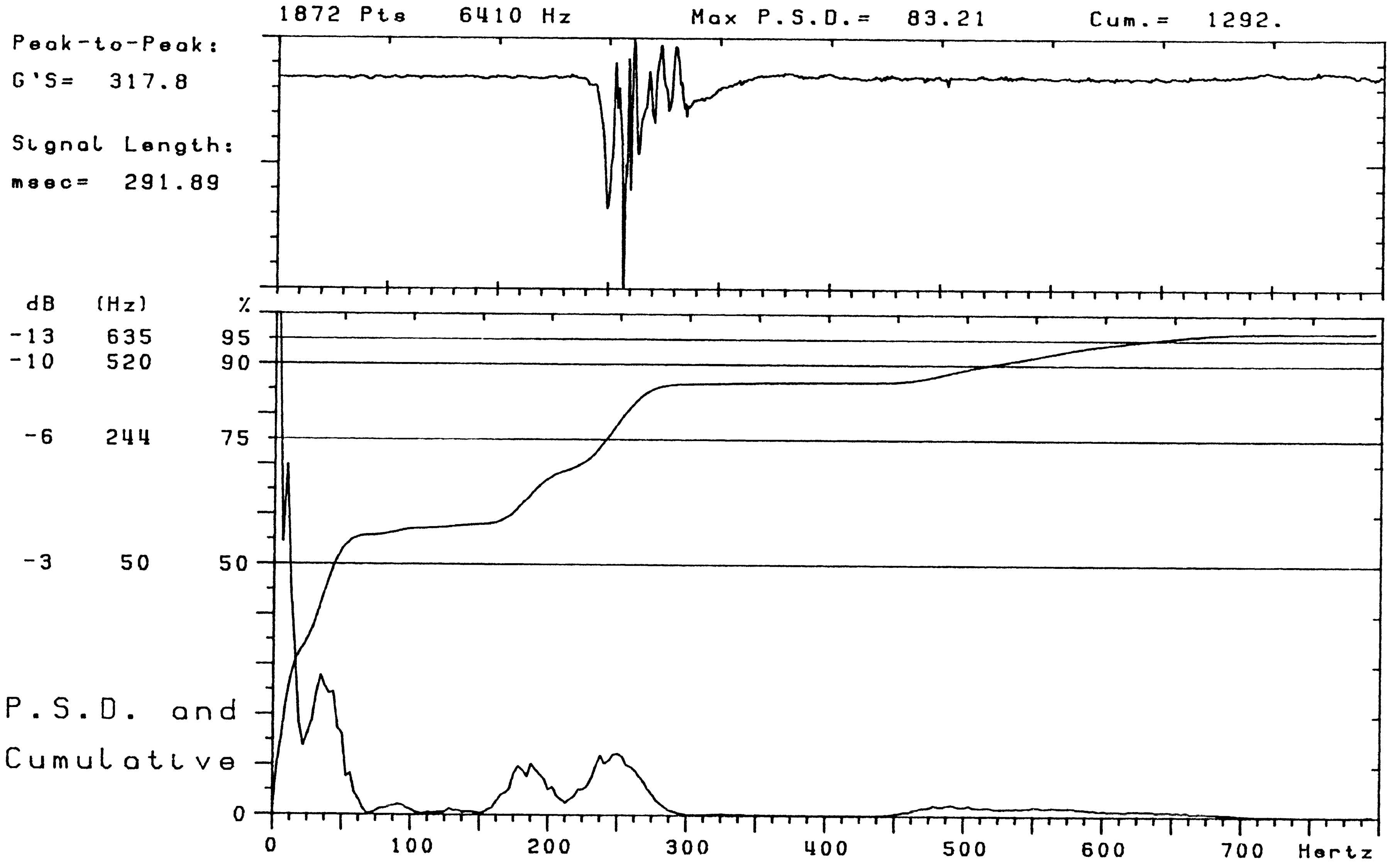

1422 Pts 6410 Hz Max P.S.D.= 57.57 Cum.= 3545.
Peak-to-Peak:
G'S= 790.1
Signal Length:
msec= 221.68
dB (Hz) %
-13 1299 95
-10 867 90
-6 469 75
-3 94 50
P.S.D. and
Cumulative
0
0
100
200
300
400
500
600
700
Hertz
T1 F2831 Ch02
Test: 77T089
Sensor: AC LUR Y



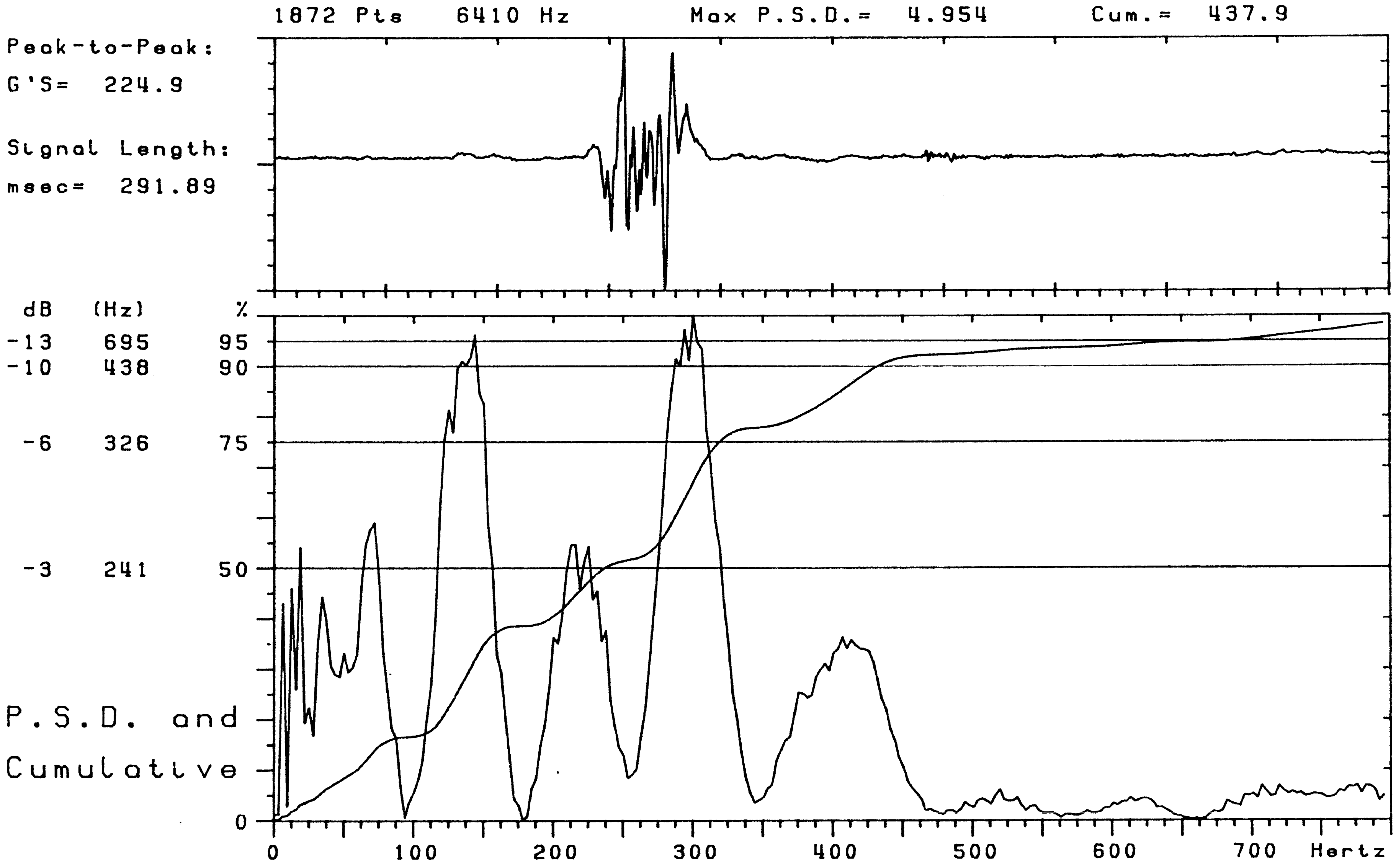
T1 F2838 Ch09 Test: 77T089 Sensor: AC T01 Y


1872 Pts
6410 Hz
Max P.S.D.= 62.22
Cum.= 2696.
Peak-to-Peak:
G'S= 701.2
Signal Length:
msec= 291.89
dB
(Hz)
%
-13
1443
95
-10
1083
90
-6
429
75
-3
153
50
P.S.D. and
Cumulative
0
0
100
200
300
400
500
600
700
Hertz
T1 F2850 Ch02
Test: 77T092
Sensor: AC LUR Y

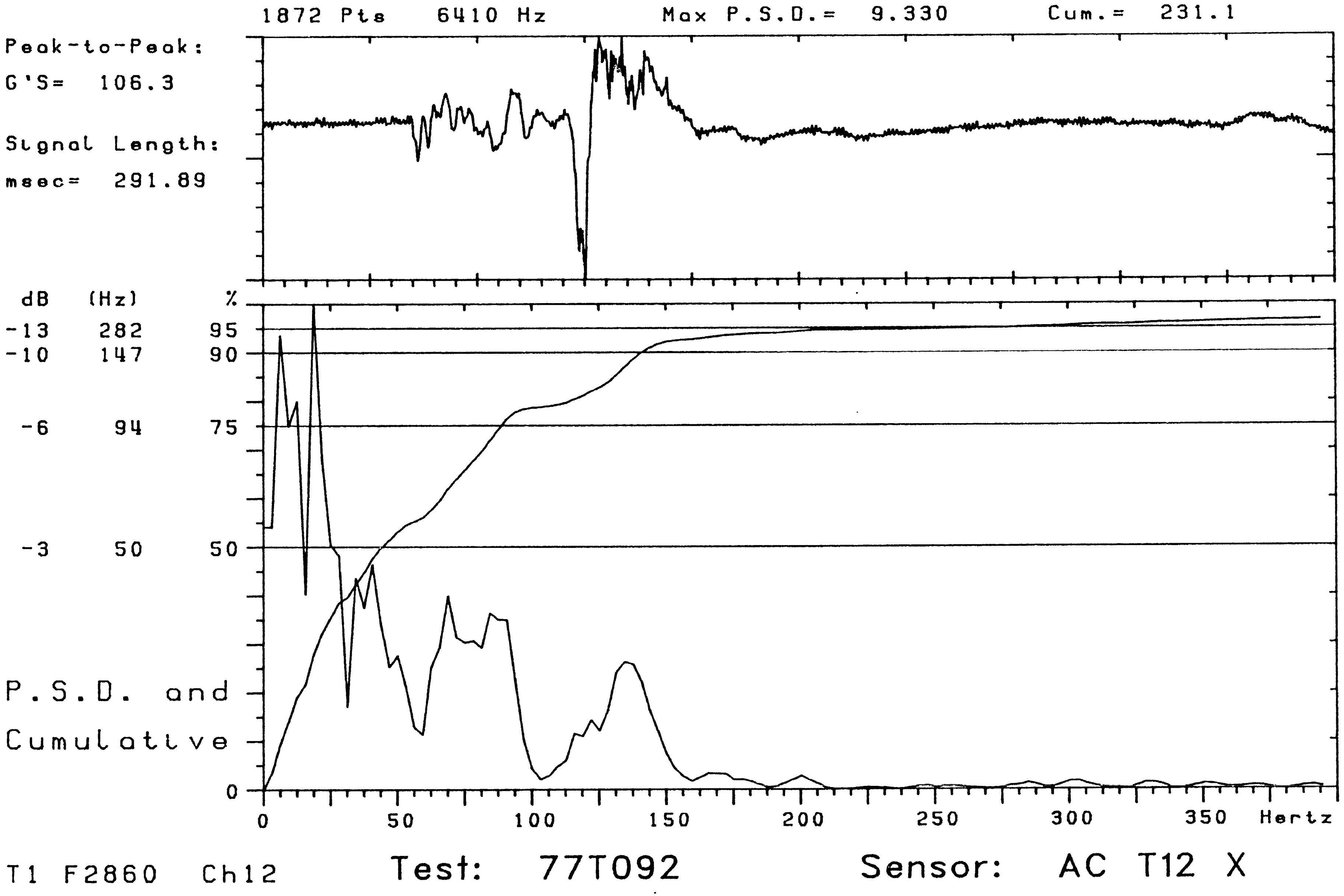

1872 Pts 6410 Hz
Max P.S.D.= 5.740
Cum.= 426.2
Peak-to-Peak:
G'S= 279.2
Signal Length:
msec= 291.89
dB (Hz) %
-13 1227 95
-10 958 90
-6 523 75
-3 341 50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2856 Ch08
Test: 77T092
Sensor: AC T01 X

