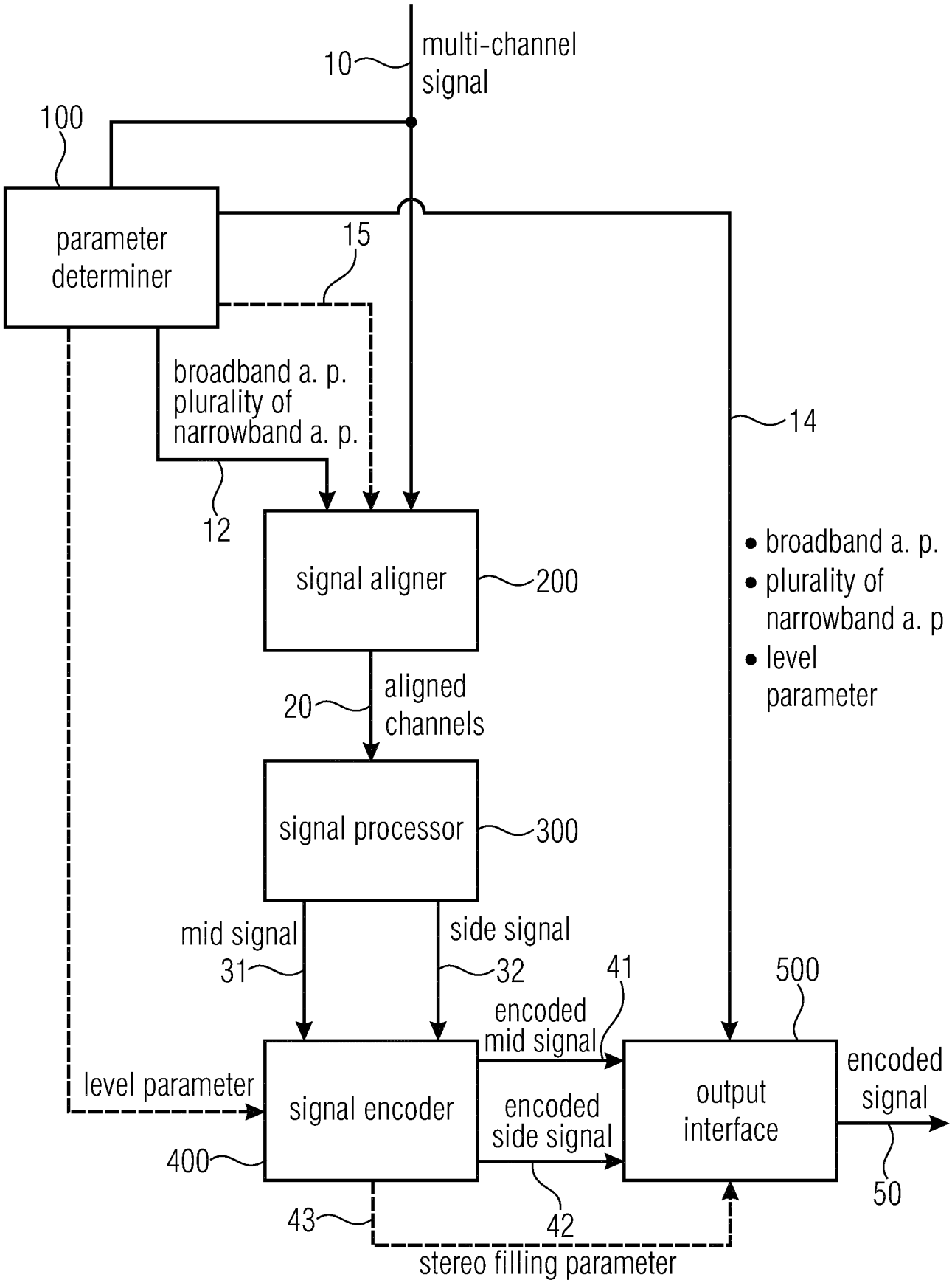

10
multi-channel signal
100
parameter determiner
15
broadband a. p.
plurality of narrowband a. p.
12
14
signal aligner
200
• broadband a. p.
• plurality of narrowband a. p
• level parameter
20
aligned channels
signal processor
300
mid signal
31
side signal
32
41
encoded mid signal
500
level parameter
signal encoder
400
encoded side signal
output interface
encoded signal
50
43
42
stereo filling parameter

Fig. 1

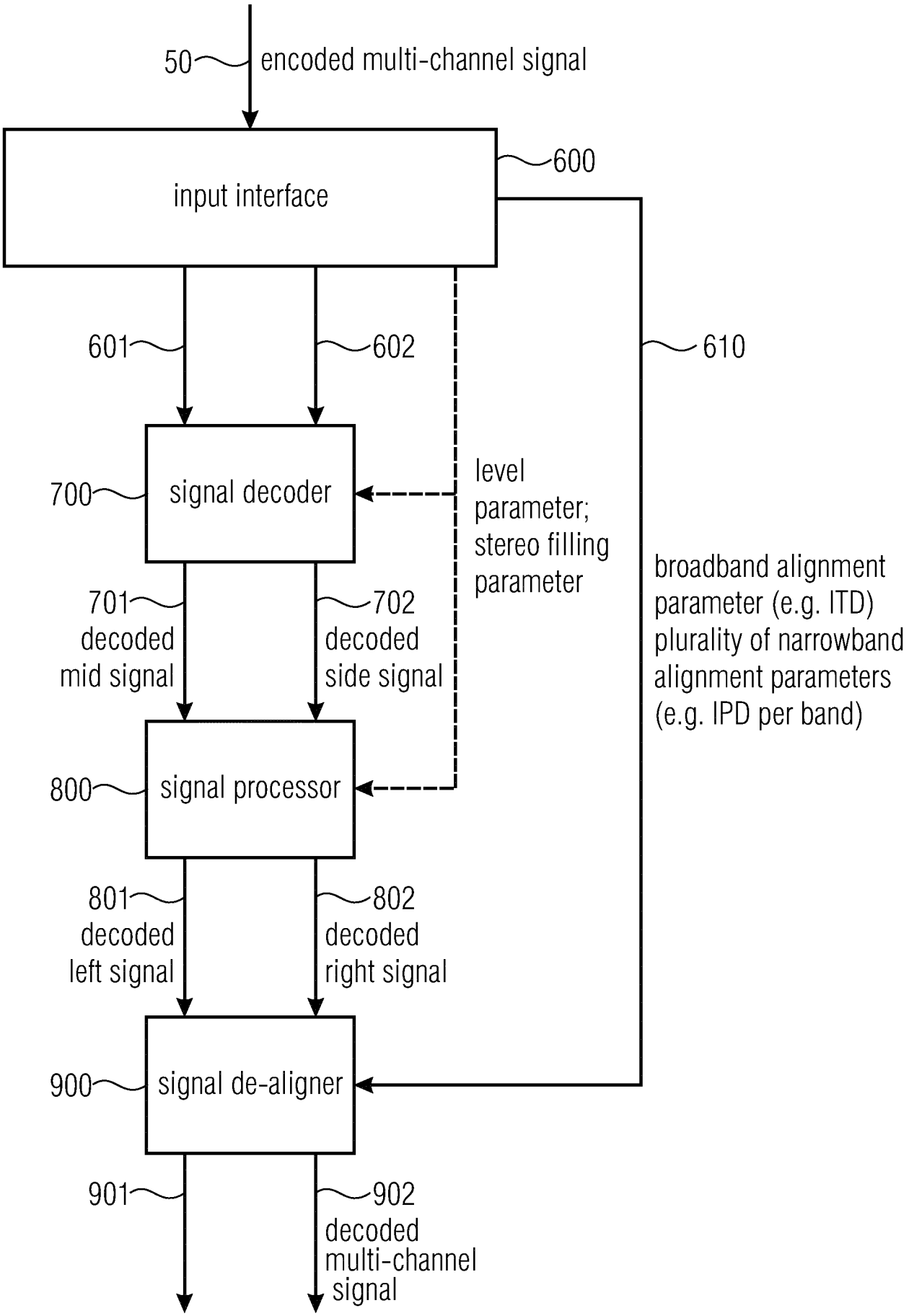
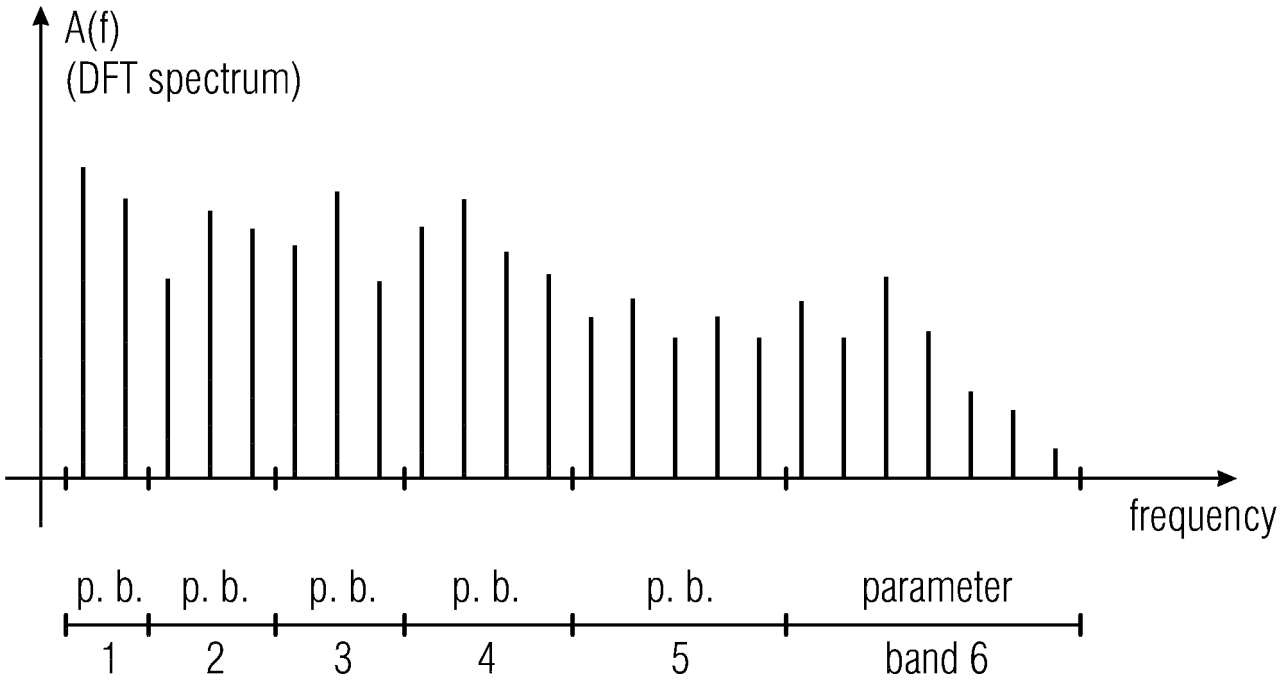

50
encoded multi-channel signal
input interface
600
601
602
610
700
signal decoder
level parameter; stereo filling parameter
broadband alignment parameter (e.g. ITD)
plurality of narrowband alignment parameters (e.g. IPD per band)
701
decoded mid signal
702
decoded side signal
800
signal processor
801
decoded left signal
802
decoded right signal
900
signal de-aligner
901
902
decoded multi-channel signal

Fig. 2



- single broadband alignment parameter for whole spectrum (e. g. p. band 1 to p. band 6);
- plurality of narrowband alignment parameters for parameter bands 1, 2, 3, 4, i. e., four narrowband parameters;
- level parameters for each parameter band, e. g. 6 level parameters;
- stereo filling parameters for parameter bands 4, 5, 6, e. g. three stereo filling parameters;
- side (residual) signal for parameter bands 1, 2, 3;
- more spectral lines in higher band, e.g. seven spectral lines in parameter band 6 versus three spectral lines in parameter band 2.

