

# Prior-Art Search Report

US 9,506,340 B2, *Downhole quartz gauge with minimal electronics* (Sercel Inc.)

|                       |                                                                                                                                             |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Search type</b>    | Invalidity-style prior-art search, claim 1 focus, with notes on selected dependent claims                                                   |
| <b>Subject patent</b> | US 9,506,340 B2; appl. 14/209,260 filed 13 Mar 2014; earliest claimed priority 14 Mar 2013 (US provisional 61/784,614); granted 29 Nov 2016 |
| <b>Cut-off date</b>   | Art dated (published, or US-filed for 102(e) purposes) before <b>14 Mar 2013</b>                                                            |
| <b>Sources</b>        | Google Patents full text (US, EP, WO, CA, AU and other offices indexed there). No non-patent literature in this sample (see section 8)      |
| <b>Date of report</b> | 30 September 2026                                                                                                                           |
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**Purpose of this document.** This is a sample search run on a published, granted patent so that a reviewing attorney can judge method, depth and presentation. It is not a validity or infringement opinion, and it was not commissioned by any party to the patent. Every reference cited below was opened and read at the pinpoint given; quotations are exact.

## 1. Bottom line

- **No single reference found anticipates claim 1.** The closest art discloses nearly every structural element but interrogates the downhole resonator with a pulse (or does not specify the interrogation scheme), rather than with a network-analyzer frequency sweep measuring phase and magnitude of the reflection.
- **Strongest obviousness case (35 U.S.C. 103): US 2009/0174409 A1** (Chevron; not cited during prosecution) in view of **US 7,162,918 B2** (Baker Hughes), optionally with **US 2010/0223011 A1** (Harris) for a vector network analyzer used as the reflectometer on a transmission line formed by well pipes. The Chevron publication supplies the downhole quartz resonant sensor, the coaxial line from the surface, the surface signal generator and receiver, reflection of the signal back up the line, and per-sensor unique resonant frequencies. Baker Hughes supplies a network analyzer sweeping frequencies to read a downhole-type resonator.
- **Weakest points of that case:** (i) element 1[c], a transmission line of at least 100 ft that is expressly *impedance-controlled to the sensor*, is not stated in terms in any reference found; (ii) element 1[g], measuring *phase and magnitude*, rests on what a vector network analyzer inherently does rather than on an express statement; (iii) the Baker Hughes network-analyzer passage describes a laboratory measurement by a third party, so motivation to combine must be argued.
- **Also relevant:** US 2013/0257435 A1 (Chevron, US-filed 29 Mar 2012) is 102(e)-type art that discusses swept peak-resonance measurement of a downhole quartz resonator over a transmission line, but criticizes it, which the patentee could cite as teaching away.

## 2. Claim 1 broken into elements

| Ref.          | Claim 1 element (verbatim, split for charting)                                                        |
|---------------|-------------------------------------------------------------------------------------------------------|
| <b>1[pre]</b> | A system for use in monitoring pressure, temperature, and/or vibration, the system comprising:        |
| <b>1[a]</b>   | a network analyzer,                                                                                   |
| <b>1[b]</b>   | at least one or more independent resonant sensors with unique resonance frequencies located downhole, |

| Ref. | Claim 1 element (verbatim, split for charting)                                                                                                                                                                                                                                                                                                                                                       |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1[c] | and a transmission line connecting the network analyzer to the at least one resonant sensor, the transmission line being a minimum of a single conductor with a ground at least 100 feet (30.48 m) in length and impedance-controlled to the at least one resonant sensor,                                                                                                                           |
| 1[d] | the network analyzer including an oscillating signal generator and a signal detector, the network analyzer being arranged to:                                                                                                                                                                                                                                                                        |
| 1[e] | apply an incident energy in the form of an oscillating signal along the transmission line connected to the at least one resonant sensor and frequency sweep the oscillating signal from one reference frequency to another reference frequency across the at least one resonant sensor, the expected natural resonance of the at least one resonant sensor being between said reference frequencies; |
| 1[f] | simultaneously receive a reflected portion of the incident energy from the at least one resonant sensor being passed back along the transmission line;                                                                                                                                                                                                                                               |
| 1[g] | measure a phase and magnitude of the received reflected portion of the incident energy; and                                                                                                                                                                                                                                                                                                          |
| 1[h] | identify a change in the received reflected portion of the incident energy across the swept frequencies.                                                                                                                                                                                                                                                                                             |

Independent method claim 13 tracks the same functional steps. Dependent claims charted briefly in section 7 are 3 (fixed resistor matching system impedance), 4 to 6 (second resonant sensor, parallel connection, simultaneous sweep), 10 (passive temperature sensor on the same line), 11 (LF or higher sinusoidal signal) and 12 (quartz pressure or temperature crystal).