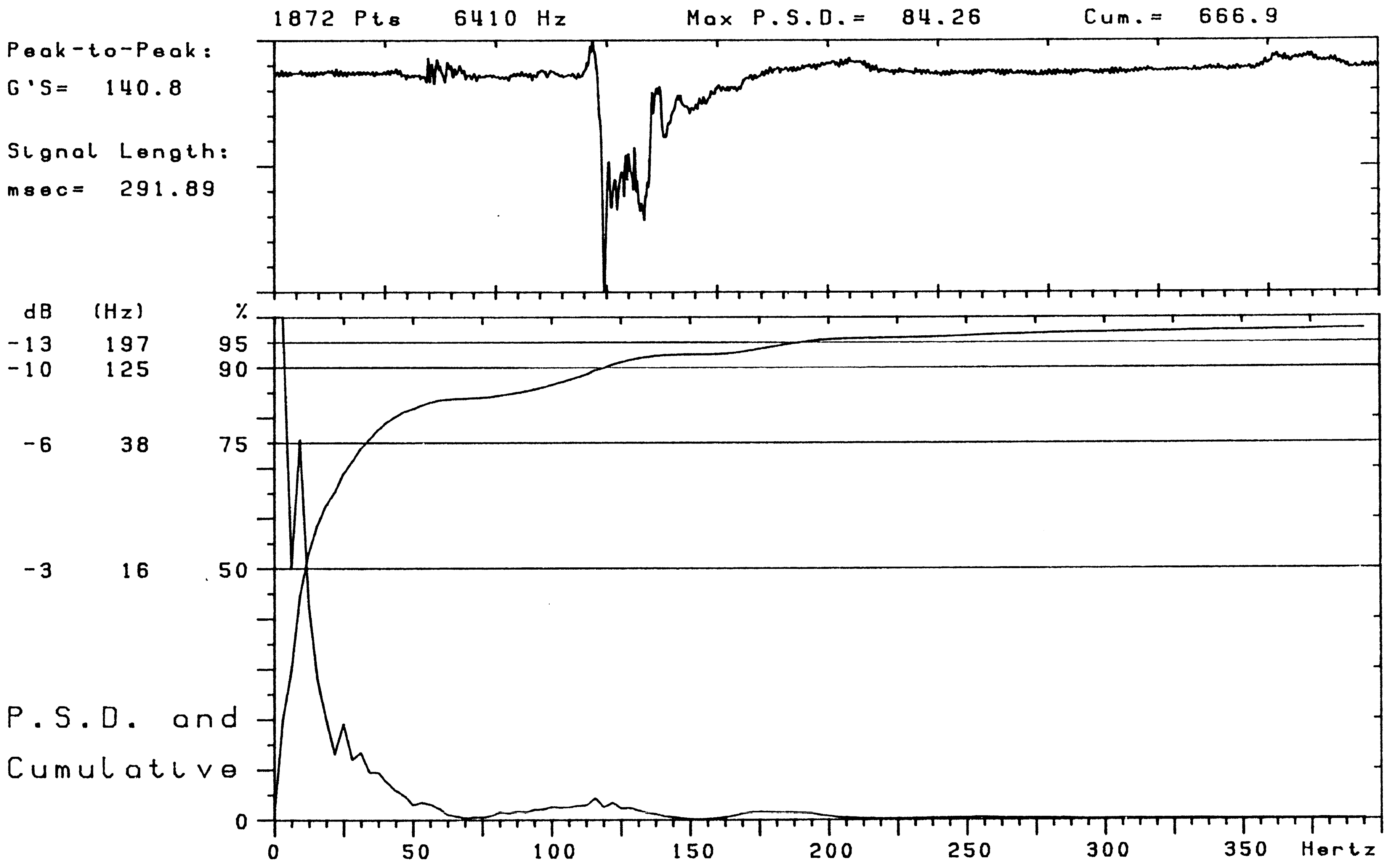


T1 F2857 Ch09 **Test: 77T092** **Sensor: AC T01 Y**

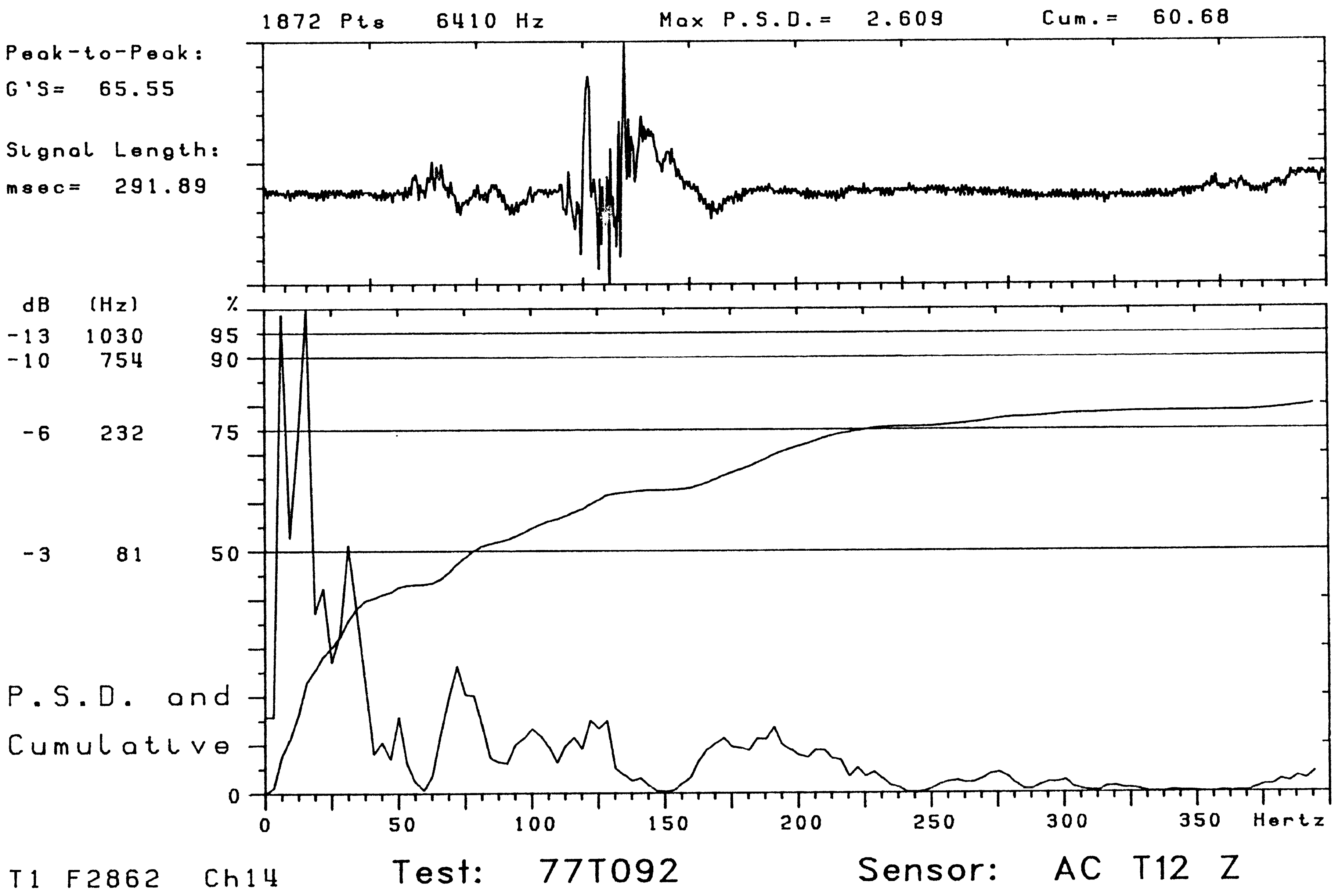


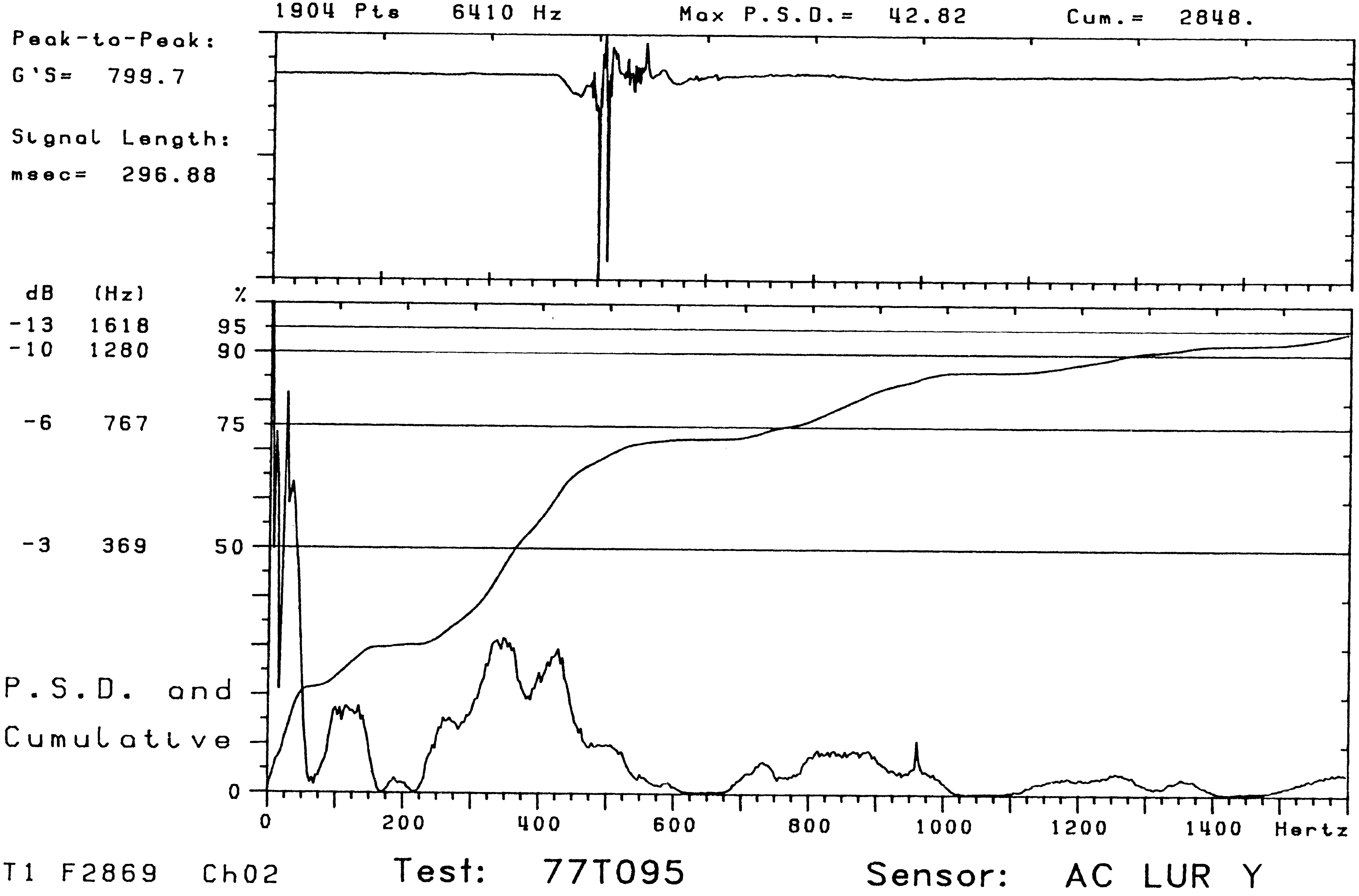
T1 F2858 Ch10 Test: 77T092 Sensor: AC T01 Z

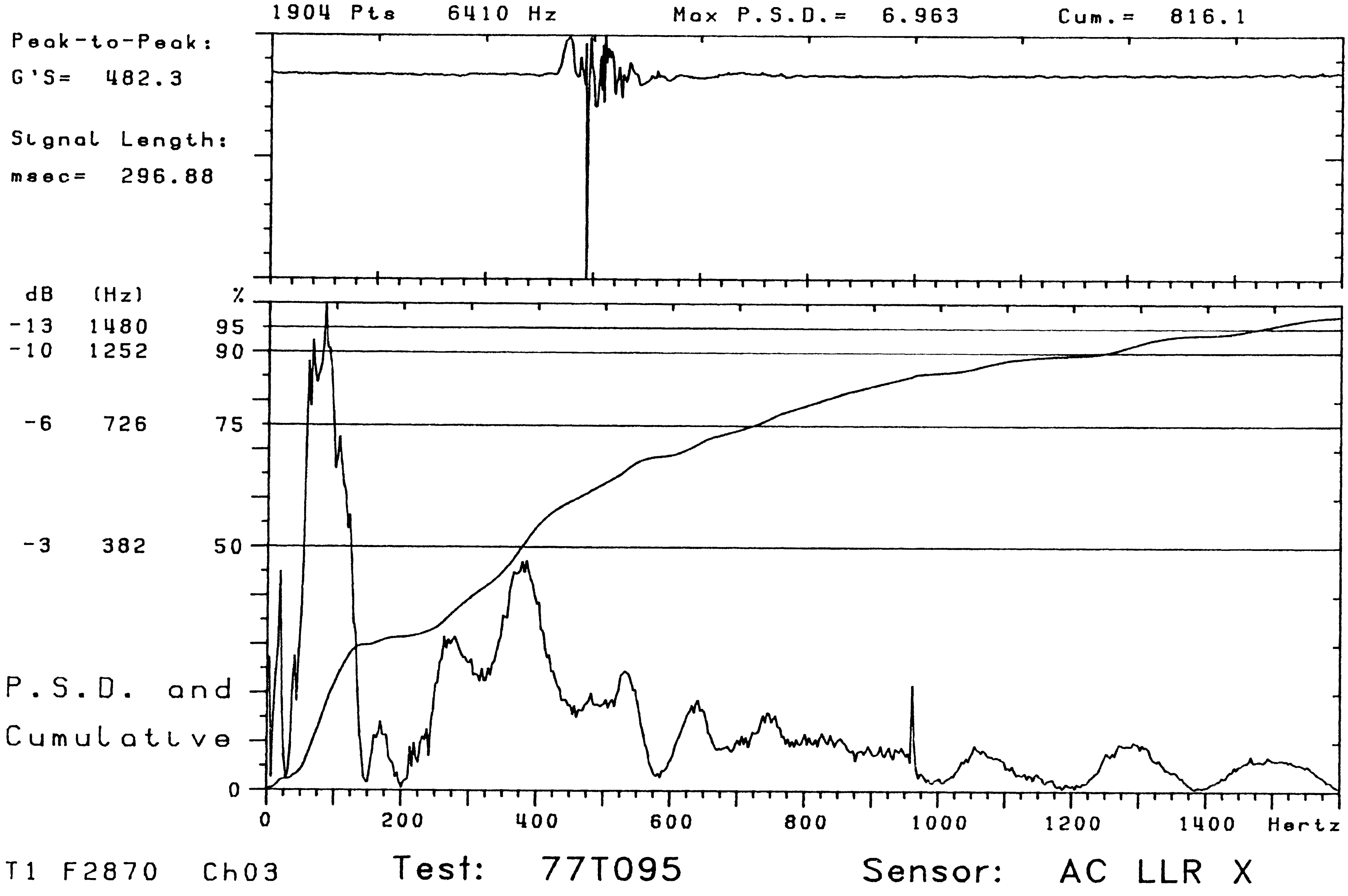

1872 Pts 6410 Hz
Max P.S.D.= 9.330
Cum.= 231.1
Peak-to-Peak:
G'S= 106.3
Signal Length:
msec= 291.89
dB (Hz) %
-13 282 95
-10 147 90
-6 94 75
-3 50 50
P.S.D. and
Cumulative
0
0
50
100
150
200
250
300
350
Hertz
T1 F2860 Ch12
Test: 77T092
Sensor: AC T12 X

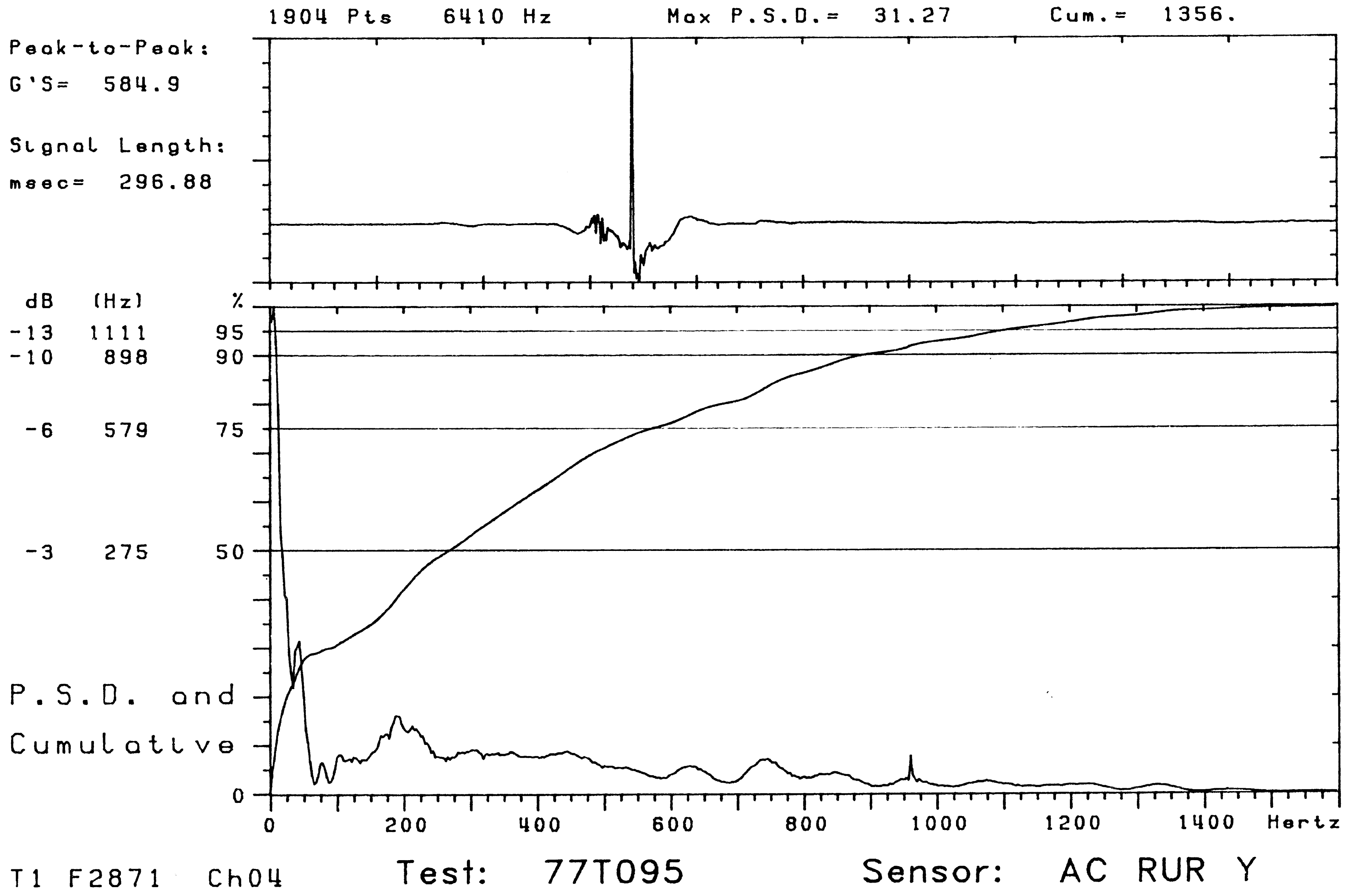


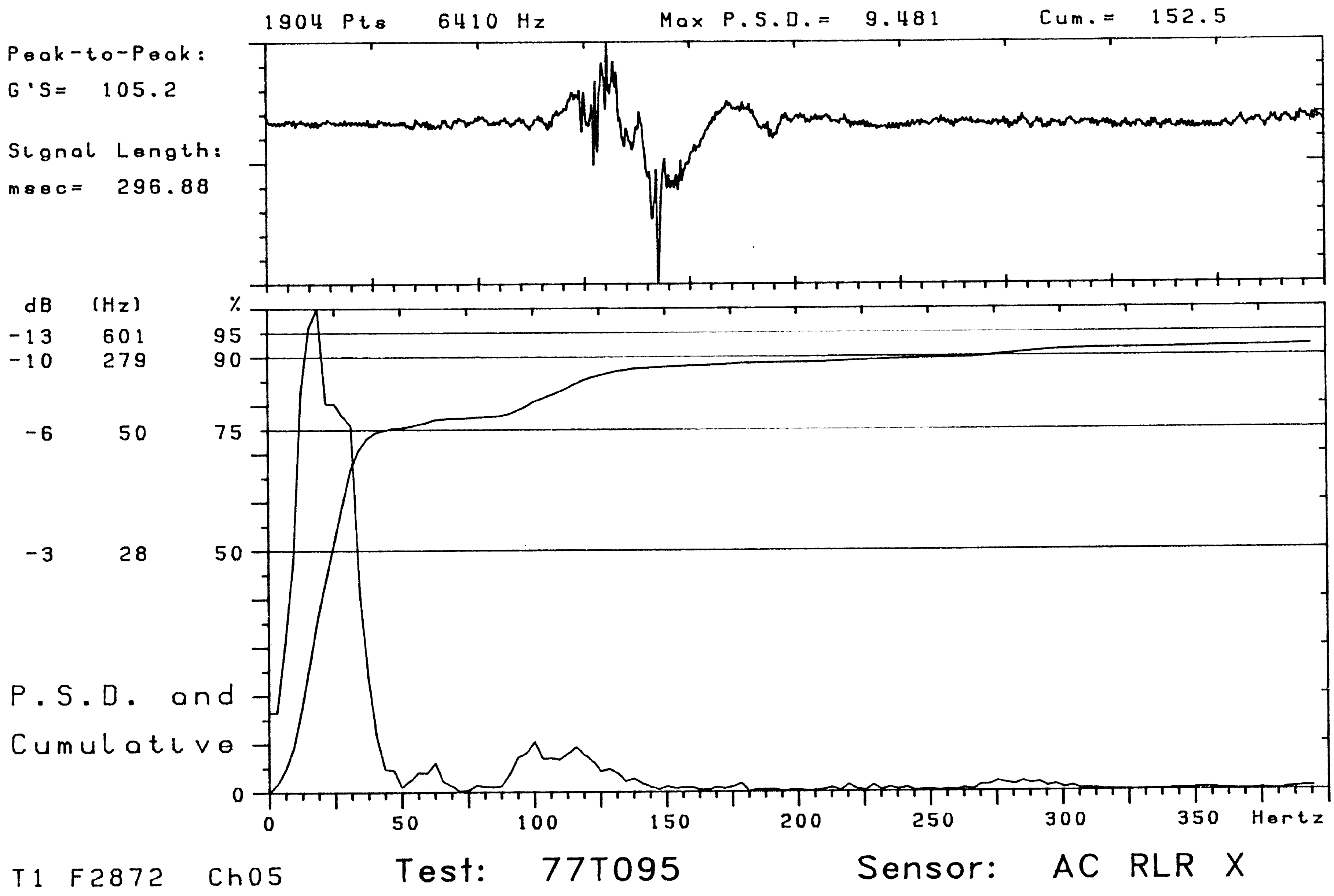
T1 F2861 Ch13 Test: 77T092 Sensor: AC T12 Y

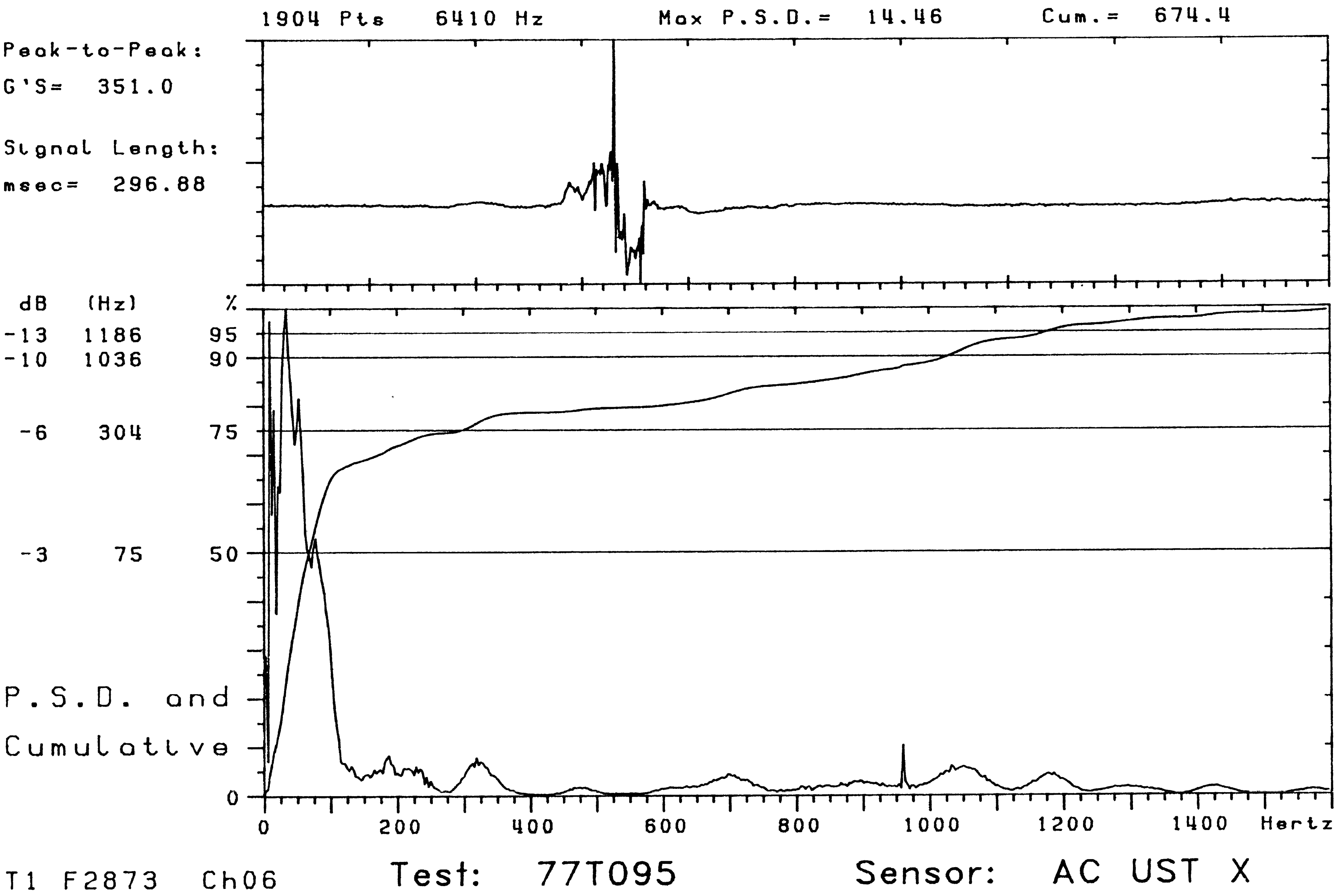

1872 Pts 6410 Hz
Max P.S.D.= 2.609
Cum.= 60.68
Peak-to-Peak:
G'S= 65.55
Signal Length:
msec= 291.89
dB (Hz) %
-13 1030 95
-10 754 90
-6 232 75
-3 81 50
0
P.S.D. and
Cumulative
0
50
100
150
200
250
300
350
Hertz
T1 F2862 Ch14
Test: 77T092
Sensor: AC T12 Z