Fig. 3

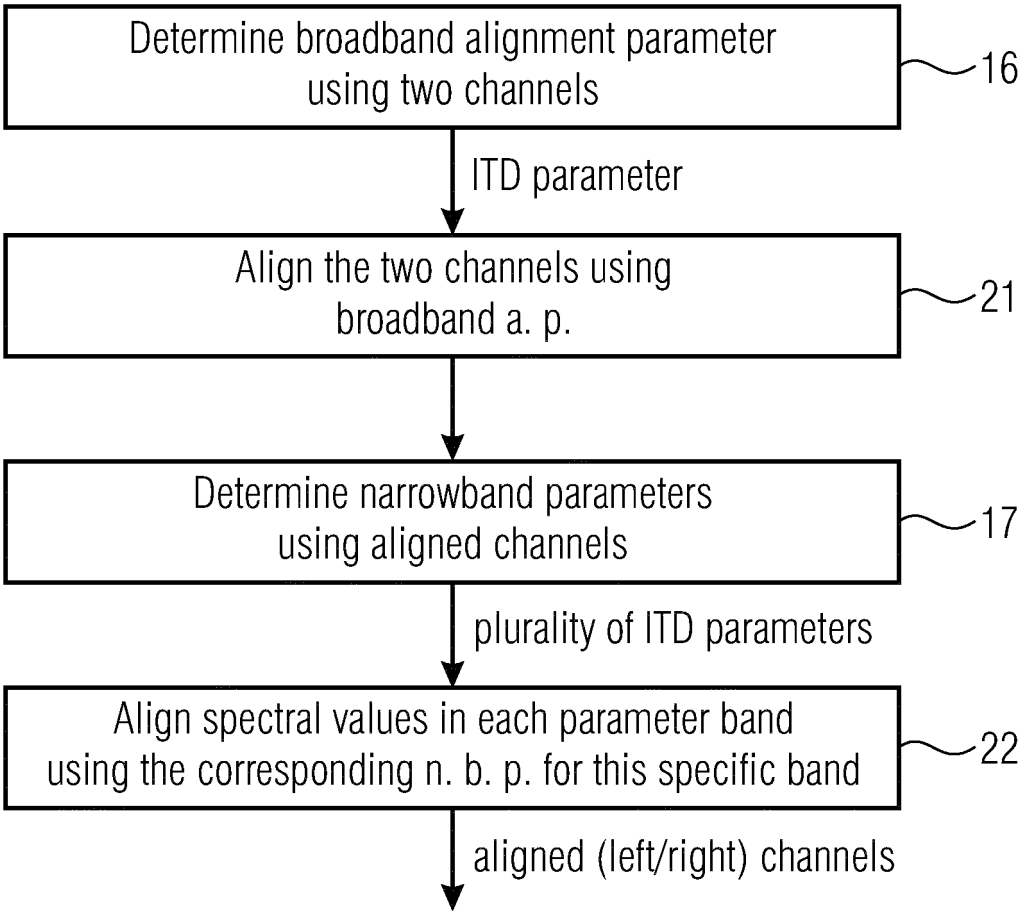

Determine broadband alignment parameter using two channels
16
ITD parameter
Align the two channels using broadband a. p.
21
Determine narrowband parameters using aligned channels
17
plurality of ITD parameters
Align spectral values in each parameter band using the corresponding n. b. p. for this specific band
22
aligned (left/right) channels

Fig. 4a

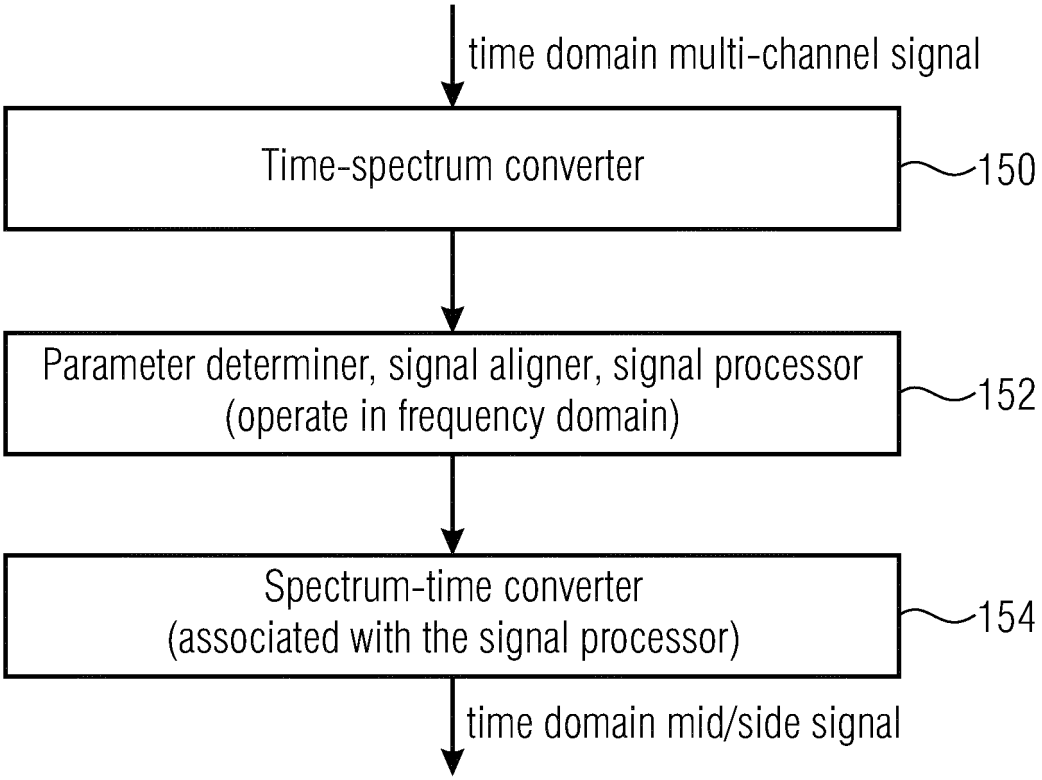

time domain multi-channel signal
Time-spectrum converter
150
Parameter determiner, signal aligner, signal processor (operate in frequency domain)
152
Spectrum-time converter (associated with the signal processor)
154
time domain mid/side signal

Fig. 4b

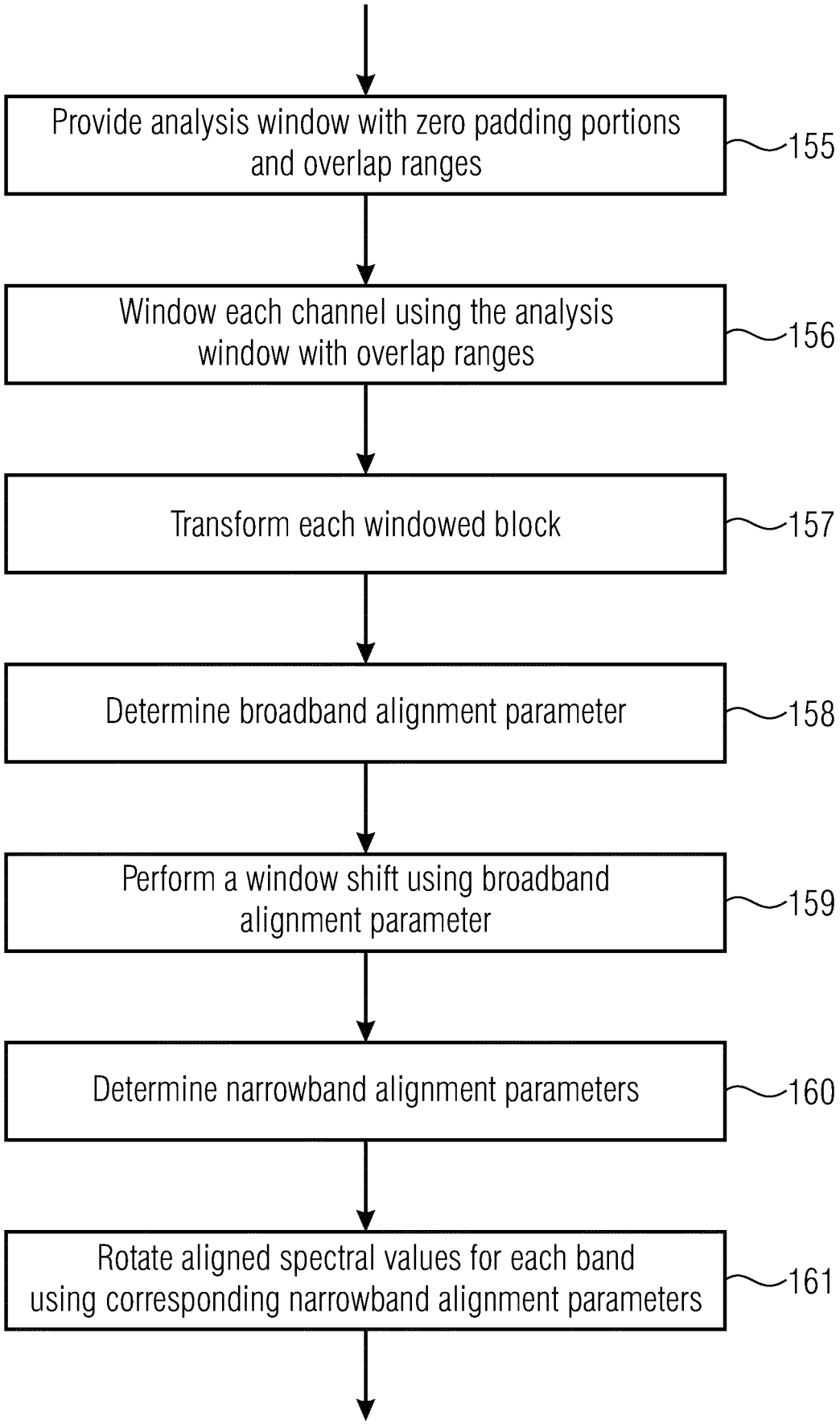

Provide analysis window with zero padding portions and overlap ranges
155
Window each channel using the analysis window with overlap ranges
156
Transform each windowed block
157
Determine broadband alignment parameter
158
Perform a window shift using broadband alignment parameter
159
Determine narrowband alignment parameters
160
Rotate aligned spectral values for each band using corresponding narrowband alignment parameters
161

