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# Proposed sonobuoy locations for 1985 Jan Mayen Ridge seismic survey

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## PROPOSED SONOBUOY LOCATIONS FOR 1985 JAN MAYEN RIDGE SEISMIC SURVEY

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### Introduction

This report is done in preparation for the 1985 seismic survey on the Jan Mayen Ridge. A summary of previous seismic refraction studies, mainly by sonobuoys, is presented and new locations are proposed.

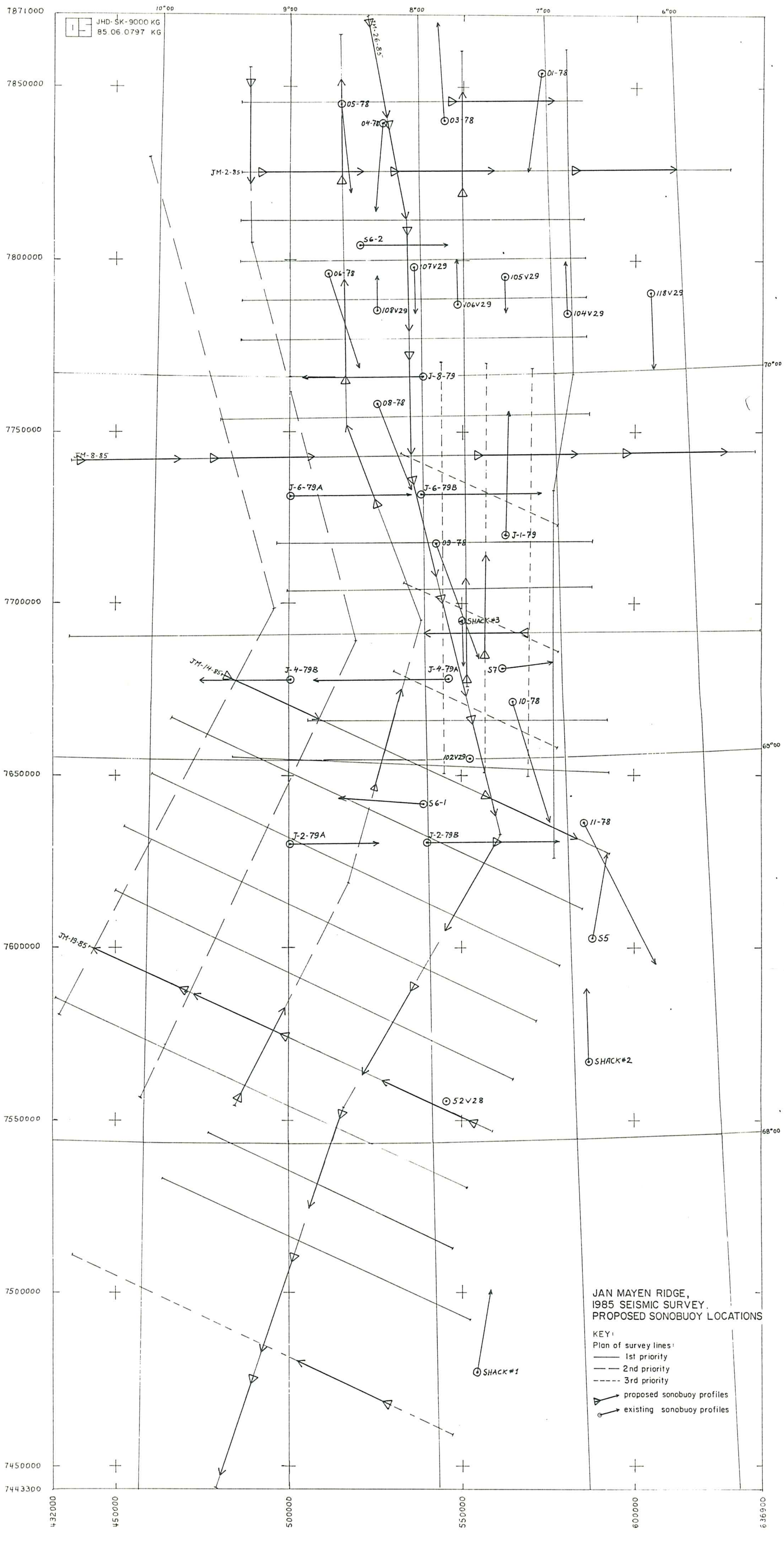
The quality of the seismic reflection data processing can depend on a realistic model of seismic velocities being available. This question is also considered here.

### Existing refraction data

Various institutes have gathered sonobuoy data on and around the Jan Mayen Ridge. Eldholm & Windisch (1974) and Talwani & Eldholm (1977) report the work from L-DGO, Garde (1978) from BGR, Sundvor et al. (1979) from the University of Bergen, and Nunns (1981) from University of Durham (Shackleton 1977 cruise). The latest review is published by Myhre et al. (1984), including a reassessment of the Bergen data. Some buoys were deployed on the Ridge during the NDP (Oljedirektoratet) 1979 cruise. They have not been interpreted or published.

The existing sonobuoy positions are plotted on the map in fig. 1, which is a reduced copy of the attached large scale map. The length and direction of the profiles are also shown where known, but in most cases these are approximate and uncertain, as they are read of indistinct maps.

The original tables of sonobuoy locations and interpretations, from the above mentioned publications, are shown in appendix 1. In appendix 2 these are compiled in one table. It should be noted that the data from Talwani & Eldholm (1977) is taken from the compilation of Sundvor et al. (1979), and the Myhre et al. (1984) version of the Bergen data is chosen.


JAN MAYEN RIDGE,
1985 SEISMIC SURVEY,
PROPOSED SONOBUOY LOCATIONS
KEY:
Plan of survey lines:
1st priority
2nd priority
3rd priority
proposed sonobuoy profiles
existing sonobuoy profiles
JHD-SK-9000 KG
85.06.0797 KG
7871000
7850000
7800000
7750000
7700000
7650000
7600000
7550000
7500000
7450000
7443300
432000
450000
500000
550000
600000
636900
10°00
9°00
8°00
7°00
6°00
70°00
69°00
68°00
01-78
05-78
03-78
04-78
JM-2-85
S6-2
06-78
107V29
105V29
108V29
106V29
104V29
118V29
J-8-79
08-78
JM-8-85
J-6-79A
J-6-79B
J-1-79
09-78
SHACK#3
JM-14-85
J-4-79B
J-4-79A
S7
10-78
102V29
S6-1
11-78
J-2-79A
J-2-79B
S5
JM-19-85
SHACK#2
52V28
SHACK#1

## Appraisal of old data - implication for new

In their compilation of sonobuoy results, Myhre et al. (1984) interpret a refractor of average velocity 5.5 km/s as a east dipping basement surface on eastern ridge flank, and 3.9 km/s for the deepest part of the sedimentary sequence. The 5.5 km/s refractor does not correspond everywhere to the acoustic basement as defined by the reflection data, which velocity appears to be usually lower. Nunns (1981) estimates average velocity 5.2 +/-0.4 km/s for the layer below horizon O, using the similar compilation of Sundvor et al. (1979), and 3.8 +/-0.3 km/s for just above "O".

Two regions appear to have rather low below basement velocities. One is the eastern slope of the J.M. Bank, where eastwards dipping refractors can be postulated below apparently oceanic or basaltic basement. An other region of possibly low velocity is further to the south where sub-O reflectors have been observed. This is however rather uncertain, as in many cases it is difficult to correlate refractors with basement from reflection data, but the low interval velocities (some 4.0-4.5 km/s) reported by Gairaud et al. (1978) and Garde (1978) support this proposition.

The planned reflection survey is primarily designed for high resolution in the upper layers, with short shot intervals of 25 m, exept for four transvers lines and one longitudinal line where the interval is 50 m and recording time will be longer. On the survey lines with the 25 m intervals, we assume that the recording time will be restricted to 6 s, the time interval between shots being 9 s. The digital sonobuoy recording time is then also 6 s, but the analog registration is 9 s although quality will be less. This recording time is rather restrictive, as inspection of previous data will show.

