Analogue Compressor (Research in progress)

The material available *free of charge* on the internet is, in my opinion, not a complete or high quality survey of dynamic range controllers or their major building blocks. Generally speaking there are very few references and even fewer references to papers published in journals.

It is my intention to survey all the material that I can obtain on the subject of dynamic range control, produce at least one design, prototype and place an extended technical report (>10000 words) in this space. Given that I'm very busy, this has already been going a year, it will continue to take time.

Warning: Journal papers are expensive!!!

Below is a list of material that I have surveyed so far. It is fairly extensive. Most of the seminal papers have been scrutinised.

Most of the patents, except for a few, have not been read closely. There is a tendency to patent every small advance in the art. This gives rise to many patents containing substantially the same material. I know of at least ten patents that are not listed here one Japanese and two German, there simply is no point, no one will sit a scrutinise them all. If you want to go over some patents start with US Pat. 4156283 If by the time you've finished *and understood* that one you might like to have a patent search for "dbx" as the assignee and read about their cell as it looks somewhat different to convention. Or just pick some numbers from the list and follow a trail of references till you find something that interests you.

There are two books listed the first is definitely in print (as of June 2007) the other may be difficult to obtain. This is a pity as it has a lengthy survey of the two common gain cell topologies. It is a good starting place for anyone wishing to understand analogue multipliers (analogue multipliers form the controlling element in companders).

THAT Corp. is an offshoot of dbx (dbx is well known in audio circles) get on the internet and do a patent search for dbx, or read the paper by Hawksford and Mills. The application notes from THAT are filled with audio circuit ideas (unlike the papers which deal with the functioning of the circuits and their integration onto silicon chips).

The AES Journal deals mostly, in this case, with circuits used for audio. The IEEE and IET Journals deal with the enhancement of analogue multipliers for the purpose advancing science. (ie without a particular application in mind) A very interesting paper is "A Feed forward Side Chain Limiter…" Oliveira, A J, J. Audio Eng. Soc. Vol 37. No. 4, April 1989 This is a very good paper if you don't care how analogue multipliers work and just want to design a compressor with a stock IC OTA (Operational Transconductance Amplifier) such as any from THAT Corp. or National Semi. etc.

If you wish to understand how analogue multipliers work then a good starting place is Gilbert. B "A Precise 4-Quadrant Multiplier with Subnanosecond Response", IEEE J. Solid State Circuits vol. SC-3 pp 365 – 373 Dec 1968

An incomplete list of material:

Application notes:

Analogue Devices
AN-255 (1990)
AN-490

National Semiconductor
OA-16

THAT Corp. (Formally part of dbx) http://www.thatcorp.com
Application Note 100A
Application Note 101A
Application Note 102
Application Note 105
Design Note 103 / 104
Design Note 105
Design Note 107 / 111
Design Note 110
Design Note 112
Design Note 114
Design Note 115

Datasheets:

Texas Instruments (Burr Brown)
VCA810 (2007)

National Semiconductor
National CLC522
National LMH6506
National LMH6502
National CLC520
National LMH6503
National CLC5526

THAT Corp.
All datasheets for VCAs and “Analogue Engines”

Journal Papers

Audio Engineering Society
Todd, Craig C, “Tracking Measurement Techniques for Compressors, Expanders, Limiters”, Volume 25, Number 12 pp. 1039-1040; December 1977

Oliveira, A. J, “A Feedforward Side-Chain Limiter/Compressor/De-esser with Improved Flexibility” Volume 37, Number 4 pp. 226-240; April 1989.

Floru, Fred, “Attack and Release Time Constants in RMS-Based Feedback Compressors“, Volume 47 Number 10 pp. 788-804; October 1999

Frey, Douglas, “The Operational Voltage-Controlled Element: Generalizing the VCA”, Volume 39, Number 10 pp. 775-784; October 1991

Curtis, Douglas R, “A Monolithic Voltage-Controlled Amplifier Employing Log-Antilog Techniques”, Volume 24, Number 2, pp. 93-102; March 1976.

Frey, Douglas, “A High-Performance Voltage-Controlled Amplifier Using Positive Feedback”, Volume 41, Number 1/2, pp. 32-43; January/February 1993

Abuelma'atti, Muhammad Taher, “Harmonic and Intermodulation Performance of Two-Quadrant Bipolar-Transistor Gain Cells”, Volume 39 Number 3 pp. 148-154; March 1991

Hawksford, Malcolm O. J.; Mills, P. G. L, “Topological Enhancements of Translinear Two-Quadrant Gain Cells”, Volume 37, Number 6, pp. 465-475; June 1989

Hawksford, Malcolm John, “Low-Distortion Programmable Gain Cell Using Current Steering Cascode Topology”, Volume 30, Number 11, pp. 795-799; November 1982