Fig. 4c

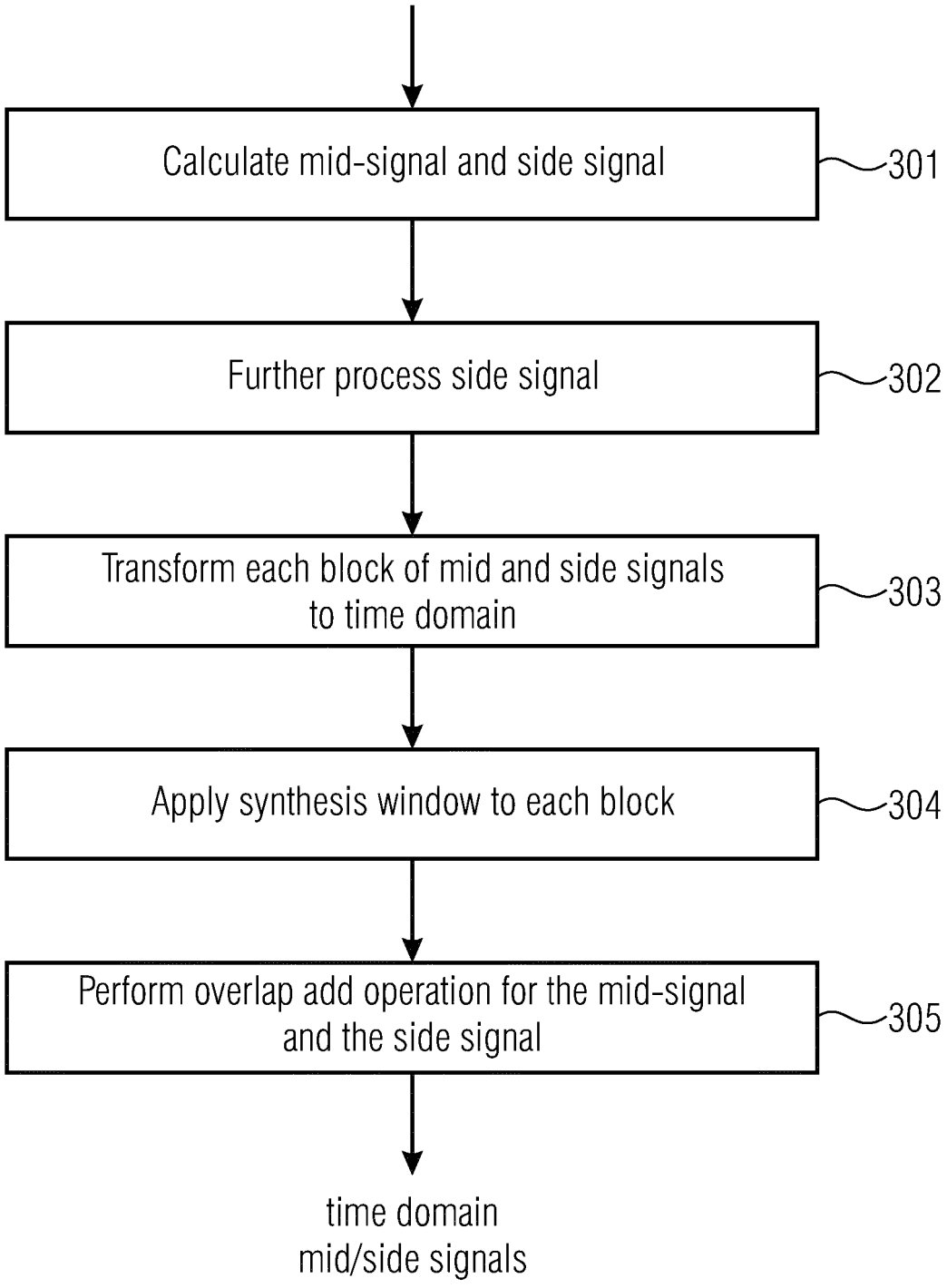
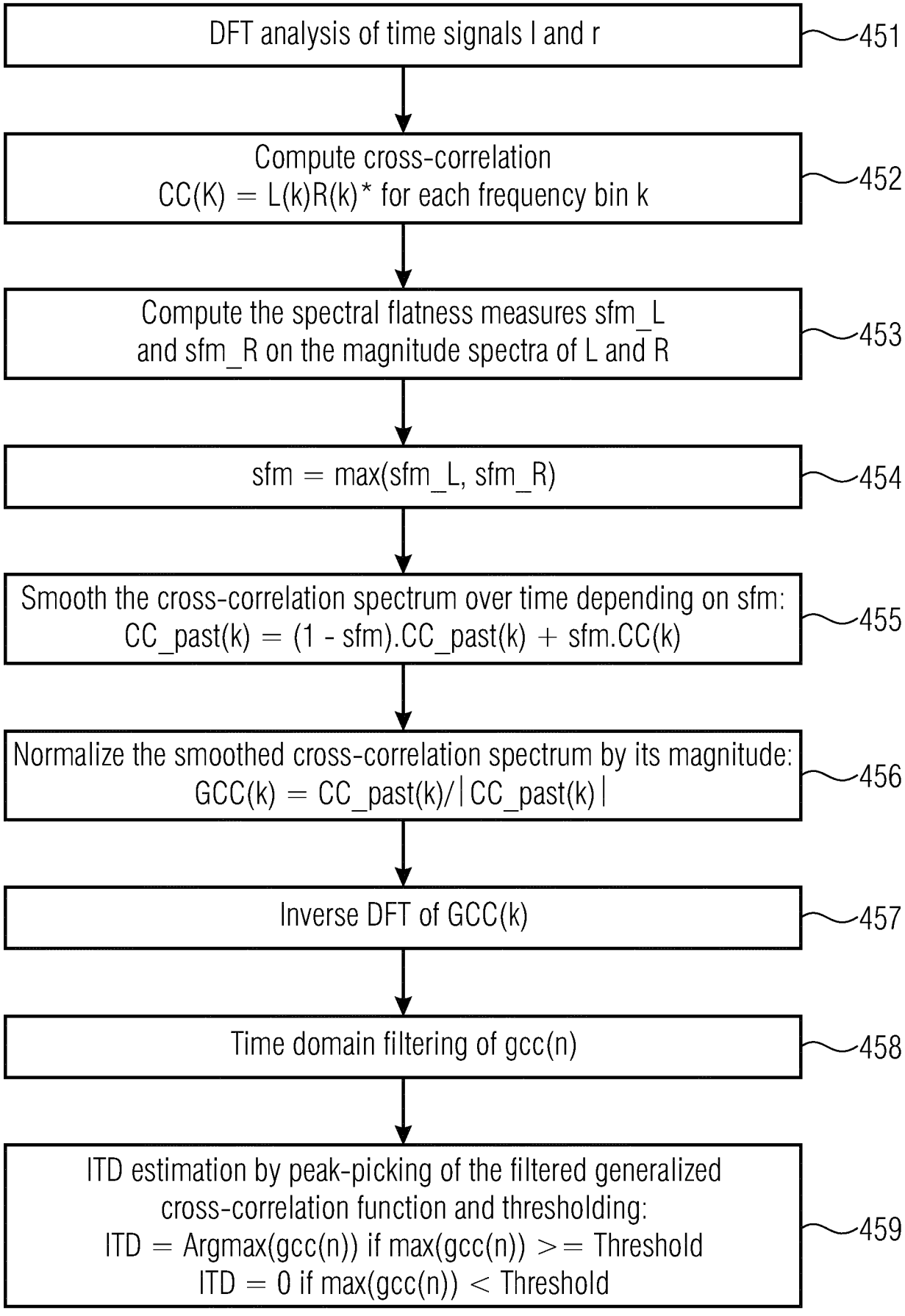

Calculate mid-signal and side signal
301
Further process side signal
302
Transform each block of mid and side signals to time domain
303
Apply synthesis window to each block
304
Perform overlap add operation for the mid-signal and the side signal
305
time domain mid/side signals