In addition to the compilation of interpretations, appendix 2 also containes tables where the seismic models have been used to generate simple artificial travel time curves for headwaves. This is for the purpose of estimating the necessary range and recording time for sonobuoys in various environments. A number of sonobuoys have been analized to estimate the range of 1st arrival at 8 s time for various water depths. The 8 s time is chosen assuming the 9 s as maximum, and that 1 s of signal following the 1st arrivals is preferable. The results are plotted in figure 2, which shows that there is an rough linear relation between the depth and the maximum useful ranges. This is as expected, as the time delay due to the water layer is relatively large. Judging from the NDP sonobuoy records, the first arrivals are at 8 s at ranges of 17 to 28 km, but energy is observed typically out to 30-40 km. The above implies that if the usefull range is required to be at least 30 km, water depths should not excede some 1.0 km, and 1.5 km for 25 km range. Regarding the detection of the first breaks, the extra second up to the 9 s limit will increase the range by some 5 km. The thickness of sediments and the velocity structure will of course affect these values to a certain degree.

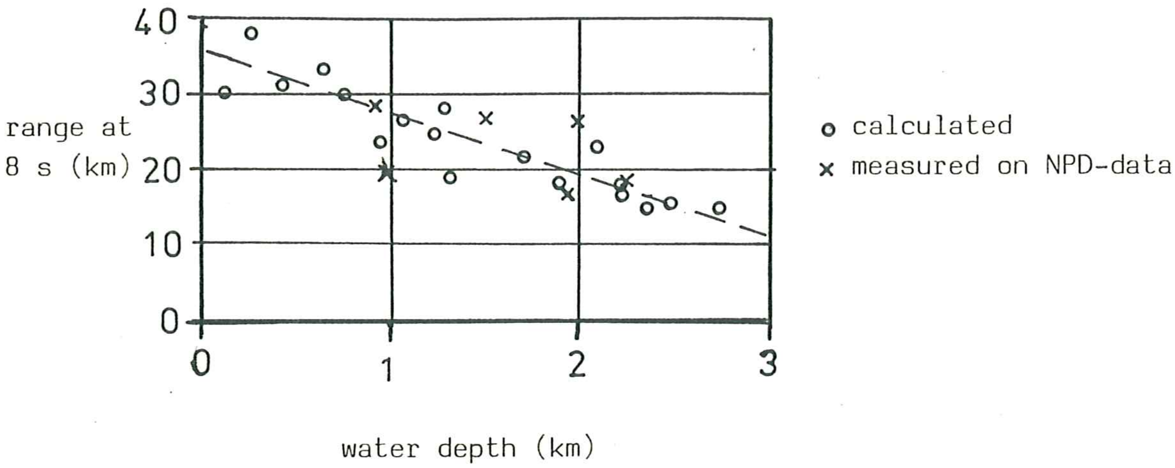



Fig. 2. Range of 1st arrivals at 8 s arrival times, as a function of water depth. The graph indicates that the relationship is roughly linear.

It would be possible to increase the digital sonobuoy recording time from 6 to 9 s, if the sonobuoy channel can be recorded longer than the others. In case an 8 s registration is used for the survey, implying 11 s between shots, the time would thus be ample, but this is probably not practical. I will not consider this possibility further here, as I do not know if it`s technically possible. If, however the analog recorder can be triggered with a time delay, much longer travel times can be recorded over a time window of 9 s. If the analog data are of sufficient quality, this would solve most of these problems.

I wonder if energy from consecutive shots at 9 s intervals can interfere. Judging from typical travel time graphs, the deep refracted wave from the last shot, and the direct water borne wave from the last shot but one, should arrive simultaneously at ranges of some 20-25 km. Will the energy of the water wave be such that interference can take place?

Proposal for new sonobuoy locations

All proposed sonobuoy locations are plotted on the map as 30 km long profiles. If, in some cases, arrivals of signifficant energy are detected beond 30 km, the plan should allow for flexibility to extend those profiles to 35 or 40 km. This is in agreement to the directions in the NPD-Geco contract, appendix VIII. The value of the refraction results is thought to be primarily in the information they give about crustal structure below the acoustic basement (the O-horizon or basalts), and this influences the chosen locations.

The direction of travel along the survey lines has to my knowledge not been decided. This increases the difficulty of positioning the refraction profiles, because in presence of lateral variations it matters which end is the buoy position. For the present purpose I have assumed certain directions of travel along the survey lines, and located the buoys accordingly. If the directions prove to be opposite, some shift of the locations will be in order.

Considering the above mentioned recording time limitations, the lines of long registration are here given priority for sonobuoy deployment. These lines are no. 2, 8, 14 and 19 traversing the Ridge, and no. 26 along the Ridge. The southern half of line 26 is rated as a second priority line, but we assume that the recording parameters will be the same as for the northern half, if the line can be shot. Nearly continuous registration is planned for these lines. The buoys are located such, that the geological units and water depth are as uniform as possible along the profiles.

In short the positioning of the buoy profiles on the survey lines are governed by the following directions:

- Lines of long registration are given priority.
- Lines along strike are preferred, as water depth and structure are then more likely to uniform.
- Lines of short registration are considered where water depth is small (less than 1.5, or preferably 1.0 km), and last but not least, where the location is geologically interesting.

The chosen sonobuoy locations are shown on the attached map (and fig. 1), and are listed in table 1 according to survey line, priority, length of registration and attitude of line. The planned survey lines are drawn according to the map produced by Geco. A total of 36 positions are shown, and of these 10 are on 2nd priority lines.

Some flexibility should be allowed for changing the sonobuoy locations during the survey, as various factors are not totally predictable. These include direction of travel, buoy failure, data quality and which lines must be omitted. Some buoys could e.g. be transferred from 2nd to 1st priority lines.

<u>Table 1.</u> A summary of the number of sonobuoy profiles planned for 1985 survey lines. Grouping is according to priority of line, length of registration, and direction of line. Abreviations: lr: long registration, sr: short registration, NS: north-south or longitudinal lines, EW: east-west or transverse lines.

| prio. | lr/ns | | lr/EW | | sr/NS | | lr/EW | | total |
|---|---|---|---|---|---|---|---|---|---|
| | line | n | line | n | line | n | line | n | |
| 1st | 26(N) | 7 | 2 | 3 | 24 | 0 | 1 | 1 | |
| prio. | | --- | 8 | 4 | 25 | 2 | 3 | 0 | |
| | | | 14 | 2 | 27(N) | 3 | 4 | 0 | |
| | | | 19 | 3 | | --- | 5 | 0 | |
| | | | | --- | total | 5 | 6 | 0 | |
| | | | total | 12 | | | 7 | 0 | |
| | | | | | | | 8 | 0 | |
| | | | | | | | 9 | 0 | |
| | | | | | | | 10 | 0 | |
| | | | | | | | 11 | 1 | |
| | | | | | | | 12 | 0 | |
| | | | | | | | 13 | 0 | |
| | | | | | | | 15 | 0 | |
| | | | | | | | 16 | 0 | |
| | | | | | | | 17 | 0 | |
| | | | | | | | 18 | 0 | |
| | | | | | | | 20 | 0 | |
| | | | | | | | 21 | 0 | |
| | | | | | | | 22 | 0 | |
| | | | | | | | | --- | |
| | | | | | | | total | 2 | 26 |
| 2nd | 26(S) | 5 | none | | 27(S) | 2 | 3rd pri: | | |
| +3rd | | --- | | | 28 | 1 | 23 | 1 | |
| prio. | | | | | 29 | 0 | 30 | 0 | |
| | | | | | 3rd pri: | | 31 | 0 | |
| | | | | | 33 | 0 | 32 | 0 | |
| | | | | | 34 | 1 | | --- | |
| | | | | | 35 | 0 | total | 1 | |
| | | | | | | --- | | | |
| | | | | | total | 4 | | | 10 |
| total | | 12 | | 12 | | 9 | | 3 | 36 |

## Velocity models and processing of seismic reflection data

Judging from previous work, the stacking-velocities for the sedimentary layer above acoustic basement should be derived by standard velocity analysis of the reflection data. Gairaud et al. (1978) and Garde (1978) even report interval velocities derived from vel. anal. of the undistinct sub-O reflectors. If these reflectors are observed in the 1985 survey, an attempt should be made to analyse the velocity, but if this fails, a predetermined model can be used to constrain the velocity values, as explained below.

