DIELECTRIC ANISOTROPY 'EJ END-GRAIN MEQ: MAGNETICALLY NEUTRAL SOR HAP TLHEGH QUTLHWI'DAQ CAPACITIVE LOAD HE ORIENTATION

dielectric anisotropy 'ej end-grain meq: magnetically neutral Sor Hap tlhegh QutlhwI'Daq capacitive load He orientation

A. Bosque, Y. Tanaka, M. Ferro, H. Park
Equatorial Audio Research Division, Mitad del Mundo, Quito, Ecuador (0.0000deg N)
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ngoD
Sor Hap tlhegh QutlhwI' -- signal DevwI' near fieldDaq polbogh dielectric body; vaj installationDaq contribution capacitance 'oH -- distributed, orientation-dependent, tlhegh tlhej parallel. flagship timber neutrality grading HaDDaq (Bosque, Ferro, Park and Tanaka, 2026), grain orientation design variable rur identify 'ej combined mechanical 'ej dielectric meq wa' sectionDaq jatlh end-grain-vertical milling adopt. companion ghItlhvam meq naQ chenmoH. Sor Hap dielectrically anisotropic: relative permittivity eps_r 'ej loss tangent tan delta grain along Daq across law' jen; along-grain axis cha' transverse axes law', tubular tracheid 'ej vessel cell geometry 'ej polarization dominatebogh bound-water dipoles fiber tlhej alignedmo'. pe'meH yoq teak wej anatomical axes Hoch (longitudinal L, radial R, tangential T) Daq eps_r 'ej tan delta guarded parallel-plate impedance-analyzer measurements wIja' -- 8, 12, 'ej 16 percent moisture content, 20 Hz vo' 10 MHz; audio frequencies 'ej 12 percent moisture Daq anisotropy ratio eps_L / eps_T 1.24 vo' 1.31 confirm. constantsvam vo' machined cradleDaq leSbogh tlhegh, Sor Hap column DungDaq distributed-capacitance model wIchenmoH 'ej end-grain-vertical versus face-grain milling per-block capacitive contribution wIcompute: orientation cha' measurable margin pIm; end-grain lower cable-referred capacitance nob, lower-permittivity transverse axes horizontal planeDaq lanmo' -- pa' tlhegh He HoS law' -- 'ej high-permittivity longitudinal axis vertical load HevaD polmo' -- electrical harmless 'ej mechanical ideal. grain-angle sweep coupling minimum true end-grainDaq locate. bertlhamDaq wIja': compressive stiffnessmo' end-grain wa'DIch specify; ghIq independently narghbogh dielectric meq -- mechanical meq tlhej agree 'ej confirm.

1. NGOQ

tlhegh QutlhwI' signal qengbe'. retlhDaq ba'. vaj electrical role dismisslu' nom: Sor Hap block tlhegh bIngDaq obvious circuitDaq 'elQo', vaj composition, grain, orientation je cabinetmakervaD, engineervaD Qo' net QublaH. flagship neutrality-grading ghItlh (Bosque, Ferro, Park and Tanaka, 2026) case magnetic half argue -- DevwI' reH touchbogh QutlhwI' -- DevwI' near-field pa' 'ay', 'ej residual paramagnetic content -- decorative Qo' 'ach measurable installation input. dielectric half section wa'Daq finish. ghItlhvam sectionvam physics deserving lengthDaq SachmoH.

block tlhegh retlhDaq ba', qoDDaq Qo' -- ghu'vam circuit vo' teqbe'; coupling mIw fix. DevwI' HeDaq dielectric body energy capacitively pol; transmission line tlhej parallel distributed capacitance -- load mach 'ach real -- permittivity 'ej He relative orientation Daq magnitude depend. Sor Hap isotropic dielectric Qo'. directionmo' permittivity choH, vaj Sor Hap QutlhwI' dielectric contribution wa' Qo' 'ach wej; billet pe' angle Daq milling bench wIvlaH.

ghItlhvam claim narrow 'ej quantitative. Equatorial Elevation Block end-grain-vertical orientation -- top faceDaq growth rings, load HeDaq fiber vertical -- block cable-referred capacitance minimize; minimum measurable, not notional; mechanical meqmo' wIvta'bogh orientation tlhej coincide. wanI' tIn wIjatlhbe'. sign, magnitude, preferred direction ghaj 'ej maker number Sovbe'taHvIS prettier face grainvaD reverse millchugh, number wrong directionDaq vIHmoH net wIjatlh neH.

