NOVELTY ASSESSMENT

Date: 2025-07-14

Matter: A Glucose Sensing System Based on Transmission Measurements at Millimetre Waves using Microstrip Patch Antennas

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CONFIDENTIAL

This report does not constitute a legal opinion. Further searching and/or attorney review is recommended before relying on these results.

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1. EXECUTIVE SUMMARY

The invention discloses a non-invasive glucose sensing system that operates in transmission mode at 60 GHz using a pair of facing compact microstrip patch antennas (Rogers 5880, 1.5 × 1.5 mm) to measure the S21 transmission coefficient across a sample (liquid phantom or thin human tissue) and correlate permittivity changes to glucose concentration changes, including an in-vivo demonstration via IVGTT in human subjects, a theoretical optimal-frequency framework based on Debye permittivity models, and a multi-sensor integration architecture (RF + temperature + accelerometer + LabVIEW DAQ) for real-time environmental correction. Note: the document is a published scientific paper (Scientific Reports, 2017) rather than a formal IDF; the inventors and affiliated institution (MediWise / Medical Wireless Sensing Ltd, King's College London) are identified, and no formal scope-of-protection statement is provided. Key inventive features include: (1) use of compact microstrip patch antennas at 60 GHz specifically for transmission-mode glucose sensing, (2) a systematic optimal-frequency selection methodology based on tissue thickness and target concentration using Debye models, (3) in-vivo human glucose detection via S21 correlation during IVGTT, and (4) multi-sensor fusion with real-time environmental correction in a portable prototype.

No single identified patent reference appears to disclose all key features collectively — in particular, the specific combination of 60 GHz compact microstrip patch antennas operating in transmission mode with multi-sensor environmental correction and confirmed in-vivo human clinical glucose sensing. However, multiple prior art references disclose sub-sets of these features: millimetre-wave transmission-mode sensing (US11229383B2), non-invasive glucose sensing via microstrip-based sensors (WO2019098947A1), and millimetre-wave glucose monitoring using rectangular waveguides and reflection mode (US7371217B2). The combination of identified references may render some aspects obvious to a person having ordinary skill in the art (PHOSITA), particularly the use of patch antennas as replacements for waveguides at mmWave frequencies. The most commercially important distinguishing element appears to be the specific system integration: 60 GHz microstrip patch antennas in transmission mode combined with multi-sensor environmental correction, optimal-frequency selection methodology, and demonstrated in-vivo human clinical performance.
Freedom-to-operate/right-to-market searches should be conducted if prior art describes features already in use.

References found: Anticipatory: 0, Combinable: 6, Background: 8+.

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2. FEATURE COVERAGE MATRIX

FEATURE COVERAGE MATRIX

Invention: Glucose Sensing System — Transmission Mode at 60 GHz using Microstrip Patch Antennas
Key Features: F1: Transmission-mode EM glucose sensing — measuring S21/transmitted signal

amplitude through biological tissue or liquid sample to correlate to glucose concentration F2: Millimetre-wave frequency band (40–80 GHz, specifically ~60 GHz) chosen based on optimal frequency analysis for tissue thickness and glucose sensitivity F3: Compact microstrip patch antennas (facing pair) on low-loss substrate (Rogers 5880) as the transmitter/receiver elements — replacing bulky waveguides F4: Multi-sensor environmental correction system — accelerometer + dual thermometers + LabVIEW DAQ integration for real-time motion/temperature compensation F5: Demonstrated in-vivo human glucose sensing during IVGTT with successful glucose spike detection via S21 correlation F6: Systematic optimal-frequency framework using Debye permittivity models for glucose solution (validated against sample thickness and target concentration sensitivity)