The velocity analysis will probably not provide realistic rms velocities for depths from below the basement reflector and down to Moho. In this case, it would probably be safer to specify interval velocities according to some chosen model, and from these the stacking velocity function can be calculated. We can estimate what effect errors in the chosen interval velocities have on the "normal move out" time of the stacking procedure, by applying the equation for a simple one layer case,

$$t_{NMO} = t - t_o = 2(h^2 + (x/2)^2)^{1/2}/v - 2h/v \ ,$$

where x is the shot-detector distace, h the thickness of the layer and v the interval velocity (in this simple case also equal to rms velocity and stacking velocity). The equation can be simplified to

$$t_{NMO} \cong x^2/4vh \ , \ \text{if} \ (x/2h)^2 \ll 1.$$

An expression of relative error in velocity resulting from a deviation in NMO-time can then be derived:

$$\Delta v/v = (\ 1+(4vh\Delta t)/x\ )^{-1} - 1 \ ,$$

where $\Delta v$ is the error resulting from error $\Delta t$ in $t_{NMO}$. If we assume $x_{max}$ = 3 km and maximum allowable error in $t_{NMO}$ as say 10 ms, and we also assume reasonable velocity and thickness, it becomes apparent that for Moho depths the stacking velocity needs only to be accurate within some 20%, and 5-10% for "intra-basement" depths. These conditions would probably be met by a simple model of crustal velocities below acoustic basement, valid for all areas, and consisting of 2 or 3 layers representing the crust. Such models would be based on the sonobuoy data, and deeper structure can be estimated from the the expanding spread profile (see Myhre et al.), the Hinz and Moe data, perhaps a refraction experiment by Sörnes and Narvestad around Jan Mayen, and recent German work.

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## Appendix 1: Sonobuoy locations and interpretations

Data as listed in the original publications, are presented here. The locations within the area of the planned survey are indicated by dots.

Data from Eldholm Windisch (1974):

TABLE 1. LISTING OF SEISMIC WIDE-ANGLE RELFECTION AND REFRACTION RESULTS

| Profile | Lat. (N) | Long. (-=W) | Water Depth | V1 | H1 | V2 | H2 | V3 | H3 | V4 | H4 | V5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39V27 | 62°33' | -09°34' | 0.56 | (1.90) | 0.13 | 3.95 | 0.78 | 5.17 | 1.49 | 5.70 | | |
| 40V27 | 63°31' | -07°35' | 1.01 | 1.73 | 0.29 | (2.26) | 0.81 | 4.94 | | | | |
| 41V27 | 63°26' | -06°01' | 1.68 | 1.67 | 0.65 | 2.26 | 1.21 | 4.55 | 1.19 | 6.40 | 1.08 | 6.70 |
| 43V27 | 69°29' | -03°06' | 3.50 | 1.85 | 0.77 | | | | | | | |
| 44V27 | 76°08' | -02°12' | 3.65 | (2.00) | 1.52 | 5.32 | 2.16 | 5.96 | | | | |
| 45V27 | 74°48' | -02°24' | 3.61 | 1.82 | 0.39 | 2.34 | 0.38 | (2.70) | 0.59 | 5.80 | 1.19 | 7.90 |
| 46V27 | 72°08' | 08°41' | 2.51 | 2.06 | 0.33 | 2.45 | 0.86 | 2.85 | 1.97 | 5.10 | 2.03 | 6.05 |
| 47V27 | 71°51' | 10°00' | 2.38 | 1.98 | 1.00 | 2.25 | 1.02 | 2.57 | 1.25 | | | |
| 48V27 | 70°44' | 13°50' | 2.35 | 1.75 | 0.56 | 2.38 | 1.52 | 3.19 | 1.35 | 3.67 | 1.11 | |
| 49V27 | 70°10' | 15°46' | 2.31 | (1.80) | 1.12 | 2.18 | 1.69 | 5.29 | | | | |
| 65V27 | 75°03' | -07°48' | 3.36 | 1.97 | 1.13 | 5.55 | | | | | | |
| 12V28 | 65°38' | -27°58' | 0.76 | 1.83 | 0.66 | 4.51 | | | | | | |
| 13V28 | 67°56' | -23°20' | 1.20 | (1.80) | 0.59 | 2.52 | 0.61 | (4.50) | 0.49 | 5.15 | | |
| 14V28 | 68°04' | -23°05' | 1.24 | 1.78 | 0.46 | 2.55 | 0.93 | 5.15 | | | | |
| 15V28 | 69°51' | -20°23' | 0.29 | 2.22 | 0.52 | 2.90 | 0.70 | 3.54 | 0.94 | 4.07 | | |
| 16V28 | 69°51' | -19°54' | 0.28 | 2.35 | 0.46 | 2.91 | 0.59 | 3.34 | 1.10 | 4.29 | | |
| 17V28 | 74°59' | -11°20' | 2.45 | 2.00 | 0.46 | 2.31 | 0.53 | 3.50 | 1.38 | 5.27 | 1.39 | 6.51 |
| 18V28 | 71°44' | 07°16' | 2.79 | 2.56 | 1.78 | 4.38 | | | | | | |
| 27V28 | 66°46' | -08°32' | 1.72 | 1.96 | 1.05 | 3.52 | | | | | | |
| 28V28 | 67°35' | -20°06' | 0.39 | (1.85) | 0.44 | 2.10 | 0.17 | 2.60 | 0.83 | 4.15 | 1.10 | 5.50 |
| 46V28 | 73°24' | 11°48' | 1.87 | 1.87 | 0.40 | 2.30 | 0.17 | | | | | |
| 51V28 | 65°46' | -00°37' | 3.15 | 2.20 | 0.77 | | | | | | | |
| • 52V28 | 68°07' | -07°50' | 1.76 | (1.85) | 0.84 | 2.12 | 0.58 | 3.41 | 0.90 | 4.25 | | |
| 56V28 | 62°43' | -07°37' | 0.44 | 5.02 | | | | | | | | |
| 61V28 | 60°47' | -08°59' | 0.14 | 4.38 | 0.34 | 5.30 | | | | | | |

*( ) denotes assumed velocity. All units are in km and km/sec.*
*For data on the eastern margin see also Talwani and Eldholm (1972), Sundvor (1971), and Eldholm and Ewing (1971). Additional deep-water profiles are published by Ewing and Ewing (1959), Houtz and others (1968), and Hinz and Moe (1971).*

Data from Garde (1978):

Tabelle 1: Sonobojen-Stationen

| Station Nr. | Positionen Breite (N) | Länge (W) | Geschwindigkeit (km/sec) $v_0$ | $v_1$ | $v_2$ | $v_3$ | $v_4$ | $v_5$ | Wassertiefe und Mächtigkeit (km) WT | $H_1$ | $H_2$ | $H_3$ | $H_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S 1 | 68°40,7' | 20°38,8' | 1.47 | 3.60 | 4.65 | 5.5 | | | 1.205 | 2.70 | 0.17 | | |
| S 2 | 68°58,1' | 10°22,5' | 1.42 | 1.53 | 2.75 | 4.38 | 4.75 | | 1.72 | 0.43 | 0.56 | 0.53 | |
| • S 5 | 68°31,0' | 06°50,8' | 1.52 | 2.55 | 4.15 | 6.00 | | | 2.36 | 3.34 | 0.29 | | |
| • S 6-1 | 68°52,8' | 08°1,30' | 1.50 | 1.68 | 3.05 | 5.55 | | | 1.87 | 1.72 | 0.96 | | |
| • S 6-2 | 70°20,5' | 08°27,4' | 1.48 | 2.15 | 3.12 | 4.22 | 4.97 | | 0.41 | 0.96 | 0.37 | 0.86 | |
| • S 7 | 69°13,9' | 07°26,8' | 1.50 | 2.82 | 3.62 | 6.06 | 6.51 | 7.27 | 2.12 | 2.03 | 0.97 | 0.69 | 1.17 |