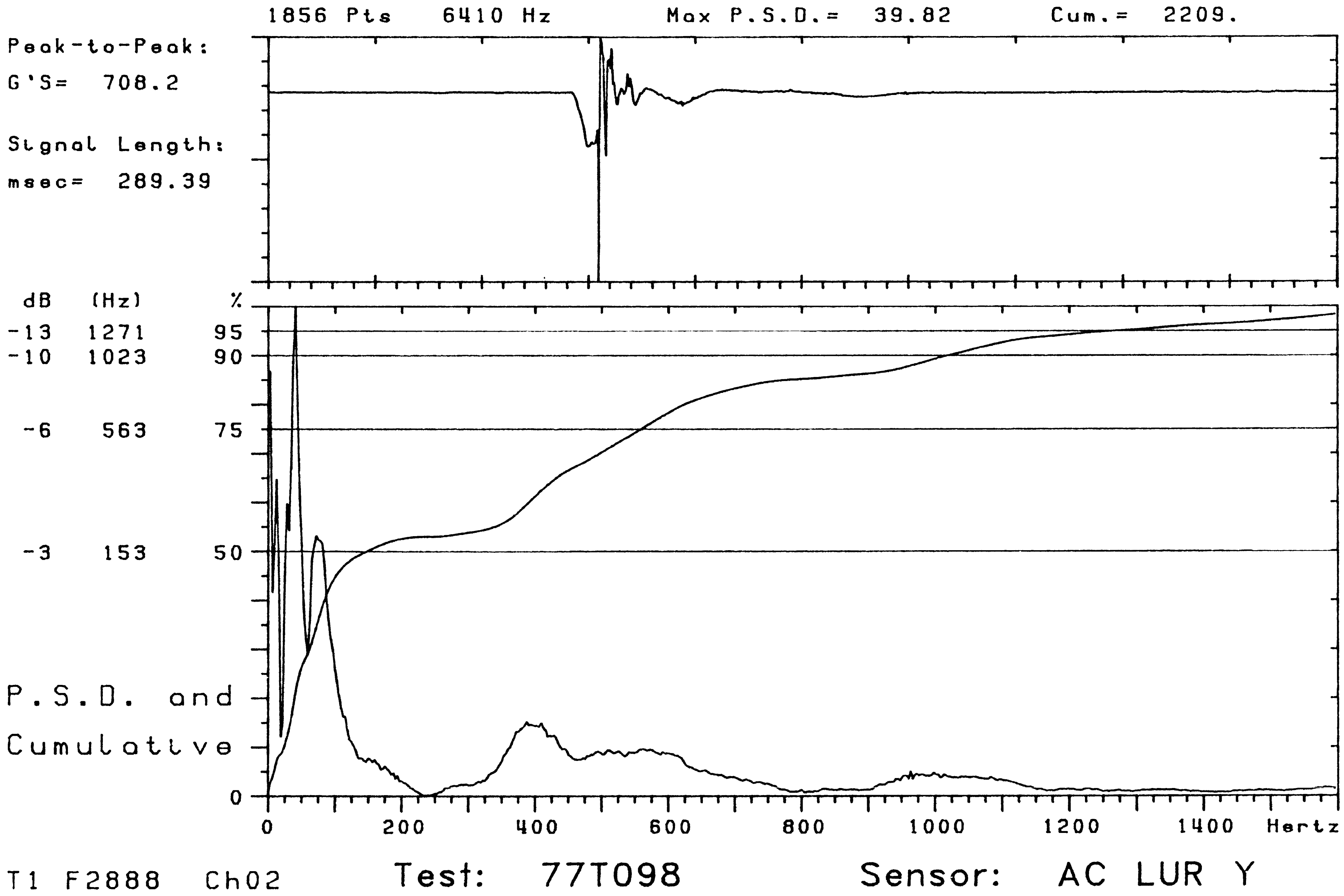

1904 Pts
6410 Hz
Max P.S.D.= 42.82
Cum.= 2848.
Peak-to-Peak:
G'S= 799.7
Signal Length:
msec= 296.88
dB
(Hz)
%
-13
1618
95
-10
1280
90
-6
767
75
-3
369
50
P.S.D. and
Cumulative
0
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2869 Ch02
Test: 77T095
Sensor: AC LUR Y

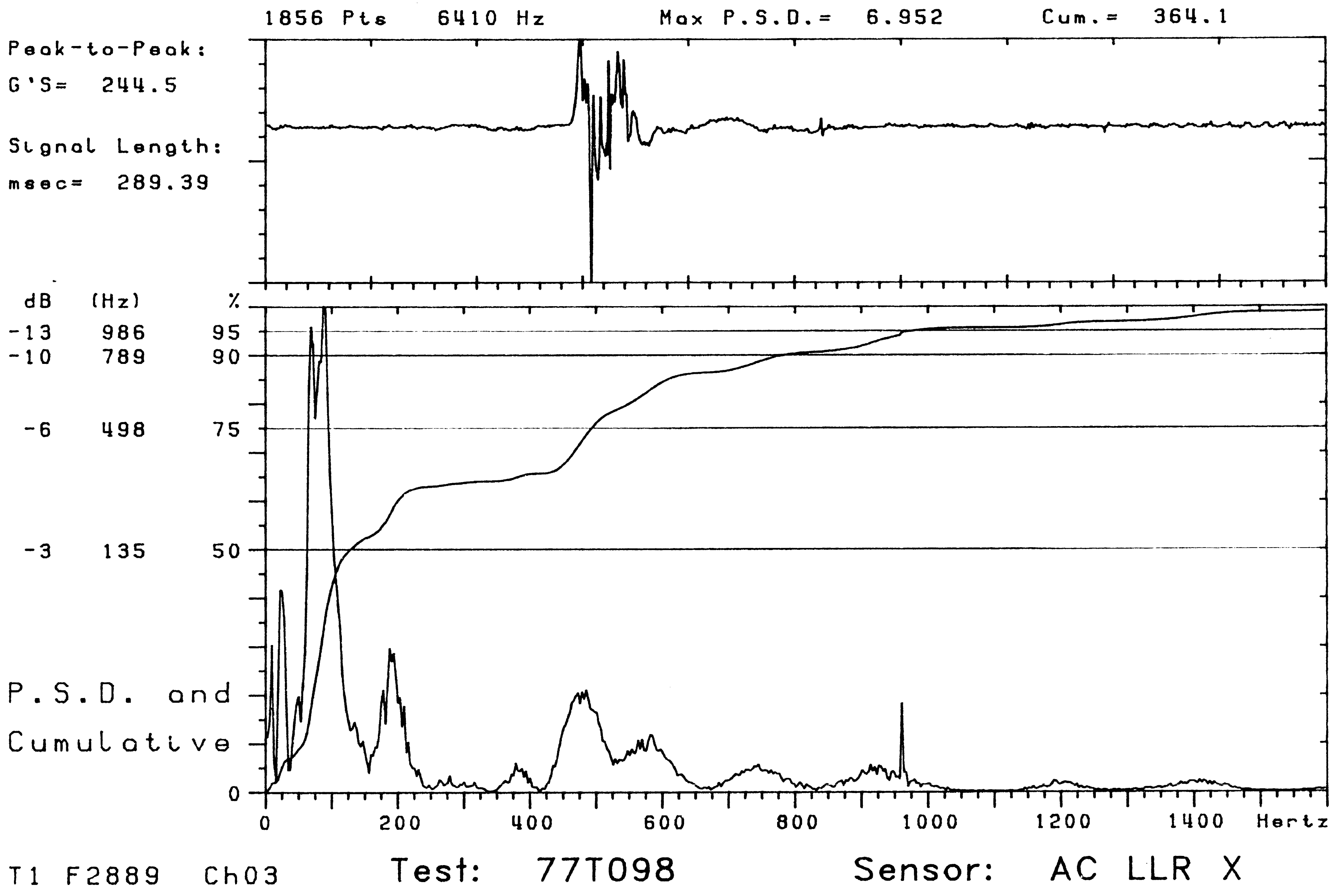

1904 Pts
6410 Hz
Max P.S.D.= 6.963
Cum.= 816.1
Peak-to-Peak:
G'S= 482.3
Signal Length:
msec= 296.88
dB
(Hz)
%
-13
1480
95
-10
1252
90
-6
726
75
-3
382
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2870 Ch03
Test: 77T095
Sensor: AC LLR X

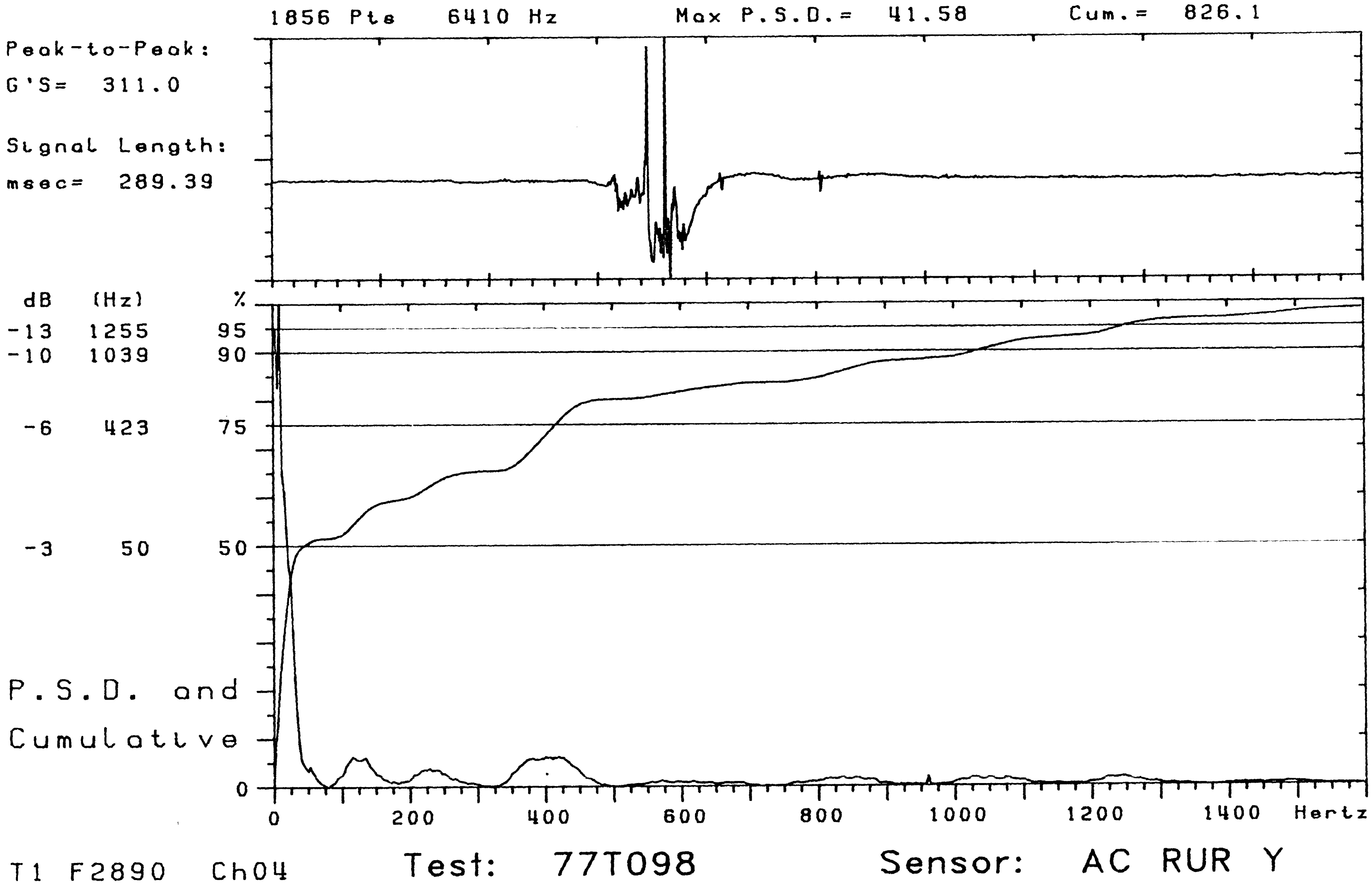

1904 Pts 6410 Hz
Max P.S.D.= 31.27
Cum.= 1356.
Peak-to-Peak:
G'S= 584.9
Signal Length:
msec= 296.88
dB (Hz) %
-13 1111 95
-10 898 90
-6 579 75
-3 275 50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2871 Ch04
Test: 77T095
Sensor: AC RUR Y

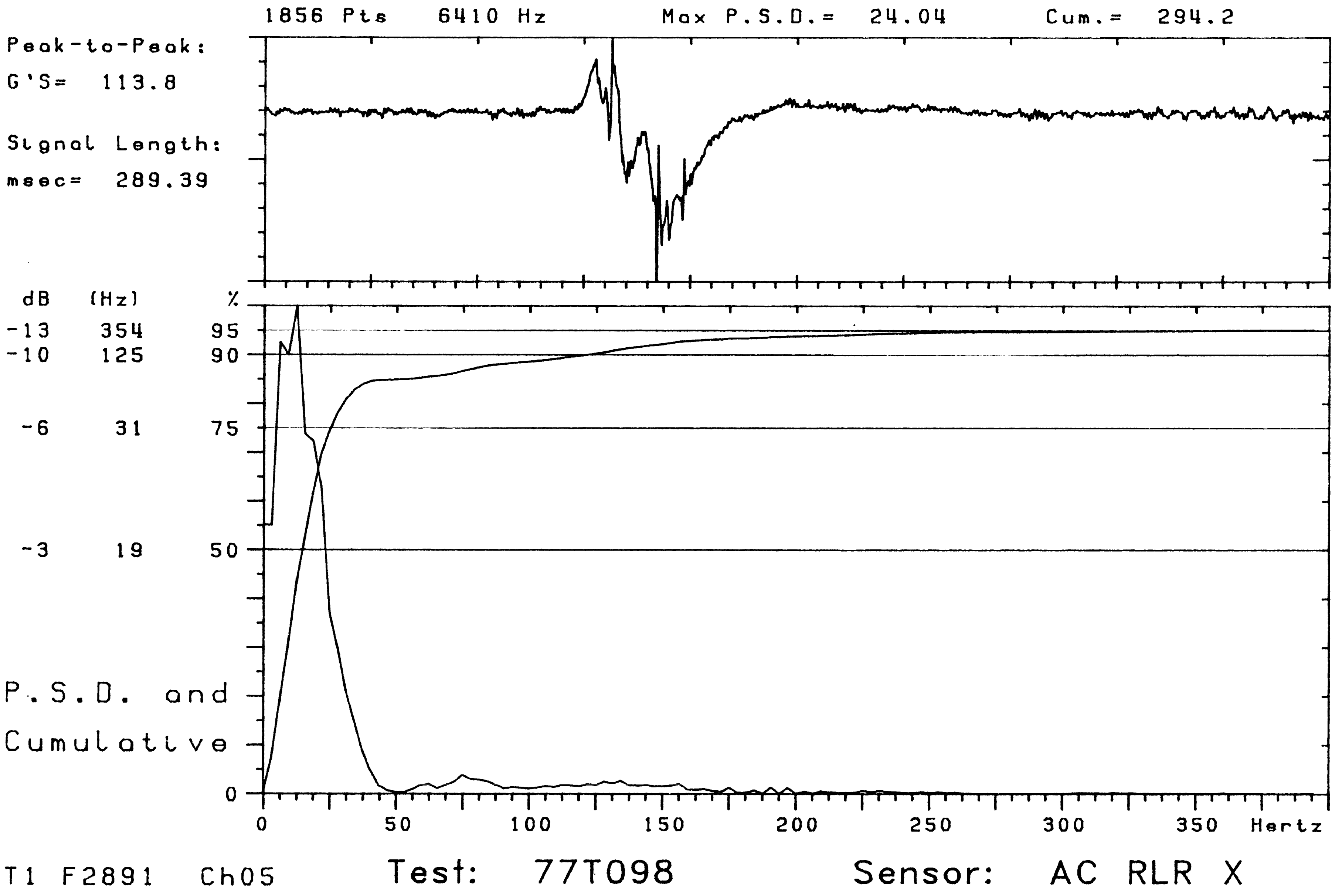

1904 Pts 6410 Hz
Max P.S.D.= 9.481
Cum.= 152.5
Peak-to-Peak:
G'S= 105.2
Signal Length:
msec= 296.88
dB (Hz) %
-13 601 95
-10 279 90
-6 50 75
-3 28 50
0
P.S.D. and
Cumulative
0
50
100
150
200
250
300
350
Hertz
T1 F2872 Ch05
Test: 77T095
Sensor: AC RLR X

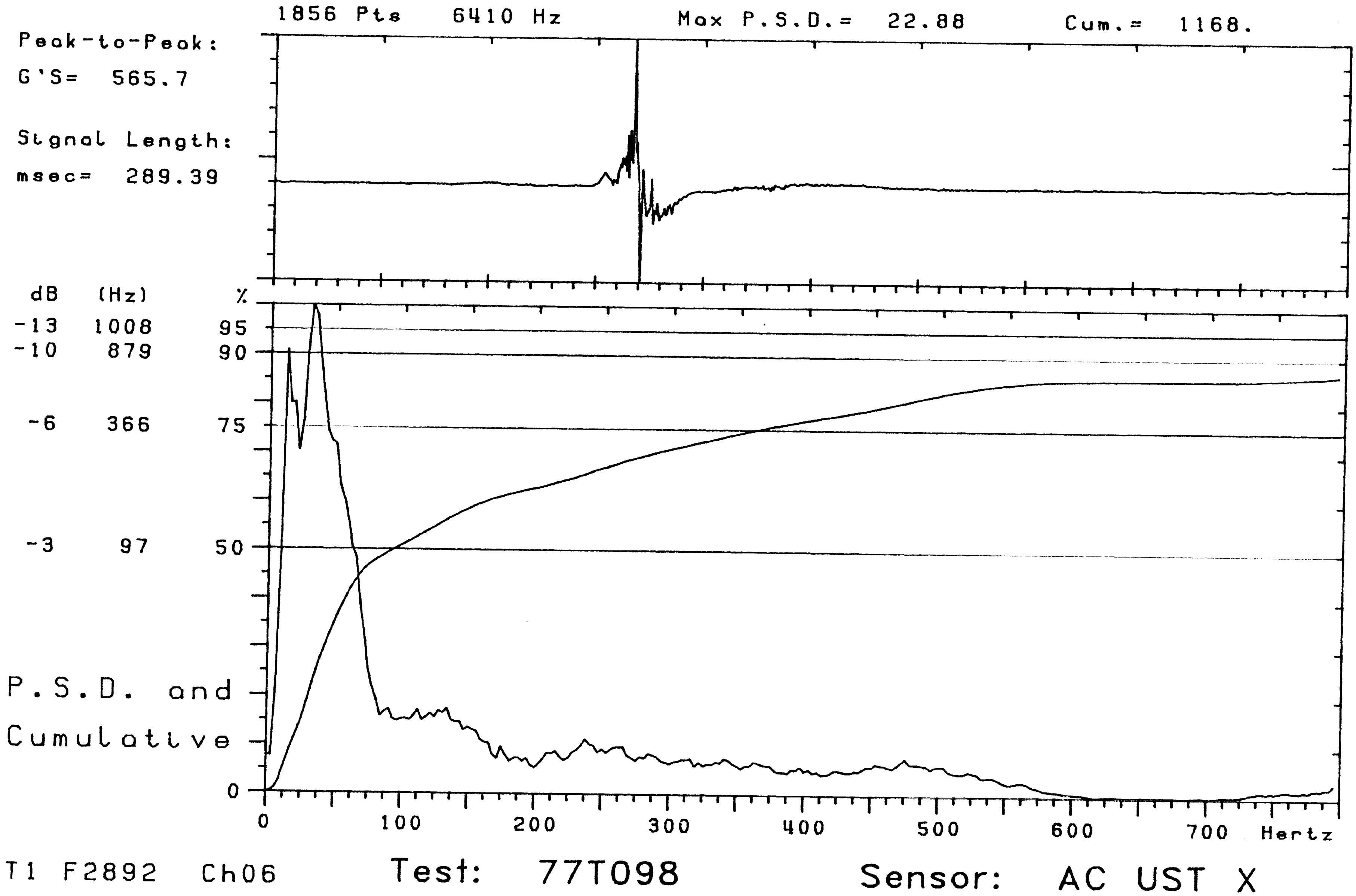

1904 Pts 6410 Hz
Max P.S.D.= 14.46
Cum.= 674.4
Peak-to-Peak:
G'S= 351.0
Signal Length:
msec= 296.88
dB (Hz)
-13 1186
-10 1036
-6 304
-3 75
%
95
90
75
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2873 Ch06
Test: 77T095
Sensor: AC UST X