Fig. 4d



ITD estimation

Fig. 4e

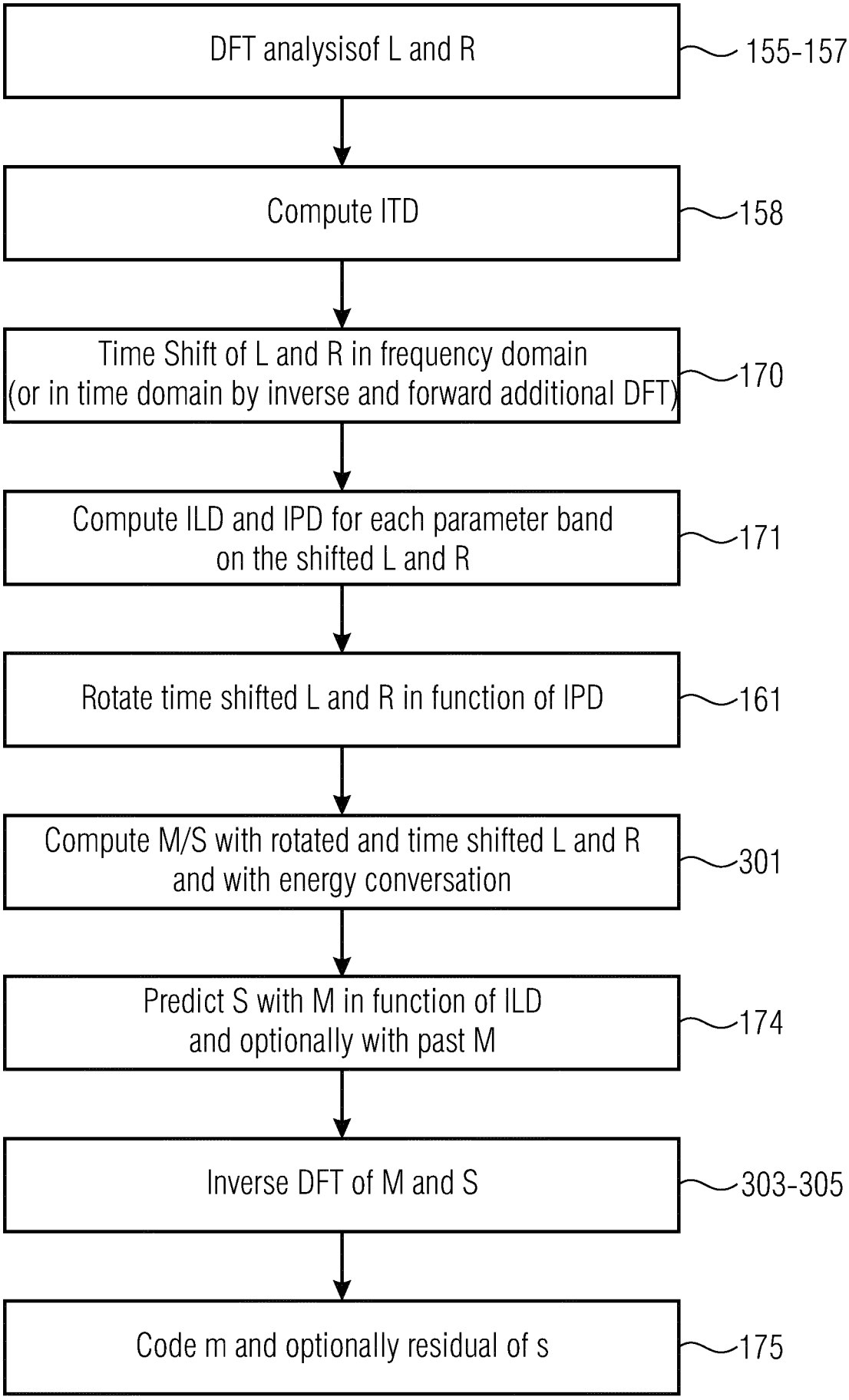

DFT analysisof L and R
155-157
Compute ITD
158
Time Shift of L and R in frequency domain
(or in time domain by inverse and forward additional DFT)
170
Compute ILD and IPD for each parameter band
on the shifted L and R
171
Rotate time shifted L and R in function of IPD
161
Compute M/S with rotated and time shifted L and R
and with energy conversation
301
Predict S with M in function of ILD
and optionally with past M
174
Inverse DFT of M and S
303-305
Code m and optionally residual of s
175

Fig. 5

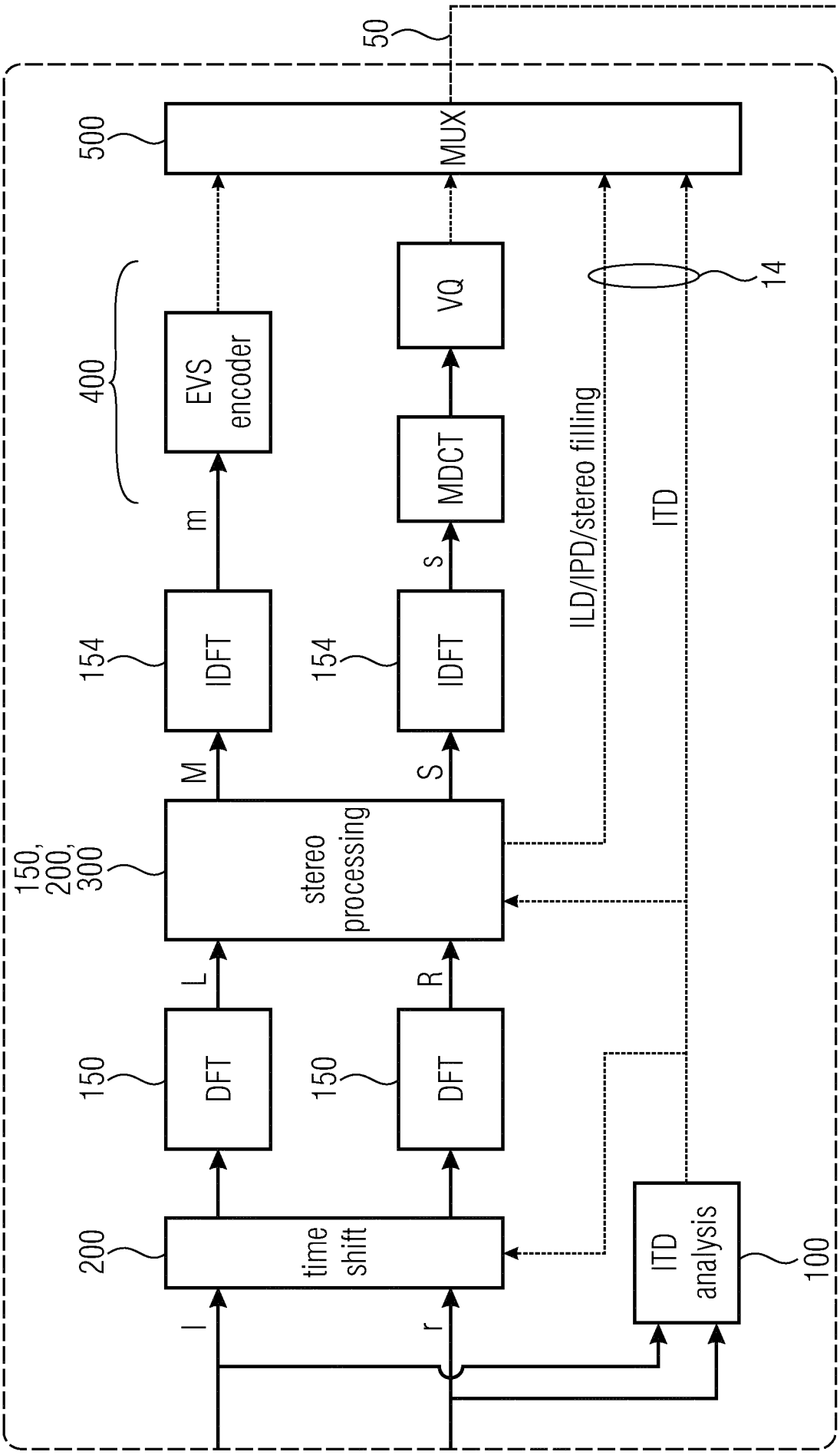

50
500
MUX
400
EVS encoder
VQ
14
m
MDCT
s
ILD/IPD/stereo filling
ITD
154
IDFT
154
IDFT
M
S
150, 200, 300
stereo processing
L
R
150
DFT
150
DFT
200
time shift
l
r
ITD analysis
100

Fig. 6a

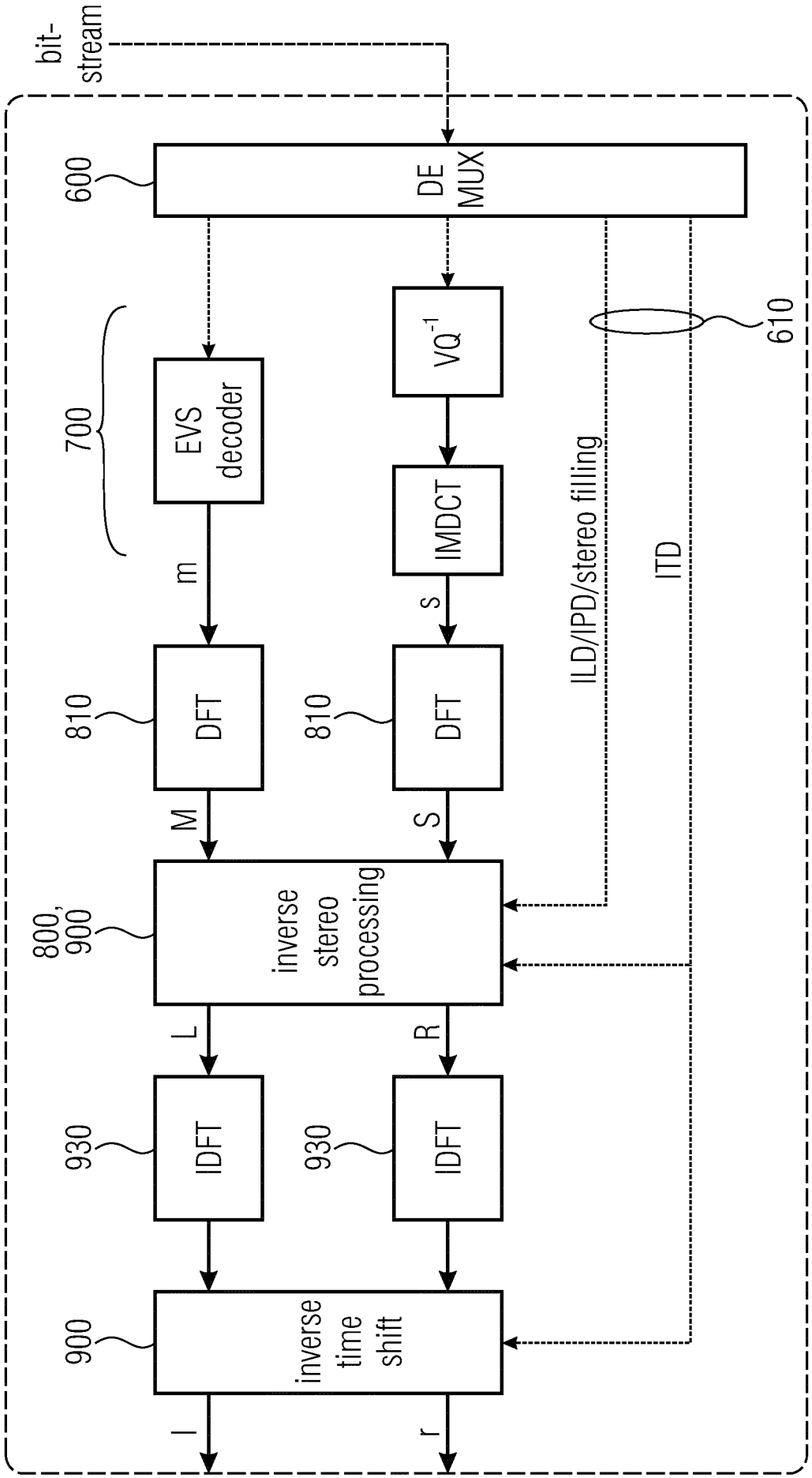

bit-stream
600
DE MUX
700
EVS decoder
VQ-1
610
IMDCT
m
s
ILD/IPD/stereo filling
ITD
810
DFT
810
DFT
M
S
800, 900
inverse stereo processing
L
R
930
IDFT
930
IDFT
900
inverse time shift
l
r