Data from Sundvor et al.(1979):

| Profile | Lat. (N) | Long. (W) | Water depth | V1 | H1 | V2 | H2 | V3 | H3 | V4 | H4 | V5 | H5 | V6 | Data source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01-B78 | 70°47.0' | 7°01.2' | 0.97 | (1.85) | 0.80 | 2.48 | 0.25 | 2.84 | 0.63 | 3.56 | 1.17 | 4.76 | 1.17 | 5.54 | Seism. |
| 03-B78 | 70°39.8' | 7°47.9' | 1.05 | 1.78 | 0.77 | 2.14 | 0.37 | 2.69 | 0.74 | 4.12 | 1.00 | 5.79 | | | Obsv., |
| 04-B78 | 70°39.6' | 8°16.8' | 0.24 | (1.80) | 0.12 | 2.30 | 0.92 | 3.90 | 1.60 | 6.46 | | | | | 1978 |
| 05-B78 | 70°42.4' | 8°35.9' | 0.11 | 2.86 | 0.27 | 4.11 | | | | | | | | | " |
| 06-B78 | 70°16.4' | 8°41.7' | 0.62 | 2.17 | 0.61 | 3.53 | 0.83 | 5.16 | | | | | | | " |
| 08-B78 | 69°56.3' | 8°20.1' | 0.76 | (1.85) | 0.29 | 3.11 | 0.34 | 3.66 | 1.44 | 5.17 | | | | | " |
| 09-B78 | 69°33.5' | 7°54.5' | 1.27 | 1.80 | 0.62 | 2.65 | 0.35 | 3.20 | 0.79 | 3.85 | 1.09 | 5.54 | 1.84 | 6.69 | " |
| 10-B78 | 69°08.3' | 7°22.2' | 2.21 | 1.76 | 1.19 | 3.21 | 1.28 | 5.08 | | | | | | | " |
| 11-B78 | 68°49.3' | 6°52.8' | 2.50 | 1.81 | 1.07 | 3.06 | 1.17 | 4.81 | 1.70 | 6.47 | | | | | " |
| 102V29 | 69°00.0' | 7°41.0' | 1.79 | (1.85) | 0.57 | 2.49 | 0.79 | 3.19 | 0.62 | 4.12 | 0.49 | 5.55 | | | Talwani |
| 104V29 | 70°09.0' | 6°53.0' | 2.21 | 1.62 | 0.46 | 2.40 | 1.29 | 4.83 | | | | | | | and |
| 105V29 | 70°15.0' | 7°21.0' | 1.31 | 1.84 | 0.76 | 2.18 | 0.47 | 2.78 | 0.86 | 3.97 | | | | | Eldholm, |
| 106V29 | 70°11.0' | 7°44.0' | 1.23 | 1.87 | 0.65 | 2.28 | 0.54 | 3.03 | 0.68 | 3.88 | 0.79 | 4.36 | 1.31 | 5.80 | 1977 |
| 107V29 | 70°17.0' | 8°03.0' | 0.67 | (1.85) | 0.20 | 2.13 | 0.86 | 3.33 | 0.97 | 4.07 | 1.04 | 5.56 | | | " |
| 108V29 | 70°10.0' | 8°20.0' | 0.68 | (1.85) | 0.10 | 2.05 | 0.60 | 3.21 | 1.06 | 3.92 | 0.27 | 5.22 | | | " |
| 118V29 | 70°12.0' | 6°14.0' | 2.74 | 1.75 | 0.56 | 2.27 | 1.02 | 3.04 | 0.37 | 4.15 | 1.26 | 6.71 | | | " |
| S 5 | 68°31.0' | 6°50.8' | 2.36 | 2.55 | 3.34 | 4.15 | 0.29 | 6.00 | | | | | | | Garde, |
| S 6-2 | 70°20.5' | 8°27.4' | 0.41 | 2.15 | 0.96 | 3.12 | 0.37 | 4.22 | 0.86 | 4.97 | | | | | 1978 |
| S 7 | 69°13.9' | 7°26.8' | 2.12 | 2.82 | 2.03 | 3.62 | 0.97 | 6.06 | 0.69 | 6.51 | 1.17 | 7.27 | | | " |

Table 1. Listing of seismic refraction results. All units in km and km/s. Parentheses indicate assumed velocities.

Data from Myhre et al. (1984):

*Table 2.* Results of sonobuoys recorded by University of Bergen in 1978. Figures in parentheses indicate assumed velocities. *r* denotes interval velocity from wide-angle reflection hyperbolas. All units in km and km/s.

| Profile | Lat. (N) | Long. (W) | Water depth | V1 | H1 | V2 | H2 | V3 | H3 | V4 | H4 | V5 | H5 | V6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-78 | 70°47.0′ | 7°01.2′ | 0.97 | (1.80) | 0.82 | 2.48 | 0.22 | 2.84 | 0.69 | 3.56 | 1.10 | 4.76 | | |
| 3-78 | 70°39.8′ | 7°47.9′ | 1.05 | 1.78 | 0.77 | 2.14 | 0.35 | 2.64 | 0.67 | 4.16 | 1.11 | 5.77 | | |
| 4-78 | 70°39.6′ | 8°16.8′ | 0.24 | (1.80) | 0.12 | 2.30 | 0.92 | 3.90 | 1.46 | 6.08 | | | | |
| 5-78 | 70°42.4′ | 8°35.9′ | 0.11 | 2.86 | 0.28 | 3.97 | | | | | | | | |
| 6-78 | 70°16.4′ | 8°41.7′ | 0.62 | 2.17 | 0.53 | 2.87 | 0.28 | 3.53 | 0.49 | 5.16 | | | | |
| 8-78 | 69°56.3′ | 8°20.1′ | 0.76 | (2.11) | 0.36 | 3.11 | 0.37 | 3.67 | 1.18 | 4.94 | | | | |
| 9-78 | 69°33.5′ | 7°54.5′ | 1.27 | 1.86r | 0.66 | 2.65 | 0.33 | 3.20 | 0.78 | 3.85 | 1.04 | 5.33 | 1.72 | 6.69 |
| 10-78 | 69°08.3′ | 7°22.2′ | 2.21 | 1.94 | 0.70 | 2.52 | 0.97 | 3.32 | 1.15 | 5.17 | | | | |
| 11-78 | 68°49.3′ | 6°52.8′ | 2.50 | 1.69r | 0.33 | 2.13r | 0.74 | 2.76 | 0.43 | 3.00 | 0.71 | 4.36 | 1.25 | 6.05 |

APPENDIX 2. Sonobuoy refraction results; Norwegian-Greenland Sea.