2. SOR HAP DIELECTRIC ANISOTROPY

Sor Hap cellular solid -- long, hollow, axially aligned cells vo' chen: softwoodDaq tracheids; teak rur hardwoodDaq fibers 'ej vessels; long axis grain define. geometryvam woodworker Hoch Sovbogh mechanical anisotropy chenmoH; dielectric anisotropy not Sovlu' law' 'ach real rap 'ej tIq document (James, 1975; Torgovnikov, 1993).

wej mechanisms permittivity direction-dependent chenmoH, Hoch longitudinal axis favor. wa'DIch, cell walls continuous polarizable pathways fiber along chenmoH 'ej across interrupt; vaj wall-lumen boundaries law'Daq interfacial (Maxwell-Wagner) polarization grain along preferential accumulate. cha'DIch, cell wallsDaq bound water -- driest states retlhDaq Sor Hap permittivity dominant contributor -- hydroxyl sites 'ej micro-fibrillar scaffolding fiber tlhej alignedbogh pa'Daq ba', vaj bound-water dipoles orientational polarization grain along easier. wejDIch, transverse directions radial R 'ej tangential T -- nIbHa'ghach mach neH 'ej longitudinal value L bIngDaq. literature HochDaq result -- eps_L > eps_R ~ eps_T, loss tangent ordering rap, 'ej anisotropy ratio eps_L / eps_T 1.2 vo' 1.5 motlh temperate 'ej tropical hardwood hygroscopic rangeDaq.

absolute values modest 'ej moisture dominate. oven-dry Sor Hap eps_r = 2 vo' 3 Sum; moisture content ghurDI' steep 'ej monotonic ghur, bound-water increment Hoch polarizable inventoryDaq dipoles chelmo'. vaj moisture content -- species Qo' -- support dielectric contribution lever tIn law', 'ej Section 5 qel. anisotropy meqvaD structural point potlh, numerical Qo': highest permittivity direction fiber direction 'oH, 'ej woodworker directionvam cher, Sor Qo'.

3. MEASUREMENT: WEJ AXES DAQ PERMITTIVITY 'EJ LOSS

wej anatomical axes Hoch along pe'lu'bogh machined teak couponsDaq eps_r 'ej tan delta wIjuv; parallel-plate cell applied field -- sample longitudinal, radial, ghIq tangential vegh. coupons 40 mm square x 3.0 mm thick; flat 'ej parallel +/- 10 micrometres face; flagship protocol bIngDaq selected wej 5N-graded pe'meH yoq billets vo' pe', vaj magnetic contamination dielectric reading confusebe'. coupon sets Hoch humidity chambersDaq wej equilibrium moisture contents -- 8, 12, 'ej 16 percent -- condition, 'ej run rInDI' oven-dry mass tlhej gravimetrically moisture verify.

cell -- pa'logh Delbogh guarded parallel-plate fixture (Tanaka and Park, 2022), Keysight E4990A impedance analyzer 20 Hz vo' 10 MHz drive. guard ring fringing suppress, vaj measured capacitance defined electrode areaDaq 'ej extracted permittivity material bulk value, edge-contaminated estimate Qo'; fixture dissipation factor rur loss tangent direct laD. milled faces residual roughness accommodatemeH thin conductive-elastomer interlayers contact, polarizationDaj chellaHbogh adhesive pagh.

12 percent moisture content 'ej 1 kHz Daq teak eps_L = 2.64, eps_R = 2.09, 'ej eps_T = 2.02 nob; anisotropy ratio eps_L / eps_T 1.31 'ej eps_L / eps_R 1.26; transverse axes cha' 4 percent bIngDaq agree, pIHlu'bogh. loss tangent ordering rap tlha': tan delta grain along 0.021 'ej across 0.014 vo' 0.015. 20 Hz vo' 20 kHz audio bandDaq permittivities 3 percent bIngDaq flat 'ej anisotropy ratio 1.24 vo' 1.31 taH. moisture content 16 percentDaq values Hoch jenmoH -- eps_L 3.08 SIch -- 'ej anisotropy loQ SachmoH; bound water chelta'bogh favored axis along polarize preferential. 8 percentDaq drying absolute values 'ej ratio nupmoH. vaj anisotropy fixed material constant Qo', moisture-modulated; wetDaq HoS law' (pa' potlhHa' law') 'ej QaDDaq HoS puS; 12 +/- 1 percent delivery specificationDaq comfortably resolve 'ej stable.