### 3. Applicable prior-art regime and cut-off

The application was filed on 13 Mar 2014 and claims priority to 14 Mar 2013, two days before the AIA first-inventor-to-file provisions took effect (16 Mar 2013). If every claim is entitled to the 14 Mar 2013 date, **pre-AIA 35 U.S.C. 102** governs. That should be confirmed by comparing the claims against the priority application; if any claim lacks support there, the AIA regime applies to the whole patent.

The conclusions below do not depend on which regime applies: every reference relied on was either published, or filed in the United States, before 14 Mar 2013, so each qualifies under both pre-AIA 102(a)/(b)/(e) and AIA 102(a)(1)/(a)(2). The practical difference is that under pre-AIA law the patentee could try to antedate (Rule 131) references that are not statutory bars. The Chevron 2009 publication, the Baker Hughes patent and the Harris publication are all more than one year before the priority date and are therefore **102(b) statutory bars** that cannot be antedated.

### 4. Search strategy

**Concepts.** (A) passive downhole resonant sensor, especially quartz; (B) surface interrogation over a wired transmission line or coaxial cable; (C) reflection-based read-out; (D) network analyzer or frequency sweep; (E) frequency-division multiplexing of several sensors on one line; (F) impedance control / matching of a long line.

**Classification checked.** The subject patent's CPC codes E21B47/065 and E21B47/07 (downhole temperature/pressure measurement), G01L9/0022 (pressure by resonant elements), G01H13/00 and G01V1/44 were used to screen results for relevance. **Date limiter:** priority before 14 Mar 2013 on every query.

| # | Query (Google Patents full-text syntax)                                                          | Hits  | Useful results                                                                         |
|---|--------------------------------------------------------------------------------------------------|-------|----------------------------------------------------------------------------------------|
| 1 | (downhole OR borehole) quartz resonator (reflected OR reflects) (coaxial OR "transmission line") | 1,978 | Chevron crystal-resonator family incl. US 9,097,101 / US 2013/0257435; US 2011/0128003 |
| 2 | (downhole OR borehole) passive resonant sensor interrogate cable surface                         | 239   | Background only                                                                        |

| # | Query (Google Patents full-text syntax)                                                                                                        | Hits  | Useful results                                                          |
|---|------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------------------------------------------------------------|
| 3 | (downhole OR borehole) resonant sensors "different resonant frequencies" cable multiplex                                                       | 20    | GE resonant-sensor family (background)                                  |
| 4 | "network analyzer" resonator (sweep OR swept) (reflection OR reflected) sensor cable                                                           | 262   | Lab-instrument art; led to Baker Hughes US 7,162,918                    |
| 5 | (downhole OR borehole) "network analyzer" (sweep OR swept OR reflectometry)                                                                    | 192   | Harris US 2010/0223011 (VNA on well-bore line)                          |
| 6 | resonant sensor "transmission line" (sweep OR swept) phase magnitude reflected                                                                 | 1,093 | Mostly non-downhole; no closer art                                      |
| 7 | (downhole OR borehole) (resonator OR resonant) "characteristic impedance" (coaxial OR "transmission line") (reflected OR reflection) frequency | 519   | Harris; Chevron US 2008/0285619 (US 7,530,737); Chevron US 2008/0061789 |
| 8 | coaxial cable resonance sensor "vector network analyzer" reflection spectrum                                                                   | 88    | Habsonic US 2012/0272741                                                |

Hit counts are as returned by Google Patents on 30 Sep 2026 with the priority-date limiter applied. Earlier exploratory strings (SAW sensors on wireline, quartz S11 measurement, frequency-domain reflectometry of resonant sensors) returned only noise and are omitted. Citation-chasing was run forwards and backwards from each useful hit.