1. Compilation of interpretations.

Velocity - layer thickness format

1-78
1.50,0.97,1.80,0.82,2.48,0.22,2.84,0.69,3.56,1.10,4.76
3-78
1.50,1.05,1.78,0.77,2.14,0.35,2.64,0.67,4.16,1.11,5.77
4-78
1.50,0.24,1.80,0.12,2.30,0.92,3.90,1.46,6.08
5-78
1.50,0.11,2.86,0.28,3.97
6-78
1.50,0.62,2.17,0.53,2.87,0.28,3.53,0.49,5.16
8-78
1.50,0.76,2.11,0.36,3.11,0.37,3.67,1.18,4.94
9-78
1.50,1.27,1.86,0.66,2.65,0.33,3.20,0.78,3.85,1.04,5.33,1.72,6.69
10-78
1.50,2.21,1.94,0.70,2.52,0.97,3.32,1.15,5.17
11-78
1.50,2.50,1.69,0.33,2.13,0.74,2.76,0.43,3.00,0.71,4.36,1.25,6.05
39V27
1.50,0.56,1.90,0.13,3.95,0.78,5.17,1.49,5.70
40V27
1.50,1.01,1.73,0.29,2.26,0.81,4.94
41V27
1.50,1.68,1.67,0.65,2.26,1.21,4.55,1.19,6.40,1.08,6.70
43V27
1.50,3.50,1.85,0.77
44V27
1.50,3.65,2.00,1.52,5.32,2.16,5.96
45V27
1.50,3.61,1.82,0.39,2.34,0.38,2.70,0.59,5.80,1.19,7.90
46V27
1.50,2.51,2.06,0.33,2.45,0.86,2.85,1.97,5.10,2.03,6.05
47V27
1.50,2.38,1.98,1.00,2.25,1.02,2.57,1.25
48V27
1.50,2.35,1.75,0.56,2.38,1.52,3.19,1.35,3.67,1.11
49V27
1.50,2.31,1.80,1.12,2.18,1.69,5.29
65V27
1.50,3.36,1.97,1.13,5.55
12V28
1.50,0.76,1.83,0.66,4.51
13V28
1.50,1.20,1.80,0.59,2.52,0.61,4.50,0.49,5.15
14V28
1.50,1.24,1.78,0.46,2.55,0.93,5.15
15V28
1.50,0.29,2.22,0.52,2.90,0.70,3.54,0.94,4.07
16V28
1.50,0.28,2.35,0.46,2.91,0.59,3.34,1.10,4.29
17V28

1.50,2.45,2.00,0.46,2.31,0.53,3.50,1.38,5.27,1.39,6.51
18V28
1.50,2.79,2.56,1.78,4.38
27V28
1.50,1.72,1.96,1.05,3.52
28V28
1.50,0.39,1.85,0.44,2.10,0.17,2.60,0.83,4.15,1.10,5.50
46V28
1.50,1.87,1.87,0.40,2.30,0.17
51V28
1.50,3.15,2.20,0.77
52V28
1.50,1.76,1.85,0.84,2.12,0.58,3.41,0.90,4.25
56V28
1.50,0.44,5.02
61V28
1.50,0.14,4.38,0.34,5.30
102V29
1.50,1.79,1.85,0.57,2.49,0.79,3.19,0.62,4.12,0.49,5.55
104V29
1.50,2.21,1.62,0.46,2.40,1.29,4.83
105V29
1.50,1.31,1.84,0.76,2.18,0.47,2.78,0.86,3.97
106V29
1.50,1.23,1.87,0.65,2.28,0.54,3.03,0.68,3.88,0.79,4.36,1.31,5.80
107V29
1.50,0.67,1.85,0.20,2.13,0.86,3.33,0.97,4.07,1.04,5.56
108V29
1.50,0.68,1.85,0.10,2.05,0.60,3.21,1.06,3.92,0.27,5.22
118V29
1.50,2.74,1.75,0.56,2.27,1.02,3.04,0.37,4.15,1.26,6.71
S1
1.47,1.21,3.60,2.70,4.65,0.17,5.50
S2
1.42,1.72,1.53,0.43,2.75,0.56,4.38,0.53,4.75
S5
1.52,2.36,2.55,3.34,4.15,0.29,6.00
S6-1
1.50,1.87,1.68,1.72,3.05,0.96,5.55
S6-2
1.48,0.41,2.15,0.96,3.12,0.37,4.22,0.86,4.97
S7
1.50,2.12,2.82,2.03,3.62,0.97,6.06,0.69,6.51,1.17,7.27
SHACK977-1
1.50,1.79,2.50,2.04,4.08
SHACK977-2
1.50,2.09,2.06,1.78,2.57,0.49,5.79
SHACK977-3
1.50,0.98,1.80,1.26,3.23,0.71,6.73

## 2. Calculated travel-time curves of N-G Sea sonobuoy results

Data in section 1. above are used to calculate synthetic travel time curves for headwaves (refracted). The table shows: Velocity, thickness, twt to bottom of layer, inverse of velocity, delay-time of headwave in layer, travel times at distances of 5, 15 and 40 km.

SMOD3-OUTPUT: 1-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.97 | 1.29 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.80 | 0.82 | 2.20 | 0.556 | 0.71 | 3.49 | 9.05 | 22.94 |
| 3 | 2.48 | 0.22 | 2.38 | 0.403 | 1.66 | 3.67 | 7.71 | 17.79 |
| 4 | 2.84 | 0.69 | 2.87 | 0.352 | 1.89 | 3.65 | 7.17 | 15.97 |
| 5 | 3.56 | 1.10 | 3.49 | 0.281 | 2.38 | 3.78 | 6.59 | 13.62 |
| 6 | 4.76 | 0.00 | 0.00 | 0.210 | 3.02 | 4.07 | 6.17 | 11.43 |

SMOD3-OUTPUT: 3-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.05 | 1.40 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.78 | 0.77 | 2.27 | 0.562 | 0.75 | 3.56 | 9.18 | 23.23 |
| 3 | 2.14 | 0.35 | 2.59 | 0.467 | 1.48 | 3.82 | 8.49 | 20.17 |
| 4 | 2.64 | 0.67 | 3.10 | 0.379 | 1.98 | 3.88 | 7.66 | 17.13 |
| 5 | 4.16 | 1.11 | 3.63 | 0.240 | 2.76 | 3.96 | 6.37 | 12.38 |
| 6 | 5.77 | 0.00 | 0.00 | 0.173 | 3.30 | 4.17 | 5.90 | 10.23 |

SMOD3-OUTPUT: 4-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.24 | 0.32 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.80 | 0.12 | 0.45 | 0.556 | 0.18 | 2.95 | 8.51 | 22.40 |
| 3 | 2.30 | 0.92 | 1.25 | 0.435 | 0.33 | 2.50 | 6.85 | 17.72 |
| 4 | 3.90 | 1.46 | 2.00 | 0.256 | 1.06 | 2.34 | 4.91 | 11.32 |
| 5 | 6.08 | 0.00 | 0.00 | 0.164 | 1.75 | 2.57 | 4.22 | 8.33 |

SMOD3-OUTPUT: 5-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.11 | 0.15 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.86 | 0.28 | 0.34 | 0.350 | 0.12 | 1.87 | 5.37 | 14.11 |
| 3 | 3.97 | 0.00 | 0.00 | 0.252 | 0.27 | 1.53 | 4.05 | 10.35 |

SMOD3-OUTPUT: 6-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.62 | 0.83 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.17 | 0.53 | 1.32 | 0.461 | 0.60 | 2.90 | 7.51 | 19.03 |
| 3 | 2.87 | 0.28 | 1.51 | 0.348 | 1.02 | 2.77 | 6.25 | 14.96 |
| 4 | 3.53 | 0.49 | 1.79 | 0.283 | 1.25 | 2.66 | 5.50 | 12.58 |
| 5 | 5.16 | 0.00 | 0.00 | 0.194 | 1.60 | 2.57 | 4.51 | 9.35 |

SMOD3-OUTPUT: 8-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.76 | 1.01 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.11 | 0.36 | 1.35 | 0.474 | 0.71 | 3.08 | 7.82 | 19.67 |
| 3 | 3.11 | 0.37 | 1.59 | 0.322 | 1.14 | 2.75 | 5.96 | 14.00 |
| 4 | 3.67 | 1.18 | 2.24 | 0.272 | 1.33 | 2.69 | 5.42 | 12.23 |
| 5 | 4.94 | 0.00 | 0.00 | 0.202 | 1.89 | 2.90 | 4.93 | 9.99 |