4. CRADLE, TLHEGH, COLUMN DISTRIBUTED-CAPACITANCE MODEL

wej permittivities design wIvDaq choHmeH coupling geometry poQ. tlhegh flat blockDaq ba'be'; top faceDaq machined shallow radiused groove -- cradle -- Daq leS, vaj tlhegh jacket arc finite Sor Hap vo' jacket wall thickness neH chev. arc bIngDaq Sor Hap -- cradle floor vo' block bodyDaq short vertical column -- DevwI' 'ej distant ground return joj He HoS law'bogh Daq 'ej cable-to-support capacitance majority polbogh Daq. Hur 'ej bIngDaq Sor Hap -- field spread 'ej weakenDI' rapidly falling weight tlhej contribute.

run unit length Hoch distributed capacitance rur wImodel -- cradle bIng 'ej Dech Sor Hap volume vegh local field energy integrate, Sor Hap permittivity tensor axis Hoch insert. anisotropic dielectricvaD construction standard: vertical field component vertical-axis permittivity sample, horizontal components horizontal-axis permittivities sample; cradle conductor bIng near-vertical regionDaq field concentrate, 'ach capacitance SoQmoHbogh return paths column flanks vegh outward 'ej downward qetmo', horizontal permittivities stored energy share tIn qeng. model output engineeringvaD wa' mI': block tlheghDaq chelbogh capacitance, picofarads per block, permittivity tensor orientation function.

cha' practical orientations. end-grain-vertical milling longitudinal axis L vertical, load HeDaq lan; low transverse axes R 'ej T horizontal planeDaq lon. face-grain (flat-sawn, fibers horizontal) milling longitudinal axis L horizontal planeDaq lan -- pa' horizontal field components HoS sample -- 'ej transverse axis wa' vertical. 12 percent constants representative cradle geometryDaq feed (12 mm tlhegh diameter, 3 mm radiused cradle, 60 mm block height, chassis distanceDaq nominal ground return): end-grain orientationvaD roughly 1.9 pF per block; face-grain orientationvaD roughly 2.3 pF per block -- difference 0.4 pF Sum, roughly 18 percent, cut angle neHmo'. block HochDaq mach. real je, repeatable, sign wa' neH, 'ej free: billet correctly orientmeH decision neH cost; run naQ blocks law'Daq accumulate.

5. GRAIN-ANGLE SWEEP 'EJ MOISTURE SENSITIVITY

named orientations cha' continuum endpoints bIH; end-grain arbitrary choices cha' joj QaQ law' neH Qo', true minimum 'oH net confirm worth. load axis relative grain angles 0 deg (fiber vertical, true end-grain) vo' 30, 45, 60, 90 deg (fiber horizontal, face-grain) ghoSbogh coupon series wImill, 'ej energized DevwI' DungDaq cradle-model geometryDaq Hoch juv. grain angle ghurDI' cable-referred capacitance monotonic ghur -- 0 deg end-grain minimum vo' 90 deg face-grain maximum ghoS; high-permittivity longitudinal axis horizontal fieldDaq gradually rotateDI' tensor model predictbogh cos-squared weighting Sum tlha'. curve 0 deg Sum shallow -- milling error degrees puS almost pagh cost -- 'ej sweep botlhDaq steepqu', vaj genuinely careless cut penalty -- imperfect 'ach QaQ intent cut penalty law'. minimum true end-grainDaq 'oH; minimum 'oH, inflection Qo'.