Fig. 6b

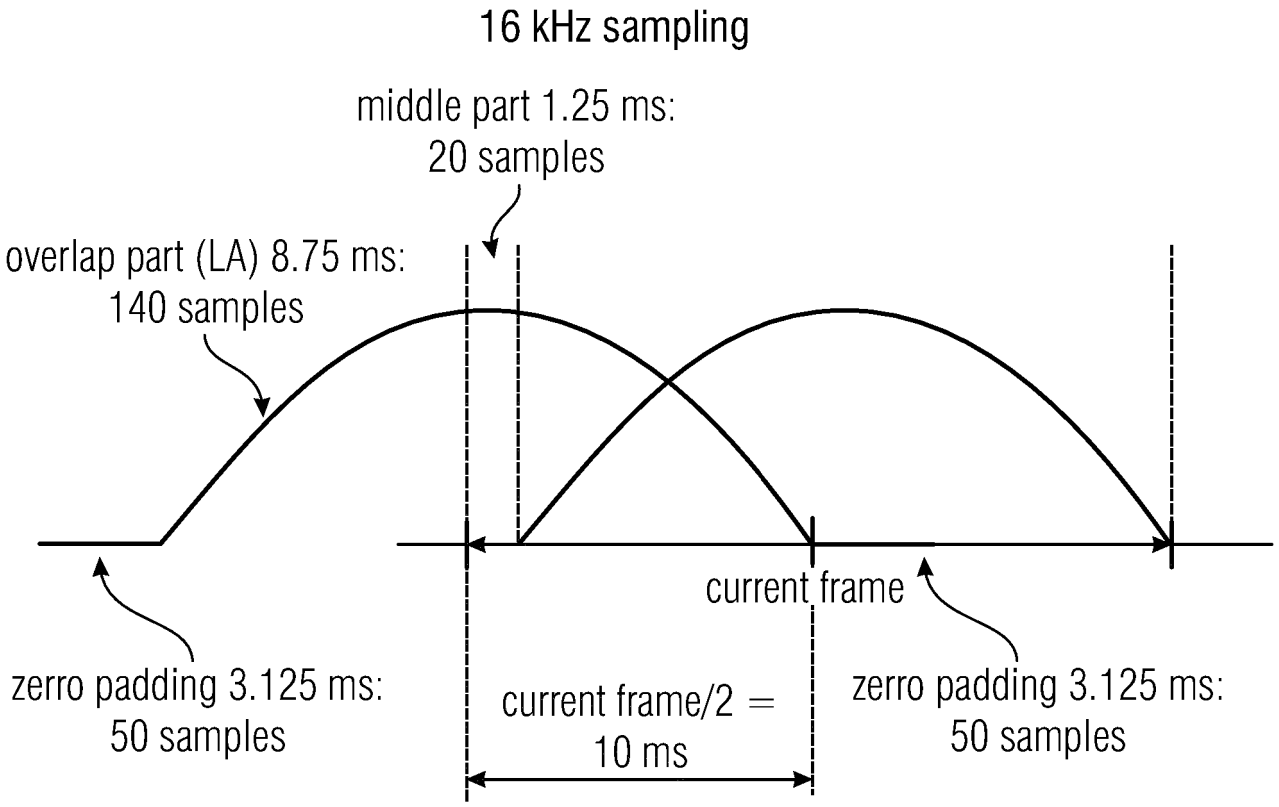


Fig. 7

parameters	bits/band	number of bands	bit-rate
ILD	5	all 12 bands	3.00 kbps
IPD	3	up to 2.5 kHz	1.05 kbps
ITD	8	whole spectrum	0.6 kbps
stereo filling	3	from 1 kHz	0.9 kbps
total			-5 kbps

Fig. 8

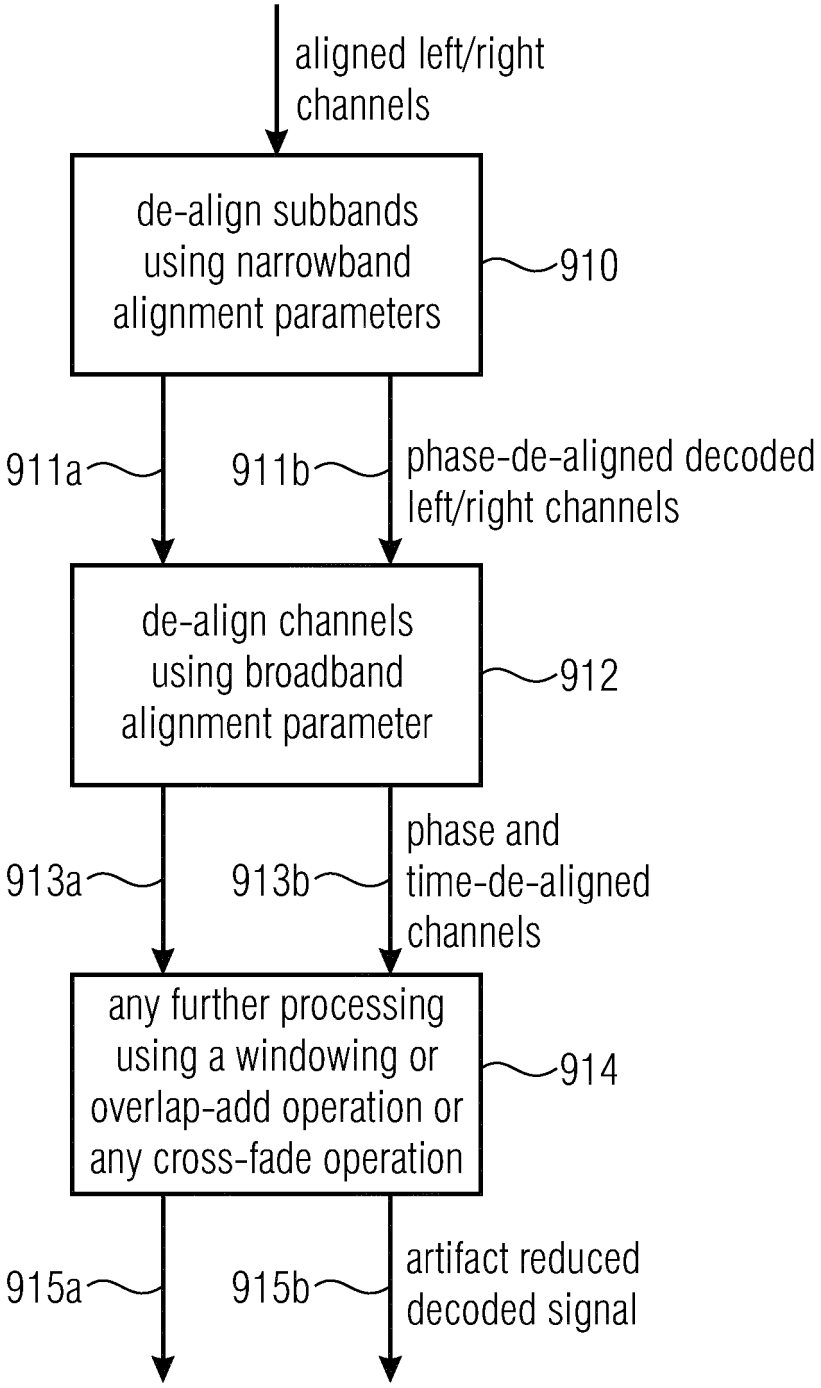

aligned left/right channels
de-align subbands using narrowband alignment parameters
910
911a
911b
phase-de-aligned decoded left/right channels
de-align channels using broadband alignment parameter
912
913a
913b
phase and time-de-aligned channels
any further processing using a windowing or overlap-add operation or any cross-fade operation
914
915a
915b
artifact reduced decoded signal

Fig. 9a

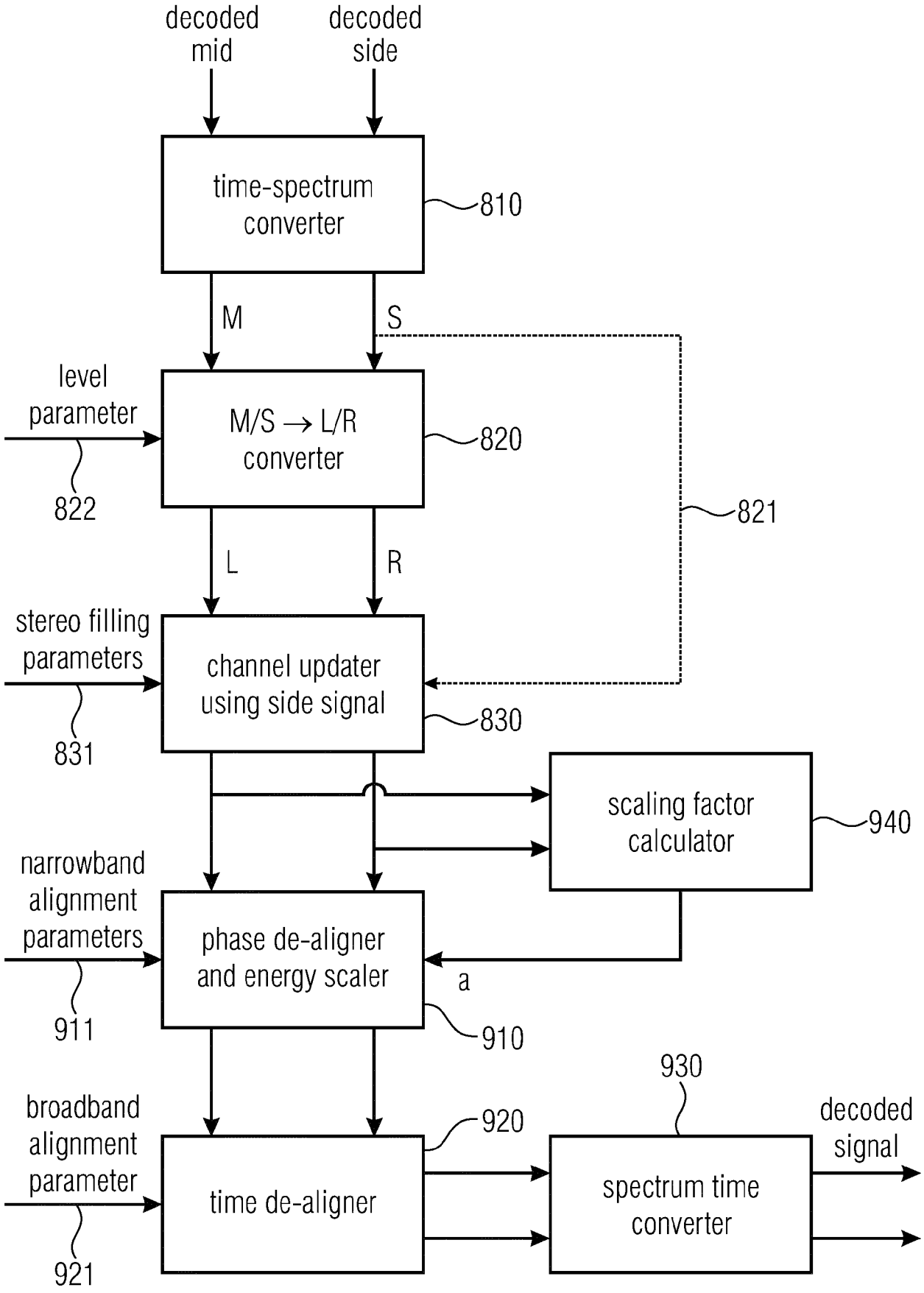

decoded mid
decoded side
time-spectrum converter
810
M
S
level parameter
M/S → L/R converter
820
822
821
L
R
stereo filling parameters
channel updater using side signal
830
831
scaling factor calculator
940
narrowband alignment parameters
phase de-aligner and energy scaler
a
911
910
930
broadband alignment parameter
920
time de-aligner
spectrum time converter
decoded signal
921

