



# LUND UNIVERSITY

## Comments on comparison of the ECG by prediction or interpolation and entropy encoding

Börjesson, Per Ola; Einarsson, G.; Pahlm, Olle

*Published in:*  
IEEE Transactions on Biomedical Engineering

*DOI:*  
[10.1109/TBME.1980.326681](https://doi.org/10.1109/TBME.1980.326681)

1980

[Link to publication](#)

*Citation for published version (APA):*  
Börjesson, P. O., Einarsson, G., & Pahlm, O. (1980). Comments on comparison of the ECG by prediction or interpolation and entropy encoding. *IEEE Transactions on Biomedical Engineering*, 27(11), 674-675.  
<https://doi.org/10.1109/TBME.1980.326681>

*Total number of authors:*  
3

### General rights

Unless other specific re-use rights are stated the following general rights apply:  
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

### Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117  
221 00 Lund  
+46 46-222 00 00

important. The vapor phase deposition of parylene C produces a coating of uniform thickness, which is impossible to achieve in a dip coating operation. The variation of the coating thickness due to each technique is shown in Table II.

Good adhesion of the coating to the substrate is a must for an efficient conformal coating. Polyvinylidene chloride and fluorinated polymers have poor adhesion to most surfaces. The lack of adhesion prevents these coatings from expanding or shrinking with the substrate due to thermal fluctuations leading to the formation of microcracks in the coating surface.

The removal of the coating using appropriate solvents would be of great advantage if the electronic modules need to be reworked. Parylene C, due to its excellent adhesion and solvent resistance, literally has to be scraped away. This might be a serious disadvantage if delicate components are involved. Also, the reworked area will have to be repaired using epoxies or silicones which leave a weak spot in the encapsulation. The silicone coatings can be removed using a sharp blade and later patched up with a drop of the same silicone system. On curing, the repaired area once again forms a continuous envelope with the original coating. If complete removal is required, the coated module should be immersed in toluene or hexane. After a few hours, the silicone coating swells considerably and can be literally brushed away. The solution coated polymers can be removed using the same solvents that were used to dissolve the polymers initially. Entire removal of the epoxy coating is very difficult as most printed circuit boards are also made of epoxies and tend to be affected by the removing agent (methylene chloride). Localized repairs are performed by mechanical removal of the coating by scraping or peeling followed by recoating with the same epoxy system.

Based on this study, it can be concluded that parylene C is the obvious choice for conformal coating of high-reliability electronic circuits.

#### REFERENCES

- [1] M. A. Spivak and G. Ferrante, *J. Electrochem. Soc.*, vol. 116, Nov. 1969.

### Comments on "Compression of the ECG by Prediction or Interpolation and Entropy Encoding"

PER-OLA BÖRJESSON, GÖRAN EINARSSON, AND  
OLLE PAHLM

**Abstract**—A recent paper<sup>1</sup> discusses prediction and interpolation for data compression of ECG. This communication points out that both methods can be viewed as linear filtering. They are therefore equivalent and give the same result in terms of the amount of data compression achieved.

In a recent paper,<sup>1</sup> Ruttimann and Pipberger seem to claim that predictive coding, where the residual is obtained by in-

Manuscript received March 25, 1980; revised July 31, 1980.

P.-O. Börjesson is with the Department of Biomedical Engineering, Malmö General Hospital, Malmö, Sweden.

G. Einarsson is with the Division of Telecommunication Theory, Department of Electrical Engineering, University of Lund, Lund, Sweden.

O. Pahlm is with the Department of Clinical Physiology, University of Lund, Lund, Sweden.

<sup>1</sup>U. E. Ruttimann and H. V. Pipberger, *IEEE Trans. Biomed. Eng.*, vol. BME-26, pp. 613-623, Nov. 1979.

terpolation, may have advantages over a data compression system using prediction.

Fig. 2 in the paper<sup>1</sup> shows their interpolator to be a linear filter producing the residual

$$e_n = (z^{-1} - a - bz^{-2})x_{n+1} \quad (1)$$

where  $z^{-1}$  stands for the shift operator (time delay  $T$ ). The coefficients are selected as  $a = b = 0.5$  in which case (1) can be written as

$$e_n = -\frac{1}{2}(1 - 2z^{-1} + z^{-2})x_{n+1}. \quad (2)$$

If a second-order predictor is used, the residual would be

$$e'_n = (1 - a_1z^{-1} - a_2z^{-2})x_n. \quad (3)$$

A second difference predictor performs linear extrapolation and has the coefficients  $a_1 = 2$ ,  $a_2 = -1$ . Substitution into (3) gives

$$e'_n = (1 - 2z^{-1} + z^{-2})x_n. \quad (4)$$

Comparison of (2) with (4) shows that the interpolator and the predictor are identical, apart from an unimportant gain factor of  $(-\frac{1}{2})$  and a difference in time delay of one unit between input and output.

Data compression of ECG's utilizing a second difference predictor has been studied previously in [1], [2], and [3].

The reconstructed signal for the interpolator (2) is

$$x_n = (1 - 2z^{-1} + z^{-2})^{-1}(-2e_{n-1}) \quad (5)$$

and for the predictor (4)

$$x_n = (1 - 2z^{-1} + z^{-2})^{-1}e'_n. \quad (6)$$

Since the residuals  $e_{n-1}$  and  $e'_n$  differ by a constant factor of  $(-\frac{1}{2})$ , the variance of  $e_n$  is 6 dB below that of  $e'_n$ . This, however, does not mean that fewer bits are required for its digital storage. From (5) and (6) it is evident that to produce the same  $x_n$ , the residual  $e_n$  must have a quantizing distortion which is 6 dB lower than the distortion of  $e'_n$ .

#### REFERENCES

- [1] K. L. Ripley and J. R. Cox, "A computer system for capturing transient electrocardiographic data," in *Conf. Rec., Computers in Cardiology*, St. Louis, MO, Oct. 7-9, 1976, pp. 439-445.  
[2] P. O. Börjesson and O. Pahlm, "Predictive coding for ECG data compression," *Telecomm. Theory*, University of Lund, Sweden, Tech. Rep. TR-87, 1977.  
[3] O. Pahlm, P. O. Börjesson, and O. Werner, "Compact digital storage of ECGs," *Comput. Programs Biomedicine*, vol. 9, pp. 293-300, 1979.

#### Author's Reply<sup>2</sup>

URS E. RUTTIMANN AND HUBERT V. PIPBERGER

We agree with the comment made above [1] that both prediction and interpolation can be viewed as linear filtering oper-

<sup>2</sup>Manuscript received July 8, 1980.

U. E. Ruttimann is with the Department of Cardiology, Children's Hospital National Medical Center, Washington, DC 20010.

H. V. Pipberger is with the Department of Clinical Engineering and the Department of Medicine, The George Washington University Medical Center, Washington, DC 20037.