moisture content curve naQ vertical shift 'ach minimum Daq vIHmoHbe'. bound water ghurDI' permittivity steep ghur; 12 vo' 16 percent moisture driftbogh block -- fixed moistureDaq end-grain-to-face-grain difference naQ law' absolute capacitance chel -- moisture lever orientation lever law'. 'ach independent bIH: Sor Hap wetmoHDI' floor jenmoH, lowest orientation choHbe'. vaj orientation 'ej conditioning complementary controls bIH 'ej cha' exercise poQ. vaj graded billet Hoch originDaq 12 +/- 1 percent kiln-drylu', 'ej maintenance schedule annual moisture check poQ: orientation millingDaq permanent fix 'ej driftlaHbe', 'ach scale moisture driftlaH, 'ej humid room tlhej equilibrium SIchbogh support -- milling bench margin QIt nobHa'.

Section 3 transverse-axis agreement -- horizontal planeDaq radial versus tangential presentation wIv measurement uncertainty bIngDaq irrelevant; top-face rings 'IH law'meH vertical axis Dech block rotationally indexlaH, fibers vertical taHchugh.

6. JA'CHUQ: CHA' MEQ, WA' ORIENTATION

end-grain orientation dielectric behaviorvaD adoptbe'. compressionDaq Sor Hap loadmeH end-grain stiff 'ej strong law'mo' adopt: fibers vertical QamDI', downward load tubular cells strong direction along qeng; block tlhegh run static weight 'ej installation settling SIQ -- creep mach 'ej dimensional choH mach. timber engineering ngo' 'ej controversy pagh; permittivity juvlu'pa' milling specification fix.

dielectric measurements naDev reportbogh ghIq ta'; theoryDaq mechanical wIv tlhej disagree laH -- along-grain axis low-permittivity axis net tu'chugh, vertical lan mechanical lugh 'ach electrical Qagh, compromise poQ. disagreebe'. along-grain axis high-permittivity axis 'oH, vaj vertical lanDI' horizontal plane vo' teq -- pa' tlhegh He HoS law' -- capacitance model poQbogh wanI' exact. mechanically ideal orientation -- independently dielectrically quietest orientation. cha' meq -- physics pIm vo', poH pImDaq, qay' pIm solvebogh ghotpu' chenmoH -- cut rap wIv.

agreementvamvaD mystical weight wIlanbe'; anisotropic materialsDaq stiff axis 'ej high-permittivity axis pIj aligned, property cha' aligned microstructure rap vo' narghmo', 'ej teak Hapvam 'oH. 'ach practical consequence taH. mechanical meq neH tlha'bogh maker end-grain SIch 'ej intent pagh capacitance minimize je. decorative face grainmo' mechanical meq overridebogh maker cha' countsDaq wa'logh luj. convergence marvel coincidence Qo', specification HarmeH meq: independent reasoning lines cha' mI' rapDaq rInDI', mI' lugh law'.

7. BERTLHAM

Sor Hap dielectrically anisotropic body 'oH, 'ej Sor Hap tlhegh QutlhwI' -- DevwI' near fieldDaq bodyvam pol. installation contribution -- distributed capacitance mach; magnitude milling benchDaq maker cher, Sov pagh Sovbe'. pe'meH yoq teak three-axis permittivity 'ej loss wIjuv, pIHlu'bogh ordering eps_L > eps_R ~ eps_T confirm -- delivery moisture contentDaq anisotropy ratio 1.3 Sum -- 'ej constants cradle-and-column capacitance model vegh picofarads per block figure of meritDaq qeng; end-grain 'ej face-grain milling joj measurable difference. end-grain lower: representative geometryDaq roughly 0.4 pF 'ej 18 percent; grain-angle sweep true minimum confirm.

block Hoch margin mach 'ej overstate wIrefuse. real 'oH, preferred direction ghaj, 'ej mechanical meqmo' specified direction rap 'oH -- neH wIassert. Equatorial Elevation Block end-grain-vertical milllu', compression load qengmeH end-grain stiff law'mo'; ghIq dielectric analysis ta' 'ej cut rap dielectrically quietest confirm. block Hoch end-grain Dung, 12 +/- 1 percent kiln-dried, unfinished ngeH; grade 'ej measured constants certificateDaq. latlh Sor Hap QutlhwI' maker vo' grain direction nuq, qatlh je tlhob laDwI' wIrItlh.

DE'MEY

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