Fig. 9b

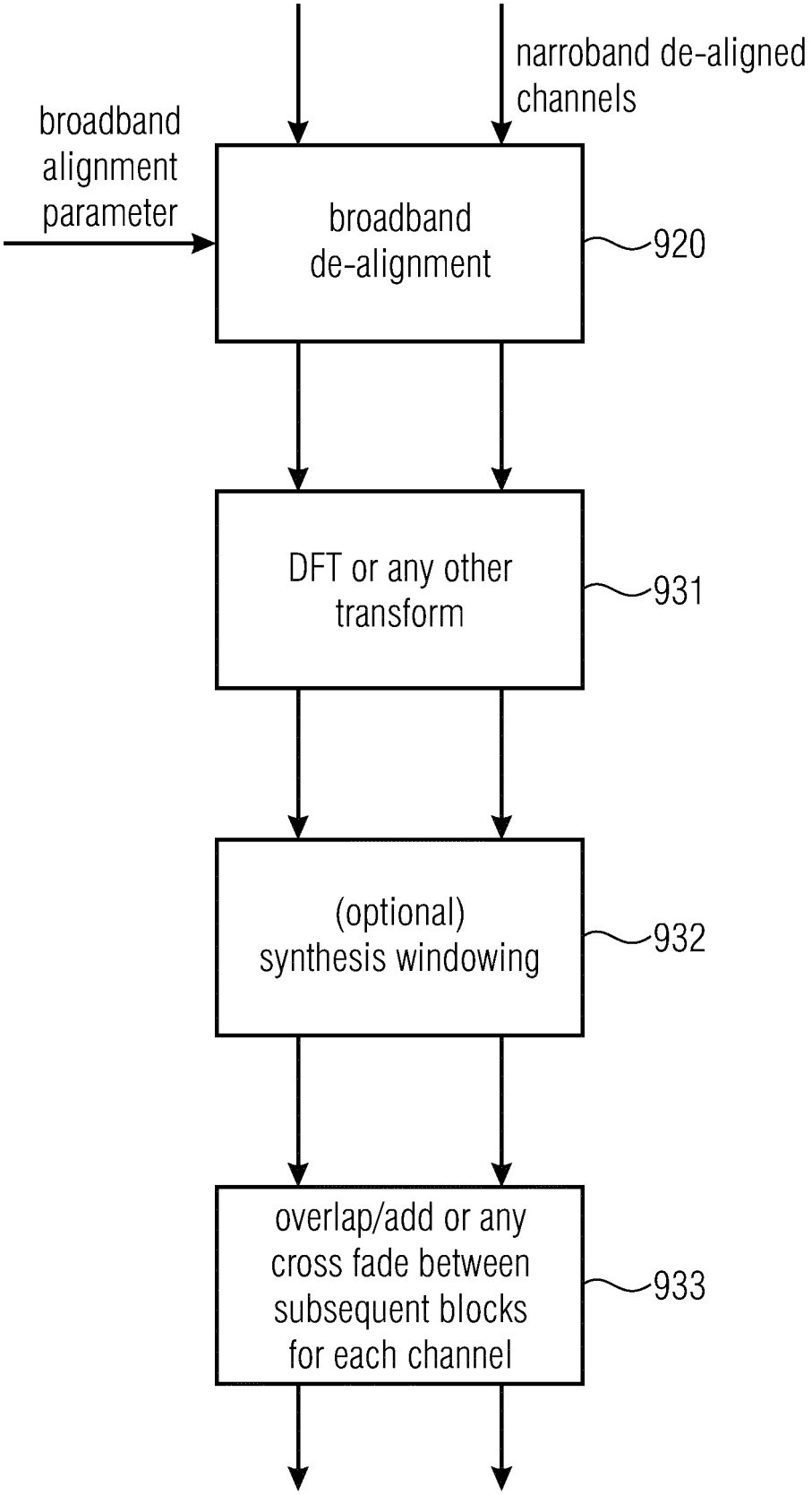

narroband de-aligned channels
broadband alignment parameter
broadband de-alignment
920
DFT or any other transform
931
(optional) synthesis windowing
932
overlap/add or any cross fade between subsequent blocks for each channel
933

Fig. 9c

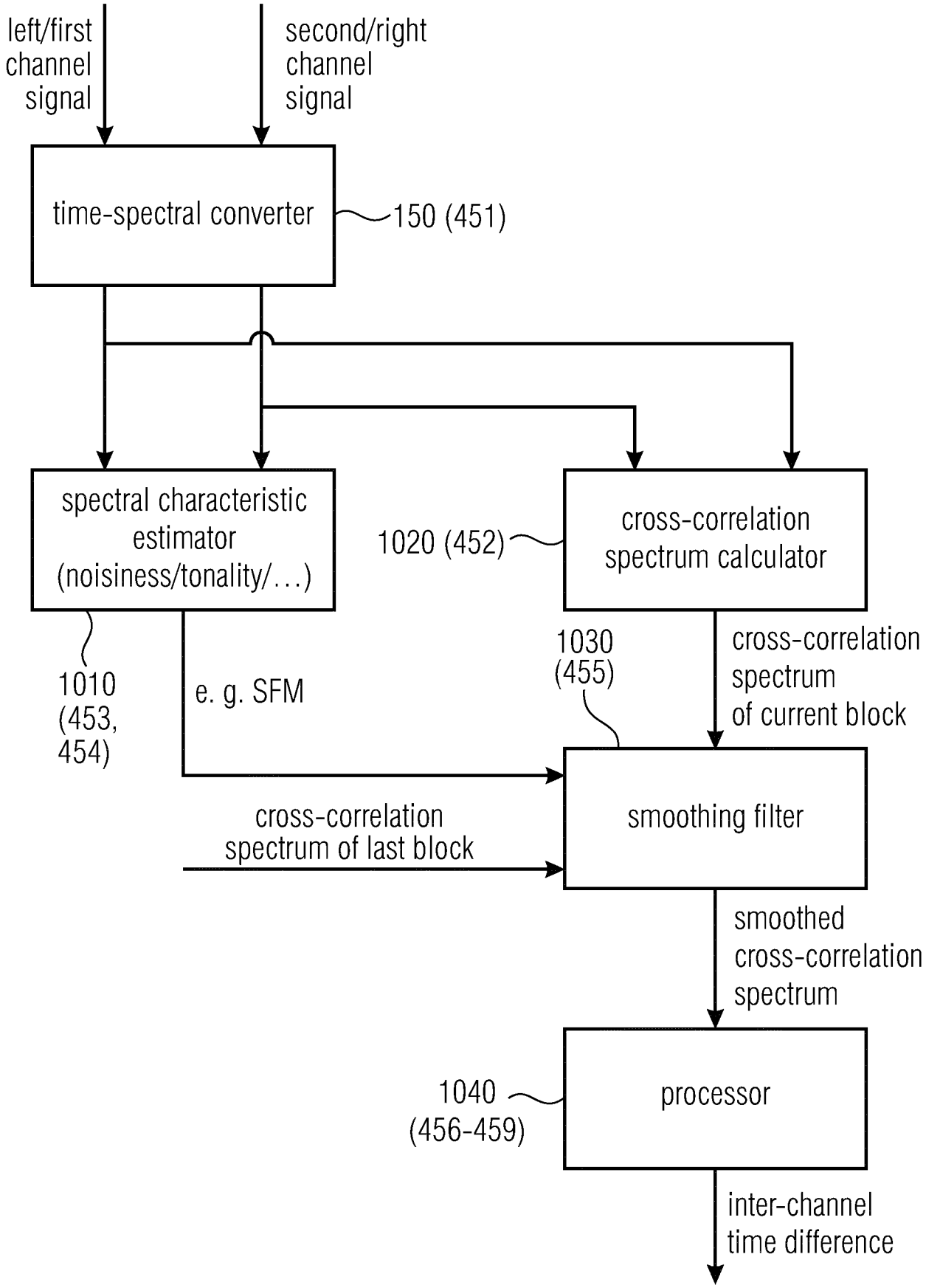
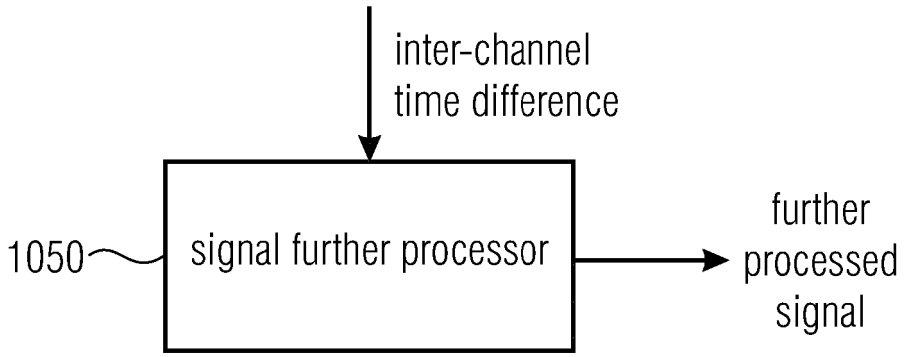

left/first channel signal
second/right channel signal
time-spectral converter
150 (451)
spectral characteristic estimator (noisiness/tonality/...)
1020 (452)
cross-correlation spectrum calculator
1010 (453, 454)
e. g. SFM
1030 (455)
cross-correlation spectrum of current block
cross-correlation spectrum of last block
smoothing filter
smoothed cross-correlation spectrum
1040 (456-459)
processor
inter-channel time difference

Fig. 10a



— storage/transmission of parametric data

— stereo/multi-channel processing/encoding

— time alignment of two channels

— time difference of arrival estimation for determination of speaker position in room with two microphones and known microphone setup

— beamforming

— spatial filtering

— foreground/background decomposition

— location of sound source
e. g. by acoustic triangulation based on time differences of two/three signals