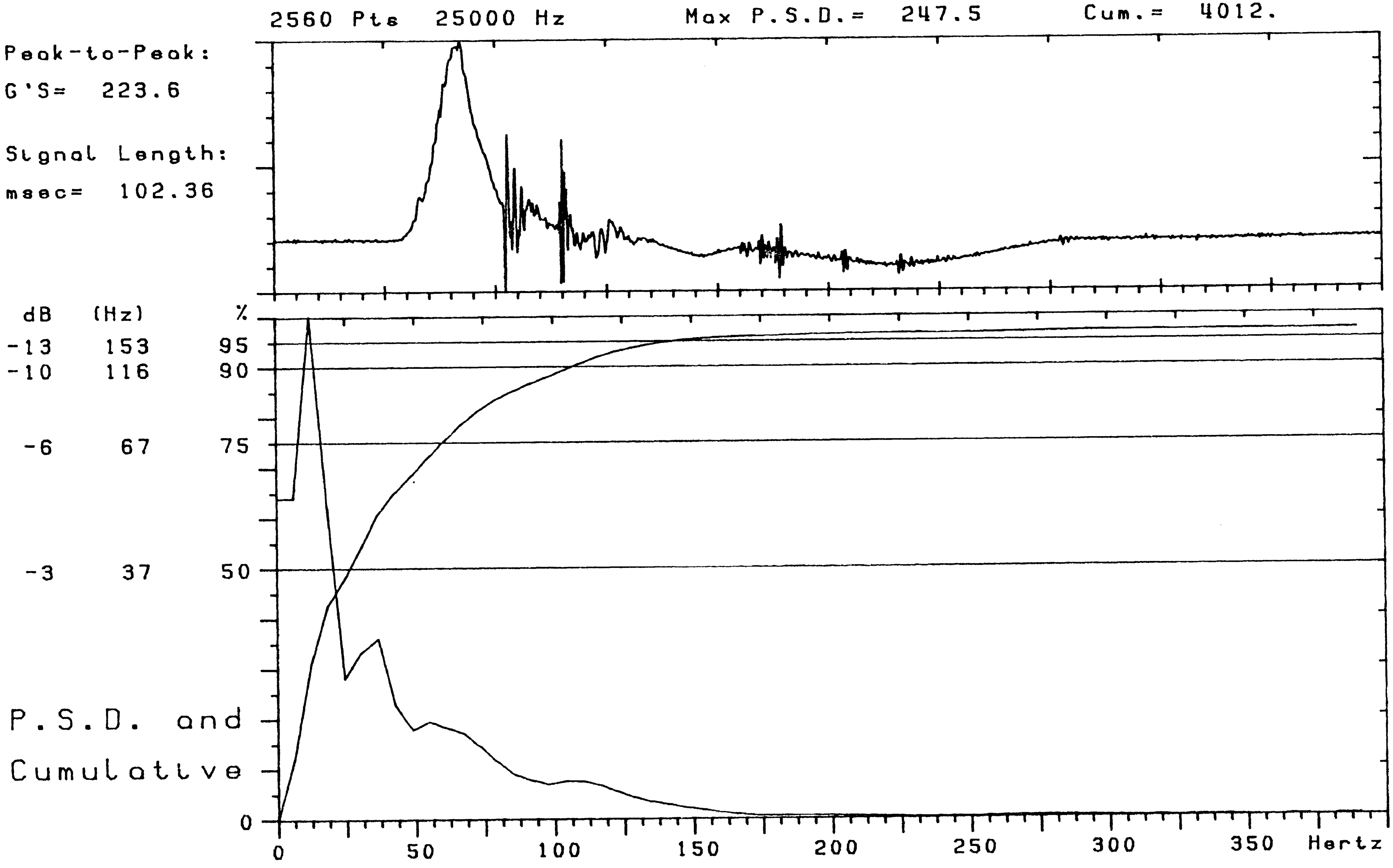

1856 Pts
6410 Hz
Max P.S.D.= 39.82
Cum.= 2209.
Peak-to-Peak:
G'S= 708.2
Signal Length:
msec= 289.39
dB (Hz) %
-13 1271 95
-10 1023 90
-6 563 75
-3 153 50
P.S.D. and
Cumulative
0
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2888 Ch02
Test: 77T098
Sensor: AC LUR Y


1856 Pts
6410 Hz
Max P.S.D.= 6.952
Cum.= 364.1
Peak-to-Peak:
G'S= 244.5
Signal Length:
msec= 289.39
dB
(Hz)
%
-13
986
95
-10
789
90
-6
498
75
-3
135
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2889 Ch03
Test: 77T098
Sensor: AC LLR X

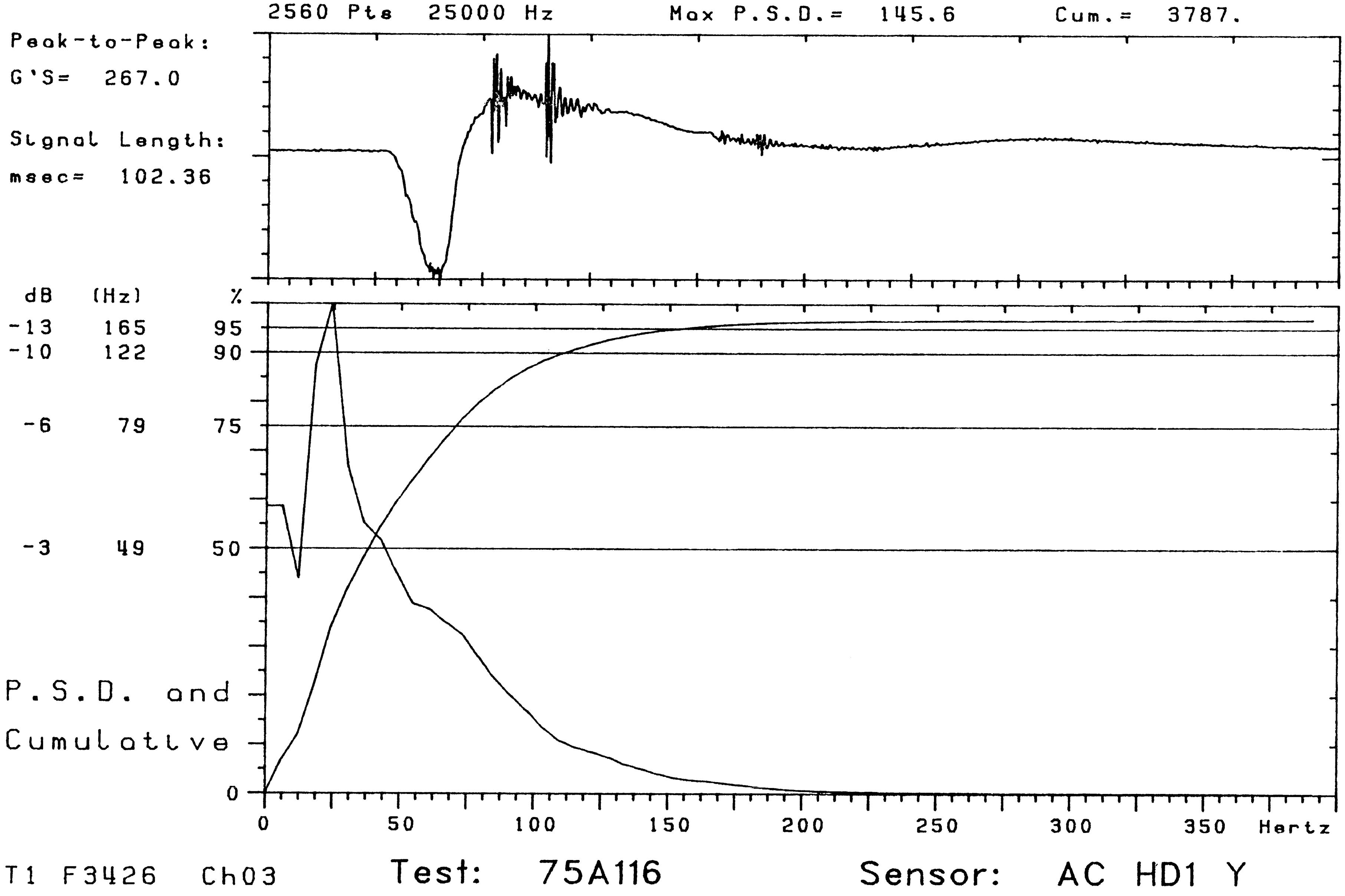

1856 Pts 6410 Hz
Max P.S.D.= 41.58
Cum.= 826.1
Peak-to-Peak:
G'S= 311.0
Signal Length:
msec= 289.39
dB (Hz)
-13 1255
-10 1039
-6 423
-3 50
%
95
90
75
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F2890 Ch04
Test: 77T098
Sensor: AC RUR Y

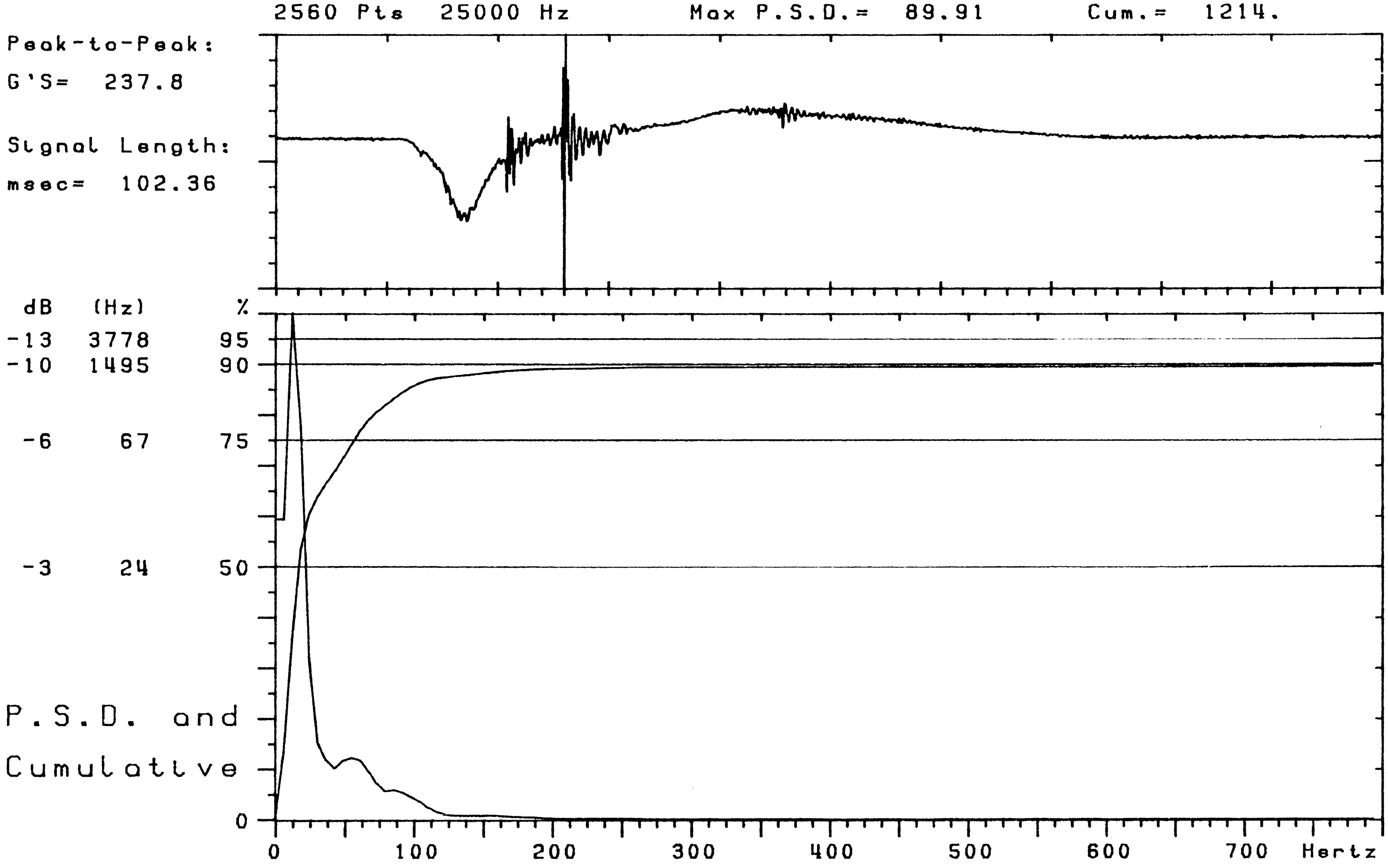

1856 Pts
6410 Hz
Max P.S.D.= 24.04
Cum.= 294.2
Peak-to-Peak:
G'S= 113.8
Signal Length:
msec= 289.39
dB (Hz) %
-13 354 95
-10 125 90
-6 31 75
-3 19 50
P.S.D. and
Cumulative
0
0
50
100
150
200
250
300
350
Hertz
T1 F2891 Ch05
Test: 77T098
Sensor: AC RLR X


1856 Pts 6410 Hz
Max P.S.D.= 22.88
Cum.= 1168.
Peak-to-Peak:
G'S= 565.7
Signal Length:
msec= 289.39
dB (Hz)
-13 1008
-10 879
-6 366
-3 97
%
95
90
75
50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T1 F2892 Ch06
Test: 77T098
Sensor: AC UST X

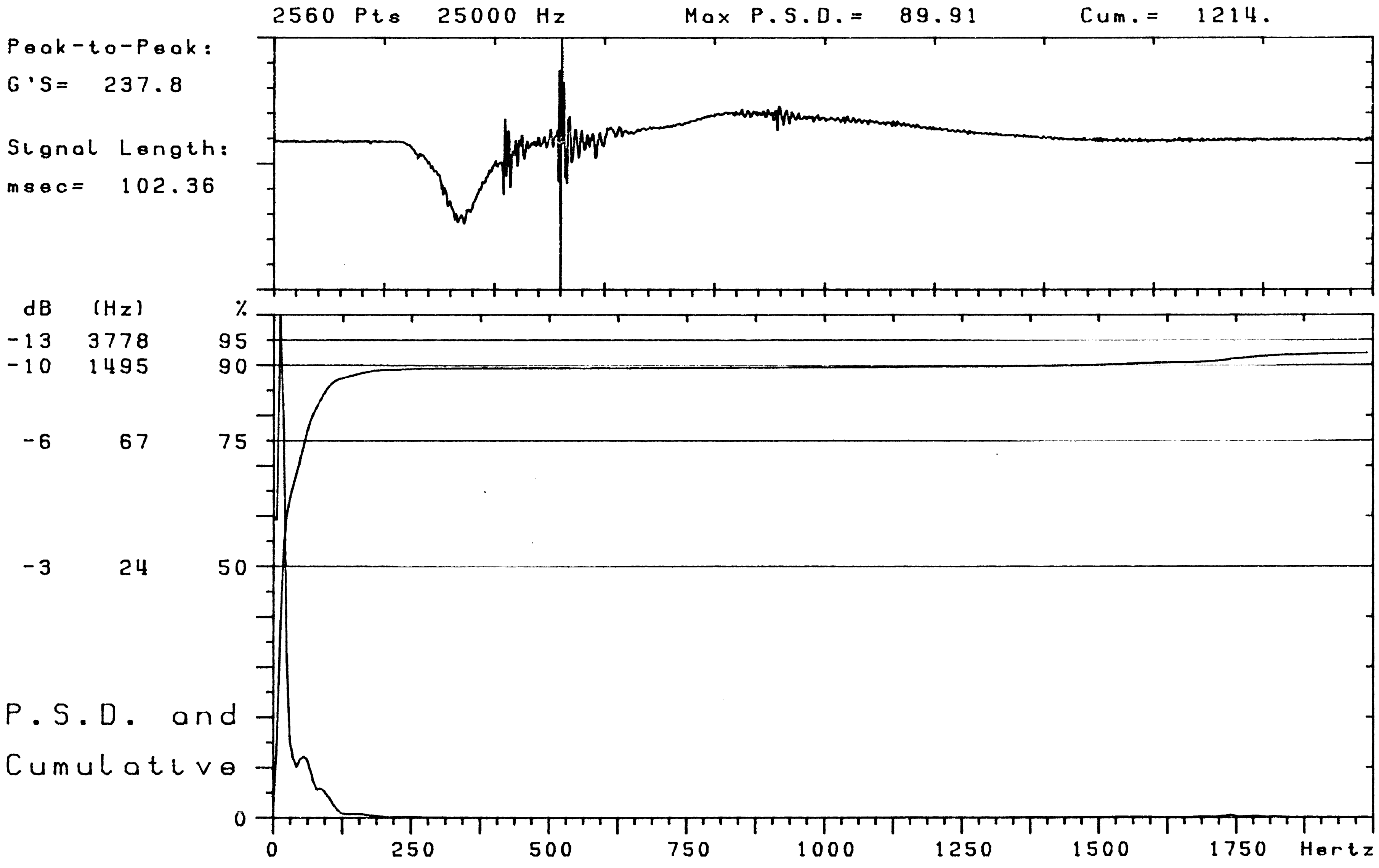


T1 F3425 Ch02 Test: 75A116 Sensor: AC HD1 X

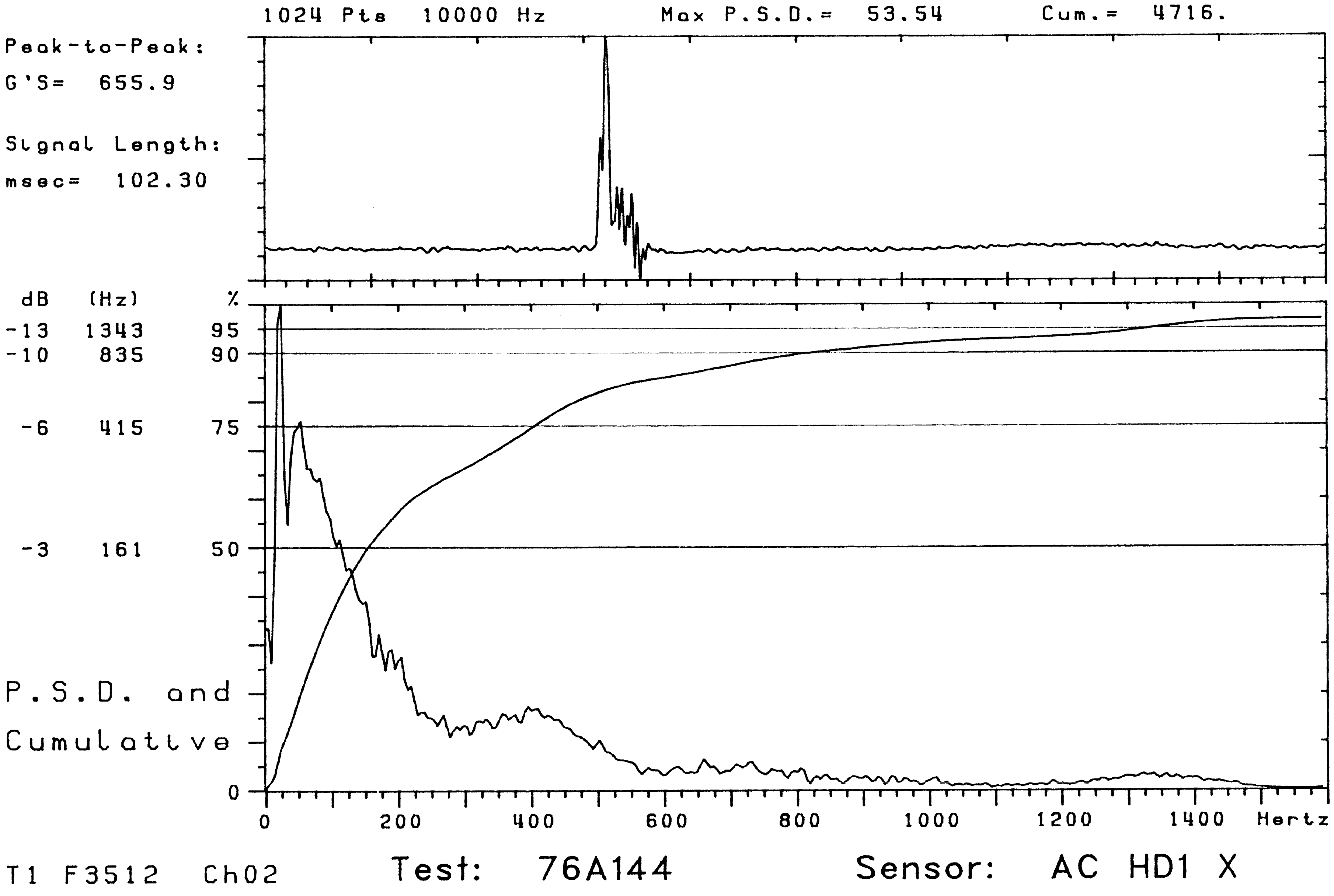

2560 Pts 25000 Hz
Max P.S.D.= 145.6
Cum.= 3787.
Peak-to-Peak:
G'S= 267.0
Signal Length:
msec= 102.36
dB (Hz) %
-13 165 95
-10 122 90
-6 79 75
-3 49 50
0
P.S.D. and
Cumulative
0
50
100
150
200
250
300
350
Hertz
T1 F3426 Ch03
Test: 75A116
Sensor: AC HD1 Y