**Excluded as already before the examiner** (cited on the face of the patent): GB 2064127 A; US 4,724,381 A; WO 93/26115 A2; US 6,157,215 A; US 6,121,894 A; WO 01/73380 A1; US 7,299,678 B2; US 2008/0289408 A1; WO 2011/066188 A1; US 2012/0211278 A1. New art is more useful to a challenger because it was not considered during examination.

## 5. References found (not cited during prosecution)

| Rank    | Reference                                                                                                                                                                           | Key dates / status as art                                                                             | Why it matters                                                                                                                                                                                                                                                                                     |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 (Y)   | <b>US 2009/0174409 A1</b> , Chevron U.S.A. (Coates, Thompson, Beck, Gonzalez, Kendrick), <i>Downhole sensor interrogation employing coaxial cable</i> . Granted as US 9,547,104 B2. | Filed 4 Sep 2008; published 9 Jul 2009. <b>102(b) bar.</b>                                            | Surface signal generator and receiver; coaxial cable down the borehole; passive probe whose resonant circuit reflects the signal back up the line; quartz crystal whose resonant frequency changes with pressure or temperature; different natural resonance frequency per probe for multiplexing. |
| 2 (Y)   | <b>US 7,162,918 B2</b> , Baker Hughes (DiFoggio et al.), <i>Method and apparatus for downhole fluid characterization using flexural mechanical resonators</i> .                     | Granted 16 Jan 2007 (priority 2001). <b>102(b) bar.</b>                                               | Expressly teaches reading a resonator's response with a network analyzer that sweeps frequencies, in the context of downhole resonant sensing.                                                                                                                                                     |
| 3 (Y)   | <b>US 2010/0223011 A1</b> , Harris Corp. (Parsche), <i>Reflectometry real time remote sensing for in situ hydrocarbon processing</i> . Granted as US 8,494,775 B2.                  | Filed 2 Mar 2009; published 2 Sep 2010. <b>102(b) bar.</b>                                            | Uses a vector network analyzer as the reflectometer on an open-wire transmission line formed by well pipes ([0035]); reflected signal characterised by magnitude and impedance discontinuity ([0031]); scattering parameters measured ([0043]). Line length not stated.                            |
| 4 (Y/A) | <b>US 2012/0272741 A1</b> , Habsonic LLC (Xiao, Fan, Wei, Wu), <i>Coaxial cable Bragg grating sensor</i> . Granted as US 9,046,342 B2.                                              | Filed 2 Apr 2012; published 1 Nov 2012. Pre-AIA 102(a)/(e) (antedatable in principle); AIA 102(a)(1). | Coaxial-cable sensor with discrete resonance frequencies interrogated by a vector network analyzer recording the reflection spectrum; temperature and strain sensing. Not downhole: analogous-art argument needed.                                                                                 |

| Rank  | Reference                                                                                                                                             | Key dates / status as art                                                                    | Why it matters                                                                                                                                                                                                           |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5 (A) | <b>US 2013/0257435 A1</b> / US 9,097,101 B2, Chevron U.S.A. (Smithson), <i>System and method for measurement incorporating a crystal resonator</i> .  | US-filed 29 Mar 2012; published 3 Oct 2013. <b>102(e)</b> only (antedatable); AIA 102(a)(2). | Downhole quartz resonator read from the surface over a transmission line; discusses sweep-based peak-resonance detection and its limits. Useful for the knowledge in the art, but the criticism is a teaching-away risk. |
| 6 (A) | <b>US 2008/0285619 A1</b> / US 7,530,737 B2, Chevron U.S.A., <i>System and method for measuring temperature using electromagnetic transmissions</i> . | Published 20 Nov 2008. 102(b) bar.                                                           | Downhole resonant network device read via a <i>gated</i> directional coupler and pulse. Shows the pulse-and-listen approach that the patent's simultaneous-receive language appears drafted to avoid.                    |

Y = relevant in combination; A = background / state of the art. Other candidates reviewed and set aside as cumulative: US 2011/0128003 A1 and US 2011/0267065 A1 (Chevron crystal-oscillator and packer-fluid applications, 2011), US 2008/0061789 A1 (Chevron telemetry), and the GE *Sensing system and method* family (continuation-in-part chain; effective dates would need element-by-element tracing).