Fig. 10b

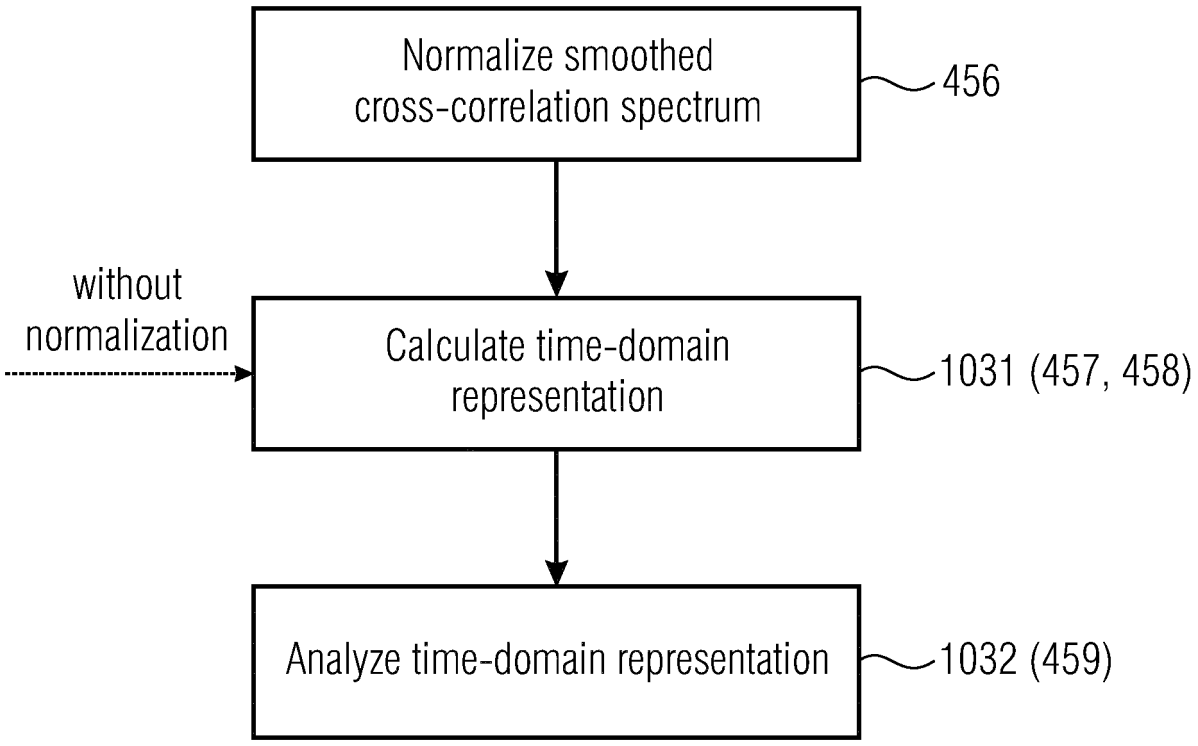


Fig. 11a

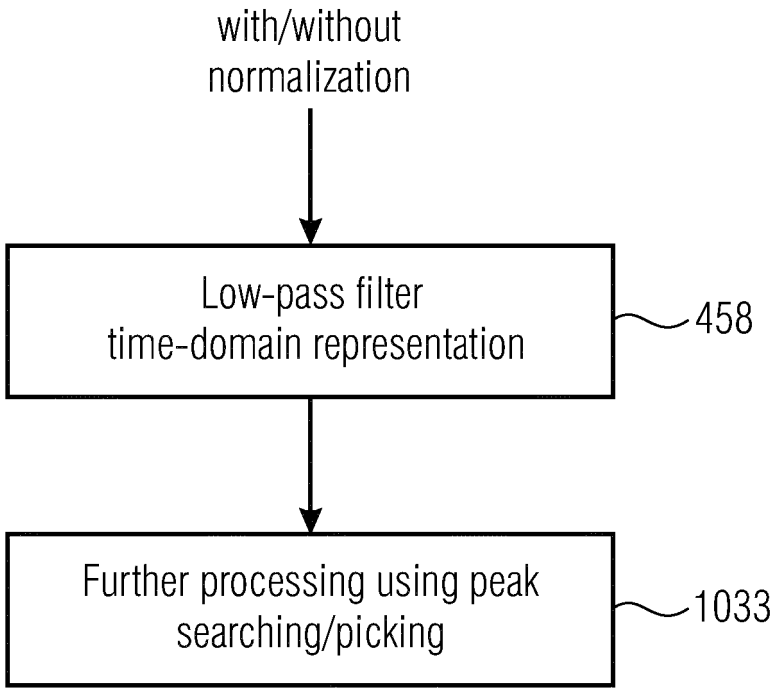


Fig. 11b

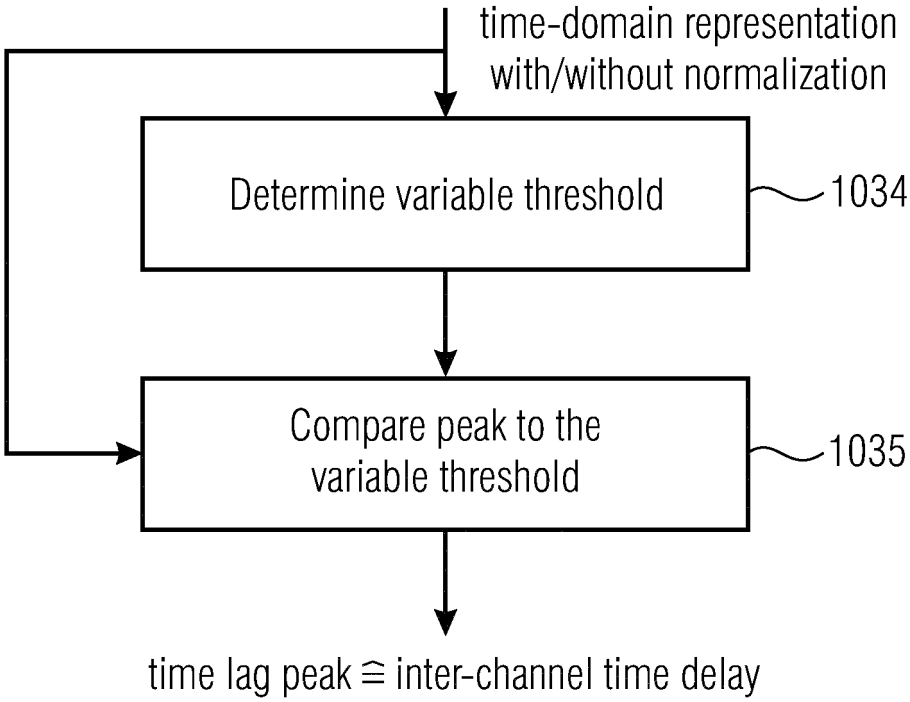


Fig. 11c

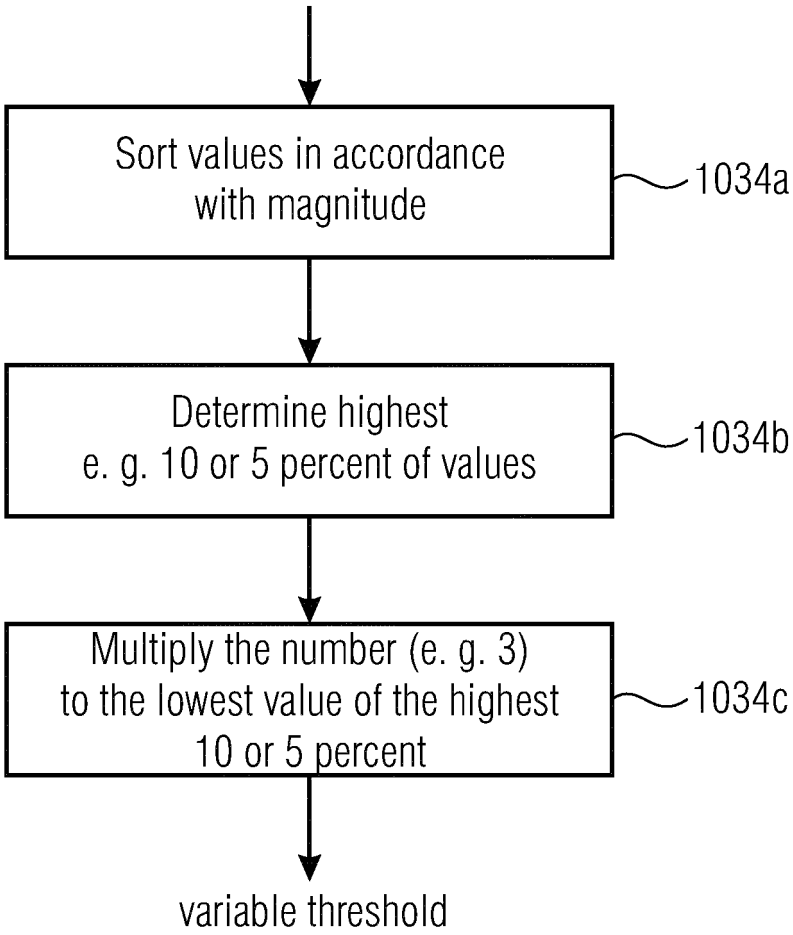


Fig. 11d

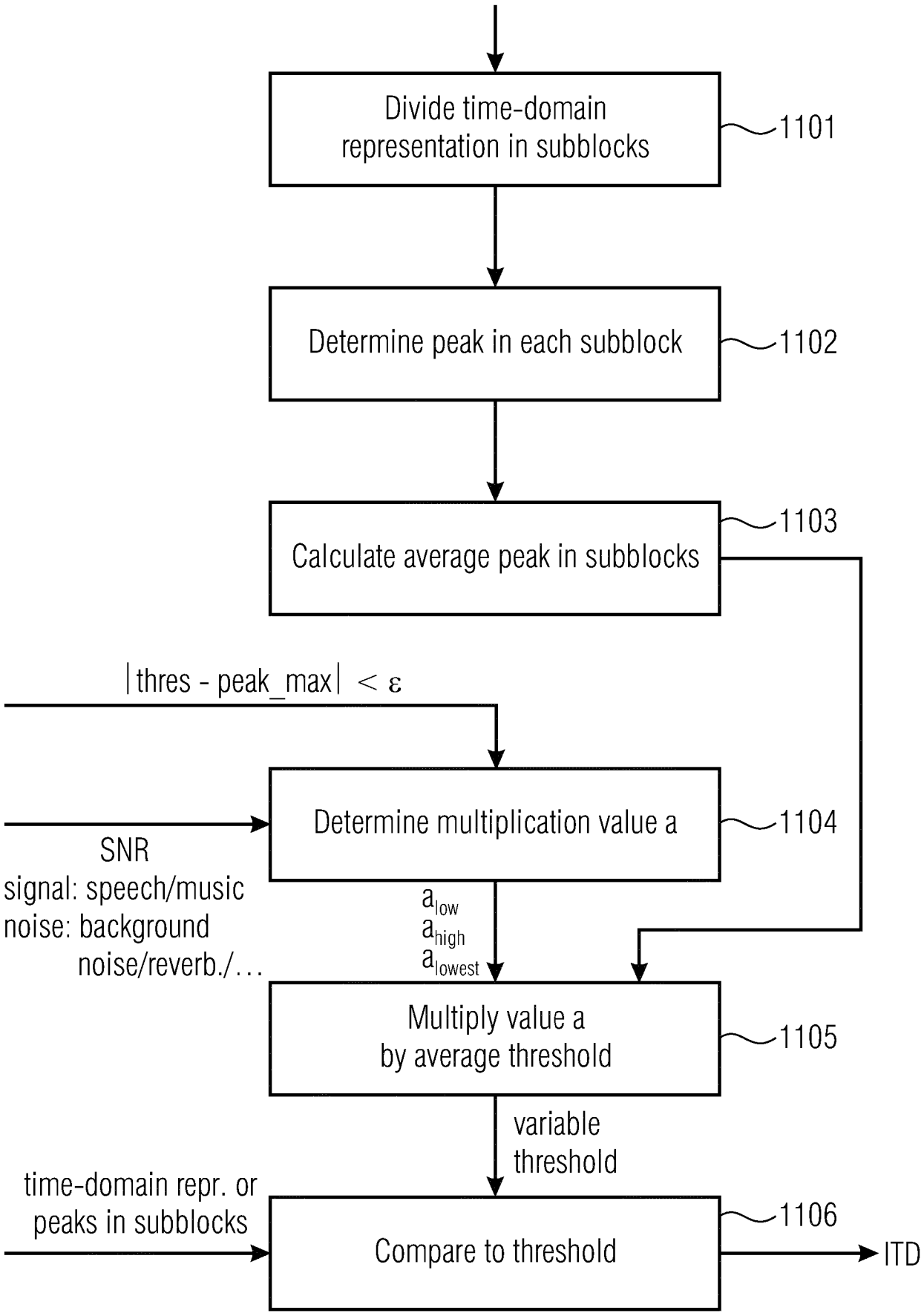

Divide time-domain representation in subblocks
1101
Determine peak in each subblock
1102
Calculate average peak in subblocks
1103
|thres - peak_max| < ε
Determine multiplication value a
1104
SNR
signal: speech/music
noise: background noise/reverb./...
a_low
a_high
a_lowest