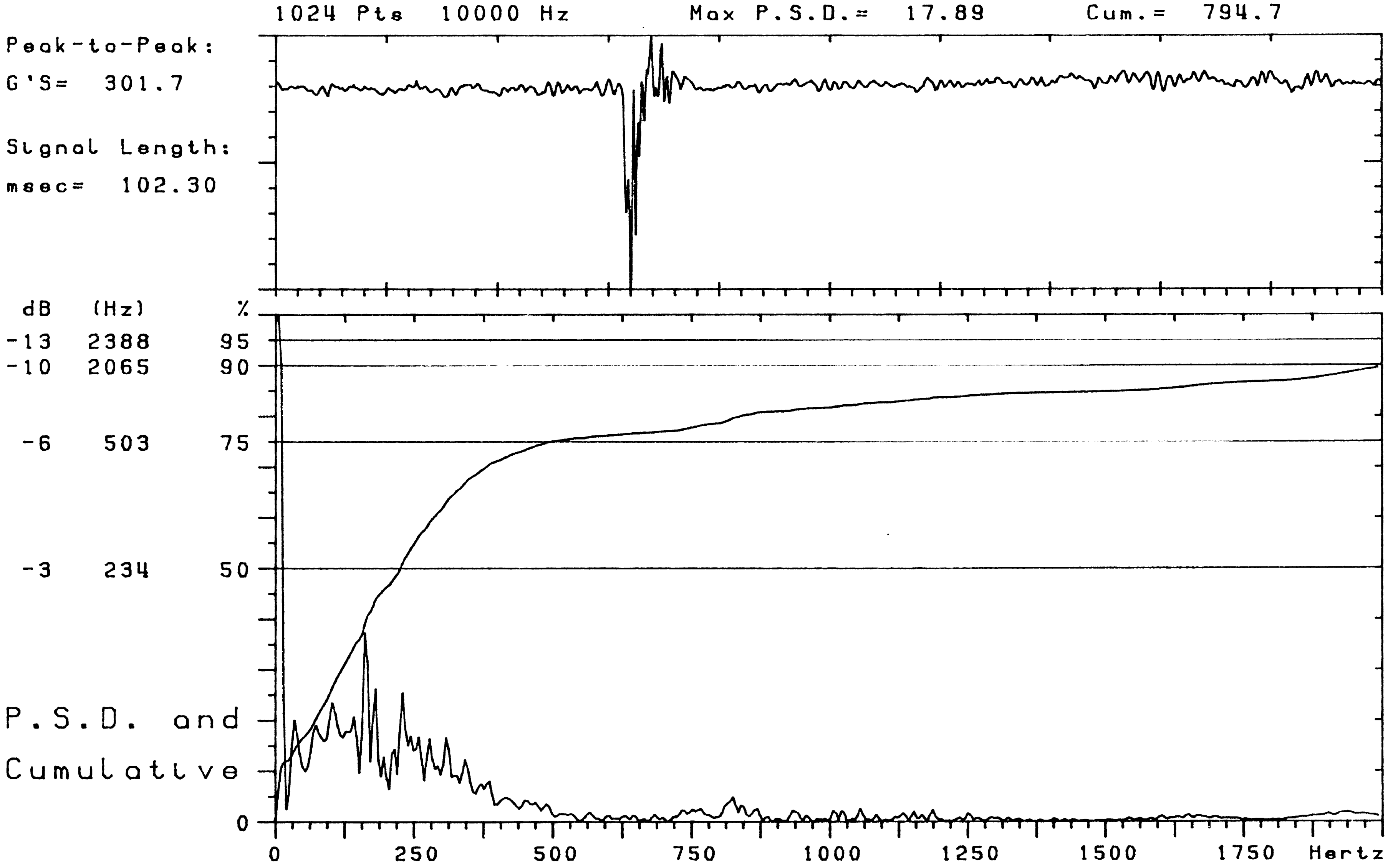


T1 F3427 Ch04 Test: 75A116 Sensor: AC HD1 Z

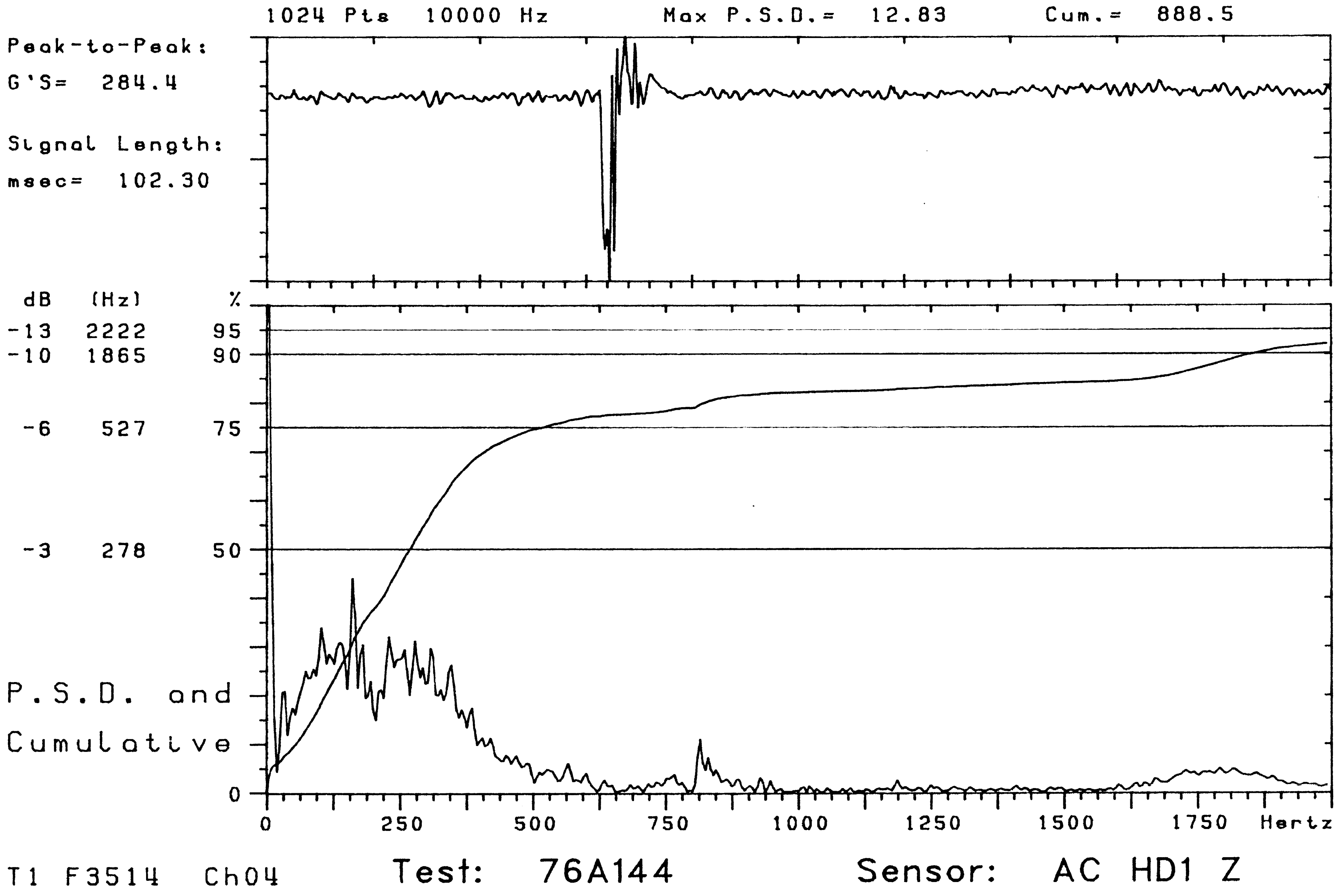


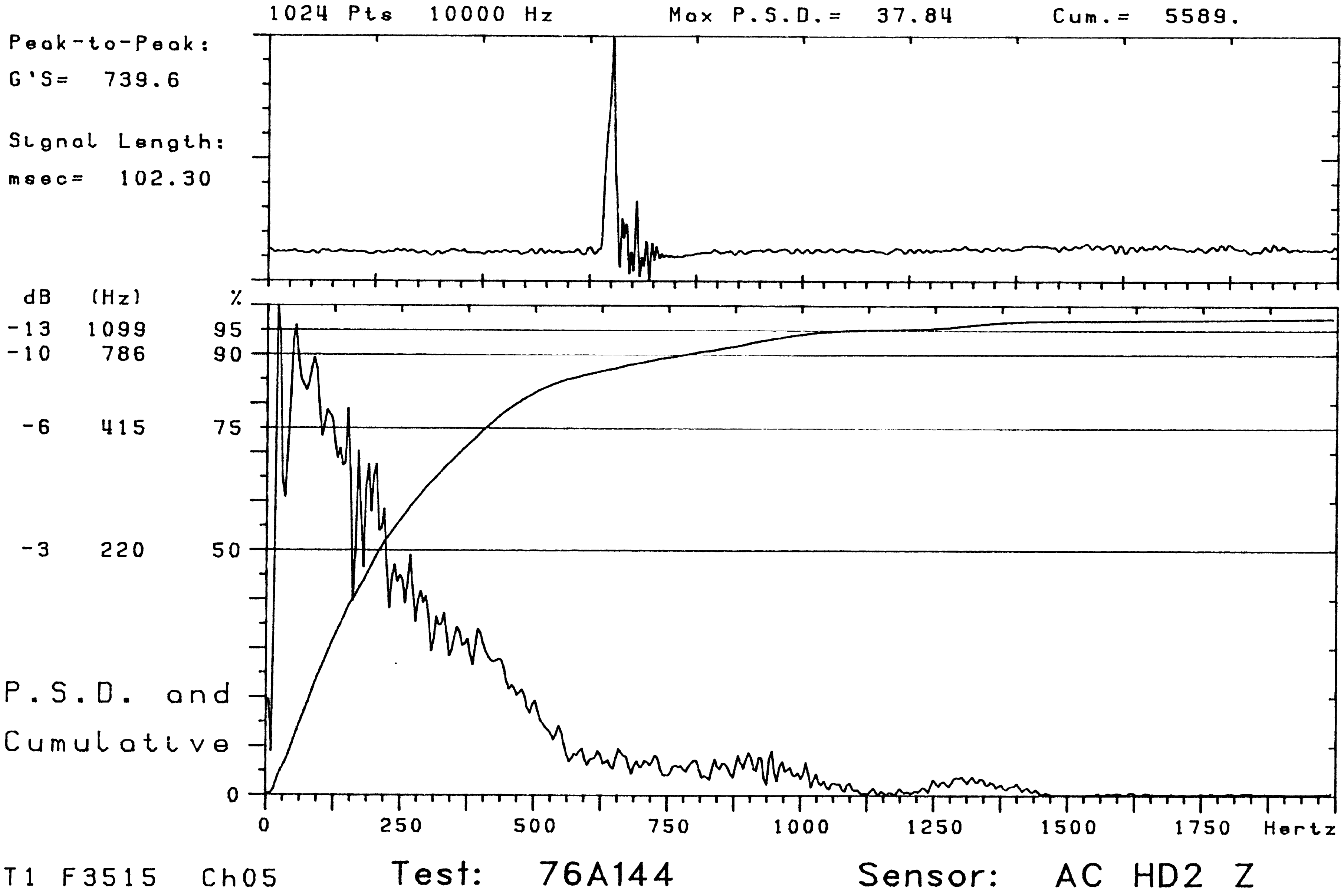
T1 F3427 Ch04 Test: 75A116 Sensor: AC HD1 Z

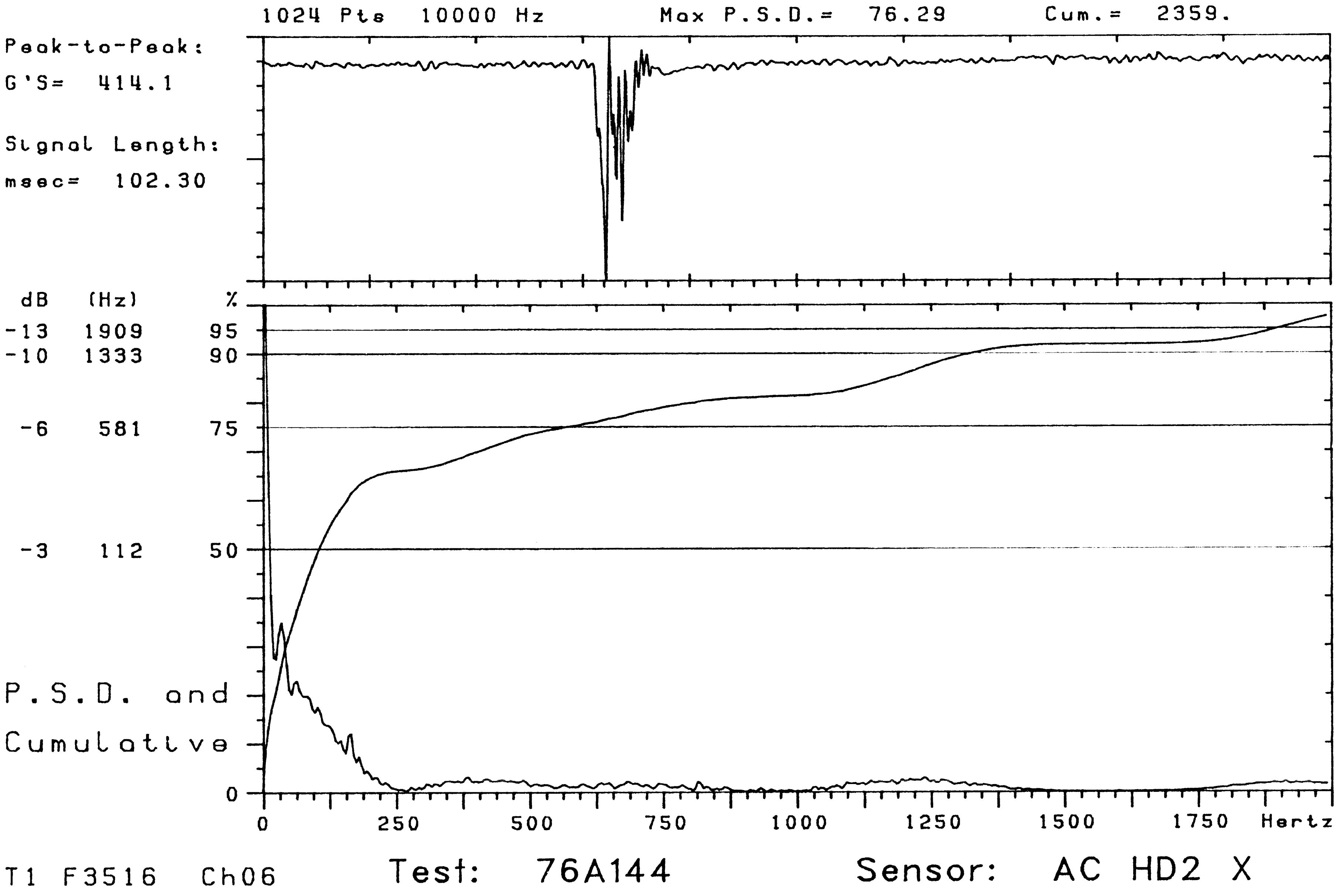

1024 Pts 10000 Hz
Max P.S.D.= 53.54
Cum.= 4716.
Peak-to-Peak:
G'S= 655.9
Signal Length:
msec= 102.30
dB (Hz)
-13 1343
-10 835
-6 415
-3 161
%
95
90
75
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F3512 Ch02
Test: 76A144
Sensor: AC HD1 X