Reference	F1	F2	F3	F4	F5	F6
US11229383B2 (Caltech/Huntington)	YES (transmission, S21 analog)	Partial (27–40 GHz, not specifically 60 GHz)	Partial (planar antennas mentioned, but main demos use rectangular waveguides)	Partial (temperature/pressure sensors mentioned)	YES (in-vivo rat, clinical patient monitoring)	NO (frequency selection by SNR/skin penetration, not Debye optimal model)
US7371217B2 (Samsung)	NO (reflection mode only — minimum power reflection coefficient)	Partial (10–100 GHz range, multiple bands)	NO (rectangular TE10 waveguide + plane parallel plate)	YES (temperature sensor for compensation)	NO (glucose solution in vitro only)	Partial (frequency-dependent dielectric model)
WO2019098947A1 (Singapore UT&D)	Partial (reflected S11 primary, S21 mentioned)	NO (1–2 GHz, sub-GHz range)	Partial (microstrip transmission line, not patch antenna)	NO	NO (in vitro NaCl solution phantom only)	NO
US11185261B2 (Univ. South Florida)	NO (resonant frequency shift of single patch antenna in reflection/single-port)	NO (5.725–5.875 GHz, ISM band)	YES (single microstrip patch antenna used)	NO	NO (in vitro oil phantom only)	NO
EP3432793B1 (Hebrew Univ.)	Partial (transmission or reflection mode mentioned)	Partial (0.5–60 GHz broadband sweep)	NO (coaxial probe / open resonator sensor)	YES (temperature sensor, optical perfusion sensor, accelerometer mentioned)	Partial (intended for in-vivo human, but no clinical glucose data presented)	NO
IN202011050895A	YES (transmission + reflection)	NO (unspecified frequency)	NO (generic EM source/detector, no specific antenna type)	NO	NO (method described, no human data)	NO

3. INVENTION SUMMARY

3.1 Technical Field

Non-invasive biomedical sensing; millimetre-wave (mmWave) electromagnetic technology; microstrip antenna design; dielectric spectroscopy; continuous glucose monitoring for diabetes management.

3.2 Problem Addressed

Existing non-invasive glucose monitors lack adequate sensitivity, accuracy, or practical compactness for clinical use. Reflection-mode systems suffer from insufficient signal penetration to blood-containing tissue. Prior waveguide-based transmission systems (including the inventors' own V-band waveguide system) require precise alignment, are bulky, and cannot be miniaturised for wearable or handheld use. Lower-frequency EM techniques (< 10 GHz) have insufficient sensitivity to clinically-relevant glucose changes across tissue thicknesses of 2–4 mm.

3.3 Proposed Solution

A compact, portable mmWave glucose sensing system operating in transmission mode at approximately 60 GHz, using a pair of opposing 1.5 × 1.5 mm square microstrip patch antennas fabricated on Rogers 5880 substrate (εr = 2.2, 254 μm thickness). The antennas are mounted in a U-shaped holder with micro-positioners for precise alignment across the area under measurement (AUM — e.g., the tissue between index finger and thumb, or earlobe). Changes in the complex permittivity of the intervening tissue/sample — caused by changes in glucose concentration — are detected as changes in the transmission coefficient $\Delta S21$ measured via a vector network analyzer (VNA). Complementary environmental sensors (thermometers, accelerometer) monitored via National Instruments DAQ and LabVIEW allow correction for temperature drift and motion artefacts.

3.4 Key Inventive Features

1. **Transmission-mode operation**: The system measures the S21 transmission coefficient (rather than reflection) across the sample, providing higher sensitivity to permittivity changes in thin tissue regions.
2. **60 GHz compact patch antennas**: Square microstrip patch antennas (1.5 × 1.5 mm) on Rogers 5880, resonating at 60.25 GHz with ~10 GHz bandwidth, gain of 7.77 dBi, and ~99% radiation efficiency, replacing bulky waveguide fixtures.
3. **Optimal-frequency selection framework**: A theoretical analysis using Debye permittivity models for glucose solutions quantifies sensitivity ($\Delta S21/\Delta g/\Delta d \approx 0.0047$ dB/mm·mmol/L at 60 GHz) and system uncertainty as functions of frequency and sample thickness, with fopt maps confirming 40–80 GHz as the optimal range for typical human tissue.
4. **Multi-sensor environmental correction**: Integration of dual thermometers, a 3-axis MEMS accelerometer, and LabVIEW DAQ to log and correct for temperature-induced S21 drift and motion/vibration artefacts in real time.
5. **In-vivo human clinical demonstration**: Successful detection of a physiological glucose spike (6 → 30 mmol/L, ΔIVGTT) via $\Delta S21 \approx 0.8$ dB measured across the thin tissue of the right hand in 10 human subjects undergoing IVGTT at University of Roehampton.
6. **Low glucose detection limit**: Detection of glucose concentrations as low as 0.025 wt% (≈ 1.33 mmol/L) in controlled water-based samples, below clinical fasting glucose levels.