Multiply value a by average threshold
1105
variable threshold
time-domain repr. or peaks in subblocks
Compare to threshold
1106
ITD

Fig. 11e

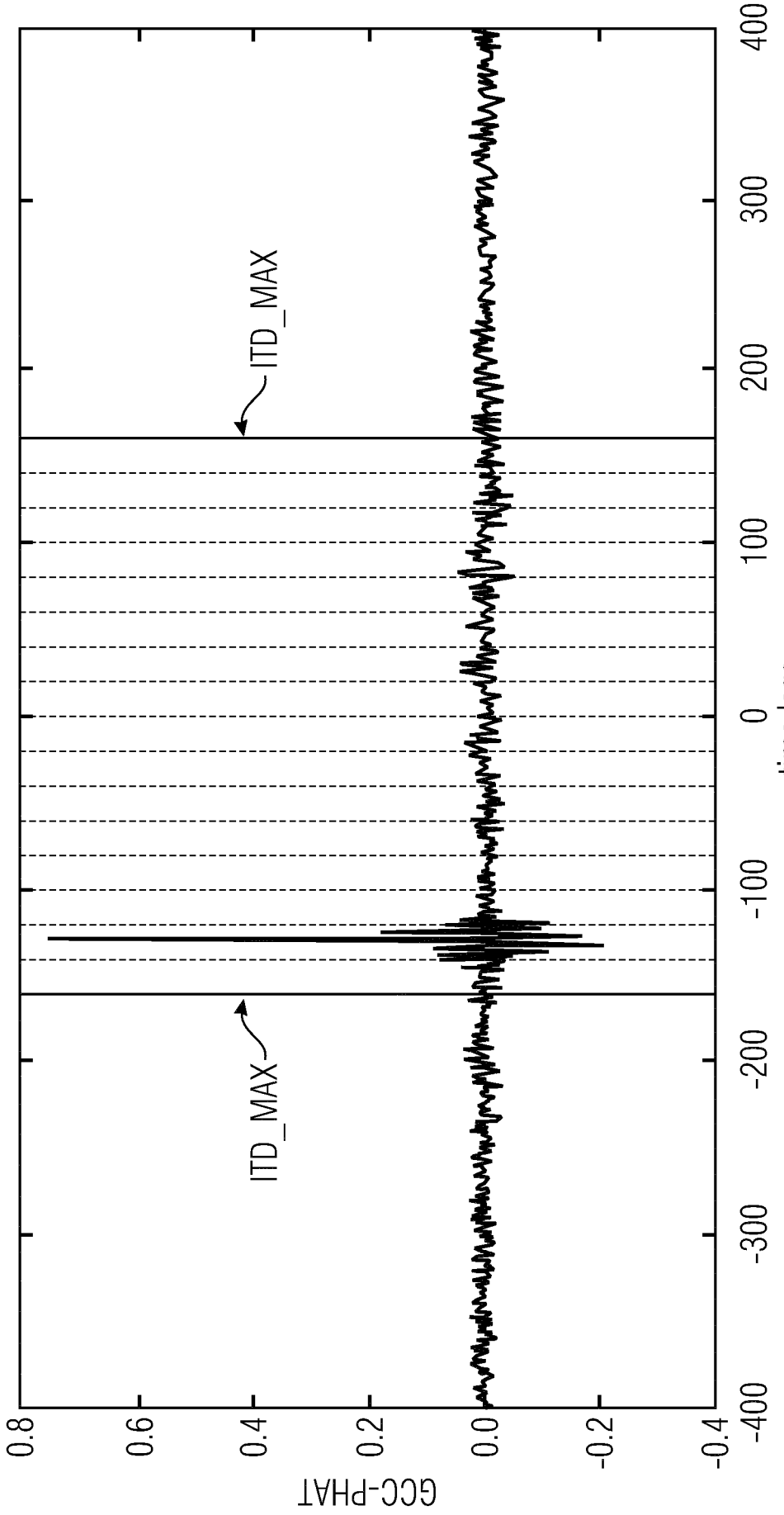

ITD_MAX
ITD_MAX
GCC-PHAT
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
400
300
200
100
0
-100
-200
-300
-400
time lags

Fig. 12

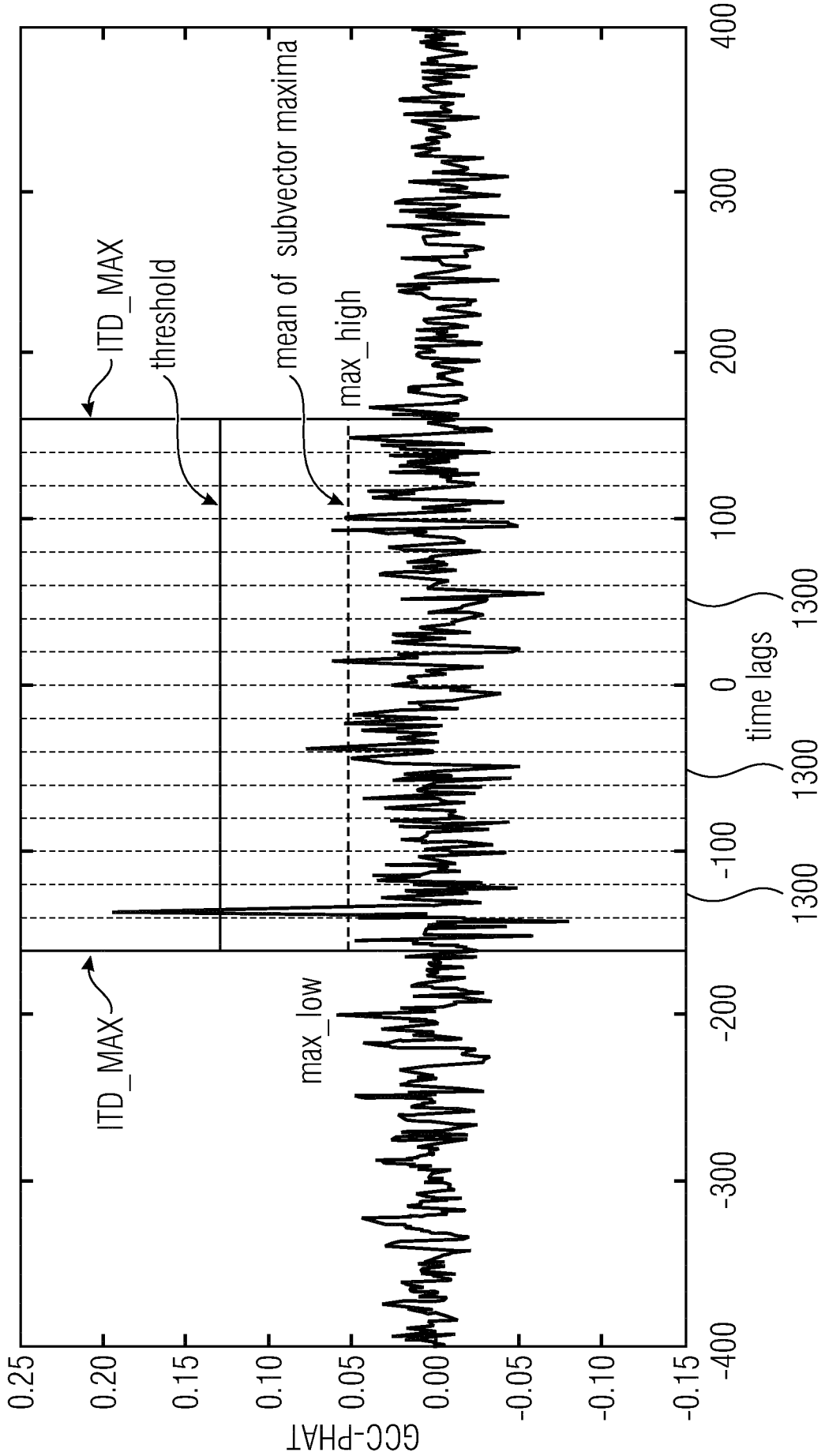

ITD_MAX
threshold
mean of subvector maxima
max_high
max_low
ITD_MAX
GCC-PHAT
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-400
-300
-200
-100
0
time lags
100
200
300
400
1300
1300
1300

Fig. 13