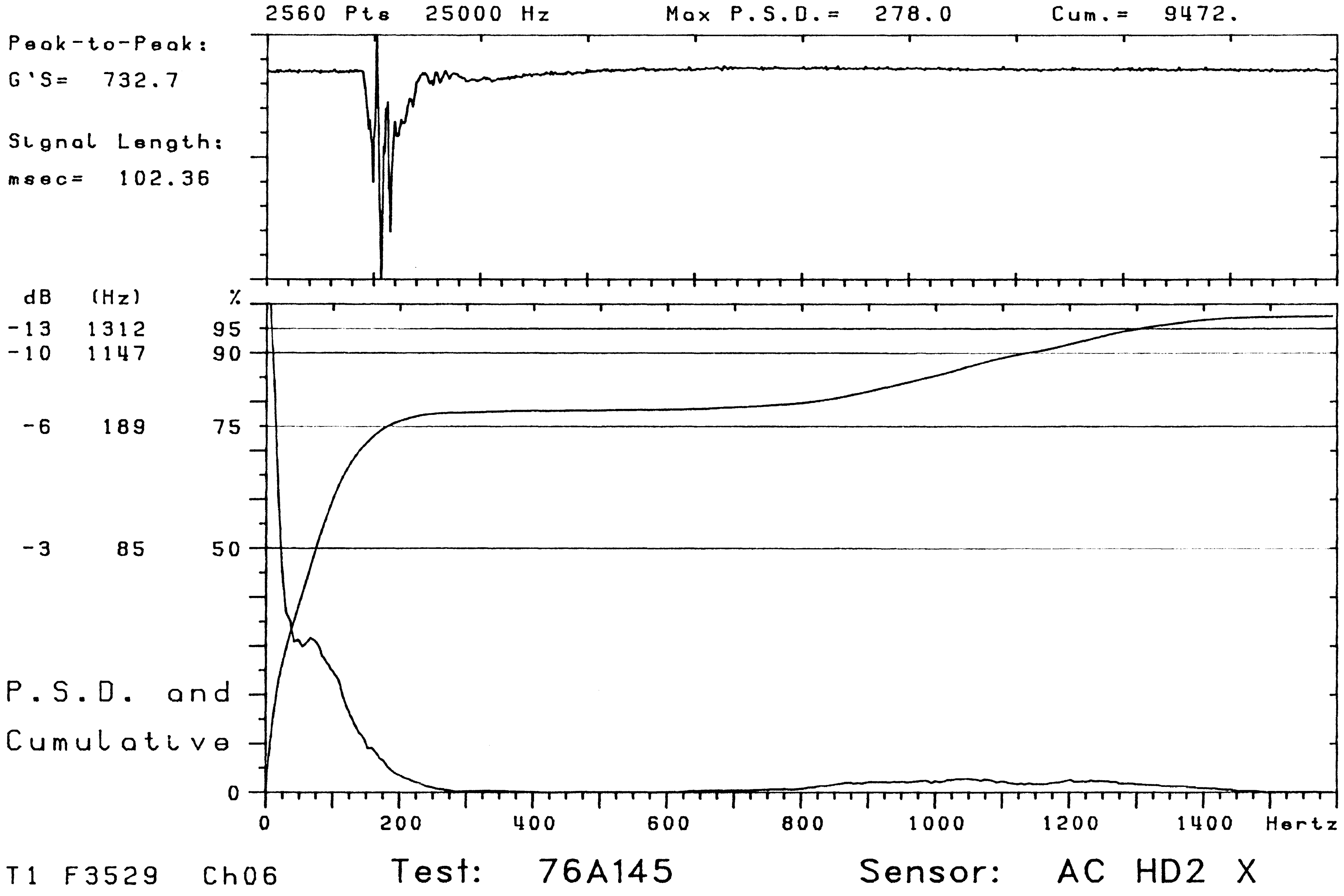


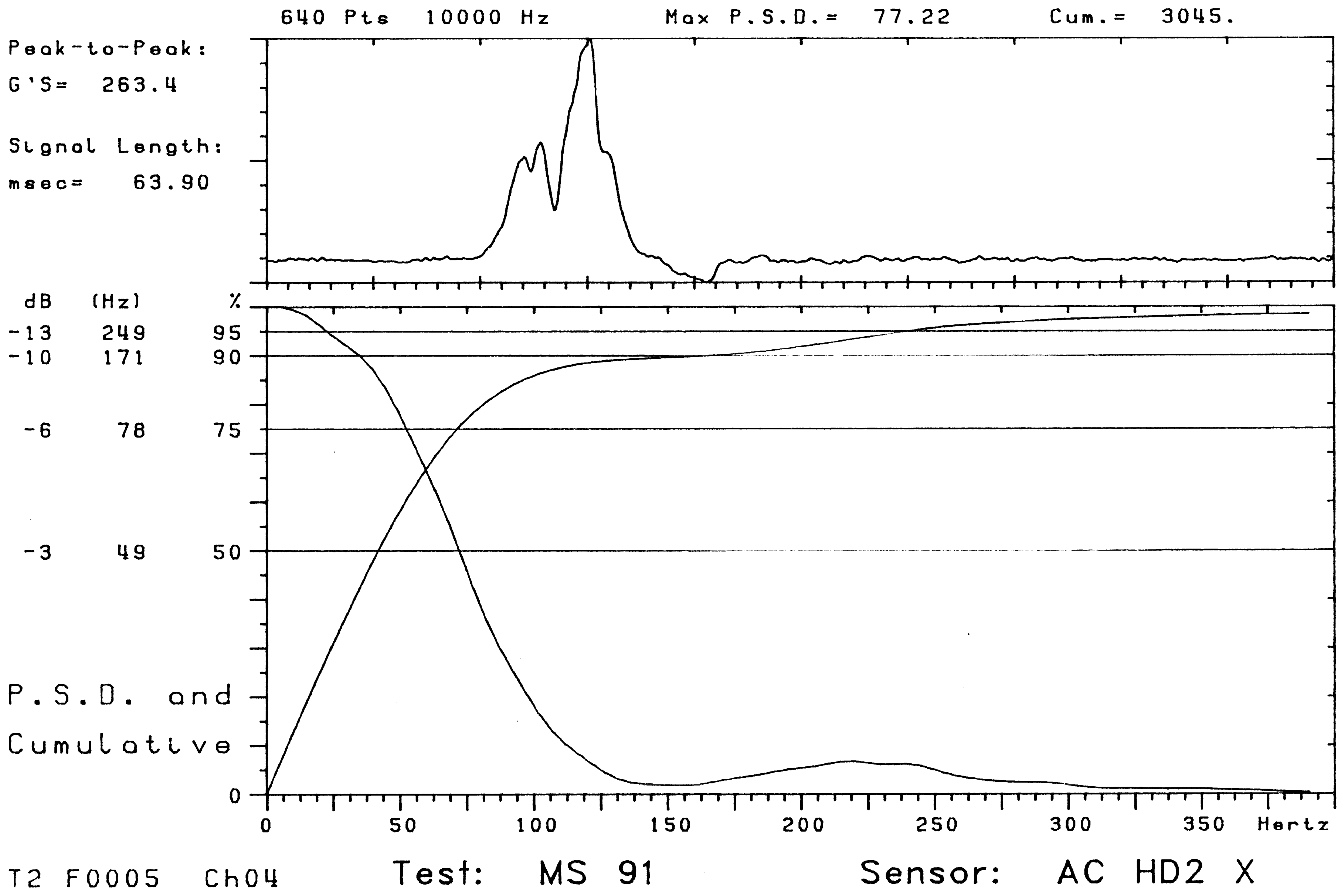
T1 F3513 Ch03 Test: 76A144 Sensor: AC HD1 Y

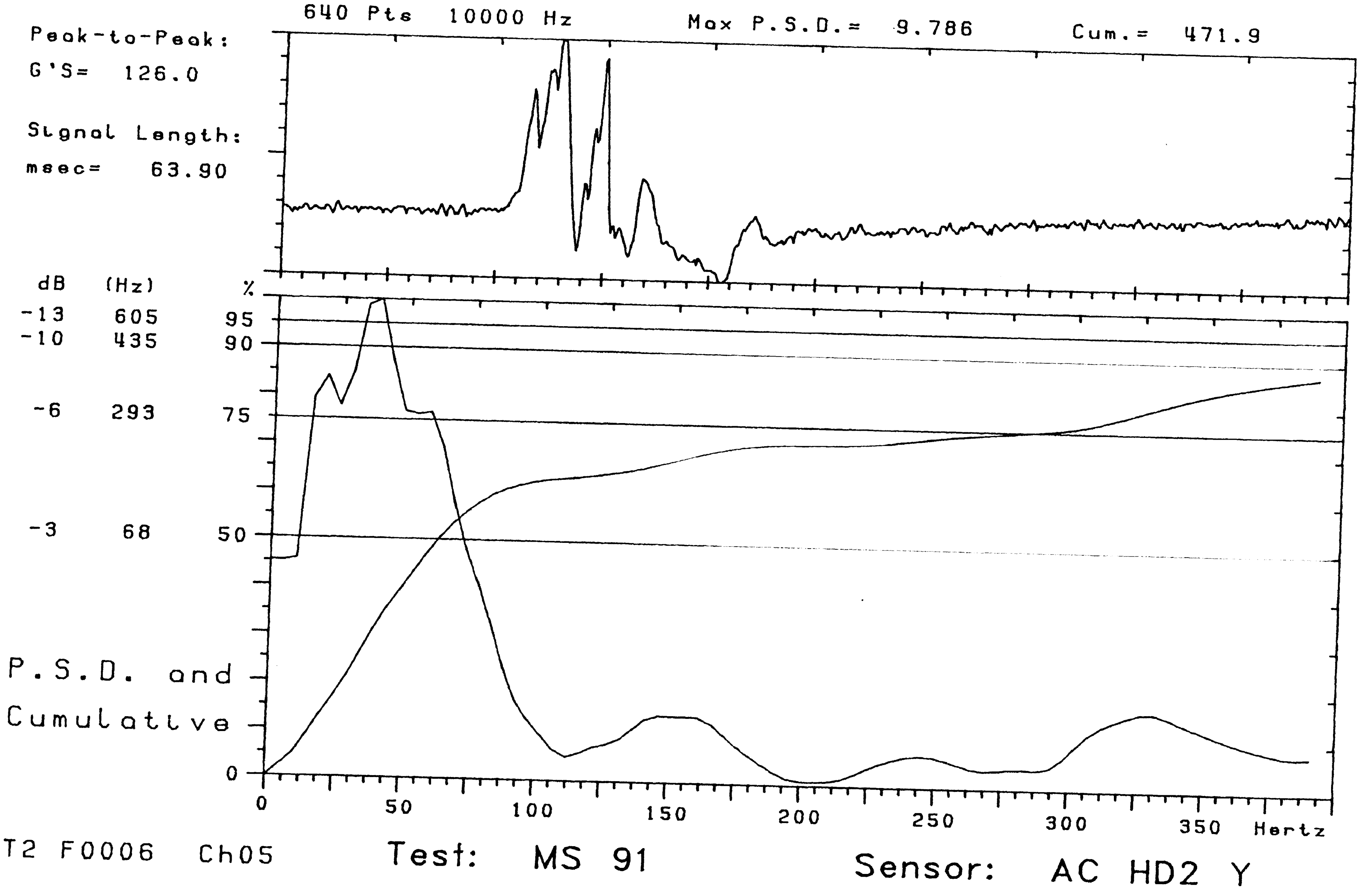

1024 Pts 10000 Hz
Max P.S.D.= 12.83
Cum.= 888.5
Peak-to-Peak:
G'S= 284.4
Signal Length:
msec= 102.30
dB (Hz) %
-13 2222 95
-10 1865 90
-6 527 75
-3 278 50
0
P.S.D. and
Cumulative
0
250
500
750
1000
1250
1500
1750
Hertz
T1 F3514 Ch04
Test: 76A144
Sensor: AC HD1 Z

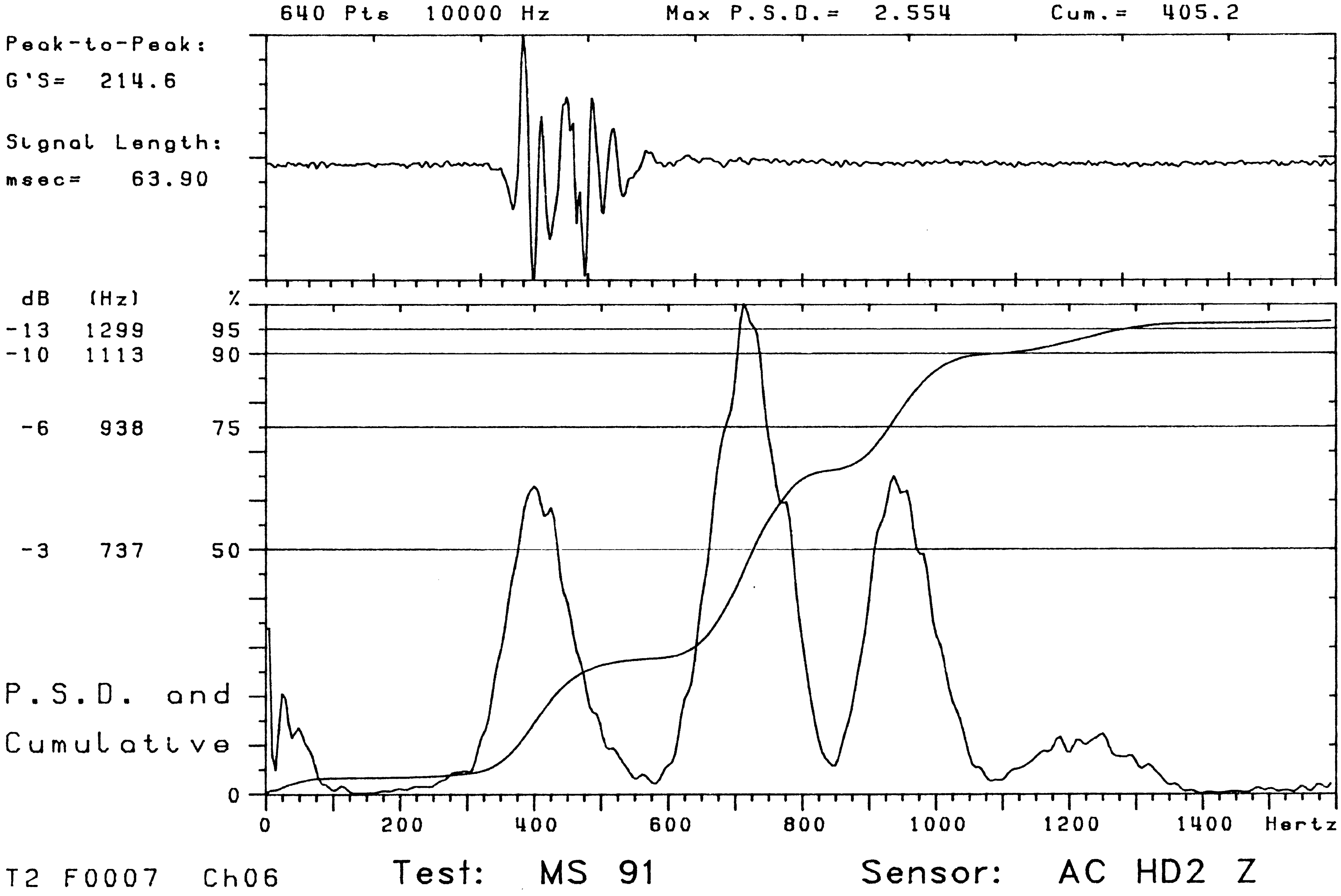

1024 Pts 10000 Hz
Max P.S.D.= 37.84
Cum.= 5589.
Peak-to-Peak:
G'S= 739.6
Signal Length:
msec= 102.30
dB (Hz) %
-13 1099 95
-10 786 90
-6 415 75
-3 220 50
0
P.S.D. and
Cumulative
0
250
500
750
1000
1250
1500
1750
Hertz
T1 F3515 Ch05
Test: 76A144
Sensor: AC HD2 Z

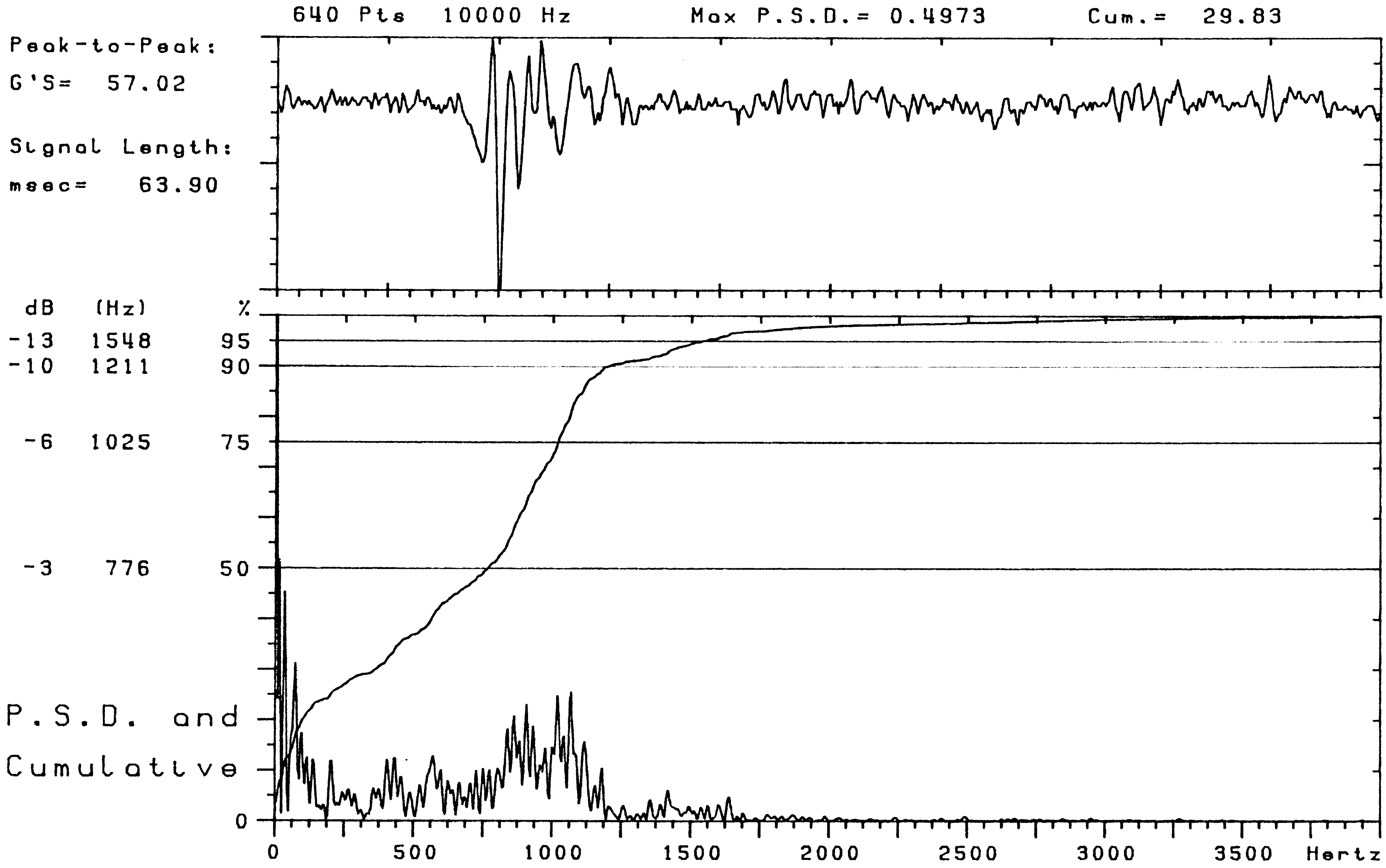

1024 Pts 10000 Hz
Max P.S.D.= 76.29
Cum.= 2359.
Peak-to-Peak:
G'S= 414.1
Signal Length:
msec= 102.30
dB (Hz) %
-13 1909 95
-10 1333 90
-6 581 75
-3 112 50
0
P.S.D. and Cumulative
0
250
500
750
1000
1250
1500
1750
Hertz
T1 F3516 Ch06
Test: 76A144
Sensor: AC HD2 X


2560 Pts 25000 Hz
Max P.S.D.= 278.0
Cum.= 9472.
Peak-to-Peak:
G'S= 732.7
Signal Length:
msec= 102.36
dB (Hz)
-13 1312
-10 1147
-6 189
-3 85
%
95
90
75
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T1 F3529 Ch06
Test: 76A145
Sensor: AC HD2 X