3.5 Point of Novelty

The specific combination of: (a) compact 60 GHz microstrip patch antennas operating in **transmission mode** (measuring S21); (b) an analytical Debye-model-derived **optimal frequency selection framework** validated against both laboratory samples and human tissue; (c) **integrated multi-sensor**

environmental compensation (temperature + motion) within a single portable platform; and (d) **demonstrated in-vivo human glucose spike detection** during a clinical IVGTT. Prior art systems at mmWave frequencies used bulky rectangular waveguides or operated in reflection mode. Prior microstrip/patch antenna glucose sensors operated at lower frequencies (< 10 GHz) and relied on resonant frequency shifts rather than broadband transmission amplitude.

3.6 Intended Scope of Protection

Apparatus (glucose sensing system with paired mmWave patch antennas in transmission mode), method (measuring S21 to determine glucose concentration), and system (integrating RF, environmental, and data acquisition components). Jurisdictions not specified in the document (UK/Europe inferred from institutional affiliations; Innovate UK funding acknowledged).

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4. PRIOR ART REFERENCES

4.1 Reference Summary Table

#	Reference	Title / Assignee	Date	Classification
1	US11229383B2	Methods and systems for non-invasive measurement of blood glucose concentration by transmission of millimeter waves through human skin / Caltech + Huntington	2022-01-25 (priority 2014-08-25)	Combinable
2	US7371217B2	Device for the non-invasive measurement of blood glucose concentration by millimeter waves / Samsung Electronics	2008-05-13 (priority 2004-06-17)	Combinable
3	WO2019098947A1	Apparatus and method for non-invasively monitoring blood glucose / Singapore Univ. of Technology and Design	2019-05-23 (priority 2017-11-15)	Combinable
4	US11185261B2	System and method for non-invasive blood glucose monitoring / Univ. of South Florida	2021-11-30 (priority 2018-01-30)	Combinable
5	EP3432793B1	System for non-invasive monitoring of blood conditions / Yissum (Hebrew Univ.)	2020-01-08 (priority 2016-03-23)	Combinable
6	IN202011050895A	Apparatus and method for non-invasive measurement of blood glucose concentration	2022-10-14	Combinable
7	US20200253502A1	Continuous Blood Glucose Monitor / Individual (Arnold)	2020-08-13	Background
8	US10921274B2	Apparatus for in vivo dielectric spectroscopy / Individual	2021-02-16	Background

#	Reference	Title / Assignee	Date	Classification
9	US12471808B1	System and method for non-invasive blood glucose monitoring / Univ. of South Florida	2025-11-18 (priority 2018-01-30)	Background
10	IN202211033211A	DGS Based Slotted Millimeter-Wave Microstrip Patch Antenna for Non-Invasive Blood Glucose Level Monitoring	2024-01-05	Background
11	US11529077B1	High performance glucose sensor / USBC Inc	2022-12-20 (priority 2022-05-05)	Background
12	KR100581518B1	Device for the non-invasive measurement of blood glucose concentration by millimeter waves / Samsung (KR)	2006-05-22	Background
13	WO2012059741A1	In-vivo monitoring with microwaves / Cardiff Univ.	2012-05-10	Background
14	US20130289370A1	Method and device for detecting blood glucose using electromagnetic wave / Nat'l Taiwan Univ.	2013-10-31	Background
15+	Various (CN111565639, JP2021502880, CN111954492, etc.)	Family members of above; various background references	Various	Background

4.2 Detailed Reference Descriptions

Reference 1 — US11229383B2 (Caltech/Huntington Medical Research)

Title: Methods and systems for non-invasive measurement of blood glucose concentration by transmission of millimeter waves through human skin **Priority**: August 25, 2014 (US Provisional 62/041,447) **Assignee**: California Institute of Technology; Huntington Medical Research Institute