## 6. Claim chart: claim 1 against US 2009/0174409 A1 in view of US 7,162,918 B2 (and US 2010/0223011 A1)

Pinpoints are to paragraph numbers of the published applications and, for US 7,162,918, to the paragraph identifier on Google Patents (p-0038). Assessment column: **D** = disclosed expressly; **I** = inherent or implicit, argument needed; **G** = gap, not found in these references. Short forms: '409 = US 2009/0174409 A1; '918 = US 7,162,918 B2; '011 = US 2010/0223011 A1; '741 = US 2012/0272741 A1; '435 = US 2013/0257435 A1; '737 = US 7,530,737 B2 (published as US 2008/0285619 A1).

| Elem.  | Where found                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Assess.                  |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| 1[pre] | <b>'409 [0019]</b> : the apparatus is for “monitoring conditions in a subsurface borehole” and “may find application in monitoring of pressure and/or temperature”; pressure sensors “may provide for acoustic monitoring” (vibration).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>D</b>                 |
| 1[a]   | <b>'918 p-0038</b> : “Matsiev used an HP8751A network analyzer to sweep frequencies and measure response” of a resonator. <b>'011 [0035]</b> : the time domain reflectometer on the well-bore line “is preferably a vector network analyzer”. '409 itself uses a signal generator 112 and receiver 114, not a network analyzer.                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>D (in '918, '011)</b> |
| 1[b]   | <b>'409 [0035]</b> : motion of the diaphragm is transmitted to a quartz crystal and “as pressure is transmitted to an edge of the quartz crystal, its resonant frequency changes”; cut selects pressure or temperature sensitivity. <b>'409 [0024]</b> : “Setting a natural resonance frequency of each probe at a different frequency would, in principle, allow for a type of wavelength multiplexing on the coaxial line”. Probes sit in the borehole (FIG. 1, probe 124).                                                                                                                                                                                                                                                                       | <b>D</b>                 |
| 1[c]   | <b>'409 [0019]</b> : “the conductive line comprises a coaxial, or other cable” conducting electromagnetic energy through the borehole (a coaxial cable is a center conductor with a ground shield). Length of at least 100 ft is implicit in a producing well (the line runs from the wellhead to a probe near the packer, FIG. 1) but no figure is stated. '011 refers to sensing “ranges of 1,000 to 10,000 feet” ([0038]), but that is propagation range into the formation, not line length, so it should not be relied on for this element. <b>Impedance-controlled to the sensor</b> : not stated in terms. Argument: a coaxial line has a defined characteristic impedance, and terminating it to minimise mismatch is textbook RF practice. | <b>D / I / G</b>         |
| 1[d]   | <b>'409 [0020]</b> : signal generator 112 “may be configured to produce a pulsed or a continuous wave signal” and is coupled with receiver 114. A network analyzer (per '918 / '011) necessarily contains a source and a detector.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>D</b>                 |
| 1[e]   | <b>'918 p-0038</b> : network analyzer used “to sweep frequencies and measure response” of the resonator. Choosing sweep limits that bracket the expected resonance is the only sensible way to use a sweep to find a resonance. <b>'435 [0036]</b> confirms swept peak-resonance measurement of a downhole crystal over a transmission line was known (while noting its drawbacks).                                                                                                                                                                                                                                                                                                                                                                 | <b>D / I</b>             |

| Elem. | Where found                                                                                                                                                                                                                                                                                                                                                                                                                    | Assess. |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| 1[f]  | '409 [0027]: the resonant circuit, "upon receiving the pulse, modulates and re-emits or reflects the pulse back up the transmission line". Simultaneous receipt: '409 uses a pulse, and '737 uses a gated coupler (receiver disabled during the pulse), so simultaneity comes from the network analyzer of '918 / '011, which measures reflection while the stimulus is applied.                                               | D / I   |
| 1[g]  | A vector network analyzer ('011 [0035]) measures complex reflection, that is magnitude and phase, by definition; '011 characterises the reflected signal by its magnitude ([0031]) and refers to "scattering parameters measured by time domain reflectometer" ([0043]). Habsonic '741 [0048] records reflection spectra with a VNA. No reference found says "phase and magnitude" of a resonant sensor's reflection in terms. | I       |
| 1[h]  | '409 [0027]: the resonant frequency changes with the sensed condition, "thereby modulating the returned electromagnetic signal"; '409 [0021]: computer 114 processes the modulated frequency "to provide a measure of the sensed characteristic". With a sweep ('918), the change appears across the swept frequencies.                                                                                                        | D / I   |