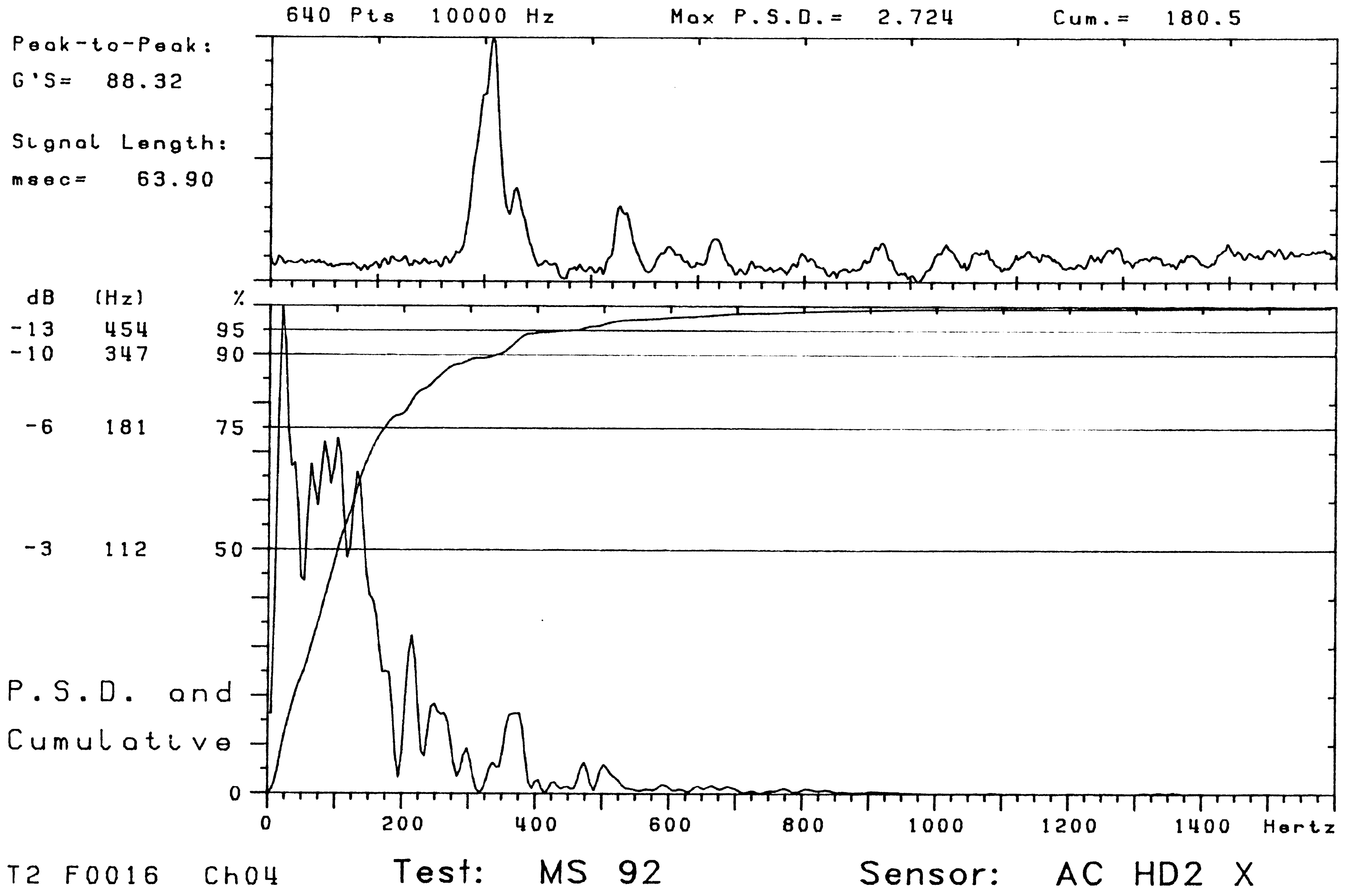

640 Pts 10000 Hz
Max P.S.D.= 77.22
Cum.= 3045.
Peak-to-Peak:
G'S= 263.4
Signal Length:
msec= 63.90
dB
(Hz)
%
-13
249
95
-10
171
90
-6
78
75
-3
49
50
P.S.D. and
Cumulative
0
0
50
100
150
200
250
300
350
Hertz
T2 F0005 Ch04
Test: MS 91
Sensor: AC HD2 X

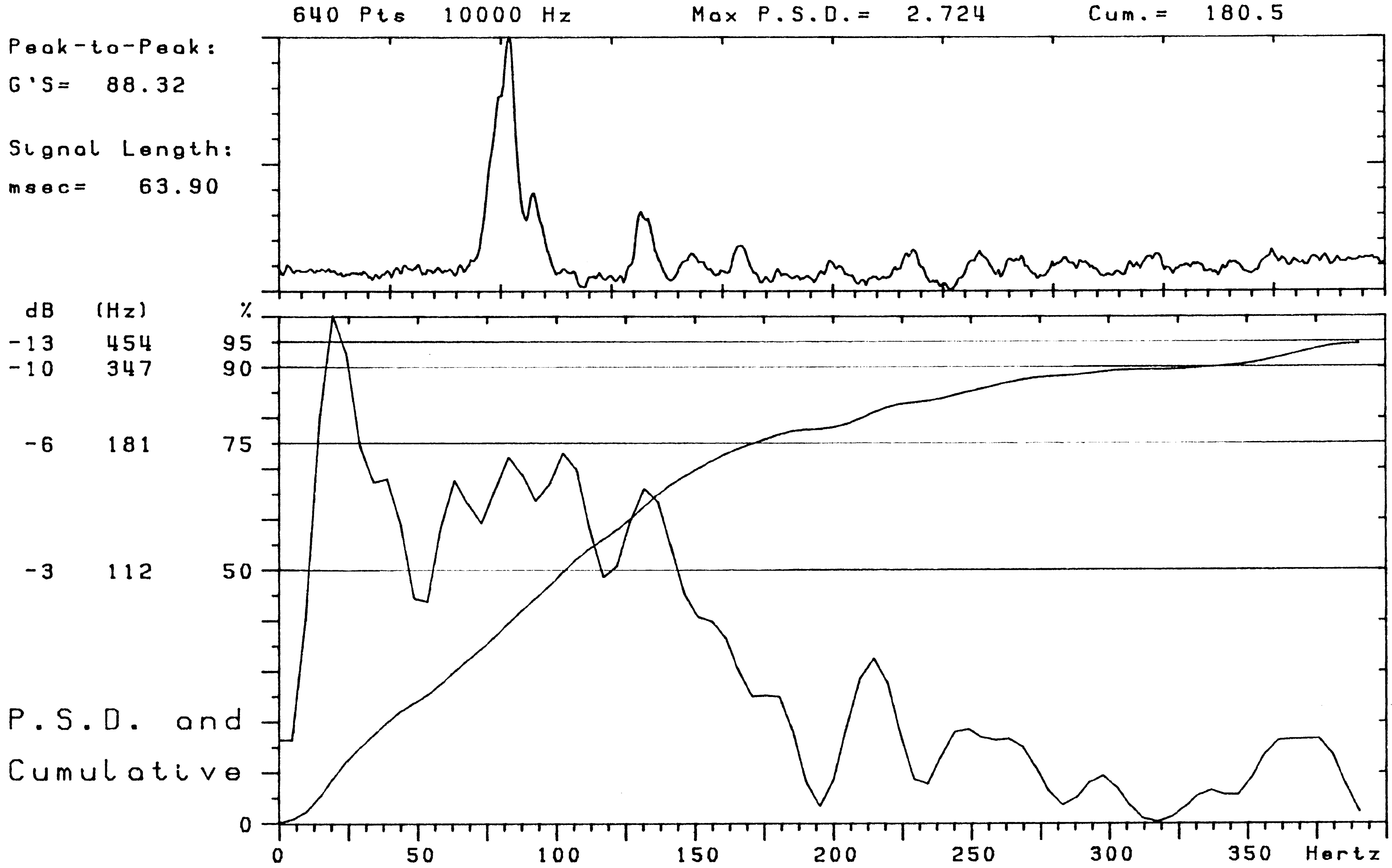

640 Pts 10000 Hz
Max P.S.D.= 9.786
Cum.= 471.9
Peak-to-Peak:
G'S= 126.0
Signal Length:
msec= 63.90
dB (Hz)
-13 605
-10 435
-6 293
-3 68
%
95
90
75
50
0
P.S.D. and
Cumulative
0
50
100
150
200
250
300
350
Hertz
T2 F0006 Ch05
Test: MS 91
Sensor: AC HD2 Y


640 Pts 10000 Hz
Max P.S.D.= 2.554
Cum.= 405.2
Peak-to-Peak:
G'S= 214.6
Signal Length:
msec= 63.90
dB (Hz) %
-13 1299 95
-10 1113 90
-6 938 75
-3 737 50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T2 F0007 Ch06
Test: MS 91
Sensor: AC HD2 Z

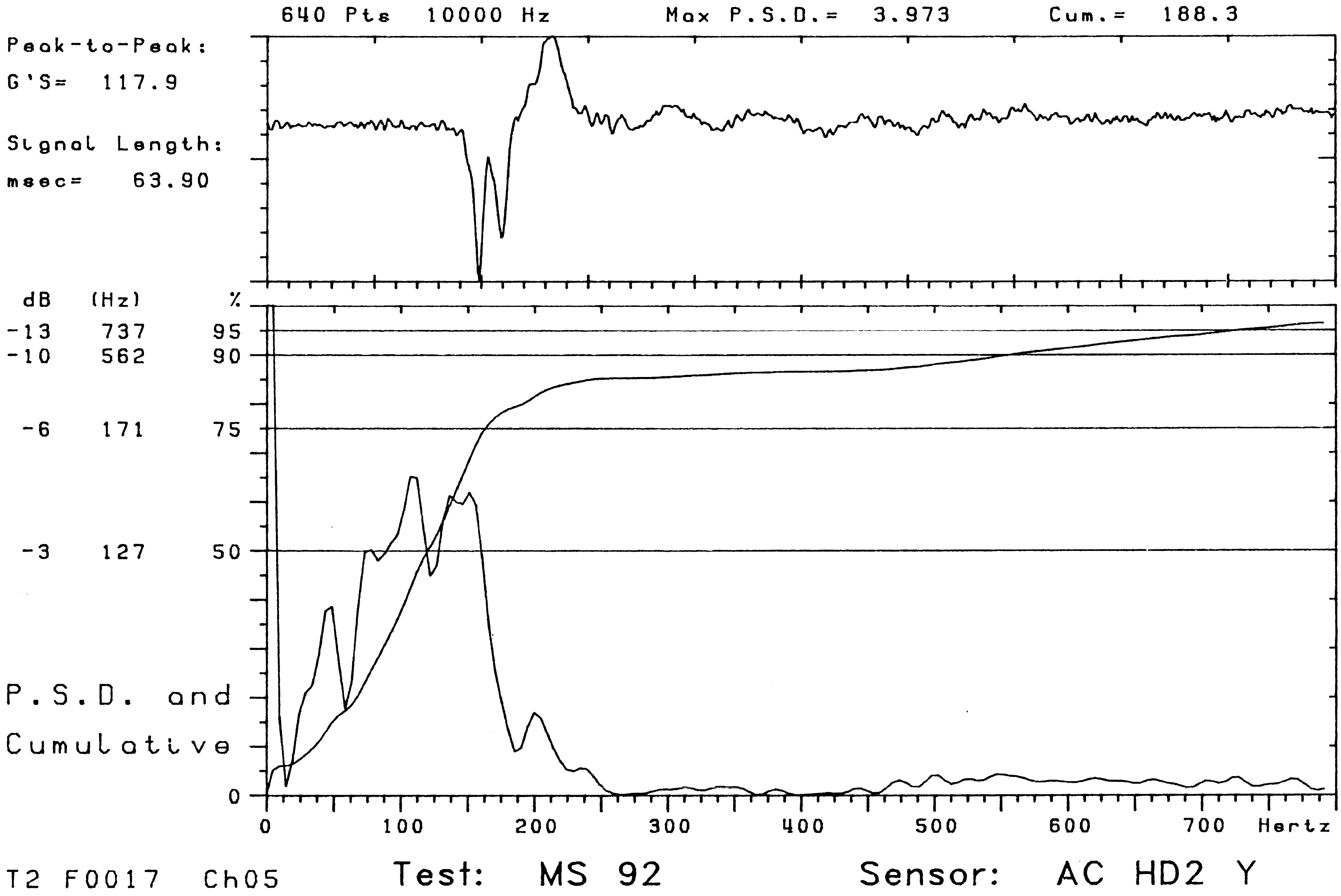


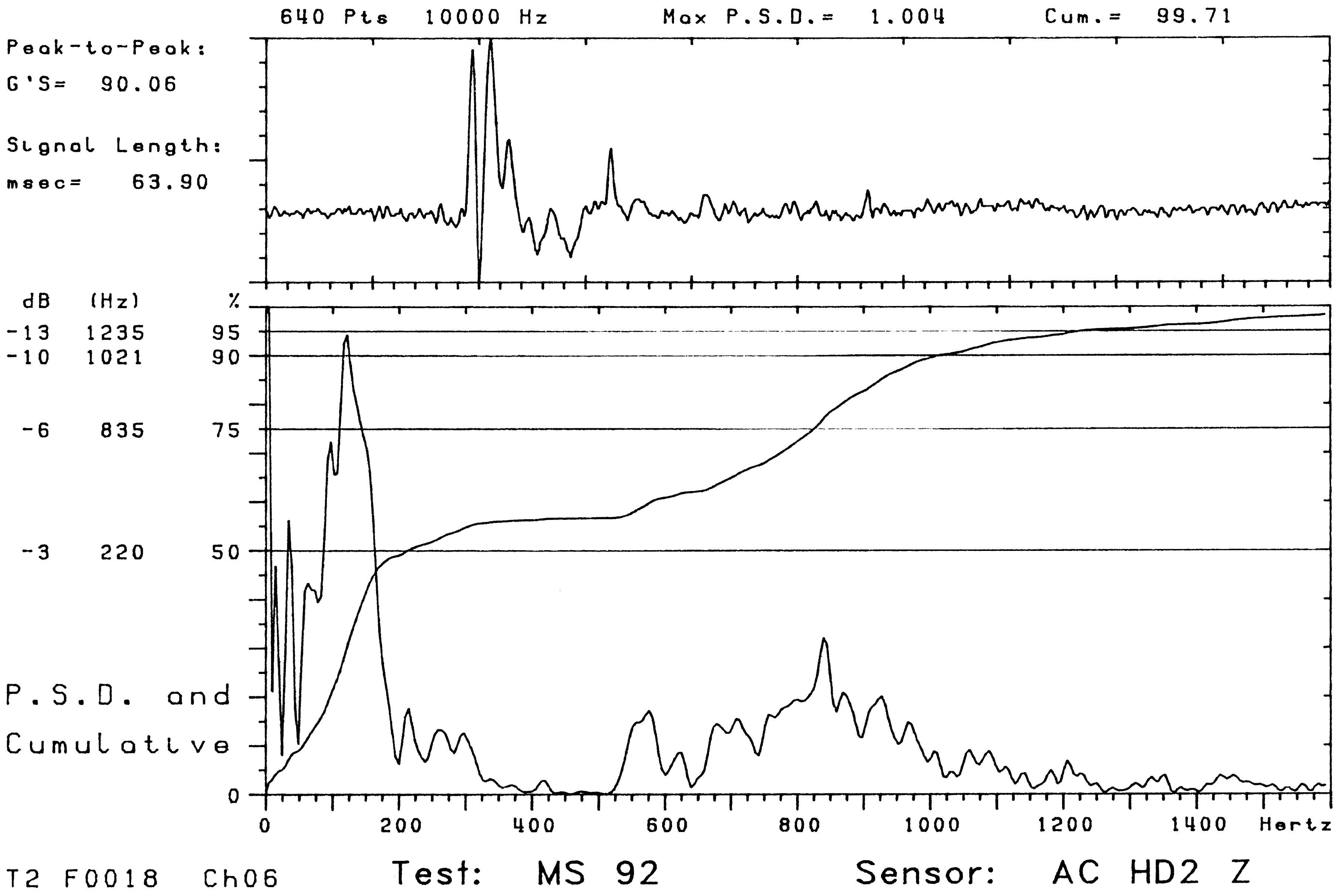
T2 F0015 Ch03 Test: MS 92 Sensor: AC HD1 Z

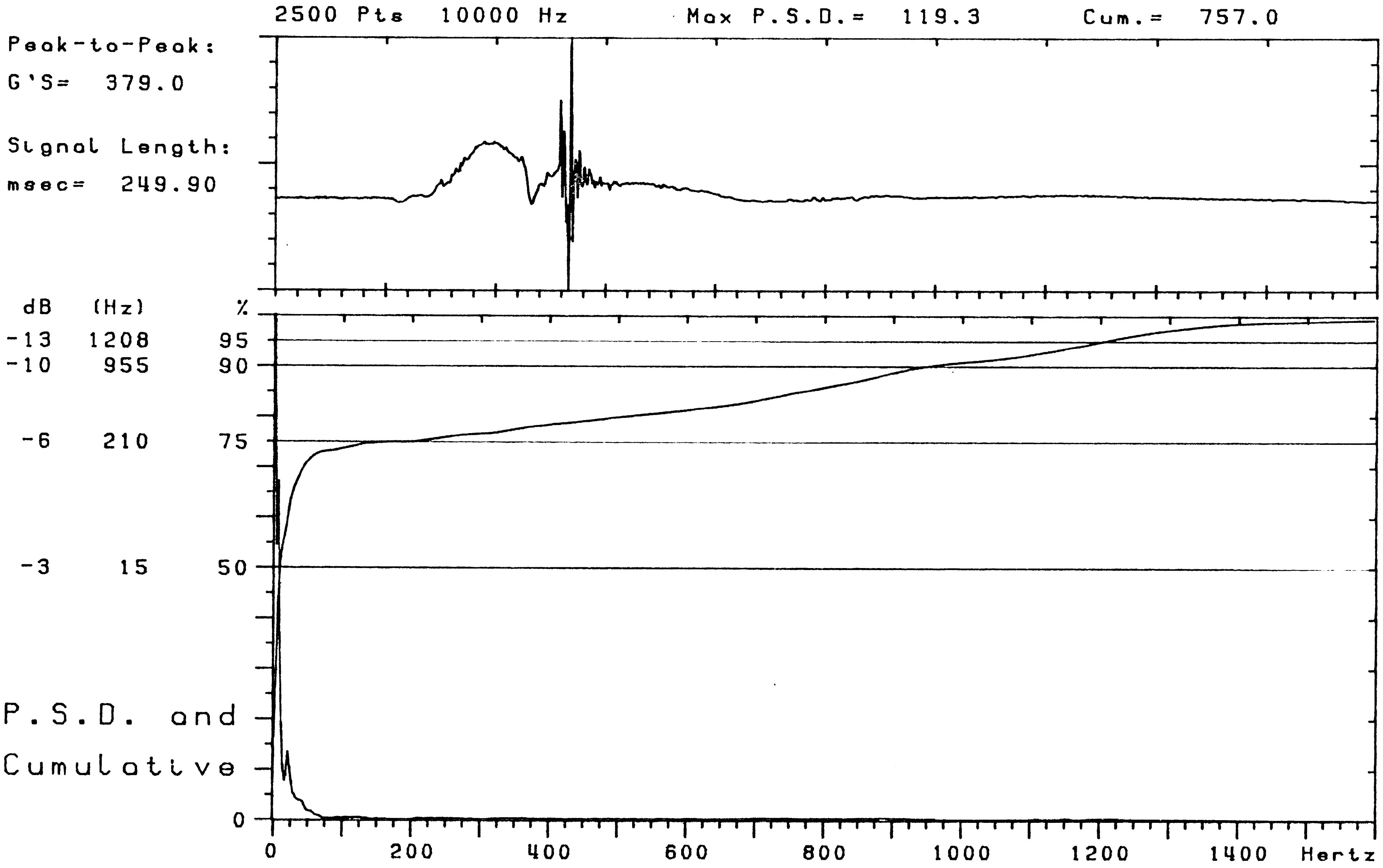

640 Pts 10000 Hz
Max P.S.D.= 2.724
Cum.= 180.5
Peak-to-Peak:
G'S= 88.32
Signal Length:
msec= 63.90
dB
(Hz)
%
-13
454
95
-10
347
90
-6
181
75
-3
112
50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T2 F0016 Ch04
Test: MS 92
Sensor: AC HD2 X