This is the most relevant single reference. It discloses a device for in-vivo transdermal blood glucose measurement using millimetre waves (20–300 GHz) in **transmission mode**, with a transmitter and receiver antenna/waveguide placed on opposing sides of biological tissue (earlobe, skin fold between fingers, etc.), measuring changes in magnitude and/or phase of the transmitted MMW signal to estimate glucose concentration. The patent describes that the transmitter and receiver can include **planar antennas** fabricated on flexible polymer substrates. In-vivo testing on rats shows 0.2–0.25 dB changes per glucose injection event at 27–34 GHz. A CMOS transceiver chip version at 35–39 GHz is also described, with folded dipole antennas on printed circuit boards. The patent explicitly covers operation from 20 to 300 GHz, frequency tuning without antenna geometry change, use of a clip to hold the tissue, and continuous 24-hour monitoring.

Key disclosure distinction from the invention: US11229383 covers the generic concept of mmWave transmission through skin for glucose sensing, including planar antennas, but: (i) its primary experimental demonstrations use rectangular waveguides (WR-28, Ka-band at 27–40 GHz) or CMOS

chips (35–39 GHz) — not specifically 60 GHz microstrip patch antennas on Rogers 5880; (ii) it does not disclose the specific optimal-frequency selection framework based on Debye models that the disclosure presents; (iii) it does not disclose the specific multi-sensor environmental correction architecture (accelerometer + dual thermometers + LabVIEW DAQ); (iv) it mentions temperature/pressure sensing in passing but does not detail a real-time multi-sensor fusion system for correction of S21 data.

Reference 2 — US7371217B2 (Samsung Electronics)

Title: Device for the non-invasive measurement of blood glucose concentration by millimeter waves and method thereof **Priority**: June 17, 2004 (Korean Patent 2004-45158) **Assignee**: Samsung Electronics Co. Ltd.

This patent discloses a device for non-invasive glucose measurement using millimetre waves in **reflection mode** (measuring minimum power reflection coefficient Rmin and corresponding frequency fmin). The device uses a TE10 rectangular waveguide and a plane parallel plate inserted between the waveguide and the tissue/sample. A temperature sensor compensates for temperature-induced dielectric changes. Measurements are demonstrated on glucose–water solutions and glucose–saline solutions in frequency bands between 9 GHz and 100 GHz (including 62–65 GHz and 83–84 GHz). The resolution achieved is about 0.05 wt% (~ 3 mmol/L) at 83 GHz.

Key disclosure distinction from the invention: Uses reflection mode (not transmission), rectangular waveguides (not microstrip patch antennas), and does not disclose in-vivo sensing or the optimal-frequency Debye-model analysis framework. The temperature compensation concept is similar to the disclosure's thermometer integration, but the implementation differs.

Reference 3 — WO2019098947A1 (Singapore University of Technology and Design)

Title: Apparatus and method for non-invasively monitoring blood glucose **Priority**: November 15, 2017 **Assignee**: Singapore University of Technology and Design

This reference discloses a microstrip transmission line (MLIN)-based glucose sensor where the subject's body part (finger or wrist) is inserted as the substrate between the microstrip conductor and a ground plane, and glucose concentration is determined from parameters (S11 reflection coefficient, input impedance) of the output signal compared against calibration curves. The sensor operates at 1–2 GHz (resonant band). Multiple parameters (real/imaginary parts of S11 and Z11) are used for multivariate estimation. It is wearable (ring, finger stall, bracelet forms). This is fundamentally different from the invention's approach: it uses low frequencies, a single-sided microstrip (body as substrate), reflection mode, and does not use facing antennas in transmission mode at 60 GHz.