SMOD3-OUTPUT: 9-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.27 | 1.69 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.86 | 0.66 | 2.40 | 0.538 | 1.00 | 3.69 | 9.07 | 22.51 |
| 3 | 2.65 | 0.33 | 2.65 | 0.377 | 1.90 | 3.79 | 7.56 | 17.00 |
| 4 | 3.20 | 0.78 | 3.14 | 0.313 | 2.21 | 3.78 | 6.90 | 14.71 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 3.85 | 1.04 | 3.68 | 0.260 | 2.63 | 3.93 | 6.53 | 13.02 |
| 6 | 5.33 | 1.72 | 4.33 | 0.188 | 3.27 | 4.21 | 6.08 | 10.77 |
| 7 | 6.69 | 0.00 | 0.00 | 0.149 | 3.82 | 4.57 | 6.06 | 9.80 |

SMOD3-OUTPUT: 10-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.21 | 2.95 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.94 | 0.70 | 3.67 | 0.515 | 1.87 | 4.45 | 9.60 | 22.49 |
| 3 | 2.52 | 0.97 | 4.44 | 0.397 | 2.83 | 4.81 | 8.78 | 18.70 |
| 4 | 3.32 | 1.15 | 5.13 | 0.301 | 3.72 | 5.22 | 8.23 | 15.76 |
| 5 | 5.17 | 0.00 | 0.00 | 0.193 | 4.69 | 5.66 | 7.59 | 12.43 |

SMOD3-OUTPUT: 11-78

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.50 | 3.33 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.69 | 0.33 | 3.72 | 0.592 | 1.54 | 4.49 | 10.41 | 25.20 |
| 3 | 2.13 | 0.74 | 4.42 | 0.469 | 2.60 | 4.95 | 9.65 | 21.38 |
| 4 | 2.76 | 0.43 | 4.73 | 0.362 | 3.55 | 5.36 | 8.98 | 18.04 |
| 5 | 3.00 | 0.71 | 5.20 | 0.333 | 3.82 | 5.49 | 8.82 | 17.15 |
| 6 | 4.36 | 1.25 | 5.78 | 0.229 | 4.68 | 5.83 | 8.12 | 13.86 |
| 7 | 6.05 | 0.00 | 0.00 | 0.165 | 5.34 | 6.17 | 7.82 | 11.95 |

SMOD3-OUTPUT: 39V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.56 | 0.75 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.90 | 0.13 | 0.88 | 0.526 | 0.46 | 3.09 | 8.35 | 21.51 |
| 3 | 3.95 | 0.78 | 1.28 | 0.253 | 0.81 | 2.08 | 4.61 | 10.94 |
| 4 | 5.17 | 1.49 | 1.85 | 0.193 | 1.10 | 2.06 | 4.00 | 8.83 |
| 5 | 5.70 | 0.00 | 0.00 | 0.175 | 1.38 | 2.25 | 4.01 | 8.39 |

SMOD3-OUTPUT: 40V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.01 | 1.35 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.73 | 0.29 | 1.68 | 0.578 | 0.67 | 3.56 | 9.34 | 23.79 |
| 3 | 2.26 | 0.81 | 2.40 | 0.442 | 1.22 | 3.44 | 7.86 | 18.92 |
| 4 | 4.94 | 0.00 | 0.00 | 0.202 | 2.23 | 3.25 | 5.27 | 10.33 |

SMOD3-OUTPUT: 41V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.68 | 2.24 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.67 | 0.65 | 3.02 | 0.599 | 0.98 | 3.98 | 9.97 | 24.94 |
| 3 | 2.26 | 1.21 | 4.09 | 0.442 | 2.20 | 4.41 | 8.84 | 19.90 |
| 4 | 4.55 | 1.19 | 4.61 | 0.220 | 3.77 | 4.87 | 7.06 | 12.56 |
| 5 | 6.40 | 1.08 | 4.95 | 0.156 | 4.30 | 5.08 | 6.64 | 10.55 |
| 6 | 6.70 | 0.00 | 0.00 | 0.149 | 4.43 | 5.18 | 6.67 | 10.40 |

SMOD3-OUTPUT: 43V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 3.50 | 4.67 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.85 | 0.77 | 0.00 | 0.541 | 2.73 | 5.43 | 10.84 | 24.35 |

SMOD3-OUTPUT: 44V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 3.65 | 4.87 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.00 | 1.52 | 6.39 | 0.500 | 3.22 | 5.72 | 10.72 | 23.22 |
| 3 | 5.32 | 2.16 | 7.20 | 0.188 | 6.08 | 7.02 | 8.90 | 13.60 |
| 4 | 5.96 | 0.00 | 0.00 | 0.168 | 6.51 | 7.35 | 9.02 | 13.22 |

SMOD3-OUTPUT: 45V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 3.61 | 4.81 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.82 | 0.39 | 5.24 | 0.549 | 2.73 | 5.47 | 10.97 | 24.70 |
| 3 | 2.34 | 0.38 | 5.57 | 0.427 | 3.96 | 6.10 | 10.37 | 21.06 |
| 4 | 2.70 | 0.59 | 6.00 | 0.370 | 4.48 | 6.33 | 10.04 | 19.30 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 5.80 | 1.19 | 6.41 | 0.172 | 5.74 | 6.60 | 8.33 | 12.64 |
| 6 | 7.90 | 0.00 | 0.00 | 0.127 | 6.14 | 6.78 | 8.04 | 11.21 |

SMOD3-OUTPUT: 46V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.51 | 3.35 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.06 | 0.33 | 3.67 | 0.485 | 2.29 | 4.72 | 9.58 | 21.71 |
| 3 | 2.45 | 0.86 | 4.37 | 0.408 | 2.82 | 4.86 | 8.94 | 19.15 |
| 4 | 2.85 | 1.97 | 5.75 | 0.351 | 3.43 | 5.18 | 8.69 | 17.46 |
| 5 | 5.10 | 2.03 | 6.55 | 0.196 | 5.25 | 6.23 | 8.20 | 13.10 |
| 6 | 6.05 | 0.00 | 0.00 | 0.165 | 5.83 | 6.66 | 8.31 | 12.44 |

SMOD3-OUTPUT: 47V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.38 | 3.17 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.98 | 1.00 | 4.18 | 0.505 | 2.07 | 4.60 | 9.65 | 22.27 |
| 3 | 2.25 | 1.02 | 5.09 | 0.444 | 2.85 | 5.07 | 9.51 | 20.62 |
| 4 | 2.57 | 1.25 | 0.00 | 0.389 | 3.66 | 5.60 | 9.50 | 19.22 |

SMOD3-OUTPUT: 48V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.35 | 3.13 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.75 | 0.56 | 3.77 | 0.571 | 1.61 | 4.47 | 10.19 | 24.47 |
| 3 | 2.38 | 1.52 | 5.05 | 0.420 | 2.87 | 4.97 | 9.17 | 19.67 |
| 4 | 3.19 | 1.35 | 5.90 | 0.313 | 4.15 | 5.72 | 8.85 | 16.69 |
| 5 | 3.67 | 1.11 | 0.00 | 0.272 | 4.81 | 6.18 | 8.90 | 15.71 |

SMOD3-OUTPUT: 49V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.31 | 3.08 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.80 | 1.12 | 4.32 | 0.556 | 1.70 | 4.48 | 10.04 | 23.92 |
| 3 | 2.18 | 1.69 | 5.87 | 0.459 | 2.94 | 5.23 | 9.82 | 21.29 |
| 4 | 5.29 | 0.00 | 0.00 | 0.189 | 5.54 | 6.48 | 8.37 | 13.10 |

SMOD3-OUTPUT: 65V27

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 3.36 | 4.48 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.97 | 1.13 | 5.63 | 0.508 | 2.90 | 5.44 | 10.52 | 23.21 |
| 3 | 5.55 | 0.00 | 0.00 | 0.180 | 5.39 | 6.29 | 8.09 | 12.59 |

SMOD3-OUTPUT: 12V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.76 | 1.01 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.83 | 0.66 | 1.73 | 0.546 | 0.58 | 3.31 | 8.78 | 22.44 |
| 3 | 4.51 | 0.00 | 0.00 | 0.222 | 1.61 | 2.72 | 4.94 | 10.48 |