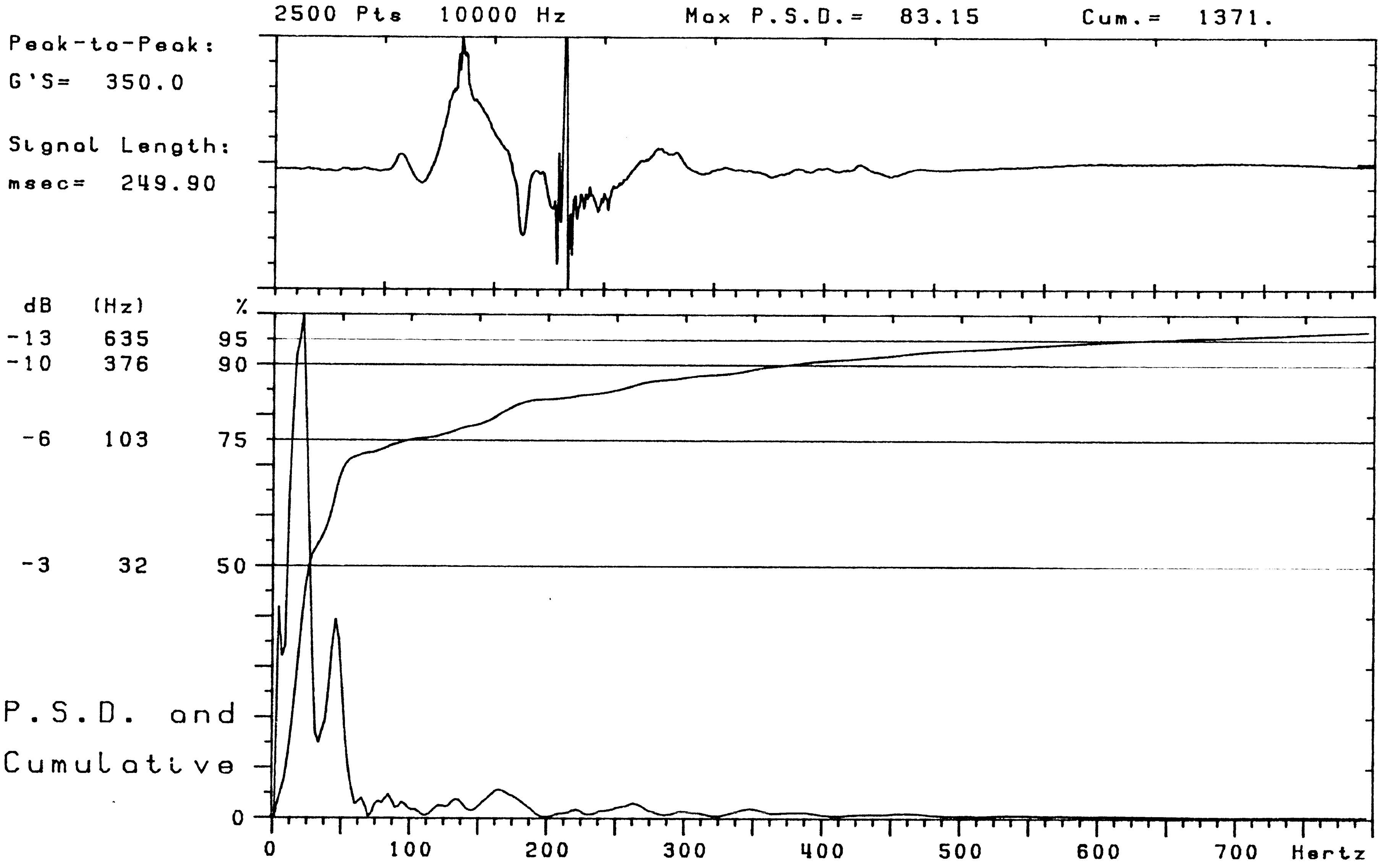
T2 F0016 Ch04 Test: MS 92 Sensor: AC HD2 X


640 Pts 10000 Hz
Max P.S.D.= 3.973
Cum.= 188.3
Peak-to-Peak:
G'S= 117.9
Signal Length:
msec= 63.90
dB (Hz) %
-13 737 95
-10 562 90
-6 171 75
-3 127 50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T2 F0017 Ch05
Test: MS 92
Sensor: AC HD2 Y

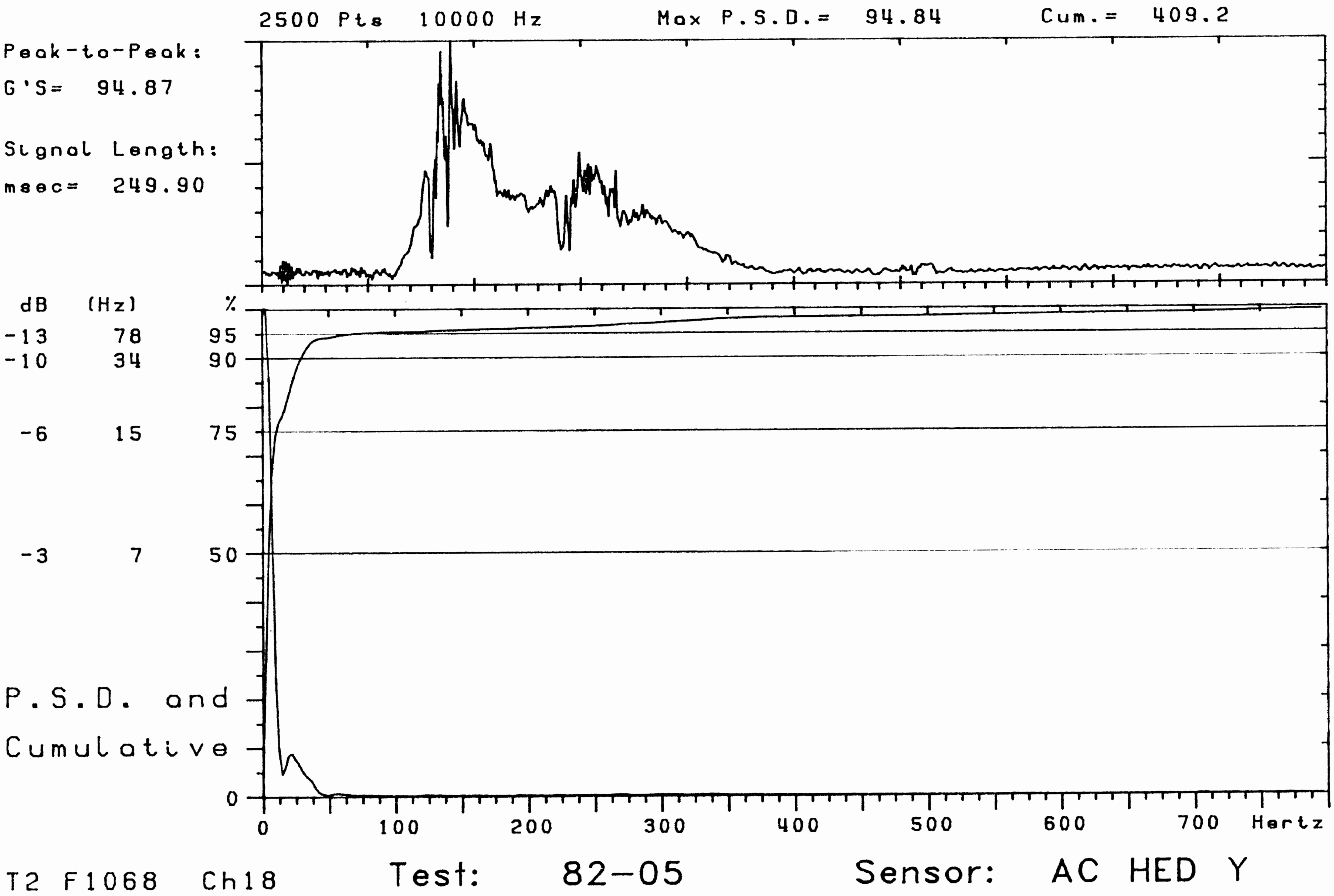

640 Pts 10000 Hz
Max P.S.D.= 1.004
Cum.= 99.71
Peak-to-Peak:
G'S= 90.06
Signal Length:
msec= 63.90
dB (Hz) %
-13 1235 95
-10 1021 90
-6 835 75
-3 220 50
0
P.S.D. and
Cumulative
0
200
400
600
800
1000
1200
1400
Hertz
T2 F0018 Ch06
Test: MS 92
Sensor: AC HD2 Z

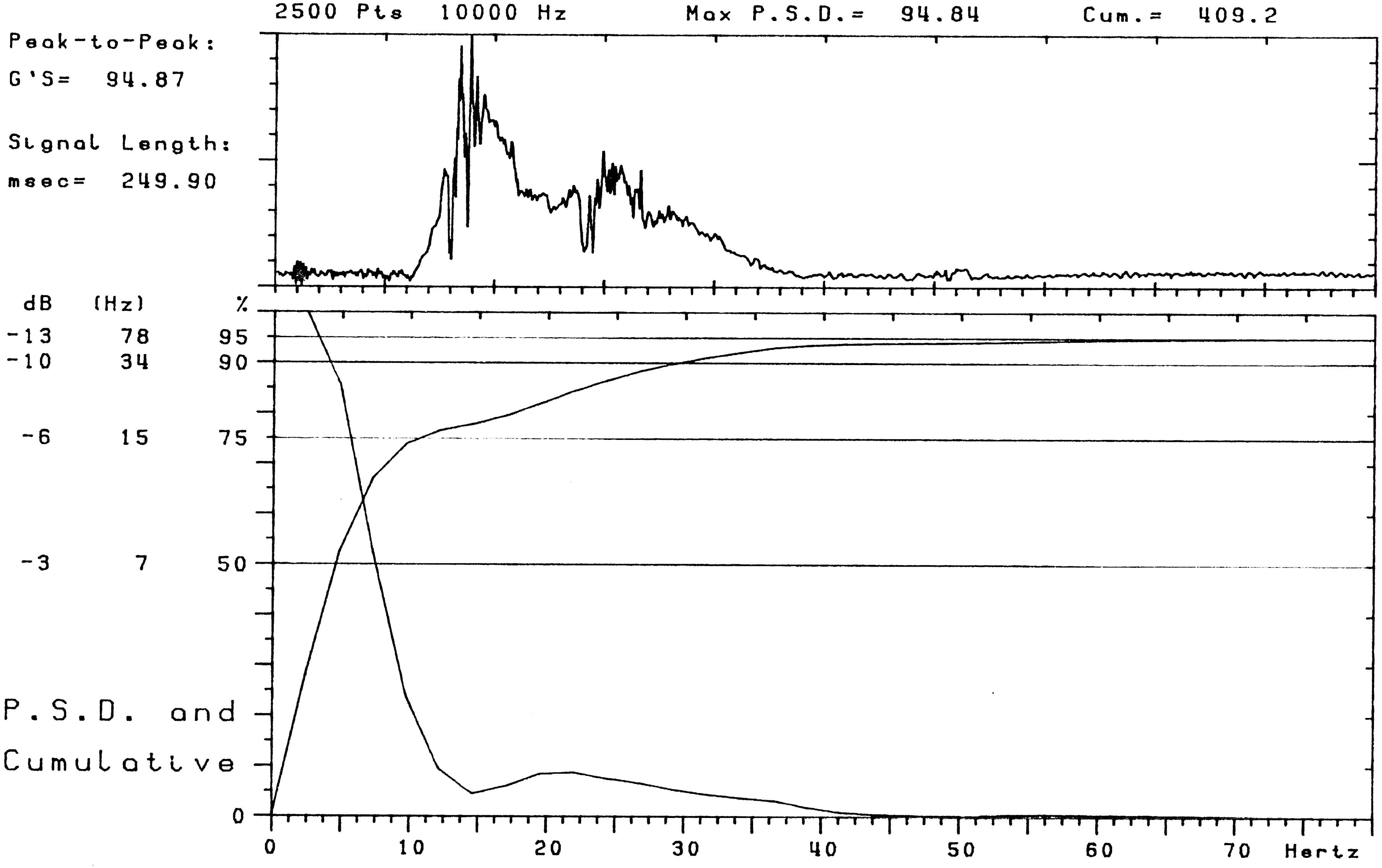


T2 F1039 Ch18 **Test: 82-04 Sensor: AC HED Y**

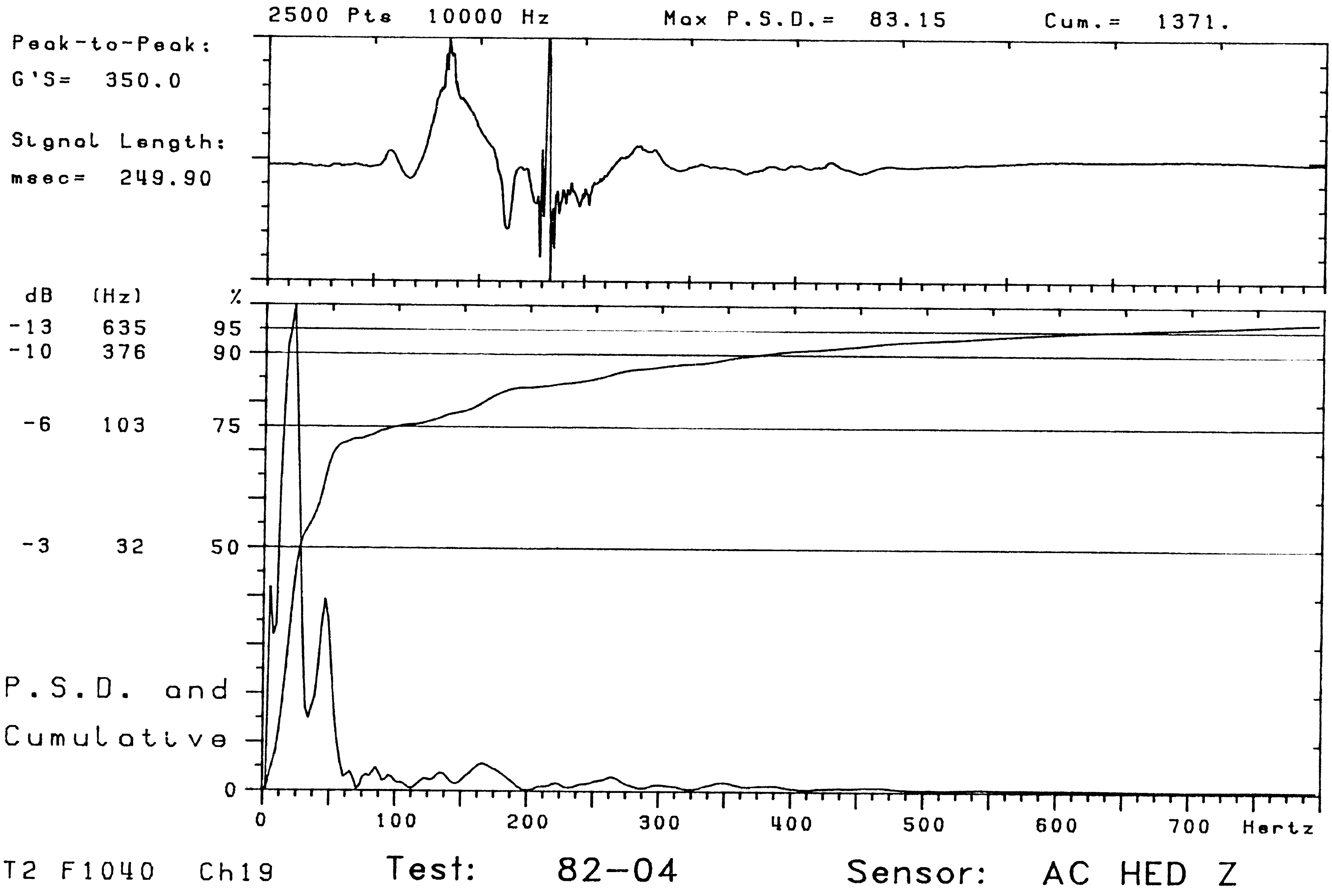


T2 F1040 Ch19 **Test: 82-04 Sensor: AC HED Z**

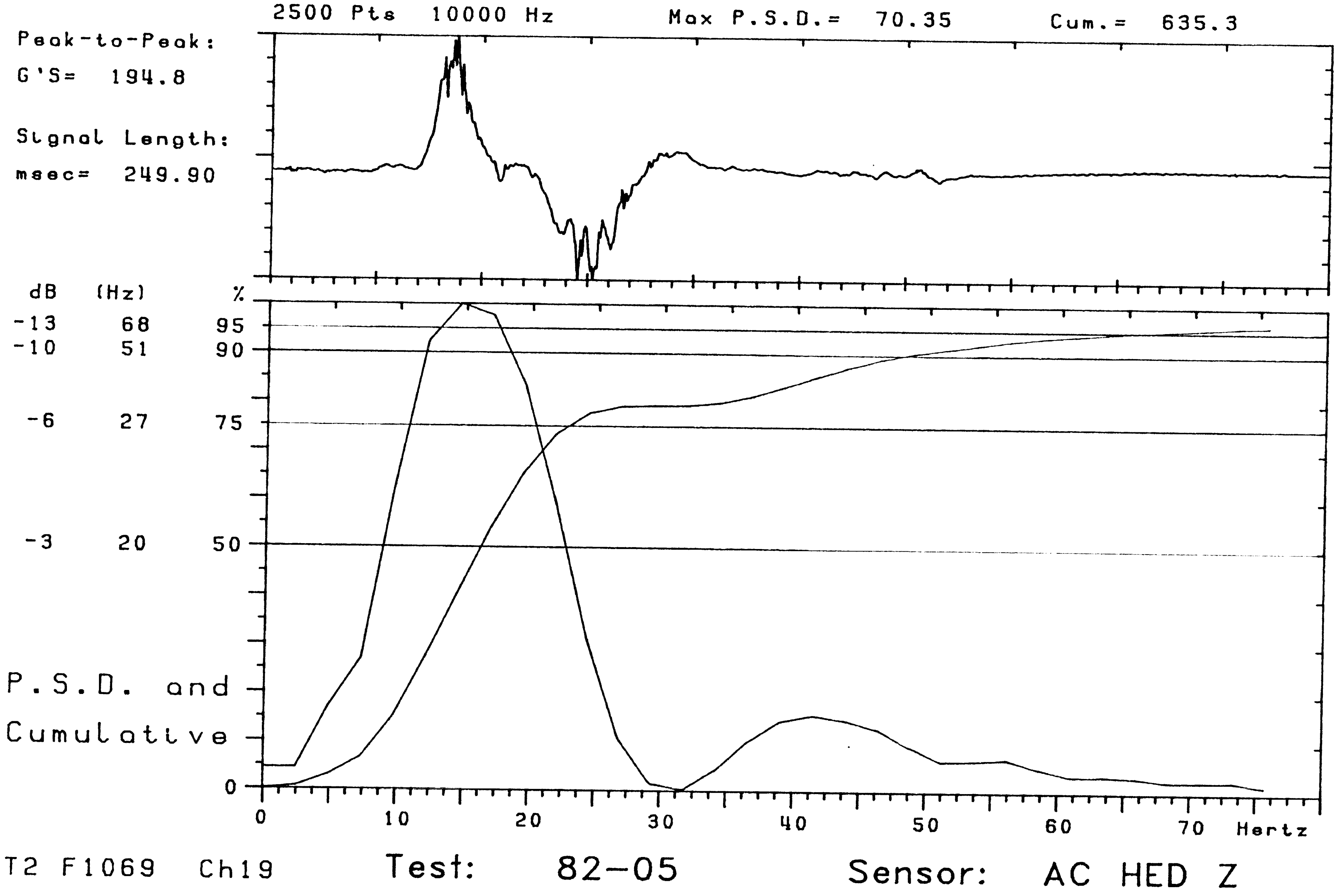

2500 Pts 10000 Hz
Max P.S.D.= 94.84
Cum.= 409.2
Peak-to-Peak:
G'S= 94.87
Signal Length:
msec= 249.90
dB (Hz) %
-13 78 95
-10 34 90
-6 15 75
-3 7 50
0
P.S.D. and
Cumulative
0
100
200
300
400
500
600
700
Hertz
T2 F1068 Ch18
Test: 82-05
Sensor: AC HED Y



T2 F1068 Ch18 Test: 82-05 Sensor: AC HED Y



T2 F1040 Ch19 **Test: 82-04** **Sensor: AC HED Z**


2500 Pts 10000 Hz
Max P.S.D.= 70.35
Cum.= 635.3
Peak-to-Peak:
G'S= 194.8
Signal Length:
msec= 249.90
dB (Hz)
-13 68
-10 51
-6 27
-3 20
%
95
90
75
50
0
P.S.D. and
Cumulative
0
10
20
30
40
50
60
70
Hertz
T2 F1069 Ch19
Test: 82-05
Sensor: AC HED Z