Reference 4 — US11185261B2 (University of South Florida)

Title: System and method for non-invasive blood glucose monitoring **Priority**: January 30, 2018 **Assignee**: University of South Florida St. Petersburg

Discloses a non-invasive CGM system using a **microstrip patch antenna** at the ISM band (5.725–5.875 GHz) positioned above the skin over a blood vessel. Glucose concentration is determined from the **resonant frequency shift** of the antenna (not S21 transmission coefficient). A VNA or RF synthesizer with directional coupler and logarithmic amplifiers drives the antenna; shift in fo correlates to blood glucose via blood permittivity changes. This differs from the invention in that it operates at ~5.8 GHz, uses a single patch in reflection/resonance mode (not paired antennas in transmission), and is not demonstrated in human IVGTT testing.

Reference 5 — EP3432793B1 (Yissum / Hebrew University of Jerusalem)

Title: System for non-invasive monitoring of blood conditions **Priority**: March 23, 2016 **Assignee**: Yissum Research Development Company (Hebrew University of Jerusalem)

Discloses a system for non-invasive monitoring of blood conditions including glucose concentration using dielectric spectroscopy across 0.5–60 GHz. The system uses antenna sensors placed on the skin (reflection and/or transmission modes mentioned) and a multi-sensor platform including temperature

sensors, optical perfusion sensors, and an accelerometer. The core mechanism is different: it tracks changes in the relaxation peak of the dielectric spectrum of RBC cytoplasm (Debye/Cole-Cole model analysis of the bulk water response), rather than measuring bulk permittivity changes caused by dissolved glucose. The frequency range overlaps (up to 60 GHz) but the measurement concept differs substantially. It explicitly acknowledges accelerometer use for correction — a concept shared with the disclosure.

Reference 6 — IN202011050895A

Discloses an apparatus combining electromagnetic transmission and reflection measurements of tissue, with a trained ML model to determine glucose concentration. Uses generic EM source and detector without specifying frequency or antenna type. Relevant as a combinable reference for multi-parameter (S11 + S21) glucose sensing.

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5. NOVELTY ANALYSIS

5.1 Anticipation Assessment

US11229383B2: Does NOT anticipate the invention in full. While this reference discloses transmission-mode mmWave glucose sensing including planar antenna embodiments and in-vivo testing, it: (a) does not specifically disclose microstrip patch antennas at 60 GHz on Rogers 5880 substrate; (b) does not disclose the systematic Debye-model-based optimal frequency selection methodology (fopt maps based on Δg vs. d); (c) does not disclose the specific multi-sensor correction architecture (accelerometer + dual thermometers + LabVIEW DAQ as a sensor fusion system); and (d) the in-vivo human demonstration in the disclosure predates the priority date of US11229383B2 (2014). However, this reference presents the closest conceptual overlap and must be carefully assessed against any formal claims.

US7371217B2: Does NOT anticipate — uses reflection mode, rectangular waveguides, and in-vitro samples only. Missing F1 (transmission), F3 (microstrip patch antenna), F5 (in-vivo human), F6 (Debye-based optimal frequency framework).

WO2019098947A1: Does NOT anticipate — different frequency range (1–2 GHz), different architecture (single-sided MLIN, reflection mode), different sensing mechanism. Missing F2 (60 GHz), F1 (transmission across tissue), F3 (facing pair of patch antennas), F5, F6.

US11185261B2: Does NOT anticipate — single patch antenna in resonance/reflection mode at 5.8 GHz. Missing F1 (transmission), F2 (60 GHz), F4 (multi-sensor environmental correction), F5 (in-vivo human), F6.

EP3432793B1: Does NOT anticipate — different sensing mechanism (RBC cytoplasm Cole-Cole spectral analysis vs. bulk permittivity amplitude), different antenna types (coaxial/resonator), no 60 GHz patch antenna specifics. Missing F3 (microstrip patch antennas at 60 GHz), F6.

IN202011050895A: Does NOT anticipate — no specific frequency, antenna type, or environmental correction architecture disclosed. Missing F2, F3, F4, F5, F6.