Baskind, David; Rubens, Harvey, “Techniques for the Realization and Application of Voltage Controlled Amplifiers and Attenuators”, 60th Convention of the Audio Eng. Soc. Preprint No. 1378

Baskind, David; Rubens, Harvey; Kelson, Gary, “The Design and Integration of a High Performance Voltage Controlled Attenuator” 64th Convention of the Audio Eng Soc. Preprint no 1555

IEEE Papers

Sansen, W.M.C.; Meyer, R.G. “Distortion in Bipolar Transistor Variable-Gain Amplifiers” Solid-State Circuits, IEEE Journal of, Volume 8, Issue 4, Aug 1973 Page(s):275 - 282

Gilbert B, “A Precise 4-Quadrant Multiplier with Subnanosecond Response” IEEE J. Solid State Circuits, vol SC-3 pp 365 – 373 Dec 1968

B. Gilbert, "Translinear Circuits: A Proposed Classification," lEE Electron. Lett., vol. 11, pp. 14-16 (1975 Jan. 9).

B. Gilbert, "A New Wideband Amplifier Technique," IEEE J. Solid-State Circuits, vol. SC-3, pp. 353 - 365 (1968 Dec.).

C. C. Todd, "A Monolithic Analog Compandor," IEEE J. Solid-State Circuits, vol. SC-Il, pp. 754-762 (1976 Dec.).

T. Yamaguchi, S. Takaoka, and K. Aizawa, "A New Configuration Using a Voltage Controlled Amplifier for a Dolby System Integrated Circuit," IEEE Trans. Consumer Electron., vol. CE-25, pp. 723-729 (1979 Nov.)

Gilbert B, “A High-Performance Monolithic Multiplier Using Active Feedback," IEEE J. Solid-State Circuits, vol. SC-9, pp. 364-373 (1974 Dec.).

Gilbert B, "A New Technique for Analog Multiplication" IEEE J. Solid-State Circuits, vol. SC-10, pp. 437-447 (1975 Dec.).

B. Gilbert and P. Holloway, "A Wideband Two - Quadrant Analogue Multiplier," in Proc. IEEE Int. Solid-State Circuits Conf. (1980 Feb.), pp. 200-201.

Bilotti, A , “Applications of a Monolithic Analog Multiplier”. J. Solid-State Circuits, vol. SC-3 Page(s): 373- 380 (1968 Dec.).

W. Jung, “Get gain control of 80 to 100 dB’ Electron. Des. pp.94-99, June 21, 1974.

Carrara. F Palmisano. G, “High-Dynamic-Range VGA with Temperature Compensation and Linear-in-dB Gain Control”, IEEE JOURNAL OF SOLID-STATE CIRCUITS, VOL. 40, NO. 10, OCTOBER 2005

DAVIS W R, SOLOMON J E, “A High-Performance Monolithic IF Amplifier Incorporating Electronic Gain Control”, EEE JOURNALOFSOLID-STATECIRCUITS, VOL. SC-3, NO. 4, DECEMBER1968

Carrara F, Filoramo P, Palmisano G “High-dynamic-range variable gain amplifier with temperature compensation and linear-in-decibel gain control”, ELECTRONICS LETTERS 18th March 2004 Vol. 40 No. 6

SANSEN W C, MEYER R G, “An Integrated Wide-Band Variable-Gain Amplifier with Maximum Dynamic Range” IEEE JOURNAL OF SOLID-STATE CIRCUITS, VOL. SC-9, NO. 4, AUGUST1974

Gilbert B, “The Multi-tanh Principle: A Tutorial Overview” IEEE JOURNAL OF SOLID-STATE CIRCUITS, VOL. 33, NO. 1, JANUARY 1998

Books

“Analysis and Design of Analog Integrated Circuits” Grey, Hurst, Lewis, Meyer, Fourth Ed. Wiley Intl. 2001 pp 708 - 720

“Analog Integrated Circuits” Herpy M, Wiley Intl. 1980 pp 408 – 465

Note: This book has extended lists of further reading which I haven’t yet had time to explore fully however it does contain many of the papers that I have already acquired or am trying to lay my hands on.

US Patents

7065334
6249170
6104226
5999053
5200655
5157350
4878031
4818951
4471324
4471320
4454433
4430626
4415866
4403199
4385364
4379995
4377792
4341962
4335361
4331931
4331929
4316107
4278945
4234804
4225794
4182993
4156283
4155047
4146845
4139824
4136314

4101849
4065725
4038566
4004141
3999141
3969680
3940603
3838262
3714462
3684974
3681618
3641350
3532868
3329836
3293450
3237028

British Patents

643574
645256
656545
1305622
1356848
1367002
1393960