SMOD3-OUTPUT: 13V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.20 | 1.60 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.80 | 0.59 | 2.26 | 0.556 | 0.88 | 3.66 | 9.22 | 23.11 |
| 3 | 2.52 | 0.61 | 2.74 | 0.397 | 1.74 | 3.73 | 7.70 | 17.62 |
| 4 | 4.50 | 0.49 | 2.96 | 0.222 | 2.51 | 3.62 | 5.84 | 11.40 |
| 5 | 5.15 | 0.00 | 0.00 | 0.194 | 2.67 | 3.64 | 5.59 | 10.44 |

SMOD3-OUTPUT: 14V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.24 | 1.65 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.78 | 0.46 | 2.17 | 0.562 | 0.89 | 3.70 | 9.32 | 23.36 |
| 3 | 2.55 | 0.93 | 2.90 | 0.392 | 1.71 | 3.67 | 7.59 | 17.39 |
| 4 | 5.15 | 0.00 | 0.00 | 0.194 | 2.70 | 3.67 | 5.61 | 10.47 |

SMOD3-OUTPUT: 15V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.29 | 0.39 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.22 | 0.52 | 0.86 | 0.450 | 0.29 | 2.54 | 7.04 | 18.30 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | 2.90 | 0.70 | 1.34 | 0.345 | 0.63 | 2.36 | 5.80 | 14.43 |
| 4 | 3.54 | 0.94 | 1.87 | 0.282 | 0.99 | 2.40 | 5.23 | 12.29 |
| 5 | 4.07 | 0.00 | 0.00 | 0.246 | 1.35 | 2.58 | 5.04 | 11.18 |

SMOD3-OUTPUT: 16V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.28 | 0.37 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.35 | 0.46 | 0.76 | 0.426 | 0.29 | 2.42 | 6.67 | 17.31 |
| 3 | 2.91 | 0.59 | 1.17 | 0.344 | 0.55 | 2.27 | 5.71 | 14.30 |
| 4 | 3.34 | 1.10 | 1.83 | 0.299 | 0.81 | 2.31 | 5.30 | 12.79 |
| 5 | 4.29 | 0.00 | 0.00 | 0.233 | 1.39 | 2.55 | 4.89 | 10.71 |

SMOD3-OUTPUT: 17V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.45 | 3.27 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.00 | 0.46 | 3.73 | 0.500 | 2.16 | 4.66 | 9.66 | 22.16 |
| 3 | 2.31 | 0.53 | 4.19 | 0.433 | 2.71 | 4.88 | 9.21 | 20.03 |
| 4 | 3.50 | 1.38 | 4.97 | 0.286 | 3.67 | 5.10 | 7.96 | 15.10 |
| 5 | 5.27 | 1.39 | 5.50 | 0.190 | 4.56 | 5.51 | 7.41 | 12.15 |
| 6 | 6.51 | 0.00 | 0.00 | 0.154 | 5.02 | 5.79 | 7.32 | 11.16 |

SMOD3-OUTPUT: 18V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.79 | 3.72 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.56 | 1.78 | 5.11 | 0.391 | 3.01 | 4.97 | 8.87 | 18.64 |
| 3 | 4.38 | 0.00 | 0.00 | 0.228 | 4.62 | 5.76 | 8.05 | 13.76 |

SMOD3-OUTPUT: 27V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.72 | 2.29 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.96 | 1.05 | 3.36 | 0.510 | 1.48 | 4.03 | 9.13 | 21.88 |
| 3 | 3.52 | 0.00 | 0.00 | 0.284 | 2.96 | 4.39 | 7.23 | 14.33 |

SMOD3-OUTPUT: 28V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.39 | 0.52 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.85 | 0.44 | 1.00 | 0.541 | 0.30 | 3.01 | 8.41 | 21.93 |
| 3 | 2.10 | 0.17 | 1.16 | 0.476 | 0.59 | 2.97 | 7.73 | 19.64 |
| 4 | 2.60 | 0.83 | 1.80 | 0.385 | 0.85 | 2.78 | 6.62 | 16.24 |
| 5 | 4.15 | 1.10 | 2.33 | 0.241 | 1.55 | 2.75 | 5.16 | 11.19 |
| 6 | 5.50 | 0.00 | 0.00 | 0.182 | 2.01 | 2.92 | 4.74 | 9.28 |

SMOD3-OUTPUT: 46V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.87 | 2.49 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.87 | 0.40 | 2.92 | 0.535 | 1.49 | 4.16 | 9.51 | 22.88 |
| 3 | 2.30 | 0.17 | 0.00 | 0.435 | 2.14 | 4.31 | 8.66 | 19.53 |

SMOD3-OUTPUT: 51V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 3.15 | 4.20 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.20 | 0.77 | 0.00 | 0.455 | 3.07 | 5.35 | 9.89 | 21.25 |

SMOD3-OUTPUT: 52V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.76 | 2.35 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.85 | 0.84 | 3.25 | 0.541 | 1.37 | 4.08 | 9.48 | 23.00 |
| 3 | 2.12 | 0.58 | 3.80 | 0.472 | 2.10 | 4.46 | 9.18 | 20.97 |
| 4 | 3.41 | 0.90 | 4.33 | 0.293 | 3.30 | 4.77 | 7.70 | 15.03 |
| 5 | 4.25 | 0.00 | 0.00 | 0.235 | 3.80 | 4.98 | 7.33 | 13.21 |

SMOD3-OUTPUT: 56V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.44 | 0.59 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 5.02 | 0.00 | 0.00 | 0.199 | 0.56 | 1.56 | 3.55 | 8.53 |

SMOD3-OUTPUT: 61V28

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.14 | 0.19 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 4.38 | 0.34 | 0.34 | 0.228 | 0.18 | 1.32 | 3.60 | 9.31 |
| 3 | 5.30 | 0.00 | 0.00 | 0.189 | 0.27 | 1.21 | 3.10 | 7.81 |

SMOD3-OUTPUT: 102V29

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.79 | 2.39 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.85 | 0.57 | 3.00 | 0.541 | 1.40 | 4.10 | 9.51 | 23.02 |
| 3 | 2.49 | 0.79 | 3.64 | 0.402 | 2.32 | 4.33 | 8.34 | 18.38 |
| 4 | 3.19 | 0.62 | 4.03 | 0.313 | 3.00 | 4.57 | 7.71 | 15.54 |
| 5 | 4.12 | 0.49 | 4.26 | 0.243 | 3.53 | 4.74 | 7.17 | 13.23 |
| 6 | 5.55 | 0.00 | 0.00 | 0.180 | 3.92 | 4.82 | 6.63 | 11.13 |

SMOD3-OUTPUT: 104V29

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.21 | 2.95 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.62 | 0.46 | 3.51 | 0.617 | 1.11 | 4.20 | 10.37 | 25.80 |
| 3 | 2.40 | 1.29 | 4.59 | 0.417 | 2.72 | 4.80 | 8.97 | 19.39 |
| 4 | 4.83 | 0.00 | 0.00 | 0.207 | 4.27 | 5.30 | 7.37 | 12.55 |

SMOD3-OUTPUT: 105V29

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.31 | 1.75 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.84 | 0.76 | 2.57 | 0.543 | 1.01 | 3.73 | 9.16 | 22.75 |
| 3 | 2.18 | 0.47 | 3.00 | 0.459 | 1.71 | 4.00 | 8.59 | 20.06 |
| 4 | 2.78 | 0.86 | 3.62 | 0.360 | 2.36 | 4.16 | 7.75 | 16.75 |
| 5 | 3.97 | 0.00 | 0.00 | 0.252 | 3.15 | 4.41 | 6.93 | 13.23 |