5.2 Novelty Conclusion

No single identified prior art reference discloses all key features of the invention. The features that most consistently distinguish the invention from the prior art are:

- **F3**: The specific use of compact 60 GHz microstrip patch antennas (1.5 × 1.5 mm on Rogers 5880) as a facing transmitter-receiver pair in a portable glucose sensing system
- **F4**: The complete multi-sensor environmental correction system (accelerometer + dual thermometers + LabVIEW DAQ) tightly integrated with the RF sensing
- **F6**: The Debye-model-derived systematic optimal-frequency selection framework (fopt maps as a function of Δg and tissue thickness d)

- **F5**: Demonstrated in-vivo human glucose sensing via S21 during a clinical IVGTT

The combination F1+F2+F3 (transmission mode at 60 GHz with microstrip patch antennas) appears **potentially novel** over the searched prior art, as US11229383B2 — the closest reference — primarily uses waveguides or non-patch planar elements at 27–40 GHz. The Debye-model framework (F6) and the specific environmental correction architecture (F4) appear novel individually.

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6. NON-OBVIOUSNESS / INVENTIVE STEP ANALYSIS

6.1 Prior Art Landscape

The prior art landscape at the time of the disclosure's priority date (paper received January 17, 2017; the inventors' earlier V-band waveguide work dates to 2015) shows:

- Millimetre-wave transmission-mode glucose sensing was known in concept but demonstrated only with bulky rectangular waveguides (the inventors' own earlier work; US11229383B2's early experiments)
- Patch and planar antenna designs at mmWave (60 GHz) frequencies were well-established for communications and radar but not yet demonstrated for glucose sensing
- Reflection-mode mmWave glucose sensing was demonstrated at 33–95 GHz (Samsung, Meriakri et al.)
- Microstrip/MLIN sensors for glucose sensing were known at lower frequencies (Singapore UT&D at 1–2 GHz; Univ. South Florida at 5.8 GHz)
- Multi-sensor environmental correction (temperature, motion) was discussed conceptually in some prior art (EP3432793B1, US11229383B2)
- Optimal frequency selection for dielectric sensing was studied generally, but the specific Debye-model-based fopt framework for glucose concentration vs. tissue thickness appears novel in the context of a portable sensing system design

6.2 Differences from Inventive Concepts

The key differences over the closest prior art (US11229383B2) are:

1. The choice of **60 GHz specifically** (V-band, supported by the disclosed fopt analysis) vs. the 27–40 GHz range emphasized in US11229383B2
2. The use of **microstrip patch antennas** (as opposed to waveguides, horn antennas, or folded dipoles on PCB) as the signal coupling elements in a portable configuration
3. The **systematic Debye-model optimal frequency framework** that provides a principled design methodology
4. The **specific multi-sensor fusion architecture** combining RF measurement with motion (accelerometer) and temperature sensing integrated in a single portable housing with real-time LabVIEW correction
5. **Demonstrated in-vivo human IVGTT results** with observed ~3 min delay between IV glucose injection and peripheral S21 spike

6.3 Potential Combinations and Motivation

Combination 1 — US11229383B2 + patch antenna art: A PHOSITA might be motivated to substitute the waveguide elements of US11229383B2 with compact patch antennas (which were well-known at 60 GHz for communication applications) to achieve miniaturisation. This combination could be argued to cover F1+F2+F3. However, the specific choice of 60 GHz and the Rogers 5880 substrate and 1.5 × 1.5 mm dimensions represent engineering choices informed by the disclosure's Debye-model analysis and optimisation work (non-trivial). The substitution of waveguides with patch antennas in a transmission-mode glucose sensor at 60 GHz was not routine or trivially predictable, as patch antenna

performance in close proximity to high-loss biological tissue is sensitive and requires specific substrate and design choices.

Combination 2 — US11229383B2 + EP3432793B1: The multi-sensor correction architecture of EP3432793B1 (temperature, perfusion, accelerometer) combined with the mmWave transmission sensing of US11229383B2 would cover F1+F2+F4 (partially). However, EP3432793B1 operates at a different frequency and uses a completely different sensing mechanism (spectral analysis vs. broadband amplitude tracking). Motivation to combine these specific references non-obviously is debatable.

Combination 3 — US7371217B2 + US11229383B2: The temperature compensation of US7371217B2 combined with transmission sensing of US11229383B2 covers F1+F4 partially. But this combination still does not reach F3 (patch antennas at 60 GHz) or F6 (Debye-based framework).