### Motivation to combine

'409 leaves the interrogation electronics open (pulsed or continuous wave, [0020]) and itself proposes frequency-division multiplexing of several resonant probes on one coaxial line ([0024]). Separating several resonances on one line calls for a frequency-domain read-out, and the network-analyzer sweep of '918 is the standard instrument for measuring a resonator's response. '011 shows that a vector network analyzer was already used as the reflectometer on a transmission line formed by well pipes. A skilled person would therefore have had reason to substitute a swept network analyzer for '409's generator and receiver, with a reasonable expectation of success (KSR: combination of known elements by known methods to yield predictable results).

**Expected patentee responses:** (1) the '918 passage is a laboratory measurement of fluid resonators, not a downhole read-out over a long line; (2) '435 [0036] teaches that swept peak detection is error-prone because of noise and "limitations of sweep rate vs. transmission line delay", so the art pointed away; (3) no reference discloses impedance control of a 100 ft plus line to the sensor. Reply to (2): a stated preference for an alternative is not a teaching away unless the art discourages the claimed path (*In re Fulton*, 391 F.3d 1195 (Fed. Cir. 2004)); '435 still describes the swept approach as workable.

## 7. Selected dependent claims

| Claim | Limitation                                                                        | Best art found                                                                                                                                       |
|-------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3     | Increasing means is a fixed resistor substantially matching system impedance load | Not found in the references above. Resistive matching terminations are standard RF practice; a textbook or NPL citation would be needed. <b>Gap.</b> |
| 4     | A second resonant sensor                                                          | '409 [0024]: several probes "placed at intervals along the length", each with a different natural resonance frequency.                               |
| 5     | Sensors connected in parallel                                                     | Not stated in '409 ([0024] places probes at intervals along the line). Argue as design choice. <b>Partial.</b>                                       |
| 6     | Analyzer sweeps both sensors at the same time                                     | Follows from '409 [0024] multiplexing on one line combined with a single sweep ('918). Inherency argument.                                           |
| 10    | Passive temperature sensor on the same transmission line                          | '409 [0035]: crystal cut may be chosen for temperature sensitivity; '737 is directed to temperature measurement via a downhole resonant device.      |
| 11    | LF or higher sinusoidal signal from a signal generator                            | '409 [0020]: continuous wave signal; a network-analyzer sweep is sinusoidal.                                                                         |
| 12    | Resonant sensor is a quartz pressure or temperature crystal                       | '409 [0035]; '435 [0028]. Expressly disclosed.                                                                                                       |

## 8. Limits of this search and recommended next steps

- **Scope.** One patent database (Google Patents), English-language full text and machine translations only. No commercial database (Derwent, Orbit, PatBase) and no non-patent literature. The single most valuable addition would be an NPL pass through SPE, IEEE Xplore and OnePetro for (i) quartz gauge interrogation over wireline and (ii) the Matsiev network-analyzer papers referred to in '918, which may be closer than '918 itself.
- **Element 1[c].** Before relying on the combination, a targeted search for impedance-matched or terminated coaxial lines to downhole passive sensors (for example SAW sensors on wireline, and TDR cable-fault literature) should be run to close the gap.
- **Priority entitlement.** Confirm claim-by-claim support in the 14 Mar 2013 priority application; this decides pre-AIA versus AIA and therefore whether references 4 and 5 can be antedated.
- **Claim construction.** “Impedance-controlled” and “simultaneously receive” are the terms most likely to decide validity; the specification and prosecution history should be read for any definition or disclaimer before a final position is taken.
- **Not advice.** This is research support for a registered practitioner or attorney, who remains responsible for any opinion given on it.

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