SMOD3-OUTPUT: 106V29

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.23 | 1.64 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.87 | 0.65 | 2.34 | 0.535 | 0.98 | 3.65 | 9.00 | 22.37 |
| 3 | 2.28 | 0.54 | 2.81 | 0.439 | 1.63 | 3.83 | 8.21 | 19.18 |
| 4 | 3.03 | 0.68 | 3.26 | 0.330 | 2.28 | 3.93 | 7.23 | 15.49 |
| 5 | 3.88 | 0.79 | 3.66 | 0.258 | 2.79 | 4.07 | 6.65 | 13.09 |
| 6 | 4.36 | 1.31 | 4.27 | 0.229 | 3.08 | 4.23 | 6.52 | 12.25 |
| 7 | 5.80 | 0.00 | 0.00 | 0.172 | 3.76 | 4.62 | 6.35 | 10.66 |

SMOD3-OUTPUT: 107V29

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.67 | 0.89 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.85 | 0.20 | 1.11 | 0.541 | 0.52 | 3.23 | 8.63 | 22.14 |
| 3 | 2.13 | 0.86 | 1.92 | 0.469 | 0.74 | 3.09 | 7.78 | 19.52 |
| 4 | 3.33 | 0.97 | 2.50 | 0.300 | 1.60 | 3.10 | 6.10 | 13.61 |
| 5 | 4.07 | 1.04 | 3.01 | 0.246 | 2.05 | 3.27 | 5.73 | 11.87 |
| 6 | 5.56 | 0.00 | 0.00 | 0.180 | 2.62 | 3.52 | 5.32 | 9.82 |

SMOD3-OUTPUT: 108V29

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.68 | 0.91 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.85 | 0.10 | 1.01 | 0.541 | 0.53 | 3.23 | 8.64 | 22.15 |
| 3 | 2.05 | 0.60 | 1.60 | 0.488 | 0.66 | 3.10 | 7.98 | 20.18 |
| 4 | 3.21 | 1.06 | 2.26 | 0.312 | 1.34 | 2.90 | 6.01 | 13.80 |
| 5 | 3.92 | 0.27 | 2.40 | 0.255 | 1.81 | 3.09 | 5.64 | 12.02 |
| 6 | 5.22 | 0.00 | 0.00 | 0.192 | 2.12 | 3.08 | 4.99 | 9.78 |

SMOD3-OUTPUT: 118V29

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.74 | 3.65 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.75 | 0.56 | 4.29 | 0.571 | 1.88 | 4.74 | 10.45 | 24.74 |
| 3 | 2.27 | 1.02 | 5.19 | 0.441 | 3.15 | 5.35 | 9.76 | 20.77 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 3.04 | 0.37 | 5.44 | 0.329 | 4.30 | 5.94 | 9.23 | 17.46 |
| 5 | 4.15 | 1.26 | 6.04 | 0.241 | 4.90 | 6.11 | 8.52 | 14.54 |
| 6 | 6.71 | 0.00 | 0.00 | 0.149 | 5.72 | 6.46 | 7.95 | 11.68 |

SMOD3-OUTPUT: S1

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.47 | 1.21 | 1.65 | 0.680 | 0.00 | 3.40 | 10.20 | 27.21 |
| 2 | 3.60 | 2.70 | 3.15 | 0.278 | 1.50 | 2.89 | 5.67 | 12.61 |
| 3 | 4.65 | 0.17 | 3.22 | 0.215 | 2.51 | 3.59 | 5.74 | 11.11 |
| 4 | 5.50 | 0.00 | 0.00 | 0.182 | 2.76 | 3.67 | 5.49 | 10.03 |

SMOD3-OUTPUT: S2

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.42 | 1.72 | 2.42 | 0.704 | 0.00 | 3.52 | 10.56 | 28.17 |
| 2 | 1.53 | 0.43 | 2.98 | 0.654 | 0.90 | 4.17 | 10.71 | 27.05 |
| 3 | 2.75 | 0.56 | 3.39 | 0.364 | 2.54 | 4.36 | 8.00 | 17.09 |
| 4 | 4.38 | 0.53 | 3.63 | 0.228 | 3.14 | 4.28 | 6.56 | 12.27 |
| 5 | 4.75 | 0.00 | 0.00 | 0.211 | 3.27 | 4.32 | 6.43 | 11.69 |

SMOD3-OUTPUT: S5

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.52 | 2.36 | 3.11 | 0.658 | 0.00 | 3.29 | 9.87 | 26.32 |
| 2 | 2.55 | 3.34 | 5.72 | 0.392 | 2.49 | 4.45 | 8.38 | 18.18 |
| 3 | 4.15 | 0.29 | 5.86 | 0.241 | 4.96 | 6.16 | 8.57 | 14.59 |
| 4 | 6.00 | 0.00 | 0.00 | 0.167 | 5.48 | 6.31 | 7.98 | 12.14 |

SMOD3-OUTPUT: S6-1

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.87 | 2.49 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.68 | 1.72 | 4.54 | 0.595 | 1.12 | 4.10 | 10.05 | 24.93 |
| 3 | 3.05 | 0.96 | 5.17 | 0.328 | 3.88 | 5.52 | 8.80 | 16.99 |
| 4 | 5.55 | 0.00 | 0.00 | 0.180 | 4.88 | 5.78 | 7.58 | 12.09 |

SMOD3-OUTPUT: S6-2

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.48 | 0.41 | 0.55 | 0.676 | 0.00 | 3.38 | 10.14 | 27.03 |
| 2 | 2.15 | 0.96 | 1.45 | 0.465 | 0.40 | 2.73 | 7.38 | 19.01 |
| 3 | 3.12 | 0.37 | 1.68 | 0.321 | 1.13 | 2.74 | 5.94 | 13.96 |
| 4 | 4.22 | 0.86 | 2.09 | 0.237 | 1.45 | 2.63 | 5.00 | 10.93 |
| 5 | 4.97 | 0.00 | 0.00 | 0.201 | 1.73 | 2.74 | 4.75 | 9.78 |

SMOD3-OUTPUT: S7

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.12 | 2.83 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.82 | 2.03 | 4.27 | 0.355 | 2.39 | 4.17 | 7.71 | 16.58 |
| 3 | 3.62 | 0.97 | 4.80 | 0.276 | 3.48 | 4.86 | 7.62 | 14.53 |
| 4 | 6.06 | 0.69 | 5.03 | 0.165 | 4.44 | 5.27 | 6.92 | 11.04 |
| 5 | 6.51 | 1.17 | 5.39 | 0.154 | 4.58 | 5.34 | 6.88 | 10.72 |
| 6 | 7.27 | 0.00 | 0.00 | 0.138 | 4.84 | 5.53 | 6.91 | 10.35 |

SMOD3-OUTPUT: SHACK977-1

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 1.79 | 2.39 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.50 | 2.04 | 4.02 | 0.400 | 1.91 | 3.91 | 7.91 | 17.91 |
| 3 | 4.08 | 0.00 | 0.00 | 0.245 | 3.51 | 4.73 | 7.19 | 13.31 |

SMOD3-OUTPUT: SHACK977-2

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 2.09 | 2.79 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 2.06 | 1.78 | 4.51 | 0.485 | 1.91 | 4.34 | 9.19 | 21.33 |
| 3 | 2.57 | 0.49 | 4.90 | 0.389 | 3.30 | 5.24 | 9.13 | 18.86 |
| 4 | 5.79 | 0.00 | 0.00 | 0.173 | 4.65 | 5.51 | 7.24 | 11.56 |

SMOD3-OUTPUT: SHACK977-3

| LAYER | V | Z | TWT | VIN | DT | TT5 | TT15 | TT40 |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.50 | 0.98 | 1.31 | 0.667 | 0.00 | 3.33 | 10.00 | 26.67 |
| 2 | 1.80 | 1.26 | 2.71 | 0.556 | 0.72 | 3.50 | 9.06 | 22.94 |
| 3 | 3.23 | 0.71 | 3.15 | 0.310 | 2.32 | 3.87 | 6.96 | 14.70 |
| 4 | 6.73 | 0.00 | 0.00 | 0.149 | 3.01 | 3.75 | 5.24 | 8.95 |