Overall Assessment: The most commercially defensible inventive aspect is likely the **specific integrated system** combining all features F1–F6, particularly the demonstrated human clinical results (F5), which represent a significant practical advancement not suggested by combination of the individual references. The **Debye-model optimal frequency selection framework** (F6) has standalone inventive merit as a design tool. Non-obviousness arguments are strongest for the complete integrated system and for F6; they are weakest for F1+F2 (transmission at mmWave) alone, which is closely anticipated by US11229383B2.

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7. SEARCH METHODOLOGY

7.1 Search Method

Semantic search via FluidityIQ Patents MCP tool (`search_patents` with `patent_details` for top candidates). Four primary queries were submitted in Round 1 (parallel), a targeted Round 3 query was submitted, and full-text details were retrieved for 7 references via `patent_details`.

Queries used:

1. Non-invasive glucose sensing at millimetre waves 60 GHz transmission mode with facing microstrip patch antennas, S21 measurement, continuous glucose monitoring
2. Microstrip patch antenna at 60 GHz on Rogers 5880 for biomedical permittivity sensing, replacing waveguide structures
3. Glucose concentration detection via electromagnetic transmission through tissue using S-parameter S21, complex permittivity, vector network analyzer
4. Millimetre-wave dielectric spectroscopy with temperature/motion compensation via sensor fusion and LabVIEW data acquisition
5. Targeted: 60 GHz V-band patch antennas in U-shaped portable casing, acrylic sample tank, micro-positioners, multi-sensor fusion

7.2 References Categorized

- **Anticipatory**: 0
- **Combinable**: 6
- **Background**: 8+ (patent family members and lower-relevance references not individually detailed)

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8. LIMITATIONS AND CAVEATS

1. **Document type assumption**: The submitted document is a published peer-reviewed scientific paper (Scientific Reports, 2017), not a formal Invention Disclosure Form. Patent claim scope, priority dates, intended jurisdictions, and filing status are unknown. Analysis assumes the paper represents the invention as intended for patent protection and that it predates any patent

application (filed around 2015–2016 based on Innovate UK funding dates and conference abstracts cited). This is a significant assumption; a registered patent professional should verify actual filing history.

2. **Priority date uncertainty**: The paper was received January 17, 2017 (published July 31, 2017). The inventors cite their own prior V-band waveguide work (2015) and EuCAP 2016 conference abstracts. If patent applications were filed before 2017, prior art dates for searching must be recalibrated.
3. **Publication as prior art**: This paper itself constitutes prior art (publication date July 31, 2017) that must be considered in any priority analysis. If no patent application was filed before this date, the publication may bar patent protection in jurisdictions requiring absolute novelty (EPC, most jurisdictions) unless a grace period applies.
4. **Jurisdictions**: No specific jurisdictions were stated in the document. UK and European coverage is inferred from institutional affiliations (King's College London, University of Roehampton) and the Innovate UK funding. US coverage may be of interest given the commercial product (GlucoWise) referenced.
5. **Search scope**: This search covers patent documents (granted patents and published patent applications) only. Non-patent literature — including the inventors' own prior publications (the 2015 V-band waveguide paper, the EuCAP 2016 abstract) — constitutes potentially invalidating prior art under most patent laws and was not searchable with this tool. The inventors' own V-band waveguide disclosure (2015) is particularly relevant and must be assessed.
6. **18-month secrecy window**: Patent applications filed within 18 months before the search date may not yet be published and cannot be identified in this search. Given the rapidly active field of non-invasive glucose sensing, this is a material limitation.
7. **Semantic search blind spots**: The search was conducted using natural-language semantic queries. References using very different terminology (e.g., references describing "V-band dielectric measurement" without explicit glucose context, or patents in Chinese describing 60 GHz permittivity sensors) may not have been retrieved.
8. **No non-patent literature**: Academic publications, conference papers, technical standards, and product literature are excluded from this search. In this particular field, academic publications (including the inventors' own prior work) constitute significant potential prior art.
9. **No legal advice**: This report represents analytical support only and does not constitute a legal opinion on patentability or freedom to operate. Review by a qualified patent attorney or agent registered to practice before the relevant patent offices is strongly recommended before any filing decisions are made.

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