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SHIELDING EFFECTIVENESS OF SINGLE
CONDUCTOR FLAT SHIELDED CABLES (Rev.)

PDO 6984751, Topical Report

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Internal Distribution September 1976

Prepared for the United States Energy Research and Development
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**Kansas City
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Topical Report

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SHIELDING EFFECTIVENESS OF SINGLE CONDUCTOR FLAT SHIELDED CABLES

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September 1976

Prepared by G. S. Darner, D/862, under PDO 6984751

The effectiveness of flat cable shielding configurations for attenuating electromagnetic radiation and interference was studied. Configurations include equal center conductor and shield widths, center conductor widths less than shield layer widths, and total wrap-around shield layers. Shield defects were studied for their effect on shielding effectiveness.

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SUMMARY

The shielding effectiveness of single conductor shielded flat cables was studied to determine if shield and conductor geometry changes could reduce shield leakage. Common cable defects were also evaluated to establish their effect on shield effectiveness.

Present design configuration flat shielded cables utilizing two shield layers the same width as the center conductor were evaluated using a Singer Stoddart shield leakage detector to establish average reference shield leakage values. Cables with their center conductor width reduced to less than the width of the shield layers were evaluated and compared to the present design cables. The results indicated that cables with reduced center conductor width exhibited significantly less leakage than the present design cables. To determine if further reduction of the center conductor width would increase the leakage attenuation, cables were fabricated with the center conductor width very narrow compared to the shield width. Leakage evaluation showed this to be of no advantage.

A sample cable made with a solid wrap-around shield was found to allow much less leakage than the reduced center conductor width design. The shield was fabricated by flattening seamless aluminum tubing around the insulated flat center conductor.

Shield defects, shifted conductors, and shifted shield layers were found to increase leakage on the flat cables of both the presently used and the reduced conductor designs.

DISCUSSION

SCOPE AND PURPOSE

Several flat cable designs employ shielding to protect the assemblies they interconnect from electromagnetic radiation and interference from extraneous signal sources. As the need for shielding becomes more critical, new methods for improving shield effectiveness must be developed. The object of this project was to evaluate new shielding configurations for flat cables.

PRIOR WORK

Previous work done primarily involved modifying and evaluating Singer Stoddard Model 500 shielded enclosure leak detector used in this project.

ACTIVITY

The shielding effectiveness of the single conductor shielded flat cable design presently produced at Bendix was evaluated and compared to that of flat cables utilizing new shielding concepts to determine if the shielding effectiveness could be increased. Common defects encountered in production cables were also evaluated to observe their effects on flat cable shielding quality.

The present shielded flat cable configuration is shown in Figure 1. The aluminum center conductor is the same width as the aluminum shield layers (8.00 mm or 0.315 in. wide). The insulating material is Kapton. Ten cables fabricated in this configuration were evaluated using a Singer Stoddard Model 500 shielded enclosure leak detection system, referred to as a *sniffer*. The *sniffer*, calibrated in decibels, was used to determine relative shield effectiveness values of these cables and of other configurations. Table 1 shows the results of *sniffing* the present configuration cables. The average weighted db column lists the value derived by defining the $\emptyset$ db point on the 30 db attenuated scale as the weighted $\emptyset$ db reference point. All values in this column are relative to this point, allowing direct comparison of leakage values regardless of the *sniffer* attenuation setting.

The present design cables allow the edge of the center conductor to be exposed, providing a radiating surface for some amount of leakage. Tests with the *sniffer* indicate that the leakage detected on the present design cables originates from this exposed edge of the center conductor.

Figure 1. Present Design Shielded Flat Cable (Section View)

Table 1. Present Design *Sniffer* Values

Average Reading (db)	<i>Sniffer</i> Attenuation Scale (db)	Average Weighted Value (db)
10	60	40
13	60	43
9	60	39
8	60	38
9	60	39
6	60	36
8	60	38
9	60	39
10	60	40
7	60	37

Average Weighted Value = 38.9 db

A new design that reduces this edge leakage was evaluated. By producing cables with the aluminum center conductor width reduced by six times the distance of the center conductor to the aluminum shield layers [that is, the thickness of the Kapton insulation (0.05 mm or 0.002 in.) between the center conductor and the shield layer], a wave guide is formed along each edge of the cable which will attenuate the leakage radiating from the center conductor. Figure 2 shows this configuration. The resulting center conductor is 7.7 mm (0.303 in.) wide.

Table 2 shows the results of *sniffing* a sample lot of ten cables fabricated with the reduced width center conductor. The overall

Figure 2. Reduced Center Conductor Width Cable Design
(Section View)

Table 2. Reduced Center Conductor
Width Design *Sniffer*
Results

Average Reading (db)	<i>Sniffer</i> Attenuation Scale (db)	Average Weighted Value (db)
8	50	28
9	50	29
8	40	18
8	40	18
10	30	10
5	30	5
8	40	18
14	30	14
13	30	13
10	30	10
Average Weighted Value = 16.3 db		

average leakage value of this configuration is 22.6 db less than that of the present design cables, showing a significant leakage reduction.

Twelve cables were fabricated with the center conductor width reduced to about 2.54 mm (0.100 in.) to determine if further center conductor width reduction would further reduce leakage. Table 3 shows the resulting leakage values. The average value for this configuration is approximately the same as that of the lesser reduced configuration, yielding no further leakage attenuation.

For comparison, a sample cable was fabricated by flattening a length of seamless aluminum tubing around an insulated flat conductor to form a total wrap-around shield. When *sniffed*, this cable exhibited an average leakage value at least 20 db less than that of the reduced center conductor cables. An accurate actual leakage value was not obtainable because at the sensitive *sniffer* attenuation setting required to register this low level leakage, the *sniffer* is easily influenced by other noise sources such as the unshielded cable termination to the *sniffer* generator.

During this study, some typical cable defects were produced into the sample cables to determine their effects on shield effectiveness. Minor over-etched areas on the shield layers, exposing the center conductor, exhibited increased leakages of 4 to 7 db in the defect area. Areas of shifted or misaligned conductors on the present design cables increased leakage readings by about 5 to 10 db in areas where shifting exposed the center conductor. On the reduced center conductor cables, shifted conductors which cause the center conductor to come closer to the shield edge than three times the distance between the center conductor and shield dimension also cause increased leakage.

ACCOMPLISHMENTS

Reduction of the center conductor width of a shielded flat cable by at least six times the distance between the center conductor and the shield layer dramatically reduces the shield leakage from the cable. Additional indentation of the center conductor provides manufacturing tolerances but does not increase shielding effectiveness.

Cables fabricated with solid wrap-around shielding made from seamless tubing exhibit optimum shielding effectiveness.

Any defect which exposes the center conductor will allow shield leakage and reduce optimum shield effectiveness.

Table 3. Very Narrow Center
Conductor Design *Sniffer*
Results

Average Reading (db)	<i>Sniffer</i> Attenuation Scale (db)	Average Weighted Value (db)
15	30	15
12	30	12
18	30	18
15	30	15
17	30	17
15	30	15
19	30	19
12	40	22
16	30	16
14	40	24
16	30	16
10	40	20
Average Weighted Value = 17.4 db		

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ELECTRICAL: Cables

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